1949
NEW ZEALAND

EDUCATION, TRAINING, AND SUPPLY OF PROFESSIONAL ENGINEERS IN NEW ZEALAND

REPORT OF THE CONSULTATIVE COMMITTEE APPOINTED BY THE HON. THE MINISTER OF EDUCATION IN FEBRUARY, 1948, TO INVESTIGATE THE EDUCATION, TRAINING, AND SUPPLY OF PROFESSIONAL ENGINEERS IN NEW ZEALAND

Laid on the Table of the House of Representatives by Leave

By Authority: R. E. OWEN, Government Printer, Wellington.—1949.

TABLE OF CONTENTS

CONSTITUTION OF COMMITTEE

Mr. E. Caradus, O.B.E., formerly Chief Inspector of Post-primary Schools (Chairman).

Mr. M. A. Bull, Principal of Timaru Boys' High School (representing New Zealand Secondary Schools' Association).

Professor G. G. Calvert, Dean of the Faculty of Engineering at Canterbury University College (representing the University of New Zealand).

Mr. H. Henderson, Senior Inspector of Post-primary Schools (representing Education Department).

Mr. E. N. Hogben, Headmaster of Wellington College (representing New Zealand Secondary Schools' Association).

Mr. H. L. Hume, Chief Designing Engineer, Ministry of Works (representing Commissioner of Works).

Mr. A. R. Hynes, Senior Inspector of Post-primary Schools (representing Education Department).

Mr. F. T. M. Kissel, I.S.O., formerly General Manager of State Hydro-electric Department (representing Engineers Registration Board).

Professor T. D. J. Leech, C.B.E., Dean of the Faculty of Engineering at Auckland University College (representing the University of New Zealand).

Mr. A. McFadyen, formerly Principal of the Hutt Valley Memorial Technical College (representing New Zealand Technical School Teachers' Association).

Mr. W. G. Morrison, Consulting Engineer, Wellington (representing New Zealand Institution of Engineers).

Mr. G. S. J. Read, Inspecting and Test Engineer, Railways Department (representing New Zealand Institution of Engineers).

Mr. J. Sukolski, Head of the Engineering Department of Wellington Technical College (representing New Zealand Technical School Teachers' Association).

Secretariat :—

Mr. A. B. Thompson, Education Department.

Mr. E. G. Budge, Education Department (Secretary to the Committee).

PREFACE

12th February, 1949.

To the Hon. T. H. McCombs, Minister of Education.

Sir,—

We have the honour to present to you our report on the education, training, and supply of professional engineers in New Zealand.

This Committee met for the first time on Tuesday, 8th June, 1948, and has met in all on twenty-eight days.

Two days were spent by the Committee in Auckland and two in Christchurch in order to see something of the facilities for engineering training at the University schools of engineering and the technical schools in those two cities. All other meetings were held in Wellington.

You will remember that the setting-up of the Committee was decided upon in consequence of representations made to the Right Hon. the Prime Minister by a combined deputation from the New Zealand Institution of Engineers and the Professional Engineers' Association. This deputation made representations about the training and also the emoluments and supply of engineers.

This Committee's original order of reference was as follows:—

(1) What are the most satisfactory courses to be undertaken at the post-primary stage by prospective entrants to the engineering profession?

(2) Is the present standard of entrants to degree and diploma courses in engineering satisfactory?

(3) To what extent, if any, should instruction in professional engineering subjects be provided in the technical schools?

(4) Are the present facilities (staffing, accommodation, and equipment) at the University colleges or at the technical schools sufficient for the numbers of students offering?

(5) If the answer to (4) is in the negative, what improvements are required?

(6) What instructional courses in engineering subjects should be provided by the Technical Correspondence School?

(7) What weaknesses, if any, exist in the present standard of instruction available at any stage?

It was, however, also within the order of reference of the Committee to inquire into and to make a recommendation with regard to any other matter not listed above which the Committee considered relevant to the inquiry.

Early in its deliberations the Committee found that certain aspects of training were dependent upon the existing and future requirements of the Dominion for professional engineers and upon the actual supply. The numbers to be accommodated at the University schools of engineering and the numbers of engineering bursaries to be made available were obviously both dependent upon the numbers of engineers required. Training and supply were interrelated to such an extent that a satisfactory investigation of one necessitated an investigation of the other. You therefore referred to us later the question of supply, and this, too, we have considered.

The Committee had power to co-opt and also to set up specialist sub-committees to make recommendations to it about any of the matters under consideration.

The present Committee includes representatives of the New Zealand Institution of Engineers, the Engineers Registration Board, the Ministry of Works, the University of New Zealand, the New Zealand Secondary Schools' Association, the New Zealand Technical School Teachers' Association, and the Education Department.

We should like to express our thanks to all those organizations and individuals who tendered evidence and thus assisted our deliberations and also to those who completed the questionnaire sent out by the Committee. This assistance was much appreciated. We wish also to express our appreciation of the efficient work of the Secretariat and to thank them for their continued attention to the whole problem.

We have the honour to be, Sir,

Your obedient servants,

E. CARADUS, Chairman.
M. A. BULL.
GUY G. CALVERT.
H. HENDERSON.
E. N. HOGBEN.
H. L. HUME.
R. HYNES.
F. T. M. KISSEL.
THOS. D. J. LEECH.
A. MCFADYEN.
W. G. MORRISON.
G. S. J. READ.
J. SUKOLSKI.

PART I

1. INTRODUCTION

1. The first part of this report may be said to provide "background data"—that is to say, it seeks to define the term "professional engineer" and to describe the qualifications required within the terms of that definition.

2. The registration of professional engineers in New Zealand is entrusted to a statutory body, the Engineers Registration Board. The Committee's definition depends upon the qualifications acceptable to this specially constituted Board, so that it is necessary to set out briefly the constitution and function of that Board and to explain its relation to the British professional institutions. As will be seen from what follows, a candidate for recognition by the Board may acquire his basic educational qualifications in two main ways—either through a University course leading to the degree of B.E. or by satisfying examination requirements similar to those necessary for admission to one of the recognized professional institutions. The second of these methods has been subject to some modification in recent years. In order to clear the ground for an evaluation of the present training it is necessary to describe the special engineering schools of the University and to set out in some detail the examination requirements, other than the University degree, acceptable to the Registration Board. Part I of this report is therefore mainly descriptive and offers little by way of comment.

2. DEFINITION OF A PROFESSIONAL ENGINEER

3. It is difficult to find an entirely satisfactory definition of a professional engineer. The Committee decided to adopt the following as defining clearly the scope of the principal inquiry:—

> "A 'professional engineer' is one who has the examination qualifications and the experience required by the Engineers Registration Board for registration."

4. These qualifications are considered in more detail later in the report, but they may be regarded as corresponding very closely to the requirements of the British Institutions of Civil, Electrical, and Mechanical Engineers. The above definition, of course, gives little indication of the duties and responsibilities of the professional engineer or of the significance of his work in society. What the Committee has had in mind throughout its deliberations, however, has been well expressed in the following passages:—

(*a*) Taken from the Charter of the Institution of Civil Engineers, London—

> Engineering is the art of directing the great sources of power in Nature for the use and convenience of man.

(*b*) Taken from submissions made by the American Society of Civil Engineers in connection with legislation—

> The term "professional engineer" within the meaning and intent of this Act shall mean a person who by reason of his special knowledge of the mathematical and physical sciences and the principles and methods of engineering analysis, and design, acquired by professional education and practical experience, is qualified to practice engineering as herein defined, as attested by his legal registration as a professional engineer.
>
> The term practice of engineering within the meaning and intent of this Act shall mean any professional service or creative work requiring engineering education, training, and experience, and the application of special knowledge of the mathematical, physical, and engineering sciences to such professional services or creative work as consultation, investigation, evaluation, planning, design, and the supervision of construction for the purpose of assuring compliance with specifications and design, in connection with any public or private utility, structure, buildings, machines, equipment, processes, works, or projects.

(*c*) Taken from a speech by an American Senator when speaking to an Engineers' Registration Bill—

The term "professional engineer" means one engaged in work—

(i) Predominantly intellectual and varied in character as opposed to routine mental, manual, mechanical, or physical work.

(ii) Involving the consistent exercise of discretion and judgment in its performance.

(iii) Of such a character that the output produced or the result accomplished cannot be standardised in relation to a given period of time.

(iv) Requiring knowledge of an advanced type in a field of science or learning customarily acquired by a prolonged course of specialized intellectual instruction and study, as distinguished from a general academic education or from an apprenticeship or from training in the performance of routine mental, manual, or physical processes.

(*d*) As incorporated into the Engineers' Registration Act of each of the provinces of Canada (slightly modified)—

The practice of professional engineering means the carrying on for hire, gain, or hope of reward of any branches of civil, mechanical, or electrical engineering, including the reporting on, designing, or directing the construction of any works which require for their design, or the supervision of their construction, or the supervision of their maintenance, such experience and technical knowledge as are required for registration or for admission by examination to membership of a chartered engineering institution or recognized engineering body; but the execution as a contractor of work designed by a professional engineer, the supervision of construction of work as a foreman or overseer or superintendent, or the superintending of operation or maintenance does not in itself constitute the practice of professional engineering.

3. METHOD OF INQUIRY

5. The general method of inquiry was easy to lay down. In approaching the Government to have this investigation carried out the New Zealand Institution of Engineers had in effect asked for a frank discussion with representatives of educational organizations so that the Institution could set out what it would like done to overcome apparent weaknesses and to effect improvements in engineering education in this country. It was then for the educational organizations to give their views as to whether the apparent weaknesses were in fact real, what the causes were and whether they were capable of control, and whether improvements suggested by the Institution could be implemented.

6. The Committee therefore called evidence first of all from the New Zealand Institution of Engineers and the Engineers Registration Board and referred this evidence to the University of New Zealand, the Deans of the Schools of Engineering who, in fact, were the representatives of the University on the Committee, the New Zealand Secondary Schools' Association, the New Zealand Technical School Teachers' Association, and the Education Department. These organizations were asked to comment on the points raised in the submissions of the Institution and the Board and were at the same time invited to make any fresh comment on any matters within the Committee's order of reference. This evidence was in turn referred to the Institution and the Board for their further comments.

7. The members of the Committee decided at an early stage that, on balance, it was desirable for them to act as far as possible in a judicial capacity. Accordingly, where it could be conveniently arranged, submissions by the organizations which had nominated members were made by other members of these organizations.

8. Meanwhile, a press statement by the Hon. the Minister of Education and advertisements in all the newspapers in the four main centres and in the publication *Engineering* invited other interested organizations and persons to submit evidence. A full list of those organizations which have made submissions is set out in Appendix I.

9. The Committee also decided to draft a questionnaire designed to obtain information to assist in answering questions relating to supply and demand. The coverage and the figures obtained from this questionnaire are referred to in Section 8 of the report. Those filling in the questionnaire were invited to make any comments relevant to the inquiry. A large number of thoughtful and valuable criticisms and suggestions were thus made available to the Committee from a wide range of employing authorities and firms.

10. Visits were paid to the following educational institutions:—

16th and 17th September, 1948: Auckland University College School of Engineering.

16th and 17th September, 1948: Seddon Memorial Technical College, Auckland.

23rd and 24th September, 1948—

National School of Engineering, Canterbury University College.

Christchurch Technical College.

6th October, 1948—

Wellington Technical College.

Hutt Valley Memorial Technical College, Petone.

11. These visits enabled the Committee to obtain a better knowledge of the facilities and equipment available at most of the institutions specializing in the education of professional engineers. During the visits sufficient time was set aside to hear formal evidence, mainly from the controlling authorities and members of the staff, but also from other interested persons.

4. THE REGISTRATION OF ENGINEERS

(1) THE ENGINEERS REGISTRATION ACT, 1924

12. The Engineers Registration Board was set up under the Engineers Registration Act, 1924, and consists of six persons appointed by the Hon. the Minister of Works, of whom three are nominated by the New Zealand Institution of Engineers, one being representative of civil engineers, one of electrical engineers, and one of mechanical engineers. The Act came into operation on the 1st April, 1925.

13. The Board considers the qualifications of applicants for registration and, where it is satisfied that the applicants' qualifications are adequate, arranges for their names to be entered on the register kept by the Board.

14. The Engineers Registration Amendment Act, 1944, which amended the original Act, increased the significance of the Board's functions by providing for the issue of annual practising certificates and, subject to certain stated exemptions, prohibited local authorities from having unregistered engineers in charge of any engineering work. The register, as now published in the *Gazette*, contains the names of those engineers holding current practising certificates, but not all professional engineers are necessarily registered. There is provision in the Act for penalties to deter persons from representing that they are registered engineers when, in fact, they are not.

(2) FUNCTIONS OF THE ENGINEERS REGISTRATION BOARD

15. The Board's principal functions, and those of most interest to this Committee, are—

(*a*) To assess examination qualifications submitted and, as a consequence of this function, to provide examinations for those whose qualifications are not accepted; and

(*b*) To determine whether the practical experience of the applicant is sufficient for registration.

16. When the principal Act was passed, and again with the passing of the 1944 Amendment Act, statutory provision was made for the registration of some engineers who, at the time of the passing of the Act or the amendment, were already engaged in the profession even though they did not possess any approved examination qualifications. The number so registered is relatively small and is continually decreasing. The Board has stated in its evidence that engineers in future will need to have approved examination qualifications, in addition to responsible experience, before being eligible for registration.

17. The Board normally grants recognition in one or other of the three main branches of engineering—that is, civil, mechanical, or electrical. Applicants who have the necessary qualifications in two or three of the main branches are recognized accordingly. Subsidiary branches, however, are recognized, if at all, only where the applicant cannot qualify in the main branch. Such recognition has been applied most frequently in the case of those people who lack the usual examination qualifications.

(3) THE BOARD'S EXAMINATION REQUIREMENTS

18. The minimum standards of approved examination qualification required by the Board are those of Sections A and B of the major British Engineering Institutions of Civil, Mechanical, and Electrical Engineers. Any other examination of equal or higher standard is accepted, including in this class the degree of B.E. of the University of New Zealand and the corresponding degrees of most of the other Universities of high standing. Other examinations may be accepted on a subject-for-subject basis if of equivalent standard.

19. In addition to the examination qualification, an applicant for registration is required to satisfy the Board that he has had adequate training and sufficient responsible experience; and to do this he is required to submit a report on his work, together with samples, and to undergo an oral and written examination on his submissions. This is known as Section C, and only candidates with at least, say, four years' training and three years' responsible experience are permitted to take it. Bachelors of Engineering seeking registration must satisfy the requirements of Section C unless they hold a certificate from one of the recognized professional institutions.

(4) LIAISON WITH THE BRITISH INSTITUTIONS OF ENGINEERS

20. Applicants who have not the necessary examination qualifications for registration may take the Board's examinations which have been set continually since 1925. Until 1940 the Board prepared its own question papers with a syllabus similar to that of the major British Engineering Institutions. During the war, however, it was arranged with each of the British Institutions for the Board to use its question papers. This practice has been continued since the war. A further advance is that the British Institutions of Civil and Mechanical Engineers now recognize passes in the examinations marked by the Board. This means that a candidate who passes the Board's examinations will be exempt from the examinations of the British Institution of Civil or of Mechanical Engineers if he applies for corporate membership of one of those Institutions at a later date.

21. It will be noted that the British Institution of Electrical Engineers has not adopted the same course. The Board, in presenting its evidence, submitted the following quotation from a letter of the Institution of Electrical Engineers:—

> It is the firm educational policy of this Institution that, as soon as it is practicable, all entrants to the profession should obtain all their higher education by means of recognized courses only and not by being coached for external examinations. It is probable that when this result is achieved our own examinations will still continue to be set in order to maintain a yardstick, but it will definitely be the hope that only in exceptional cases would the examination be actually written by candidates. In conformity with this policy, it is now the practice of the Council in according recognition to academic qualifications, whether they be obtained at a University or a technical college, to pay more attention to the conduct of the course itself than to the content of the examination, though naturally this, and the method of its conduct, are carefully scrutinized.

22. This statement of policy reflects the growing tendency to realize that educational institutions will accept enthusiastically any proposals which, by placing less stress on final external examinations, give them greater scope and flexibility in providing courses of instruction best suited to the needs of the students and of the profession.

5. THE EDUCATION OF UNIVERSITY STUDENTS IN ENGINEERING

(1) THE B.E. DEGREE

23. Candidates for the degree of B.E. of the University of New Zealand must have passed the University Entrance Examination. The engineering student is not specially restricted in the subjects which are to be taken for University Entrance, but the Calendar of the University of New Zealand contains a note that students who propose to take the B.E. degree should include English, Mathematics, and Physics or Chemistry or Mechanics in their school course. Probably about half the students remain at school at least a year after passing University Entrance, partly in order to get a better grounding in subjects such as Mathematics and the physical sciences and partly to qualify for more remunerative bursaries or scholarships than the ordinary University bursary which is awarded to any student who obtains University Entrance.

24. Examinations in professional engineering were first instituted by the University of New Zealand in 1892 when certificates were drawn up in mechanical, civil, mining, and metallurgical engineering for issue to students "who have gone through a course of study at the School of Engineering and technical science at Canterbury College." In the following year, however, the University substituted for these the degree of B.Sc. (Eng.) in one or other of the above branches. The degree of B.E. was instituted in 1905. The degree of B.E. (Hons.) dates from 1934 for the civil, electrical, and mechanical branches and from 1947 for the chemical branch. The first stage of the B.E. course is known as the Intermediate Examination, and this may be taken at any University college, the subjects being Pure Mathematics, Applied Mathematics, Physics, and Chemistry, all as set out in the prescription for Stage I of the B.A. degree. Candidates in B.E. (Mining) or B.E. (Metallurgical) may offer Geology in lieu of Applied Mathematics. The complete range of subjects for the professional examinations which are taken when the Intermediate Examination is completed, and particulars of the practical experience necessary before the degree is conferred, are set out in Appendix 2.

(2) THE SPECIAL SCHOOLS OF ENGINEERING

25. Instruction for the professional examinations is given in three special schools of the University of New Zealand. These special schools are attached—one to the University of Otago, one to Canterbury University College, and one to Auckland University College.

(*a*) The Otago School of Mines

26. The special school in Engineering at the University of Otago is not only the oldest school of engineering, but the oldest University special school in this country. When the University of Otago was founded in 1871 provision was made for four Chairs. For one of these, a Chair in Natural Science, preference was to be given, other things being equal, to a candidate able to teach Chemistry and Mineralogy, and the application of these sciences to Agriculture and Mining. It so happened that the University Council found a person with the somewhat varied qualifications required, and a School of Mines developed at once under his capable guidance. Since that date, in spite of considerable financial difficulties from time to time, the Otago School of Mines has built up a reputation as enviable as the National School of Engineering in Christchurch. The Otago school specializes in the Mining and Metallurgical branches of the B.E. degree, being the only school in this country offering complete courses in these branches. It also offers a course leading to the Associateship of the Otago School of Mines.

(b) The National School of Engineering

27. The history of the National School of Engineering at Canterbury University College dates back to 1885, when certain lectures were given. These were so successful that a Lectureship in Engineering was established in 1887. By 1894 there had been sufficient development to warrant the establishment of a Chair in Engineering and the appointment of Professor R. J. Scott as the first Professor in charge of the school. The great majority of the students had not in fact matriculated, but for those who had there was a course of four years embracing mechanical or civil engineering. The successful students obtained the certificate of the school until the institution of certificates by the University of New Zealand in 1892, as already mentioned. When the University instituted the B.Sc. (Eng.) degree in 1893 the Canterbury College School was recognized as the engineering school of the University in civil and mechanical engineering. Instruction in electrical engineering began in 1901.

28. In 1920 the school was explicitly recognized by the Government as the National School of Engineering for the Dominion. On the retirement of Professor Scott in 1923 it was decided to create a Chair in each of the three main branches—civil, electrical, and mechanical. The school now provides complete courses for the B.E. and the B.E. (Hons.) degree in mechanical, civil, electrical, and chemical engineering. Details are set out in Appendix 3.

(c) Auckland University College School of Engineering

29. A study of the development of the School of Engineering at Auckland University College is bound up with the history of the thorniest problem in University affairs—the location of special schools. Soon after the opening of Auckland University College in 1883 the question of the distribution of special schools came up at a time when the University of Otago was finding it increasingly difficult to finance special schools of both Medicine and Mines. The suggestion was made from Otago that Otago should concentrate on Medicine, Canterbury on Engineering, and Auckland on Engineering and Mining. This proposal made no progress until 1904, when the Prime Minister promised assistance to the Otago Medical School on the sole condition that the School of Mines be transferred to Auckland. Otago, however, successfully resisted the transfer, and finally a compromise was arrived at by which Auckland University College was also to have a School of Mines. A Government grant was made in 1906, and a Professor was appointed to take charge of the School of Mines and to give some instruction at technical-school level to engineers. As there were four mining schools on the Auckland mining field where the students could get theoretical and practical training at the same time, the University school failed to attract many students. Accordingly, the equipment was used for the training of engineering students. In 1918 the Senate of the University of New Zealand permitted Auckland University College to start classes in Architecture, and in the following year the School of Architecture was formally recognized.

30. With the Schools of Mines and Architecture Auckland found itself authorized to teach all of the subjects for the first three years of the full B.E. course in mechanical engineering and practically all those for civil and electrical engineering. For a long time the anomalous position continued, that for most of the examinations in the first two professional examinations of the degree in engineering an Auckland student could sit and count a pass towards degrees in mining and architecture, but he could not sit for civil, mechanical, or electrical engineering degrees, although the examination papers were identical.

31. In course of time the Senate recognized the Auckland school as being competent to prepare students for the First Professional Examination of the B.E. degree. This was extended later to cover the Second Professional Examination, and from

January, 1943, the school was permitted to prepare students for the complete course of B.E. (mechanical). In 1949 the Senate of the University of New Zealand agreed to recognize the Auckland school for the complete course in civil engineering. In other branches Auckland is permitted to prepare candidates except for the final year. Details of the courses offered in 1948 are set out in Appendix 4.

6. EDUCATION FOR PROFESSIONAL ENGINEERING OTHER THAN BY A UNIVERSITY DEGREE

32. The British Institutions of Civil, Mechanical, and Electrical Engineers provide in their regulations for exemption from the purely theoretical examination requirements for graduates in engineering from recognized Universities and for others who hold qualifications equivalent to examinations conducted by the Institutions. There is a considerable measure of uniformity in these examinations, but there are some differences of detail.

(1) THE COMMON PRELIMINARY EXAMINATION AND RECOGNIZED EXEMPTIONS FROM IT

33. So that there may be as much uniformity as possible the three main Institutions, and some Institutions in other branches of engineering, have combined to form the Engineering Joint Examinations Board which conducts some examinations for all the Institutions. The best known of these examinations, known as the Common Preliminary Examination, is, subject to exemptions, compulsory for Civil Engineers ; it is compulsory for Electrical Engineers only if they do not complete the next stage, Section A, by the end of the year in which they become twenty-three. It is not required for Mechanical Engineers, but those who pass it or secure exemption normally gain exemption also in English for Section A. The subjects for the Common Preliminary Examination are—

(1) English.
(2) Arithmetic and Algebra,
(3) Geometry and Trigonometry, all of which are compulsory,
And any two of the following—
(4) Elementary Mechanics,
(5) Elementary Physics,
(6) Elementary Chemistry,
(7) A foreign language.

34. As the Institution of Civil Engineers requires a candidate to pass in a foreign language, either as part of the examination or separately, before proceeding to Section A, this considerably restricts the options for civil engineers. There is no provision for a partial pass in the Common Preliminary Examination. It may be stated here that throughout the associateship examinations the general rule is that a candidate must pass a complete section or division at the one time. The standard of the Common Preliminary Examination may be judged by comparing it with British examinations which are accepted by the Institutions for exemption purposes. These are—

(*a*) The School Certificate, provided it includes the requisite subjects passed at one and the same time. The foreign language unit required by the Institution of Civil Engineers may be taken separately.

(*b*) The University Entrance Examination : There is no special restriction about subjects, but the Institutions prefer applicants to have passes in English, Mathematics, and Chemistry or Physics.

(2) THE PRELIMINARY EXAMINATION REQUIREMENTS OF THE ENGINEERS REGISTRATION BOARD IN NEW ZEALAND

35. The Engineers Registration Board also has a preliminary examination requirement which is slightly different from the above. The Board accepts any one of the following:—

(1) A New Zealand School Certificate if passed in five subjects or a Certificate of Attainment (School Certificate Standard) provided in either case that the optional subjects include a physical science (Chemistry, or Electricity and Magnetism, or General Science, or Heat, Light, and Sound) and a technical subject (Applied Mechanics, or Heat Engines, or Technical Drawing or Technical Electricity) ; or
(2) A New Zealand School Certificate endorsed in at least Mathematics and a physical science subject ; or
(3) University Entrance ; or
(4) Any other educational qualification which the Board considers at least equivalent to one of the above.

36. As the Institutions of Civil and of Mechanical Engineers accept Sections A, B, and C of the Board examinations, there is thus an alternative method of complying with the requirements of the Common Preliminary Examination in those branches.

(3) SECTION A EXAMINATIONS

37. The various examinations for Section A of the Institution examination and for those of the Registration Board are set out in detail in Appendix 5. Here it may be said that there is little real variation in the subjects to be taken.

38. It will be convenient to use, as a basis of comparison, the requirements of the Engineers Registration Board in considering the examinations of the various British Institutions. The Board, when setting its requirements in any branch, has naturally modelled them on the requirements of the British Institution controlling that branch, partly on general grounds and partly to avoid difficulties for any engineers who may pass the Board's examinations and later seek recognition by the British Institution. On the other hand, because the one Board controls all branches, it is in a position to take the best from the requirements of each branch. It is assisted in this by the attitude of the British Institutions, which view with favour the development by the Board of standards and requirements in New Zealand ranking equal to their own but with sufficient variation in detail to suit our own conditions.

39. The subjects for the Civil examination of the Engineers Registration Board are set out below as a guide:—

(1) Mathematics.
(2) Applied Mechanics.
(3) Applied Heat (with Light and Sound).
(4) (*a*) Principles of Electricity ; or
 (*b*) Workshop Technology.
(5) (*a*) Theory of Structures ; or
 (*b*) Theory of Machines.

40. The Board's requirements for the Electrical Branch are the same as for Civil. For Mechanical they are also the same, except that Engineering Drawing takes the place of 5 (*a*) or 5 (*b*) above. The Institution examinations theoretically require English, but there are exemptions available except in the Electrical Branch. Apart from this, the Institution examination for Civil is the same as the Board's for Civil, except that Workshop Technology is not a subject. The Institution examination for Electrical is as set out above for the Registration Board, excluding subjects 4 (*b*), 5 (*a*), and 5 (*b*). The Institution examination for the Mechanical Branch contains all the subjects detailed above except 5 (*a*) and 5 (*b*), but allows additional subjects and so provides some options.

(4) SECTION B EXAMINATIONS

41. Section B contains the subjects which cover the special branch of engineering which the candidate is taking, and there is accordingly little that is common to them all. The details are set out in Appendix 6.

42. The basic conditions to be complied with before sitting Section B of the Engineers Registration Board examination are set out in the following extract from a leaflet issued by the Board:—

Section B is to test practical knowledge in fundamental engineering subjects and in specialized applications of Civil and Structural, Mechanical, and Electrical Engineering. It is open to any applicant who (*a*) has passed in or is exempt from Section A and (*b*) has satisfied the Board that he is receiving or has received satisfactory regular training in professional engineering. The general requirements are as follows—

(*a*) The continuous period of training received or arranged for shall in general be not less than four years.

(*b*) Training received or arranged for under Articles of Training accepted and approved by the Council of the New Zealand Institution of Engineers will be recognized if any application to enter for examination is appropriately endorsed by the Secretary of the Institution; otherwise applicants must give full particulars of their training and experience, together with an undertaking from their employer and teaching engineer . . .

(*c*) The following classes of training alone are not acceptable: Purely trade apprenticeship in mechanical or electrical trades such as fitting and turning, boiler making, electrical wiring, &c.; purely draughting and tracing experience without opportunity for engineering design and for experience in construction or fabrication or erection; purely survey work whether under the Land Transfer Act or for engineering purposes.

43. This statement of policy may be regarded as setting a middle course. It is more liberal than that of either the Institution of Civil Engineers or the Institution of Mechanical Engineers, each of which adheres strictly to the policy that candidates may not proceed beyond the Common Preliminary Examination without giving evidence of practical training. On the other hand, the Board's practice of allowing reasonable latitude in sitting for examinations is not so open as that of the Institution of Electrical Engineers, which permits candidates to take both Sections A and B without giving evidence of training. The Institution of Electrical Engineers would, of course, expect that the corporate member supporting a student's proposal to sit the examination would use discretion as to whether the opportunities ahead of the student justified his proposal. The specific requirements for practical training and the age-limits for corporate membership in each of the branches are set out in Appendix 7.

(5) SECTION C

44. Candidates who have passed Sections A and B then take Section C. Quoting again from the Board's leaflet:—

Section C is in the nature of an inquiry into a candidate's practical training and experience, to ascertain if he has made full use of the opportunities available and has profited therefrom and to determine whether he has had the necessary responsible engineering experience required for registration. It consists of the submission of a written report covering the candidate's engineering history together with samples of work or a thesis, followed by oral and possibly written questioning on the report and submissions. For entry an applicant must have passed in or be exempt from Sections A and B and have received regular training and instruction in professional engineering and also have had practical experience subsequently.

45. The practical experience subsequent to training and instruction required for entry for Section C must, unless otherwise approved by the Board, involve at least one year on design and at least one year on supervision of construction, erection, or fabrication. The total period required is normally a minimum of three years, but two years in the case of a B.E. (Hons.), (five-year course) or a B.E. with one year approved post-graduate research. Experience gained under agreements which have been accepted and approved by the Council of the New Zealand Institution of Engineers will be recognized if the application to enter for Section C is appropriately endorsed by the

Secretary of the Institution, otherwise applicants must give full particulars of their training and experience. It may be mentioned here that in the Mechanical Branch Section C deals specifically with industrial management.

46. The Institutions attach great importance to the practical requirements associated with Sections B and C of the examination, and it is, of course, in this respect that the associate member of an Institution has a qualification lacking in the University graduate who has gone straight to a full-time course from a post-primary school. University graduates, therefore, are required to qualify in Section C before being admitted to corporate membership of the Institution or before being registered by the Engineers Registration Board.

(6) CURRENT EDUCATIONAL FACILITIES FOR CANDIDATES FOR INSTITUTION MEMBERSHIP AND ENGINEERS' REGISTRATION

47. For the candidate taking a degree in engineering there is only one method of obtaining instruction. The student must attend one of the University colleges, either as a part-time or a full-time student, until he has completed the Intermediate Examination, and thereafter he must attend one or other of the University schools of engineering, in almost every case as a full-time student.

48. For other candidates there is no such clear-cut path. In the past a large number attended the University as evening students. This avenue is no longer open. At Auckland University college the Institution candidates are at present accepted on the understanding that they attend full-time and take the lectures with the degree students. There are approximately eighty Institution candidates at Canterbury University College, most of whom are full-time students. Evening classes are no longer held. The temporary inability of the Auckland University College School of Engineering to cater for Institution candidates whilst located in Auckland, and the subsequent removal to Ardmore, has increased the need for the Auckland Technical School to provide facilities for these students. Of the technical schools this school has perhaps gone farthest in providing for Institution candidates—an interesting innovation being the successful arrangements made with employers to grant students reasonable time off during the day. The technical schools in Wellington, the Hutt Valley, and Dunedin have to provide facilities in centres where there are no suitable University courses offering. Development at the Christchurch Technical School has been carried out in full co-operation with Canterbury University College, and care has been taken to prevent any duplication. Facilities are provided in the technical schools in some of the smaller centres as occasion demands. In 1948 the Education Department's Technical Correspondence School began to conduct courses for the Institution examinations, to cater for students located outside the main centres. An endeavour is being made to integrate the courses as nearly as may be with what is offered in the technical schools so that students who are transferred temporarily in the course of their work can continue with their studies until they are once again in one of the main centres. It is known that a considerable number of students take courses from private correspondence schools.

PART II

7. APPROACH TO THE PROBLEM

49. This Committee was set up under the authority of the Hon. the Minister of Education as a result of representations made to the Right Hon. the Prime Minister by the New Zealand Institution of Engineers and the Professional Engineers' Association. The New Zealand Institution, in making its representations, pointed out that the war and its aftermath had dictated new forms of engineering. There was therefore more work to be done and it was necessary for more men to be trained for that sort of work. Now that peacetime conditions prevailed it was necessary that the education and training of professional engineers be accelerated. It appeared to the Institution that

the University Schools of Engineering were very short of accommodation and of staff to deal adequately with those seeking a degree in engineering and that the facilities for those endeavouring to qualify by passing examinations leading to corporate membership of one of the British Institutions of Engineers were inadequate. The New Zealand Institution asked, therefore, that a representative committee be set up to consider and report on the whole question.

50. The problem which the Committee has been asked to consider is one that has been exercising the minds of those interested in engineering education in other parts of the British Commonwealth and in the United States of America. The great British Institutions of Civil, Electrical, and Mechanical Engineers, with a long tradition behind them, have standing committees on education which have been very active in the past few years. The New Zealand Institution of Engineers has a similar standing committee which had discussed the problems of professional engineering education and training at length before it approached the Government with the request that this Committee be set up.

51. These discussions have varied with the special problems of the countries concerned, but they all recognize that it is a matter of vital importance to the community that engineers shall be fitted to the tasks which they will be called upon to perform. In our present complex civilization we place on the shoulders of our professional engineers the responsibility for the operation and maintenance of the whole material basis of modern living. Very serious difficulties may arise in the near future unless steps are taken to ensure that this country has sufficient well-qualified professional engineers for its needs.

52. The New Zealand Institution of Engineers in its evidence stated that New Zealand B.E. graduates had by their competence established an enviable reputation in other quarters of the globe as well as within the Dominion. The Institution, however, expressed concern lest the advantages and the reputation hitherto enjoyed by degree students might be partially lost.

53. The Committee in its inquiry did not confine itself to the education and training of degree students, but it may be stated here that little evidence was found to suggest that the deterioration presaged by the New Zealand Institution of Engineers had in fact begun. However, the reason for the Institution's concern was soon made clear to the Committee. It is in many ways the crux of the problem. Although the solution is difficult, the problem can be simply stated.

54. In this country there are two main ways of receiving the education and training required to qualify as a professional engineer. Students may attend one of the University schools of engineering and obtain the B.E. degree; alternatively, they may study for the examinations of one or other of the British Institutions of Engineers or the New Zealand Engineers Registration Board at the University, at a technical school, by correspondence, or by private study. The requirements of the various courses as they exist to-day have already been referred to in Section 5 dealing with the education of University students in Engineering, and in Section 6 dealing with education for professional engineering other than by a University degree. Suggestions for improvement and modification to meet new requirements are considered in Sections 10, 11, and 12.

55. The Committee heard about forty witnesses, who, in the aggregate, covered a very wide field. It appeared, however, to the Committee that the best approach to the problem was by trying to answer the question, "By what way should a professional engineer qualify?" This is done in Section 9, which the Committee regards as one of the most important parts of the report. The recommendations made elsewhere follow logically from the conclusions reached in Section 9. For the reasons given in detail in the section the Committee is convinced that a continually increasing proportion of professional engineers will be and should be trained through the University Schools of Engineering.

56. These University schools, which before the war managed to provide for all students who wished to attend, found themselves disorganized when, after the outbreak of war, they made some of their facilities available to the Service Departments. With the war still unfinished there began an influx into the schools as students returned to take up uncompleted courses. Moreover, the generous policy of the Rehabilitation Department gave to many an opportunity of qualifying for a career that, in the ordinary course of events, may have been beyond their financial resources. The special problems of the schools of engineering will be dealt with in more detail in Section 10, but here it must be mentioned that the major difficulty—lack of accommodation—has been almost impossible of solution except by the provision of further temporary buildings. The principal difficulty is that the same problem of influx of students that has embarrassed the schools of engineering is being faced in every faculty in every University institution in this country and that the accommodation problem is one not peculiar to the University. Student rolls are double the pre-war figure and, if the experience of the last war is any guide, the rolls for the University colleges as a whole will stabilize not very far below the peak period. The School of Engineering at Auckland University College is solving its accommodation problem for the time being by moving to the R.N.Z.A.F. station at Ardmore. The National School of Engineering at Canterbury University College has obtained partial relief by adding temporary buildings. So far the staff have carried on under adverse conditions with some loss of efficiency, a loss which will increase unless conditions are improved.

57. The Committee has heard evidence suggesting the desirability of restricting the entrants to the National School, based on the argument that it is better to handle a restricted number efficiently than a large number indifferently. It soon became evident to the Committee that, while this would ensure the maintenance of a high standard it would not provide the necessary numbers nor would it provide a complete solution to the problem. The weight of evidence makes it clear that, far from limiting entry, effective measures must be taken to encourage a greater number of capable young men to enter the profession. While some easing off in the total roll at the National School of Engineering is envisaged, it will be necessary for it to continue to train far more engineers than it did at any time in the pre-war period. A forecast of future requirements is set out in Section 8 dealing with supply and demand. If sufficient students can be drawn into the engineering profession to meet the requirements indicated in that section, and it will be a serious matter for this country if they are not, then everything possible must be done to provide additional facilities for their education.

58. A good deal of evidence was heard by the Committee about the qualifications for entry to the profession. This is considered in Section 9.

59. Although the Committee is firmly convinced of the desirability of offering every encouragement for prospective professional engineers to qualify through the University it nevertheless decided to make provision for those who for one reason or another cannot undertake a full-time University course. Some of these will already have begun study for the examinations leading to corporate membership of one of the British Institutions of Engineers. Their case is considered in Section 11.

60. However, the evidence presented to the Committee suggested another alternative. The growth of the system of national diplomas and certificates in engineering in Great Britain is indicative of the willingness of the British Institutions of Engineers to grant exemptions from their own examinations to applicants for corporate membership who have completed approved courses conducted by other authorities. The Institutions, too, encourage the Dominions to develop courses better designed to suit local conditions. The Committee therefore has decided to recommend the establishment of a system of diplomas in professional engineering. It is hoped that these diplomas will be accepted by the British Institutions of Engineers and that the courses and examinations will in time supersede the Institution examinations in New Zealand. This matter is discussed in Section 12, and the detailed courses and prescriptions are set out in Part IV.

61. It has already been mentioned that the number of students at the University Schools of Engineering is considerably above the pre-war figures. Some of these students are receiving assistance from the Rehabilitation Department. This form of assistance will disappear when the returned servicemen at present studying complete their courses. When the influx of returned servicemen is spent, there will be no hope of maintaining numbers without increasing the number of bursaries of one sort or another and also their value. The increase may have to be more than proportionate to the increased output required because the additional numbers may have to be found very largely from those unable to afford a full-time university education. It will be necessary, too, to provide bursaries for at least one year for selected diploma students during the one year of full time study which forms part of the course proposed for them. This and related topics are dealt with in Section 13.

62. Most of the special problems of the University schools of engineering on which evidence was heard are considered, as mentioned earlier, in Section 10. One related topic on which the New Zealand Institution of Engineers and the Engineers Registration Board gave evidence was the desirability of setting up a Council of Engineering Education to co-ordinate the policy for professional engineering education. This question has been considered separately in Section 14.

63. In the preliminary discussions during which the scope of the principal inquiry was defined, the Committee found that there was a considerable body of men holding positions intermediate between those of tradesmen and those of professional engineers. Generally speaking, these people consist of two main classes—firstly, those with little or no academic qualifications, who by virtue of ability and long experience have achieved positions of considerable responsibility; and, secondly, those who have set out to obtain a professional qualification but who have not succeeded in completing this qualification. There is also a third, and smaller, group with expert qualifications in a field which is considered too limited. It was at first considered that the Committee should take steps to provide some form of certificate for these men, but after taking evidence from some groups it became clear that the solution to the problems of these people would have taken a disproportionate amount of the Committee's time to the detriment of the principal subject of the inquiry. This question is touched upon in Section 15.

64. It appeared to the Committee that the main questions on which it was asked to deliberate could best be considered by dealing with the education and training of professional engineers as a whole. It is true that references in the report and the recommendations made by the Committee are mainly about the civil, electrical, and mechanical branches of engineering. These branches are, however, the oldest established and they employ the great majority of professional engineers. The general conclusions drawn would apply equally to the newer branches of engineering, the initial training for which depends basically on that given in one or other of the three main branches. Recommendations are made about other branches where action is considered necessary.

65. Section 16, which gives the specific findings of the Committee, sets out the answers to the questions raised in the order of reference. The recommendations made throughout the report are summarized for convenience in Part III.

8. SUPPLY AND DEMAND

66. It was clear to the Committee at a very early stage in its deliberations that no firm conclusions could be reached about some aspects of training until it knew for certain whether the present supply of engineers was equal to the demand and what the relation between supply and demand would be in, say, five years' time. The Committee felt that no reliable estimate of requirements could be obtained for any longer period ahead.

(1) SURVEY CONDUCTED

67. To obtain information on supply and demand a questionnaire was forwarded to present and likely future employers of professional engineers. The groups approached are set out below: —

Table A.—Distribution of Questionnaire

Addressee.	Number Sent.	Number Returned.
Government Departments	23	20
Local Bodies—		
City and Borough Councils, &c.	137	115
County Councils and Road Districts	136	113
Town Boards	29	12
River and Drainage Boards	71	33
Catchment Boards	11	10
Power Boards	45	39
Harbour Boards	49	24
Hospital Boards	45	24
Educational Institutions	40	24
	586	414
Consultants	84	38
Private firms	324	130
	994	582

68. In all some 994 questionnaires were distributed and 582 replies were received. These gave a total of professional engineers, excluding mining engineers, of 1,080, as compared with 968 in the 1936 census and 1,050 in the 1945 census. The 1945 census figures excluded personnel serving overseas with the Forces.

69. A review of the list of employers who rendered no return satisfied the Committee that the number of engineers likely to be employed by these employers was very small, probably not more than 70 professional engineers or approximately 6 per cent. of the total number employed. The conclusions reached as a result of the survey are therefore considered sound. The estimated total number of engineers at present employed has been fixed at 1,150.

The following information was sought from employers: —

(1) The number of professional engineers employed at present.
(2) The present number of vacancies for professional engineers.
(3) The probable number of professional engineers who will be employed in five years' time, if men with the necessary qualifications are available.
(4) The number of replacements of professional engineers in 1947.
(5) The number of professional engineers employed in 1928, 1933, 1938, and 1943.

70. Employers were at the same time asked to classify their professional engineers according to the branch of engineering (civil, electrical, mechanical, or other branches), and according to their qualifications (graduates in engineering, men with A.M.I.X.E.† but not degrees, and others). They were invited, too, to make any general comments on the employment of professional engineers which might be helpful to the committee in its investigation.

† A.M.I.X.E. means A.M.I.C.E., A.M.I.E.E., or A.M.I.Mech.E.

(2) ANALYSIS OF REPLIES

71. The most important features of the returns are set out in the following table. Further figures from these returns will be found in Appendix 8:—

Table B.—Number of Professional Engineers as Revealed by Questionnaire

—	Branch of Engineering.	Number with University Degrees in Engineering.	Number with A.M.I.N.E.†, but not Degrees.	Number Registered as Professional Engineers, but not with Degrees or A.M.I.N.E.†	Totals.
1. Number of professional engineers employed at 31st July, 1948	Civil ..	212	220	103	535
	Electrical ..	176	135	33	344
	Mechanical	54	77	22	153
	Others ..	11	23	14	48
		453	455	172*	1,080
2. Number of vacancies for professional engineers at 31st July, 1948	Civil ..	61	73	11	145
	Electrical ..	73	14	3	90
	Mechanical	27	22	1	50
	Others ..	1	..	..	1
		162	109	15	286
3. Probable number of professional engineers in five years' time, if men with necessary qualifications are available	Civil ..	334	344	115	793
	Electrical ..	360	198	39	597
	Mechanical	108	126	30	264
	Others ..	27	34	18	79
		829	702	202*	1,733

* NOTE.—The increase from 172 to 202 is based on a misapprehension of the position. Professional engineers can no longer qualify in this manner. † A.M.I.N.E. means A.M.I.C.E., A.M.I.E.E., or A.M.I.Mech.E.

(3) PRESENT AND FUTURE DEMAND

72. An examination of this table shows—

(1) That the present unfilled vacancies are as follows—

Civil ..	.. 145, 27 per cent. of present class total of		535
Electrical	.. 90, 26 per cent.	,,	344
Mechanical	.. 50, 33 per cent.	,,	153
Other branches	.. 1, 2 per cent.	,,	48
Total	.. 286, 26 per cent. of present grand total of		1,080

(2) That the estimated numbers of *additional* professional engineers required in five years' time (inclusive of present vacancies) are—

Civil ..	.. 258,	an increase of	48	per cent. on present class total.
Electrical	.. 253,	,,	73	,,
Mechanical	.. 111,	,,	73	,,
Other branches	.. 31,	,,	65	,,
Total	.. 653,	an increase of	60	per cent. on present grand total.

(3) That the percentage of graduates in the totals will have increased in all branches in five years' time, if graduates are available—

—	Percentage of Graduates in Group Total.	
	1948.	1953.
Civil	40	42
Electrical	51	60
Mechanical	35	41
Other branches	23	34
Total	42	48

(4) WASTAGE IN PROFESSIONAL ENGINEERING PERSONNEL

73. Employers were asked to give the number of replacements of professional engineers in 1947 in order that some indication might be obtained of the annual percentage of wastage. The returns showed 57 replacements in a total of 1,080 professional engineers, or approximately 5·3 per cent. One would have expected this figure to be higher, as it must include a large proportion of transfers to other professional engineering positions. It would seem that the low figure reflects the present shortage of engineers. It is impossible to estimate the number of transfers, but wastage must be taken to include retirements, transfers to other occupations and losses by emigration or death before retirement.

74. The Committee decided after very careful study of the problem to allow for a wastage of 4 per cent. per annum for this investigation. This was lower than the figures suggested by some witnesses, and it would not be sufficient under different conditions. The Committee was influenced, however, by the following considerations. The annual rate to replace wastage through retirements which, with a stable number in the profession, would be about 3 to 3·3 per cent., is as yet very much smaller because of the rapid development in the profession. The plans which the Committee has for increasing the supply of professional engineers during the next decade or so will, if implemented, result in there being an even greater proportion of young engineers. Moreover, calculations indicated that, even though a number of our graduates go overseas, either many of them ultimately return or this country receives a substantial number of graduates trained elsewhere. Finally, the present known shortage and the unsettled world conditions may well result in fewer of our graduates leaving our shores and more graduates trained elsewhere coming to this country during the next few years.

(5) PROFESSIONAL ENGINEERS PER MILLION OF POPULATION

75. The figures below are extracted from information contained in the census reports of 1911, 1916, 1926, and 1936. It should be stated that it is only recently that the returns of occupations presented in the census reports listed professional engineers separately. Even now the householder filling in the census form is his own judge of what constitutes a professional engineer, and there is considerable room for difference of opinion. The figures are, however, useful in providing an estimate of the number of

professional engineers per million of the population at the respective periods. The questionnaire shows that the number of engineers per million of the population is now 630, a figure which represents a decrease from earlier years:—

Year.	Number of Professional Engineers.
1911	750 per million of population.
1916	845 ,,
1926	835 ,,
1936	670 ,,
1948	630 ,,

76. The following figures submitted as evidence have not been verified by the Committee, but they are included as offering an interesting comparison with the figures for New Zealand:—

Country.	Number per Million.	Date of Information.
Australia	700	1941
United Kingdom	795	1933
Canada	1,800	1941
United States of America	2,250	1946

77. The figures taken from the questionnaire are sufficiently arresting to require some further comment. It is possible that if engineers could suddenly be supplied to fill all the 286 vacancies that are stated to exist, they might not be absorbed immediately. On the other hand, there is ample evidence that staffs are inadequate to cope with existing demands even though a good deal of engineering work is held up for lack of essential materials.

78. When the Prime Minister received the deputation from the New Zealand Institution of Engineers, which resulted in the setting-up of this Committee, he received at the same time a deputation from the Professional Engineers' Association which drew attention, among other things, to the extreme shortage of qualified engineers in this country. Several local bodies when sending in their return commented on the fact that they had advertised vacancies without success—sometimes without receiving a single reply. One large Government Department indicated that its return was based on the assumption that the same policy would be pursued in the future as in the past of employing equal numbers of qualified and unqualified engineers. This policy had been forced on it for the time being by the impossibility of securing greater numbers of qualified professional engineers. As one illustration of the effect of this shortage the Committee was informed that the Project Engineer of the Waikato hydro-electric scheme estimated his requirements at 21 experienced engineers and 22 juniors, a total of 43 for the work to be carried on with efficiency. The staff is actually 18 experienced engineers and 5 juniors, a total of 23, or little more than half the number required. It is known that all the Government Departments employing large numbers of engineers are having extreme difficulty, not only in handling the tasks immediately ahead of them, but also in planning for the future.

79. It is interesting to note that a similar investigation into the requirements of scientific man-power revealed a present shortage of 20 per cent., compared with twenty-six per cent. for engineers and an additional fifty-three per cent. required in five years, inclusive of present vacancies, compared with sixty per cent. in this inquiry.

80. According to the questionnaire answers the total number of positions available to professional engineers to-day is 1,366. It seems probable that, had complete coverage been obtained, there would have been revealed an additional 70 filled positions (see para. 69) and a further 14 or so vacant positions, making some 84 in all. The number 1,366 must therefore be increased to 1,450, which works out at about 800 per million. If similar adjustments are made to the number required in five years' time, the questionnaire figure of 1,733 would become, say, 1,825, or approximately 935 per million of the estimated population at that date.

81. The Committee thinks that, though there is a continually increasing demand for professional engineers as industries develop, the above forecast of future requirements must be regarded with some reserve. The difference between the present inadequate figure of 630 per million, and 935 per million in five years' time seems too great to be accepted without further evidence, but in any case it would be virtually impossible to bridge the gap over such a short period. Even if it could be done, there are considerable drawbacks to attempting such a plan. The school population in the higher forms of our post-primary schools is not likely to increase materially for another ten years. Continued enrolment of engineering students at a high figure is therefore unlikely to be possible. If it could be achieved it would tend to defeat its own object through the greater proportion of failures that would occur. Moreover, once the shortage had been overcome it would be necessary to reduce the output very considerably. Violent fluctuations of this kind are disturbing and inefficient at the time, and by creating similar difficulties in, say, thirty to thirty-five years, when large numbers would retire over a short period, they tend to perpetuate themselves. There is, too, always the danger that changing economic conditions might result in supply overtaking demand with very large numbers of students still undergoing training.

82. A long-term plan is therefore much to be preferred, designed to overcome the shortage within a reasonable period and providing automatically for a gradual increase in the proportion of engineers per million of the population. There should be sufficient flexibility to allow for an increase in the number completing training if altering conditions make this necessary; and, if possible, the number in training during the plan should be related as nearly as may be to the output which will be required when shortages have been overcome and conditions become stable.

83. The details of such a plan are set out later in this section. At this stage it may be stated that the Committee, after taking into account all the above factors and the figures available showing the proportion of professional engineers in other countries, considered that the number should be increased not to 935 per million in five years, but to 850 per million in ten years.

(6) OUTPUT OF PROFESSIONAL ENGINEERS TO DATE AND ANTICIPATED IN THE FUTURE

84. Over the ten-year period 1928–37 (both years inclusive) the total number of engineering graduates was 213, an average of 21·3 annually. Over the ten-year period 1938–47 (both years inclusive) the total was 215, or 21·5 annually. The first period covered included the depression, when not many students could afford to take a B.E. course, and the second period included a period of war. In 1947, the last year of the second period, there were 55 graduates. The increase is largely on account of the return of servicemen with partially-completed courses. There were 74 graduates in 1948, and in 1949, which will be the peak year, there should be as many as 100. After that there will be a drop to about 75 graduates. The numbers may stabilize at something approximating 55 graduates a year without any special action being taken, but it is too early yet to forecast this with any certainty.

85. The numbers of students qualifying for Institution membership have also to be taken into account. Figures have been supplied to the Committee by the New Zealand representatives of the British Institutions, who point out, however, that the raising of examination standards robs the figures of much validity for our purpose. These figures, too, have been affected by the war.

86. Institution candidates do not complete their qualification until they pass in Section C. Section C is, however, taken by degree students so that, in order to exclude them, it is necessary to consider the figures for Section B. Table C shows the position for the last three years. The figures in the Mechanical Branch are estimates, while those showing the approximate total number of students studying Institution examinations beyond the Common Preliminary are taken from the results of a questionnaire sent out by the New Zealand Institution of Engineers.

TABLE C. Results of Institution Examinations for Section B, 1946–48

Branch.	1946.		1947.		1948.	
	Sat.	Passed.	Sat.	Passed.	Sat.	Passed.
Civil	8	8	24	24	48	37
Electrical	7	6	20	10	45	23
Mechanical	13	6	19	9	19	10
	28	20	63	43	112	70
Total studying beyond C.P.E.	220		300		500	

87. It will be noticed that the number of students sitting the Section B examination is only a small proportion of the total number studying. As a matter of interest it may be mentioned that the total number of those in training under some form of engineering cadetship is approximately 500.

88. It is exceedingly difficult to forecast what is likely to be the number who would qualify for Institution membership in a normal year apart from any action which might result from the Committee's recommendations. The general effect of these, too, remains to be seen. As opportunities for University study are increased, particularly on the financial side, the successors of the present Institution candidates will, it is hoped, take the degree courses. It must be remembered that in the last three years there have been, on the average, 100 Institution students in the University schools of engineering. As these students have been studying for the most part as full-time students, it may be expected that they figure to a large extent in the passes referred to in the above table. There should be a tendency for students of this type to transfer to the degree course, which would probably lower the number of successful candidates at Institution examinations. On the other hand, the recommendations for general improvement in facilities proposed by the Committee should, if implemented, result in a reduction in the average length of time taken by Institution candidates to qualify and in a smaller proportion of failures.

89. It is possible that there could be 50 completing their Institution membership qualification at the end of 1948 from those successful in 1948 and the two preceding years, and that this figure could be maintained for two or three years, reducing to, say, 40 for a year or two as the effect of increased numbers in the immediate post-war years becomes spent. From then onwards the numbers will be subject to the effect of the factors outlined in the previous paragraph.

(7) ESTIMATED TOTAL OUTPUT DURING THE NEXT FIVE YEARS

90. The estimates considered in the previous paragraphs are summarized below:—

Table D—Estimated Output of Professional Engineers, 1948–52

Year.	Graduates.	Institution Members.	Total.
1948	74	50	124
1949	100	50	150
1950	75	50	125
1951	60	40	100
1952	55	40	95
	364	230	594

i.e., an average of 119 annually during this short-term period.

(8) A LONG-TERM PLAN

91. The average anticipated output during the next five years is so very much greater than the output in the years immediately preceding the war as to suggest that there is very little real difficulty about providing a sufficient number of engineers for future requirements. It must be emphasized, therefore, that the anticipated output for the next few years is not only very much in excess of that of any of the pre-war years, but it is also in excess of what is likely to be maintained once the effect of the increased numbers of students in the immediate post-war years is spent. The estimate for 1952 is near the level at which output would establish itself in the absence of any special provision to increase it. It may be a little too high. The following short calculation will indicate that an output of, say, 90 to 95 would not be sufficient to reach the desired figure of 850 per million in ten years' time.

Short Calculation Based on Present Population of 1,825,000 and 25,000 Per Annum Increases

Present number of professional engineers	1,150
Number in ten years' time at 850 per million	1,764
Increase necessary	614
Wastage on 4-per-cent. per-annum basis over ten years (approx.)	580
Total output required over ten-year period	1,194

i.e., 120 annually.

92. It would appear, therefore, that a figure of 120 annually would meet the position over a ten-year period. It is now necessary to consider the following questions:—

(i) What is the long-term effect of providing for an output of 120 per year ?

(ii) How many students will it be necessary to train to provide such an output ?

(iii) Is it possible to obtain a sufficient number of these students ?

(iv) If the students can be obtained, what accommodation problems, if any, are likely to be caused at the University colleges ?

These questions are considered in order below.

(i) What is the Long-term Effect of Providing for an Output of 120 Professional Engineers Per Year?

93. The following more detailed table shows the effect year by year of bringing 120 engineers annually into the profession, allowing wastage at 4 per cent. per annum and an increase of 25,000 in the population each year. It will be seen that on reaching the goal of 850 per million of the population in ten years, it is possible to consider a goal of 900 per million, which would be reached in a further five years, and then a goal of 950 per million which would be reached in a little under a further ten years. At the expiration of the period the annual wastage on a 4 per-cent per-annum basis will be rising slowly from 92 and the number required to cover increases in population will be 24, giving a total annual requirement rising slowly from 116. This corresponds very closely with the figure of 120 adopted for the annual output, which indicates that the plan fits in very well with the requirements when shortages have been overcome and conditions become more stable. As will be seen later, the plan is limited during the first ten years by the fact that the school population is not likely to increase during that period, but after that it would be possible to increase the annual output of professional engineers should an alteration be required in the estimate for wastage, for increased population, or for any other cause.

Table E below has been worked out exactly on the basis indicated above, but it must be remembered that it is merely a forecast for the next quarter of a century.

Table E—Effect of Providing 120 Professional Engineers Annually

Year.	Number of Professional Engineers at Beginning of Year.	Deduct Wastage at 4 Per Cent.	Balance.	Add Intake.	Balance at End of Year.	Number Required to Provide 850 Per Million, &c.	Shortage.	Actual Number Per Million of Population.
1 ..	1,150	46	1,104	120	1,224	1,572	348	660
2 ..	1,224	49	1,175	120	1,295	1,593	298	690
3 ..	1,295	52	1,243	120	1,363	1,614	251	720
4 ..	1,363	55	1,308	120	1,428	1,635	207	740
5 ..	1,428	57	1,371	120	1,491	1,657	166	770
6 ..	1,491	60	1,431	120	1,551	1,678	127	790
7 ..	1,551	62	1,489	120	1,609	1,699	90	810
8 ..	1,609	64	1,545	120	1,665	1,729	55	820
9 ..	1,665	67	1,598	120	1,718	1,742	24	840
10 ..	1,718	69	1,649	120	1,769	1,763	−6	850
			Transfer to Goal of 900 Per Million					
10 ..	1,718	69	1,649	120	1,769	1,868	99	850
11 ..	1,769	71	1,698	120	1,818	1,890	72	870
12 ..	1,818	73	1,745	120	1,865	1,913	48	880
13 ..	1,865	75	1,790	120	1,910	1,935	25	890
14 ..	1,910	76	1,834	120	1,954	1,958	4	900
15 ..	1,954	78	1,876	120	1,996	1,980	−16	910
			Transfer to Goal of 950 Per Million					
15 ..	1,954	78	1,876	120	1,996	2,090	94	910
16 ..	1,996	80	1,916	120	2,036	2,114	78	920
17 ..	2,036	81	1,955	120	2,075	2,138	63	920
18 ..	2,075	83	1,992	120	2,112	2,162	50	930
19 ..	2,112	84	2,028	120	2,148	2,185	37	930
20 ..	2,148	86	2,062	120	2,182	2,209	27	940
21 ..	2,182	87	2,095	120	2,215	2,233	18	940
22 ..	2,215	89	2,126	120	2,246	2,257	11	950
23 ..	2,246	90	2,156	120	2,276	2,280	4	950
24 ..	2,276	91	2,185	120	2,305	2,304	−1	950
25 ..	2,305	92	2,213	120	2,333	2,328	−5	950

(ii) How Many Students Will it be Necessary to Train to Provide an Output of 120 Per Year?

94. The answer to this question entails an investigation of the incidence of student mortality. Before considering this, however, it is necessary to divide the proposed output of 120 into graduates and non-graduates. A distribution on the following basis will be sufficiently correct:—

Graduates	75
Non-graduates	45

95. There is not enough information available to make any further estimates about the number of non-graduates—*i.e.*, Institution membership students—beyond what has been given earlier in the chapter. However, even if no more enter the profession by this avenue it would be possible to obtain 45 a year for some years from those already at various stages of their training. The effect of the improvements which the Committee is suggesting will be to reduce the time which the average candidate for Institution membership takes. This will automatically result in a greater annual output for as long

as should be necessary. The Committee has in mind, as already set out in Section 7, that the number of non-graduates will be negligible at the end of twenty years or so, but it is very doubtful whether there will be sufficient students offering for the degree courses to make possible any substantial increase in the number of graduates during the first few years of the plan.

96. Figures obtained showed that of 419 students beginning the first professional course in the period 1920–1939, 202 completed the degree in three years, 159 in a longer period, and 58 failed to qualify—that is, 48 per cent. qualified in the minimum period, 38 per cent. in a longer period, and 14 per cent. not at all. Figures covering the period from 1940 to 1948 are considerably affected by the interruption to studies on account of the war and by the considerable increase in numbers towards the end of the war and since. Information obtained about those taking the final professional year showed the following. From 1937–1942, both years inclusive, the annual rolls for final year students totalled 103. During the same period 102 (not necessarily entirely the same group) completed the degree. From 1943–1946 the respective totals were 107 and 78. In 1947 only 55 completed the course, although there were 91 on the rolls. In 1948 there were 74 out of 105. More students are taking honours courses each year, but this would not account for the difference between the position up to 1942 and since then. Either more students are taking more than one year to complete the final year or the mortality rate has increased because increasing numbers have affected the general standard. Possibly both factors are operating. The Committee considers that under normal conditions the great majority of students in the final year will complete the course in the minimum period, especially if more stringent conditions are laid down in the earlier years requiring students to complete each year's work before proceeding to the next. It considers, too, that when conditions become stable the percentage of failures will not be much greater than during the period 1920–1939. It must be remembered that the Intermediate Examination is a severe test and those who pass it should not experience difficulty later provided they have a real desire to become professional engineers.

97. The following distribution of every 100 students over the course, excluding the intermediate year, should be reasonably correct:—

First professional year	40
Second professional year	30
Third professional year	27
Fourth professional year (Chemical and Honours)	3
Graduates	25

That is to say, there will be 25 graduates annually for every 100 students in the schools, so that 300 students will be needed to obtain 75 graduates per year.

(iii) Is it Possible to Obtain a Sufficient Number of These Students?

98. It is necessary now to consider what the above figures for degree students mean in terms of intake into the various University colleges. Mortality at the intermediate stage is very high. The total rolls of students at the four University colleges who stated that they were engineering students (the Intermediate Examination is similar for various professions) for the years 1941–47, both years inclusive, amounted to 1,038. The rolls of first professional year students for the years 1942–48 totalled 624, or 60 per cent. of the other figure. Some students are counted at least twice in both totals. The proportion is probably considerably larger in the total of intermediate students because at this stage students can be part-time, in which case they would not take all four subjects in a year. Moreover, the change from post-primary school to the University often necessitates a period of adjustment during which failures tend to be higher. On the other hand, returned servicemen taking up the first professional year would affect the totals for that class.

99. The above figures are useful as a guide in estimating the relative numbers at the intermediate and the first professional stages, but to ascertain the annual intake it is necessary to estimate the proportion of engineering candidates in the Intermediate Examination who ultimately succeed. On the evidence available this has been fixed at 55 per cent. An annual output of 75 graduates would require a total roll of 300 in the University schools of engineering, assuming, as explained above, that there would be an output of 25 graduates annually for every 100 students in the schools. Of these 300 there would be, it is estimated, 40 per cent. in the first professional year—*i.e.*, 120. The calculations which were necessary to arrive at the distribution of every 100 students over the course (as shown in para. 97) indicated that an intake of 100 students each year would probably result in about 130 students in the first professional year because of the number who spend more than one year on the first year of the course. In order to maintain 120 in the first professional year an annual intake of about 92 would be necessary. On the assumption that about 55 per cent. of those who began the Intermediate Examination will succeed, it is estimated that the annual intake at the intermediate level to produce 92 candidates who have completed intermediate would be 167. A final estimate is that an intake of 167 would result in a total roll in the intermediate year of approximately 250.

100. The greatest number taking the intermediate course in any one year so far was 244 in 1946. This figure dropped to 205 in 1947 and to 176 in 1948. It will probably drop a little further in 1949, by which time the carry-over from the peak years of students taking more than one year should be spent. An annual intake of 167 would constitute a substantial proportion of the youths leaving the Sixth Forms of our post-primary schools. In 1947 there were 1,480 boys leaving the Sixth Forms. Some of these would leave without completing University Entrance. Of the 1,480 boys, about 400 qualified for the Higher School Certificate. Nor is it possible to hope for any appreciable increase in the number of boys leaving the Sixth Forms during the next few years. The dominating factor, of course, is the low birth-rate during the "thirties." The number of births per year, which in 1926 had been as high as 28,473, had fallen by 1930 to 26,797. From 1930 to 1935, the period which is of particular importance for this inquiry, there was a further drop to 23,965. The downward trend was then reversed, but it was not until 1938, when the total births reached 27,249, that the 1930 figure was exceeded. The Committee would like to see as many boys as possible entering the engineering profession with the Higher School Certificate. It will be obvious, however, that many boys so qualified will wish to enter other walks of life. The number who wish to enter the engineering profession will depend in the last essence on the attractiveness of the financial and other rewards in it. This is a matter which lies beyond the Committee's province. It can only assume that others will take what measures are necessary in this direction. The Committee is concerned, however, with ensuring that adequate opportunities are given to all who are likely to succeed as professional engineers.

(iv) What Accommodation Problems, if any, are Likely to be Caused at the University Colleges?

101. Accommodation at the University colleges will be referred to again in Section 10. At this stage it will be sufficient to compare the anticipated roll under the plan with the numbers the colleges have in fact been accommodating recently. As mentioned earlier, an initial output of 75 graduates annually would require a total roll of 300 students in the two schools of engineering, excluding Institution membership candidates, for whom it is hoped other arrangements will eventually be made. When the number of graduates increases to, say, 100 annually there would be a roll of 400 degree students. By that time there would be very few Institution membership candidates wishing to attend University lectures.

102. There were 381 degree students in the two University schools of engineering during 1948 and there were 82 candidates for Institution membership examinations, a total of 463. The plan therefore makes no fresh demands and, in fact, gives some relief from a difficult situation.

103. Sufficient has been said to indicate that the plan outlined above is possible of achievement, though there may be room for doubt whether sufficient graduates can be obtained. Something ought to be said about the inception of the plan. In the ordinary course the recommendations of the Committee, if implemented, could not be fully effective until five years hence. Some of the improvements suggested will bear fruit earlier. Fortunately, however, the influx of students during the war years, which has created many problems, is already providing numbers equal to those set out in the plan. It is therefore virtually in operation to-day.

The Committee recommends :—

RECOMMENDATION—

That the number of professional engineers be increased to 850 per million of the population in ten years time, and thereafter, as opportunity offers, to 950 per million during the following fifteen years.

9. BY WHAT WAY SHOULD A PROFESSIONAL ENGINEER QUALIFY ?

104. The question of how a professional engineer should qualify is one that the Committee has asked a number of witnesses ; it was asked not so directly in the questionnaire referred to in Section 8 ; and it is a question which members have been asking themselves and each other. It is fundamental to this inquiry. It is not likely that there is any one answer that would cover all circumstances or satisfy every one.

105. In a discussion of this question there are three fundamental aspects to be covered. First to be considered is the education which the prospective professional engineer should receive at the post-primary school stage—that is, as a pre-requisite to entry to the profession. Next there is the academic training during the professional course, and, finally, there is the practical training in his chosen calling.

(1) PRE-REQUISITE EDUCATION

106. A good deal of evidence was heard by the Committee about the qualifications desirable for entry to the profession. It was interesting to note that the majority of witnesses from the ranks of professional engineers expressed themselves in favour of a broad general education and so were in agreement with the views of the New Zealand Secondary Schools' Association, which was opposed to early specialization.

107. The principle underlying the opposition to early specialization is, of course, that the broader the education the further a student can go. There is no doubt that, in the professions at least, for the man who will reach the top, the longer his general education can be continued the better. Professional knowledge rests more easily on a broad base of general culture. Although an occasional specialist reaches great heights with a relatively restricted education, the general concept is of a broad pyramid rather than of a narrow spire. There would be general agreement with this principle. The difficulty, of course, is to decide in any particular case how broad the base should be, and, because students cannot be taught individually, some average base has to be found which suits the majority.

108. Without drawing invidious comparisons, it is perhaps true to say that in the past secondary schools have tended to attract a great proportion of those for whom the base should be wide and the technical schools a large proportion for whom the base might well be narrower. Both types have, of course, a large number of students of average ability. The secondary schools have frowned on what may be termed vocational specialization. The technical schools, which have the facilities necessary to

provide for those who will soon cease formal education, see no objection, and in fact see certain advantages in using these facilities to give practical training to those who hope to qualify as professional engineers. They favour an early introduction to subjects which will give as far as possible a glimpse of what an engineer does. They consider, too, that there is a lot to be said for bringing a boy up in the atmosphere surrounding his future work. He learns so many little things at an age when he is prepared to do little things. These will stand him in good stead when at a later age such knowledge is acquired with difficulty and at the expense of time which should be used for more important things. The practical experience thus given is probably better than that which many apprentices in industry would receive from their employers. It is of considerable value and not lightly to be disregarded.

109. The opponents of this view point out, rightly, that this early vocational specialization, while unobjectionable, is time-consuming, and can only be at the expense of other subjects which are desirable. The course is thus made unduly narrow. They favour, therefore, the introduction of general cultural subjects in order that the student may develop a broad outlook on the world and society in general and some feeling for the arts. At this stage it becomes necessary to decide to what level a student should aspire. Individuals will vary, but the duties of a professional engineer entail as a general rule such heavy responsibilities to society as to make it undesirable that he should have a narrow circumscribed outlook.

RECOMMENDATIONS—

(i) *That for intending engineering students there should be no specialization before the end of the School Certificate year.*

(ii) *That for these entrants instruction at the post-primary stage in technical engineering subjects is not essential.*

110. There is more than one form of early specialization to be guarded against. The vocational specialization already referred to may not be so harmful in its effects as the constant pressure on post-primary schools to concentrate on subjects forming part of examination courses. The Committee feels strongly that at the post-certificate stage even the demands of mathematics and the physical sciences should not be allowed to hinder the cultural development of the student.

RECOMMENDATION—

That, even at the post-certificate stage, concentration on mathematics and the physical sciences should not exclude English and other cultural subjects.

111. The minimum educational standard which the Committee regards as being adequate for entrance to the engineering profession is the University Entrance Examination. According to the evidence submitted, this is, however, hardly adequate for those who propose to take a degree course. For these at least one year in the Sixth Form after qualifying for University Entrance appears to be necessary if the initial hurdle of the intermediate year is to be successfully negotiated.

RECOMMENDATION—

That intending entrants for the engineering degree course should spend at least one year in the Sixth Form after qualifying for University Entrance.

(2) THE HISTORICAL DEVELOPMENT OF PROFESSIONAL TRAINING

112. Traditionally the training of most professional groups was mainly by a method known variously as pupilage, cadetship, or apprenticeship. The advantages in favour of this system were real and for the most part they were obvious. In short, they were that the young man received practical training in the handling of real problems from a person whose standing and experience in the profession qualified him to instruct. This practical training not only proved to the young man that it was necessary for him to study to succeed in his profession, but also provided numerous examples ready to hand which made the theory easier to understand.

113. The economic simplicity of the system, too, had its merits. From the youth's point of view, even if he paid a premium for a time, he was soon earning and, if he found the study too difficult, he could take his place at a lower level without wasting any time. In earlier times, when labour was not so mobile as it is to-day, there was considerable incentive to an employer to train a young man properly. The country as a whole was spared any expensive overhead.

114. In the early stages the gap between the professional class and those approximating to our present-day technicians was probably very small. The gap has, however, been widened markedly by the continually increasing fund of scientific knowledge which the professional man has to master. In fact, the latter has really achieved professional status at the point where he agrees to the imposition of a reasonably difficult qualifying examination. It is this examination that distinguishes the two groups, and it is this examination which, sooner or later, is liable to break down the pupilage system. As the standards are raised for one reason or another it becomes harder and harder for young men trained under the traditional methods to qualify. For one thing the employers are usually unable to give the theoretical instruction, and for another so much time is required that the apprentice becomes less and less an apprentice and more and more a student.

115. The development has not been the same in all professions. The legal profession, for example, has managed to avoid any conflict, but here work and study happen to go very closely hand in hand. In some other professions the attempt to obtain practical experience and to study at the same time has been given up completely as a matter of official policy.

(3) PRESENT NECESSITY FOR AT LEAST SOME OF THE ACADEMIC TRAINING TO BE FULL TIME

116. For a long time a large proportion of our professional engineers have gone to the University and received their B.E. degree without serving any form of cadetship. Without implying that this is an ideal practice, it may be stated that there is ample evidence to suggest that the pupilage system of the traditional type in professional engineering is breaking down. It is true that a few of those who commented in the questionnaire saw no difficulty facing students studying by correspondence or by private study or by other means entirely in their own time. Nevertheless, all the witnesses who were questioned on the point had no hesitation in stating that it is almost impossible for a youth to qualify to present standards unless he is granted some time off for study or lectures or both during the day while he is still fresh. The evidence of the Auckland Technical School showed that progressive employers accepted this, and willingly supported a scheme suggested by the school at the beginning of 1948. Under this scheme students are receiving time off without loss of pay, amounting in some cases to as much as twelve hours per week during the school session. Most witnesses considered that at least one year should be spent in full-time study. The Committee is in complete agreement with this view.

117. When this stage is reached the pupilage system is no longer self-sufficient. Once it is admitted that there must be some full-time study, then it appears to be only a matter of time before the period of full-time study is lengthened. There are many who see no objection to a lengthening of the full-time course. There are others, however, who would not welcome the change. The evidence suggests that some mechanical engineering firms and local bodies would be in this latter group.

118. Reference has been made to the traditional method of training in which the employer was both the theoretical and the practical tutor. In fact, it must be a long time since many employers gave theoretical instruction. Students sitting the examinations of the British Institutions or the Engineers Registration Board get tuition in a number of ways, including the technical schools and the Universities.

(4) WHERE SHOULD FULL-TIME TRAINING BE GIVEN ?

119. The suggestion that candidates hitherto sitting the examinations of the British Institutions or the Engineers Registration Board take a full-time course raises the question: Where should that course be taken ?

(a) Technological Institutes

120. It is fitting that in considering the future requirements of this country full use should be made of the ripe experience of Great Britain in the field of engineering education. At the same time care must be taken in drawing comparisons and conclusions to ensure that the relevant conditions are the same in both countries. A good deal of evidence was presented in favour of the establishment of institutes of technology similar to those which operate so successfully in Great Britain and elsewhere. Here it is necessary to be clear what we have in mind. An institute of technology is not a technical school. It teaches to a higher standard—that is, to a standard equivalent to a University degree—and it normally would exclude the majority of the students in our present technical schools. It is not a University, however, because the method of treatment of courses and subjects is different. The University expects a student to take a complete course, in which there is a group of related subjects designed to provide a broad base for the field in which he will ultimately specialize. An institute of technology will, if necessary, take a student in a single subject. Some of the better-known technological institutes, though still retaining this title, are in effect University schools of engineering.

121. The system of education in New Zealand is sufficiently different from that in England to be worth studying in this connection. When the technological institutes began to develop in England educational policy was directed to ensuring that no brilliant boy would be denied educational facilities beyond the primary-school stage. It is only recently that an attempt has been made to provide adequate facilities for all those who want them. The position is very different in New Zealand. The free-place system has made the way to the University more open. If the courses at the Institute are likely to be full time, why should the youths not go to the University ? And if they do, will there be sufficient students to warrant maintaining well-staffed and well-equipped technological institutes ?

122. The Committee is not at all sure that the answer to this question is "Yes" so far as professional engineering is concerned. There are other reasons for establishing technological institutes, but they are beyond the purview of this Committee. It must be remembered that even in our large technical schools the proportion of engineering students at the professional level is very small.

123. Before leaving this for the time being, and considering the arguments of those who favour full-time instruction at the University for a degree course, it is necessary to state the point of view held by a considerable number, as set out in the following quotation taken from one of the replies to the questionnaire :—

> It is admitted that the Institution examination is not as high in academic standard as the B.E. degree, but it is sufficient for the purpose for a large number of positions. These positions are filled, and will continue to be filled, adequately by professional engineers whose somewhat limited academic qualifications are offset by practical ability of a high order.

124. These arguments are best considered in retrospect. Professional standards tend to rise. Already the bare Institution qualification which was once regarded as adequate in any circumstances is now conceded to be insufficient for certain types of positions. It is probable, therefore, that the passage of time will make the above arguments largely invalid. In the conditions prevailing in New Zealand to-day, however, they have force and there are other arguments to support them. It has already been shown in the preceding section that the number of engineers to be trained in the next decade or so is large enough to raise doubts whether there will be sufficient young people coming

forward who want to be professional engineers. At least some of those who do offer will be of only moderate ability. It is probable, therefore, that a lowering of standards would result if the University schools of engineering attempted to cater for all entrants to the profession. It seems clear that for some years to come other methods of qualifying must be left open and, where necessary, improved upon. The principal steps which the Committee proposes to take in this direction are set out in Section 12, which is an elaboration of the following recommendation.

RECOMMENDATION—

That for some years a proportion of professional engineers should be trained by means of courses leading towards Diplomas in Professional Engineering.

(b) THE UNIVERSITY SCHOOLS OF ENGINEERING

125. While not even the staunchest supporters of the traditional form of training would go so far as to suggest that no engineers should qualify through the University, there are some, however, who consider that all engineers should qualify in this way. Some of those who favour the method of entry via the University do so wholeheartedly. They regard other ways as second-best methods which have become out of date and which can be accepted, if at all, only by making a virtue of necessity. The New Zealand Institution of Engineers has the following in its evidence :—

> The Institution's Committee on Engineering Education and Training is well aware that there exists a section of thought holding that qualification in engineering should be exclusively by University degree. This opinion has indeed been debated and deliberated upon at great length, and the opinion of sub-committees in the various centres sought and co-ordinated to ensure that the Central Committee's final conclusion on this aspect should be truly representative of engineering thought in the Dominion.
>
> However praiseworthy the principle of exclusively University preparation may be, the Institution's Committee has been obliged to realize that conditions rule out such a possibility at the present time. The considerable expansion of University buildings called for, one factor alone, is obviously outside the realms of possibility for some time to come.

126. There was considerable evidence from people of standing to leave no room for doubt about the truth of the first sentence in the quotation. The figures in the questionnaire show the increasing number of graduates period by period, until to-day approximately 42 per cent. of all engineers are graduates. There are more vacancies for graduates than for Institution members, and this increase is reflected in the figures for 1953, when it is anticipated that there will be 48 per cent. of graduates if they can be made available. This means that the proportion of graduates among those entering the profession must be considerably higher.

127. The arguments of those who favour training via the University may now be summarized. The increasing complexity of the demands now made on professional engineers is such that it is no longer possible, if it ever was, for engineers to have a detailed knowledge of all of the problems which they may encounter. Conditions are changing rapidly, and adjustment to these changing conditions can be adequately made only by men who have a broad and profound knowledge of the basic principles in mathematics and the physical sciences on which all branches of engineering depend. This knowledge of the fundamental principles can be gained only within the atmosphere of a University. Perhaps because of the attitude adopted by the University towards broad principles, it attracts within its walls a highly-qualified staff, each of whom by specializing in his chosen field acquires an outstanding knowledge of that field. At the same time the University lecturer is constantly able to refresh his teaching by day-to-day contact with gifted specialists in other faculties.

128. There are many other advantages in taking the degree course quite apart from the calibre and the content of the tuition. The student does his study while the knowledge which he has acquired at the post-primary school is still fresh in his mind.

Moreover, as a full-time student he is able to devote all his energies to his course instead of having to listen to evening lectures at the end of a long day of hard work. He has the advantage, too, of adequate library facilities. His course lasts for four years, but this is better than spending year after year in part-time study as others have done in the past. With his formal studies behind him the graduate is in a position to read the professional literature available to him and so keep up to date, whereas the person struggling on a part-time basis cannot spare time for this.

129. Then, too, there are the considerable advantages attached to life as a University student. The presence of others of high intelligence in his own faculty is a constant spur and means of inspiration, but it is perhaps not so important as the opportunity of exchanging ideas with able young men training for other professions. For those who wish to take an active part in the activities of the student body there is ample opportunity for developing the powers of organization and leadership so valuable to an engineer.

130. After hearing the evidence and considering the replies to the questionnaire the Committee is firmly of the opinion that the goal to which this country should aspire is to train the great majority of its professional engineers through the University schools of engineering. It thinks that this stage will be reached in the civil and the electrical branches within the measurable future. It considers, too, that the new and rapidly developing fields of aeronautical and radio engineering should endeavour to reach graduate status at an early date.

RECOMMENDATION—

That in future all civil and electrical engineers qualify by way of a University degree.

(5) SPECIAL PROBLEMS OF MECHANICAL ENGINEERING

131. In the general field of mechanical engineering, however, there are special problems to be considered. The view is widely held that early contact with industry is essential, and this has hitherto not been possible for those taking a degree course. This view applies with special force in New Zealand because, in general, firms are small and few are likely to employ more than one professional engineer, and that in an executive capacity. In such circumstances a wrong choice will have a serious effect on the business and most firms, therefore, prefer a man who has grown up with them and who has been selected on account of character and leadership rather than purely technical ability. This view is corroborated by the evidence of one witness approached by the Committee, who stated that, although New Zealand B.E. (Mech.) graduates held positions of high responsibility overseas, New Zealand industry did not appear to want them.

132. On the other hand, the existing method of training is far from satisfactory. The proportion of failures in the Institution examinations is highest in the mechanical branch. Employers state that their trainees have difficulty with their studies though they have time off, and yet in spite of this they wish to continue training their own men. It would be possible to argue that the difficulties in the mechanical branch might be resolved by a greater willingness to accept graduates. It must not be imagined, however, that there has been no increase in the proportion of graduates in the mechanical branch. The proportion at present is, in fact, not very different from that in other branches. Undoubtedly, however, there is less enthusiasm for more graduates among employers in this branch than there is in the civil and electrical branches. The following recommendation sets out the Committee's considered view of the position:—

RECOMMENDATION—

That the policy for development in mechanical engineering be based on the assumption that there will be a demand for some years for engineers who obtain their professional qualifications while employed in industry.

(6) PRACTICAL TRAINING OF PROFESSIONAL ENGINEERS

133. So far in this section consideration has been given mainly to the academic aspect of a professional engineer's training. It is necessary to consider now the equally important question of practical training. Although adequate academic training is a basic necessity for an engineer, his is essentially a practical calling. Academic training is not an end in itself. It gives background, meaning, and system to the skills of his profession which an engineer will continue to acquire throughout his career.

134. The Committee is not directly concerned with all stages of practical training. It is interested to a certain extent in the training which traditionally ran currently with study. It has had to consider also whether any recommendations which it is making affect the carefully built up system of practical training of the British Institutions of Engineers. Moreover, the Committee's view that an increasing number of professional engineers should be and will be trained through the University schools of engineering implies that an increasing number of trainees will be taken from their working environment for up to four years. The diploma courses proposed in Section 12 at present require only one year as a full-time student, a break from industry that is relatively short. If for any reason it becomes necessary to extend the full-time period of the diploma courses then the question of separation from industry will have to be faced.

135. The engineering problems that will face the engineer after completion of training will rarely be found to be capable of statement in terms similar to those in which problems encountered during his academic training are expressed—that is, text-books will not provide the required solution. Instead, the engineer must determine the problem and then seek its solution. This will usually depend upon the organization and methods used in the particular branch of industry with which he is dealing. In order, therefore, that the engineer may be equipped to handle such problems it is necessary that he receive a carefully planned practical training, so that he will be acquainted with the techniques of the trades with which he will later be concerned.

136. For this purpose the practical training should be planned along broad lines. The Committee considers that much of the present practical training is far too restricted in scope and that those responsible for the direction of training should correct this weakness and direct the practical effort of students into channels that are more useful to the future engineer. It is unnecessary that the trainee acquire any marked degree of manual dexterity at the various trades with which he comes into contact, but he ought to know the potentialities and the limitations of each. He must, however, be more than an observer of the activities of tradesmen and must actually perform a wide variety of trade operations. By so doing, and through his contacts with tradesmen, he will gain an insight into the processes of thought of men whom he may one day have to control, at a time when these men will be willing to discuss their problems with him.

137. There will be two groups requiring practical training—(*a*) degree students and (*b*) students taking the diploma courses discussed in Section 12. The period available for the degree student is nine months, which embraces vacation periods at the ends of the three professional years. The diploma student will have longer as his study is on a part-time basis, except for the third year. It can be assumed to be four years of 49 weeks each, a total of 196 weeks.

138. So much for general principles; the requirements for a satisfactory practical training may now be considered in further detail.

(*a*) Civil Engineering

139. For many non-degree students practical training has been wholly confined to civil engineering works or office training, whereas degree students are required to spend six months in approved workshops. All students should be given a period of workshop training. For diploma students this period should be at least six months.

140. During this period the student should be employed at various trades, and an endeavour should be made to include as many of the following trades as possible: patternmaking, foundry, smithy, welding, sheet-metal work, structural steelwork, erecting or assembly, bench fitting and machining. Conditions are such that it is not practicable to detail the amount of time that should be spent at each trade.

141. Degree students are also required to spend three months in approved practice. This should be carried out on approved civil engineering works such as a civil engineering construction job or a large building contract, with the Ministry of Works, with a harbour board, city council, or other public body, or with a contractor. During this period the student should work at more than one task such as concreting, erecting or placing steelwork, or carpentry.

142. The diploma student will have a longer period of civil engineering training, and this should include a variety of tasks. He should be engaged on setting out, measuring up, and on such tasks as are normally performed by an engineer's assistant. In addition to work of this nature, the diploma student should, if possible, spend a period of at least one year in a civil engineer's office, where he would gain experience in design work.

(*b*) Electrical Engineering

143. Many potential electrical engineers aspiring to Institution qualifications have spent a great period of their time in acquiring sufficient manual dexterity to secure a pass in the Wiremen's Registration Board examinations. Too much of this type of training the Committee considers to be of only limited value for the potential electrical engineer. Degree students, on the other hand, are required to spend six months in approved workshops and three months either in approved workshops or in approved practice. The Committee considers the degree type of training is preferable.

144. The workshop period should be occupied in the same manner as is suggested for civil engineers. If three months are spent in approved practice it should not include office work, but preferably one or more of the following: communications, power-station or substation erection and installation, power-station maintenance and operation, construction of transmission and distribution lines, factory and domestic installations. In addition to work of this nature the diploma student should spend a period of at least one year in an electrical engineer's office, where he would gain experience in electrical design and specifications.

(*c*) Mechanical Engineering

145. It has been customary for mechanical engineers who are not taking a degree to rise from apprentice fitters. These men have spent five years learning a trade, and during that time will have acquired a fair standard of manual skill. The Committee considers that the apprentice type of trade training is not the best suited for the future mechanical engineer as the emphasis is necessarily on the acquirement of manual dexterity and the scope of training is apt to be too narrow. The Committee thinks that apprenticeship regulations should be altered, if necessary, so that future mechanical engineers who are not taking a degree can be apprenticed to mechanical engineering or take up a mechanical engineering cadetship. This would allow a widening in the scope of training which should include a certain amount of time engaged in such processes as patternmaking, moulding, forging, and sheet-metal working. Provision should also be made for apprentices to one particular mechanical engineering trade who have completed the first three years of the diploma course to change over to a mechanical engineering apprenticeship. During the last two years these apprentices would be given training in the basic trades of the foundry, where necessary.

146. The Committee considers that a suitable course of practical training for degree students and for those taking the diploma course in mechanical engineering should include acquaintance with as many of the following processes as possible: erecting or assembly, bench fitting, including marking off, machining, patternmaking, foundry, welding, sheet-metal work, smithy or structural steelwork, boilermaking, planning, maintenance of works equipment. In addition to work of this nature the diploma student should spend a period of at least one year in a mechanical engineer's office on design work. No attempt has been made to lay down the order in which these periods of training will be carried out, as this will vary with the number of apprentices or cadets undergoing training in a particular workshop.

147. The Committee is of the opinion that the present period of practical training for the student taking B.E. (Mech.)—nine months—is too short in view of his close association with skilled tradesmen, and considers that some arrangement should be made to increase this period.

148. There seems to be a considerable majority in favour of a period of practical training before the professional subjects of the degree course are entered upon. This would give a youth an opportunity of finding out what engineering is like; it would help him in appreciating later the significance of his professional studies. The best time to make the break is probably at the end of the intermediate year. Opinions vary about the length of the period of this practical training, but it must be long enough for the youth to find his feet and receive proper training. It cannot be very long, for reasons which are obvious. The main difficulty, of course, is in arranging a suitable system. Co-operation is required between the employer, the University, and the student.

149. The Committee was impressed by the scheme put into operation by Metropolitan Vickers, Ltd., and referred to in a pamphlet published by the firm entitled "Education Schemes in Industry." It considers that the best solution may well be along the lines set out in the following quotation from p. 12 of the pamphlet:—

> This method of two years' practical training following three years' full-time study has been varied by the company by the introduction of its probationary College Apprenticeship Course, which consists of one year's practical training before entry to the University or senior technical college, followed by one year on the completion of full-time academic studies. The company accepts some thirty-five such apprentices each year.
>
> The company pioneered this method of training and after some twenty years' experience is firmly convinced that it represents the best form of training for the great majority of professional engineers. That this point of view is being increasingly accepted throughout the profession is shown in the publications of the Institution of Mechanical Engineers, the Institution of Electrical Engineers, and the Institute of Physics. From the company's, as well as the individual's, point of view by no means the least advantage lies in the opportunity offered to the apprentice in his initial year to discover whether or not his real interests and aptitudes are for the engineering profession before committing himself to a three-year University course. It is, in other words, a very practical form of vocational guidance which helps young men to make a choice of career based on real knowledge of conditions. Those who have followed this course have repeatedly expressed their appreciation of its value whilst many of those who did two years' practical training after graduation have said that their experience led them to wish they had had a year's practical training before entry on their full-time University studies.

150. The Committee commends this system to prospective entrants to the profession as one well worthy of trial. The objection may be raised that the necessary break in academic studies might cause some difficulty to students and that the subsequent study would suffer thereby. The Committee considers that the suggested trial would show that the difficulties were more imaginary than real, especially if the students attended evening classes during the period of practical training.

10. COURSES LEADING TO DEGREES IN ENGINEERING

(1) THE AIM OF UNIVERSITY SCHOOLS OF ENGINEERING

151. In Section 9 consideration was given to alternative ways of obtaining professional status as an engineer. The Committee holds strongly the view that, for future leaders of the profession, the basic training should consist of a full University degree course. Indeed, the time may not be far distant when practically all civil and electrical engineers will be educated in this way.

152. The holder of a B.E. degree is not necessarily a fully-trained engineer, and the criticism made by some witnesses on this account is scarcely reasonable. What the University schools can and should do is to provide a sound foundation of scientific knowledge, and develop in their students good habits of thought, study, and investigation. If, in addition, the schools assist the development of the personal qualities that distinguish a "University man," in the best sense of that term, they will have done their work. The student so equipped will have little difficulty in acquiring the practical experience in the art of engineering that will complete his professional training. Ultimately he should be able to meet emergencies by reverting to first principles, and cope with new problems by concentrating on essentials without neglect of detail. It is the belief that an engineer properly trained in a good University course can do these things that has led the Committee to attach great importance to degree courses.

153. This section then, deals with the courses in chemical, civil, electrical, and mechanical engineering leading to the University degree in Engineering. A brief description of the work allotted to the two schools is followed by a more detailed consideration of the entrance qualifications. Next comes a discussion of the best means of providing, during the professional years, for the efficient teaching of the number of students found to be necessary. Suggestions are then made for improvement of the existing courses and for keeping the work of the two schools in close touch with those engaged in the practice of the profession.*

(2) THE PRESENT POSITION

154. The degree courses in civil, electrical, and mechanical engineering consist of an intermediate year followed by three professional years leading to the ordinary degree of Bachelor of Engineering. To obtain the degree of B.E. (Honours) a fourth professional year is required; this course is available only to selected students. The intermediate course, comprising pure and applied mathematics, physics, and chemistry, as for B.A. or B.Sc., is common to all three branches, and may be taken at any one of the four constituent colleges. The professional years of the course are provided only in Auckland and Canterbury, but, as the five required subjects of the first professional year are common to all three branches, a student need not elect to follow a particular branch until the end of that year.

155. The course leading to the degree of B.E. (Chemical) consists of four professional years. As is the case with the other three branches, election to follow this course need not be made until the end of the first professional year. The fourth professional year is taken only at the Canterbury School.

156. The Canterbury school, then, provides complete courses in civil, electrical, mechanical, and chemical engineering. The Auckland school offers complete courses in mechanical engineering, and from 1949 in civil engineering, but does not at present provide for the final year in any of the other branches. The distribution of students by years and schools is shown in Table F.

157. From Table F it will be seen that, in addition to the degree students, the two schools together included in their 1948 classes 82 students who were not seeking degree qualifications.

---

* For reasons set out at the end of this section only brief mention has been made of the University of Otago School of Mines.

Table F—Student Enrolments Two Engineering Schools, by Stages, 1945–1948 (Inclusive)

——	1945.			1946.			1947.			1948.		
	A.U.C.	C.U.C.	Total.	A.U.C.	C.U.C.	Total.	A.U.C.	C.U.C.	Total.	A.U.C.	C.U.C.	Total.
First professional ..	20	66	86	38	97	135	61	110	171	44	79	123
Second professional—												
Civil	6	8	14	9	24	33	10	28	38	24	52	76
Electrical	3	5	8	7	22	29	7	36	43	6	31	37
Mechanical	4	3	7	5	11	16	10	13	23	7	17	24
Chemical	..	..	..	..	..	..	1	4	5	..	6	6
Total	13	16	29	21	57	78	28	81	109	37	106	143
Third professional—												
Civil	..	13	13	..	17	17	..	43	43	..	43	43
Electrical	..	13	13	..	13	13	..	31	31	..	36	36
Mechanical	..	1	1	5	1	6	5	11	16	14	10	24
Chemical	..	1	1	..	1	1	..	1	1	..	1	1
Total	..	28	28	5	32	37	5	86	91	14	90	104
Fourth or subsequent professional—												
Civil	..	..	..	..	..	..	..	..	..	..	3	3
Electrical	..	..	..	..	..	..	..	..	..	..	4	4
Mechanical	..	..	..	..	..	..	..	..	..	3	..	3
Chemical	..	..	..	..	..	..	..	..	..	..	1	1
Total	..	..	..	..	..	..	..	..	..	3	8	11
Totals, first, second, and third	33	110	143	64	186	250	94	277	371	98	283	381
Other students	26	119	145	42	79	121	16	72	88	9	73	82
First, second, third, and others	59	229	288	106	265	371	110	349	459	107	356	463

(3) ENTRANCE QUALIFICATIONS

158. Before commencing study in the intermediate year, a student is required to have University Entrance qualifications. The attention of the Committee was drawn to the apparently high mortality occurring in the intermediate year. Figures indicate that only about half of those entering the B.E. intermediate year will survive the examination. Part of this loss is possibly accounted for by students who transfer to an Arts or Science course during or at the end of the intermediate year.

159. Witnesses who remarked upon the quality of students embarking upon the engineering course were not unanimous as to the improvements, if any, that should be made. Some considered that greater specialization was desirable for future engineering students in the post-primary school; others thought that the greatest need was not for any relatively narrow or specialized post-primary course, but for a general well-balanced course designed to produce a student with interests outside his own selected field of training. One very convincing piece of evidence indicated that students who had spent at least one year in the Sixth Form after they had obtained University Entrance qualifications showed much better performance than those who commenced the intermediate year with the minimum entrance requirements.

160. The Committee does not think it wise to lay down any rigid requirements as to subjects to be studied in the Sixth Form, but it holds very strongly the view that intending entrants for the engineering degree should spend at least one year in the Sixth Form after qualifying for University Entrance. Even during the second Sixth Form year the curriculum should not neglect the general cultural needs of the pupil.

161. Since mathematics plays a large and increasing part in the basic equipment of the engineer, a thorough grounding in this subject is essential. The Committee received some criticism of the present prescriptions in mathematics for both the University Entrance and the Entrance Scholarship Examinations. It was pointed out to the Committee that students in many of the better schools were taught more advanced mathematical processes than were required in either of these examinations, but that the relatively narrow prescriptions tended to discourage such advanced teaching and the development of courses that would provide a better foundation for the future engineer.

RECOMMENDATION—

That as the present prescriptions in mathematics for University Entrance and University Entrance Scholarships are too narrow, the University of New Zealand be strongly urged to broaden them.

162. Witnesses also suggested that there should be a much more rigid selection of students proposing to enter the engineering schools. Other witnesses, however, quoted cases of students who, though commencing badly, had developed into first-class engineers. The Committee is emphatically of opinion that everything possible should be done to maintain at the highest level the quality of the students coming forward for the engineering profession, and it would strongly oppose any lowering of degree standards in order to achieve the substantial increase in the average annual number of engineering graduates which appears to be necessary. If at any time it becomes desirable to limit the number of graduates, the Committee is of opinion that selection should be made at the end of the intermediate year. It is not sound economy to use the professional years as a means of selection. Then, too, students rejected at this early stage would be able to transfer to some other University course for which they were better suited, and would not sacrifice a year unnecessarily.

163. It is worth emphasizing at this stage that the time and efforts of University teachers of engineering should not be wasted on students of poor ability. The course in engineering is an exacting one, and should not be attempted except by able students.

RECOMMENDATION—

That if at any time further restriction is necessary, having regard to the number of engineering graduates which the Dominion can reasonably be expected to absorb, selection of students for this purpose be made at the end of the Engineering Intermediate Course.

(4) THE PROFESSIONAL YEARS

164. Neither of the schools of engineering is equipped or housed to a standard in keeping with the work they at present have to do or the demands that are likely to be made of them if the recommendations of the Committee are accepted.

(*a*) AUCKLAND

165. Until recently the Auckland school occupied buildings which were, in the words of an eminent visiting English engineer and authority on education, "a disgrace to the city and to the University." Efforts had been made in 1943 to remedy the situation by establishing a new school at Western Springs, three miles to the west of Auckland City. The College Council, however, had some misgivings about the prospective separation of the School of Engineering from the remainder of the college. When, therefore, in 1944 the College Council purchased a site at Tamaki of 120 acres it was proposed that

this area should become the ultimate home of all faculties of the college. Sketch-plans for new permanent buildings for the School of Engineering on this site were prepared in 1946, but early in 1947 it became apparent that buildings could not be erected until 1953 at the earliest. This gave rise to the interim proposal of removing the school to the R.N.Z.A.F. Station, Ardmore, which has now been put into effect. The school has now ample area for immediate needs, and accommodation which, though of a temporary nature and far from ideal, is immeasurably better than that which it has hitherto occupied.

166. The portion of the Tamaki site reserved for the School of Engineering is understood to be about 12 acres in extent. The Committee thinks that future developments may well prove this area to be inadequate, and that the most careful consideration should be given to the alternative possibility of developing the school at Ardmore. This alternative has many attractions, but should not be followed unless permanent tenure can be assured.

167. One thing is certain: in order that planning may be properly carried out, and permanent buildings erected as soon as possible, a decision as to the future site should be made immediately.

(*b*) CANTERBURY

168. The National School of Engineering at Christchurch occupies buildings on the main college site. Few, if any of these buildings measure up to modern requirements, and most of them are crowded, poorly lighted, and inconvenient. Temporary buildings, alterations, and additions have given some relief and have enabled the school to cope with heavily swollen numbers. The Committee was informed that the present policy of the College Council is to erect eventually a new engineering school on a portion of the city block lying to the north of the present site. It was also informed that the proposed building does not at present stand high in priority in the building requirements of the College Council.

169. A decision as to the future location of the Canterbury school should not be delayed. The Committee has some sympathy with the views expressed by those Canterbury witnesses who stressed the advantages of alternative sites within four miles from the city. Such a site should allow for flexible planning on modern lines and would allow ample room for future developments. Against this must be placed the disadvantage of separating the school from the other faculties of the college. It is easy to exaggerate such disadvantages, particularly when the new site would be within easy cycling distance of the main buildings. The problem of providing adequate laboratory space has been solved in many cases in Great Britain by the building of new engineering schools at a considerable distance from the main University buildings. Birmingham is an example.

170. The north block site may be justified if the Canterbury school is thought of as having a relatively stable enrolment considerably lower than that of 1948, and as a school covering a limited range of courses. The present accommodation, however, should not be made a criterion of future, and largely unpredictable needs. The laboratory space in the existing building was considered sufficient twenty-five years ago, when it was thought that 200 students would be the maximum capacity; even for that number present-day standards require much more equipment, largely because of the rapid advances in all branches of engineering science. In present conditions, with large numbers of students requiring laboratory instruction in rooms where the equipment is too closely spaced, classes have to be repeated as many as six times, and even then with too many students in each class.

171. To meet modern requirements it is necessary to provide for the increasing needs of honours students and for reasonable research by members of the staff. Something like 250 square feet of space for each student is not an extravagant allowance. If, as is suggested in Table H, the school is to accommodate upwards of 230 students,

say 250, it should have an area of from 60,000 to 65,000 square feet, which is one and a half times the floor space at present available. A school of this enrolment and size would be comparable with well-known schools of engineering in Great Britain.

172. Something must be done immediately. If the present conditions are allowed to continue, the quality of graduates must decline. It has been suggested that a move to temporary quarters within easy cycling distance of the present buildings would tide the school over the next twenty years or so, when permanent buildings could be constructed. The Committee does not favour this proposal. The labour costs for temporary buildings are so little less than those for permanent buildings of a type suitable for a modern engineering school that it is doubtful whether the double move could be justified. The Committee thinks, therefore, that large-scale rebuilding of the Canterbury school in temporary buildings should be avoided, and has reached this conclusion with a full knowledge of the fact that rebuilding on the north block, which is at present occupied by residential properties, will be out of the question for many years. The weight of argument is clearly in favour of permanent building on a new and spacious site.* Proximity to main lines of communication should, of course, be kept in mind.

RECOMMENDATION—

That the question of building a new engineering school at Canterbury be considered to be one of the greatest urgency, that steps should be taken to secure a suitable site and that the building be given a high priority.

(5) SHOULD THERE BE TWO SCHOOLS OF ENGINEERING?

173. In Section 8 it was shown that the immediate aim should be an output of 75 graduates a year and that to maintain this output a total of about 300 student-places would be necessary. This number is considerably smaller than the number of student-places at present available. Table G will make this obvious.

Table G.—Distribution of Students, by Schools, Courses, and Years, 1948

—	Canterbury.	Auckland.	Total.
First professional year	79	44	123
Second and subsequent professional years—			
Civil	98	24	122
Electrical	71	6	77
Mechanical	27	24	51
Chemical	8	..	8
	283	98	381
Non-degree students	73	9	82
Total student-places	356	107	463

174. It will be seen from Table G that, even leaving out of account the 82 non-degree students, the schools at present accommodate 81 students in excess of the number which the Committee considers reasonable.

* Since this report was written the College Council has asked the Government to acquire a new site for this purpose.

175. In general, however, the Committee considers that two schools of engineering will be required. Even on the basis of present known needs the number of required student-places is greater than that which could be efficiently provided in a single school. When possible future expansion and specialization are taken into account, the case for two schools becomes even stronger.

176. The Committee also considered, but rejected, the possibility of consolidating certain branches of engineering in one or other of the schools. At first sight it seems illogical that instruction in mechanical engineering, by far the smallest of the three main divisions of engineering, should be divided. Indeed, it happens to be the only branch in which complete duplication of teaching has hitherto been provided.

177. The three major branches of engineering—civil, electrical, and mechanical—are by no means self-contained. Some instruction in mechanical engineering, for example, is necessary for all three branches, and any theoretical advantage that might appear to be obtainable from water-tight division of courses is likely to prove illusory in practice. In the training of engineering students it is important that final specialization should be delayed as long as it is reasonably possible. The professional engineer who knows something at first hand of the work carried out by his colleagues in other branches of the profession will, particularly in New Zealand conditions, be a more useful man. The Committee considers, therefore, that up to the standard of the B.E. degree it would be false economy to plan for concentration of any of the major branches in a single school. For B.E. (Honours) and for post-graduate courses where highly specialized teaching and equipment may be required, there should be reasonable concentration of resources, and the schools should avoid duplication.

RECOMMENDATION—

That the equipment of the Auckland University College School of Engineering be improved and that further equipment be provided to permit the extension of the courses in civil and electrical engineering to the final year of the B.E. course.

178. Assuming, then, that there are to be two schools of engineering, it remains to show how the student-places should be allotted. To arrive at a hypothetical distribution of student-places among the various branches of engineering the Committee has obtained a ratio by combining (*a*) the annual wastage at 4 per cent., (*b*) possible annual filling of vacancies, and (*c*) possible additional engineers to provide for new posts. The results obtained are set out in Table H which, for convenience, also includes the present enrolments.

Table H—Allotment of Student-places (Estimates)

——	Present Enrolments.			Estimated on Basis of Wastage, Vacancies, and New Posts.		
	C.	A.	Total.	C.	A.	Total.
First professional year	79	44	123	80	40	120
Second and subsequent years—						
Civil	98	24	122	43	21	64
Electrical	71	6	77	55	28	83
Mechanical	27	24	51	16	8	24
Other	8	..	8	6	3	9
Non-degree	73	9	82	33	17	50
	356	107	463	233	117	350

179. For reasons which will appear later in this section fifty additional places are distributed between the two schools. An examination of Table H will show that the numbers at present enrolled in the first professional year are almost identical with the estimated enrolments. In civil engineering the Auckland figure remains about the same as that for present enrolments, but the Canterbury figure shows a decided reduction. In electrical engineering the estimated figures assume that Auckland will increase its enrolment and that the Canterbury enrolment will decrease. The estimated figures for mechanical engineering (totalling 24) are less than half the present number of students. It has already been pointed out that in mechanical engineering many professional engineers obtain their qualifications by means of Associate Membership of the British Institution of Mechanical Engineers. It may well happen that in future the demand for graduates will increase at the expense of those qualified by other means, in which case the estimated number of 24 may be greatly exceeded.

180. It must be emphasized that the estimated figures in Table H are purely hypothetical. The Committee does not suggest that the numbers should be rigorously limited in accordance with the estimate, but on the evidence available it would seem that some such enrolment would meet requirements. Whether the estimates are sufficiently high to provide the necessary number of graduates depends on what may be broadly called the efficiency of the schools—that is to say, anything that can be done to increase the percentage of passes in the professional years without reducing the quality of the work done will have the effect of increasing the output of graduates. The Committee's attention was drawn to the fact that a number of students took longer than the normal time to complete their courses because failure to pass all the examinations of one professional year may prevent their completing the succeeding year. The Committee considers that this difficulty would be partly overcome by instituting a system of supplementary examinations conducted before the commencement of each academic year. At these examinations students whose work is very little below pass standard might present themselves for a second examination and so avoid losing a full year. It would, of course, be necessary to provide safeguards against an abuse of this system.

Recommendation—

That the University of New Zealand consider the institution of supplementary examinations for the professional years of the B.E. degree.

181. In general, the estimates in Table H may be said to suggest that the Canterbury school should be stabilized at an enrolment somewhere about 250 and that further places should be developed in the Auckland school. This raises the broader question of co-ordination of the work of the two schools. In the opinion of the Committee there should be some body responsible for such co-ordination, a body able to decide the number of student-places to be made available in each school and to guide the development of specialist courses. Such matters should be considered by the Council of Engineering Education (recommended elsewhere) in collaboration with the two faculties.

182. Broadly speaking, then, the Committee does not think that the immediate need is for an over-all increase in the number of student-places. Indeed, as has been shown in Section 8, the recruitment of any greatly increased number of entrants to the first professional year would, in present circumstances, be extremely difficult. The Committee thinks rather that there should be a reduction in the numbers of students at the Canterbury school and that the enrolments at the Auckland school should be gradually increased. It considers, further, that everything possible should be done to ensure that the reasonable progress of students from year to year is not unnecessarily retarded and that for this purpose conditions of building, staffing, and equipment should be improved, where necessary, as soon as possible.

183. It remains now to consider how far the University schools of engineering should provide courses for non-degree students. The Committee is of opinion that, since degree courses should be conceived as a unit rather than an aggregate of separate subjects, the inclusion in University degree classes of students who, though doing similar work, are not similarly prepared for it and are not aiming at a full University course is distracting and unsatisfactory both to staff and to degree and non-degree students alike. As has already been pointed out, some 82 such students were in attendance at the schools during 1948. On general principles the Committee thinks that provision should be made elsewhere for such students, and it has recommended the establishment of diploma courses. In the immediate future, however, it may be necessary for some non-degree students to attend the University schools until the technical schools are able to accommodate them in diploma courses.

RECOMMENDATION—

That, as soon as the necessary facilities can be made available in technical schools or technological colleges for other students in engineering, the University engineering course be restricted to those students proceeding to a degree in engineering.

(6) FURTHER COURSES

184. It is necessary now to consider certain branches of engineering for which degree courses are not at present available. The Committee received evidence that, despite the very great importance of refrigeration in our economy, opportunities for training in this branch of engineering are inadequate. Evidence on the subject of telecommunication engineering was even more convincing. There is at present little engineering training for this important public service. Recruitment is at present from graduates in science, but there is reason to believe that a course in engineering, with a special bias towards telecommunications, would be a more suitable preparation for at least some of the people engaged by the Post and Telegraph Department and the Broadcasting Service. It was represented, too, that the previously existing course in locomotive engineering should be reinstated.

RECOMMENDATIONS—

That optional subjects (locomotive engineering and refrigeration engineering) be added to the list of subjects for the third professional examination for the degree of Bachelor of Engineering (Mechanical).

That a subject (telecommunications) be added to the list of subjects for the third professional examination for the degree of Bachelor of Engineering (Electrical), and that this subject be optional with hydraulics and pneumatics.

(7) DEGREES

185. Courses are at present offered for B.E. and B.E. (Honours). The honours degree, as has already been mentioned, involves a course of at least four professional years and is awarded only to candidates who have presented a satisfactory thesis. Some witnesses considered that the nature of the degree of B.E. (Honours) might not be readily understood. It was further suggested that there was room for some form of degree that would indicate that the successful candidate had pursued his studies after completing his Bachelor's degree, and had, after gaining experience in the practice of his profession, made a significant contribution in his special field. The Committee does not feel justified in expressing a final opinion on this matter, but recommends—

RECOMMENDATION—

That the University of New Zealand be asked to investigate the question of establishing a Master's Degree in Engineering.

(8) REFRESHER COURSES AND SUMMER SCHOOLS

186. With the rapid development of engineering practice and theory the provision of means whereby the practising engineer can be kept abreast of the requirements of his profession becomes increasingly important. Short post-graduate courses to meet this need would act as an important stimulus to the teaching staff, and would enhance the reputation of the schools. Summer schools, at which courses might be conducted by visiting lecturers either from overseas or from important State and private engineering undertakings in New Zealand, could do much to promote post-graduate study.

RECOMMENDATION—

That the schools of engineering provide, from time to time, short post-graduate courses in special branches of engineering in which important recent developments have taken place.

(9) THE SCHOOLS AND THE PROFESSION

187. It is most important that the University schools of engineering should not lose touch with current engineering practice. Even in the training of students there is a need to ensure that work done in the schools is closely interwoven with the practical work which the student is required to perform in industry as part of his course. The Committee was informed that there was already some co-operation between the staffs of the schools and the engineers under whose supervision the students are gaining practical experience, but it considers that there is room for an extension of this practice.

188. In the selection of teaching staff, too, care should be taken to ensure that a reasonable proportion have had wide practical experience. There is also room for a scheme that would permit of the interchange of staff between the schools and practising engineers. The Committee thinks that the value of University teachers of engineering would be enhanced if they were able to return to active practice for short periods. There are admittedly difficulties to be overcome in putting such a plan into practice, but they should not be insuperable even in the case of the University schools. In the higher branches of work in the technical schools such a plan is imperative. The Committee accordingly recommends—

RECOMMENDATIONS—

That means be provided to permit engineering teachers at University schools of engineering, and technical schools to return periodically to active practice.

That the possibility of engineering specialists giving short lecture courses be explored, and that greater use be made by the University schools of engineers who would lecture on a part-time basis and practise part time.

That there be a greater amount of co-operation between University college engineering staffs and engineers under whom students are carrying out practical work to ensure that students are making the best possible use of the time spent in practical work.

189. In making these recommendations the Committee is thus suggesting an extension of the principle of liaison already established at the Auckland and Canterbury University Colleges. The engineering schools at both colleges already have advisory committees which include practising engineers. At Auckland the College Council has set up an Engineering Sub-Committee, on to which are co-opted members of the engineering profession. At Canterbury there is also a special sub-committee of the College Council consisting of Council members, two of whom are engineers, and the three Professors of Engineering. To provide a link between the College Council and the profession there is an Engineering Panel, made up of Council members, the three Professors of the School, and leading engineers of the city. It is obviously desirable at the college level that the plans adopted should be those best meeting local conditions and the Committee sees no reason to suggest any alteration in the present arrangements.

190. At the national level, however, the development of diploma courses (which the Committee recommends in Section 12) will mean that there will be two main doors to the engineering profession, and that, in consequence, some co-ordination of effort will be very necessary. There must be some means of carrying out a regular audit of both ways of preparing students for the profession. To provide for close co-operation of the Education Department, the University authorities, the technical schools, and the engineering profession, and to ensure that the professional training of students undertaking either degree or diploma courses is co-ordinated and kept under review, the Committee considers that there should be established a Council of Engineering Education. The constitution and functions of this Council are set out in Section 14.

(10) RESEARCH

191. The Schools of Engineering, in common with other departments of the University, have two important functions—the extension and dissemination of knowledge. While the teaching functions of the schools must never be obscured by other functions, the Committee believes that a school of engineering which does not give a reasonable place to research and which fails constantly to enliven its teaching by inquiry is unworthy of the status of a University school. The Committee was informed that the heavy teaching load carried by many members of the staffs of the schools prevented them from engaging in research. While recording its belief that the schools should be careful to preserve a reasonable balance between teaching and research, the Committee recommends—

RECOMMENDATION—

That the staffing at both University schools of engineering be sufficiently liberal to permit of a reasonable amount of research being undertaken.

(11) THE OTAGO SCHOOL OF MINES

192. Attention has been given almost entirely in this section to the functions of the Auckland and Canterbury Schools of Engineering. There is, of course, a third school providing courses in Engineering. The School of Mines and Metallurgy, a constituent part of the University of Otago, prepares students for its own associateship and for degrees of B.E. (Mining) and B.E. (Metallurgical). During 1948 there were 53 students attending the school, some 34 of whom were following degree courses. The Committee has not considered that a full review of the work of the School of Mines came within its order of reference. It may be noted, however, that equipment and staffing at the school have been improved in recent years, and that steps have been taken to establish closer liaison with the coal-mining industry and with related New Zealand industries. Throughout its history the school has been closely associated with the Geological Survey. The Committee was informed that a Chair of Coal Mining was to be established, and that the Mines Department had in mind the establishment of a system of bursaries designed to recruit to that Department men with appropriate professional qualifications for management and development. The Committee considers that, broadly speaking, these new arrangements are all to the good. It notes with approval, too, the increased emphasis that is now placed on research.

193. Since the State is now the chief mine-owner in New Zealand, it would seem that so long as the present close liaison is preserved, any modification of intake at the school could be more readily brought about than has been possible in the other University Schools of Engineering which cater for a wider variety of courses. If, as the Committee recommends, there is set up a Council of Engineering Education, the functions of the School of Mines should be reviewed along with those of the Auckland and Canterbury schools.

11. COURSES LEADING TO INSTITUTION MEMBERSHIP EXAMINATIONS

194. Although the Committee is firmly of the opinion that the completion of a University degree course is the best method of entering the engineering profession, it realizes that this is out of the question for a number who are already in the various stages of qualifying by other means. It has been made clear, too, earlier in the report (see paras. 124 and 131 and Section 8, *passim*) that for some years to come it will be necessary to provide for those who will qualify for the profession without obtaining a University degree. Hitherto those who qualified in this way passed the examinations of one or other of the British Institutions of Engineers or of the Engineers Registration Board of New Zealand. The principal steps which the Committee proposes should be taken to cover this long transition period are referred to in the recommendation in para. 124 about courses leading to diplomas in professional engineering. These diplomas are dealt with at some length in Section 12. It will be shown that these diploma courses are more desirable than the existing methods of obtaining Institution membership other than by a degree. The Committee considers, therefore, that the great majority of those who do not seek a University degree will take the diploma courses. Here, too, there will be a transition period, but, because the diploma courses are based to a large extent on the existing Institution examinations, students will in most cases be able to transfer to the diploma courses without difficulty. The transition period, therefore, need not be long.

195. The purpose of this section is twofold. It will outline steps which the Committee proposes should be taken during the interim period for those who decide to continue with their Institution examinations. It will also make some reference to the weaknesses of those examinations under the conditions in which they may be taken in this country, thereby giving an indication of the reasons which have led the Committee to recommend a system of diplomas in professional engineering.

196. One of the problems brought out in the evidence, particularly of the technical schools, was the inadequate educational background of many of those studying for Institution examinations. No doubt a number have left school early to enter industry without any clear idea, or perhaps without any idea at all, of qualifying as a professional engineer. The development of a laudable ambition finds these people with an academic background that is not only generally inadequate, but also frequently deficient in the kind of basic education generally regarded as being essential for a professional engineer. Moreover, there is a natural desire to catch up with what has come to be regarded as wasted years. In other words, the young man, perhaps he is not so young, wishes to spend as little time as possible before beginning the professional examinations of the Institution to which he is seeking membership. In most cases the deficiency clearly revealed before very long is insufficient knowledge of mathematics and the physical sciences. The Committee considers that it would be in the best interests of students to insist on a slightly higher pre-entry qualification which, when passed, would be an adequate background for further study. The present minimum entry requirements have already been set out in Section 6. It was indicated to the Committee in the evidence that the Engineers Registration Board would not object to a suggestion that the pre-entry qualification be raised and that the British Institutions of Engineers would probably fall into line and require any New Zealand candidates to comply with the new conditions.

RECOMMENDATION.—

That the Engineers Registration Board ensure that the minimum standard of entry to the engineering profession in New Zealand be University Entrance either by accrediting or examination, and that intending students be strongly advised to include both mathematics and the physical sciences among the subjects taken at the Sixth Form stage.

197. It was made clear to the Committee that many students in the past worked under conditions of extreme difficulty and that such a state of affairs is quite common to-day. It is quite true, as quoted in Section 9, that the overcoming of difficulties is a salutary training for a professional life that will be full of trials and problems. On the other hand, standards have risen to the point where the strain has become too great. The evidence of witnesses showed that all professional engineering students should have at least one year of full-time study in order to have a chance of completing their qualifications within a reasonable time. This would help to overcome one of the main drawbacks of part-time study—namely, the difficulty of endeavouring to pass an examination when the whole syllabus cannot possibly be covered in any one year on a part-time basis. A year as a full-time student would have the further advantage of making it easier for students to get at least some acquaintance with laboratories. The existing position where it is possible for a candidate to complete the Institution examinations entirely by correspondence and without doing any laboratory work at all appears to the Committee to be quite unsatisfactory. It notes that the British Institution of Electrical Engineers has just altered its prescriptions to make laboratory work compulsory as from 1949. The system of diplomas referred to in the next section overcomes the weaknesses indicated above by making provision for one year as a full-time student, by arranging the work of each of the four part-time years so that the student can cover a reasonable amount of ground in each year, and also by providing for adequate laboratory work in each year of the course. These are some of the proposed steps in the development of a co-ordinated local system of courses and examinations which the Committee knows the British Institutions of Engineers will welcome as a substitute in this country for their own external examinations.

198. Very few of those students who qualify as professional engineers other than by degree courses can afford to spend a year in full-time study. It is hoped that in the future mere lack of money will not prevent any student from attending the University, but in the meantime there are numbers already in training who would benefit by the full-time study mentioned above. The Committee would prefer these trainees to take the diploma courses, but in the interim period provision may have to be made for those who cannot do this. It is recommended, therefore—

Recommendation—

That for a limited period men who have the necessary preliminary qualifications and who can produce evidence that they have already entered upon an approved course as students for one of the recognized Institutions should be regarded as eligible for bursaries on terms similar to those recommended for diploma students.

199. Candidates for the Institution examinations are spread throughout the country, but the largest numbers at present are in the four main centres. It is not easy to estimate the full effect of all the Committee's proposals, but with additional incentives to take a degree course, and with the facilities to be provided for diploma courses, it is likely that there will not be very many trying to qualify by other means once the diploma courses have been approved by the British Institutions of Engineers. Probably, as other measures become effective, the majority of students taking external examinations will consist of those who have to study by correspondence. The Committee hopes that increased use will be made of the facilities at the Education Department's Technical Correspondence School, which, if the Committee's recommendations are put into effect, will have a definite place in the organization for the diploma courses. This school endeavours to integrate its work with that of the technical schools so that students who are transferred from one place to another because of their employment may continue their studies with little inconvenience. Moreover, the Technical Correspondence School is in a good position to organize short, concentrated courses of the laboratory work which is so desirable. These courses, too, would give the students and their instructors an opportunity of meeting each other.

RECOMMENDATION—

That to meet the needs of those who in the interim period will still be sitting external examinations, instruction be provided through the Technical Correspondence School and that arrangements be made for laboratory work in those subjects requiring it.

200. The evidence of the New Zealand Institution of Engineers suggested that greater facilities should be made available for candidates for the examinations of the British Institutions of Engineers. The Committee feels certain that the New Zealand Institution will agree that the steps being taken to establish diploma courses will obviate the need for any extension of the facilities for Institution membership examination candidates. There will have to be development of the facilities in the technical schools to provide adequately for the new diploma courses. These extended facilities will in most cases be available for those candidates who elect to continue with external examinations, but the Committee is of the opinion that the technical schools should not be required to do any more than keep faith with those who have already begun courses under the old conditions. It hopes that the technical schools will be able to organize themselves in such a way as to handle the new diploma courses at the earliest possible date. There will be certain practical difficulties arising during the transition period. For example, the provision of full-time bursaries for Institution membership students will entail some problems as these students would not necessarily wish to take the full-time part of the course for the diploma which is taken in the third year. This difficulty can perhaps be largely overcome by concentrating such students in one school which might be selected as one which could be usefully developed to senior status at an early date.

201. These are matters which depend to a large extent on factors over which the Committee has little control. It would seem proper that the administrative adjustments which may become necessary should be decided on by the Education Department as they arise, bearing in mind the general policy to be followed. The Committee's view of this policy is expressed in the following recommendation:—

RECOMMENDATION—

That while having due regard to the necessity of keeping faith with students who have begun courses for other examinations, the technical schools be organized as soon as possible to provide exclusively for the courses for the diplomas in professional engineering as set out in Section 12 of this report.

12. ESTABLISHMENT OF A SYSTEM OF DIPLOMAS IN PROFESSIONAL ENGINEERING

(1) NEED FOR COURSES RATHER THAN SUBJECTS

202. Submissions made to the Committee by the New Zealand Institution of Engineers, the Engineers Registration Board, and other witnesses stressed the value of the establishment in New Zealand of a system of Diplomas in Professional Engineering on lines similar to those operating in Great Britain. Arrangements in the United Kingdom between the various professional bodies and the Ministry of Education provide for the award both of National Certificates and of National Diplomas in various branches of professional engineering, the National Certificates being awarded in respect of approved part-time courses of two or three years' duration and the National Diplomas in respect of approved full-time courses of a minimum of two years' duration.

203. With the general principle of establishing courses leading to some nationally recognized qualification the Committee is in complete agreement. It considers that such a system would have marked advantages over the present method of meeting the examination requirements of the professional Institutions. Some of the weaknesses of the present examinations have already been mentioned. Here it may be noted that too

much stress has been placed on the passing of a written test, and too little attention given to the course followed by the candidate. That this is an undesirable practice is recognized both by the Engineering Institutions in the United Kingdom and by those making submissions to the Committee. Hitherto the Institutions have not required that the student shall have undertaken a properly organized course of study. Students in this country have obtained their instruction in the best way they could, by attendance at University and technical school classes, through the Education Department's Correspondence School, or through private correspondence schools. The limit of absurdity is reached when students pass (as they frequently have done) in practical subjects without doing any laboratory work in these subjects.

204. A further, though less objectionable, weakness in the present system lies in the fact that the prescriptions laid down for Institution Membership Examinations, though probably suitable for conditions in the United Kingdom, do not always meet fully New Zealand needs.

(2) DIPLOMAS

205. Both these weaknesses could be remedied by the development of properly co-ordinated courses of study for which adequate instruction was available. To be effective, however, such courses should reach in all subjects a standard at least equal to that of the Institution Membership Examinations. The Committee has little doubt that if this standard were reached and maintained the professional Institutions would be prepared to recognize the courses and the examinations to which they would lead as a substitute for the examinations set by the Institutions themselves.

206. While agreeing with the general principle, the Committee does not favour the establishment in New Zealand of full-time courses. As has been made clear in previous sections, any student able to undertake a full-time course should endeavour to qualify by way of a degree course in engineering. At the present time, however, there is a real need for an alternative method of qualifying as a professional engineer, and it is likely that this need will continue for at least some years. Indeed, the Committee thinks that this "second door" to the profession should not be closed. What is considered necessary is the establishment of diploma courses, which will be mainly part-time courses, but will include at least one year of full-time study. Without this full-time year the course is likely to be unduly long. One of the objections to the present means of reaching professional qualifications is the great length of time over which the student is compelled to spread his programme of studies.

207. In using the term "diploma" for the course which it recommends, the Committee is departing from British practice, where this term is applied only to full-time courses. It is desirable, however, to use this term in preference to the term "certificate" so as to avoid confusion with the recently established New Zealand Trade Certificates.

208. The "diploma courses," then, will be provided in certain technical schools, but it is not intended that each school approved for this purpose should set its own standard of examination. In order to obtain uniformity of standard and ensure ready recognition of the diploma by the Engineers Registration Board and the various professional bodies, the Committee considers that examination-papers in all subjects should be set, moderated, and marked by examiners appointed by the Education Department.

209. The nature of the proposed diploma courses, the subjects suggested, and the content of those subjects are set out fully in Part III. They have been arranged so far as possible to allow for gradual development of a properly grouped course spread over five years. In translating these prescriptions into vivid purposeful teaching it will

be necessary for teachers to have constantly before them the needs of the engineering profession. In particular the Committee would emphasize that engineering students should commence learning as early as possible to analyse the problems that they encounter and to develop ordered processes of thought in their solution. These matters will depend upon the selection of suitable teachers for this work. The Committee hopes that the diploma courses will be established in a spirit of enterprise and that classes organized in the selected technical schools will have an atmosphere of purposeful endeavour. Anything suggestive of a disconnected "cramming" in individual subjects would be fatal.

RECOMMENDATIONS—

That the Education Department institute a system of Diplomas in Professional Engineering of a standard at least equal to that of the present Institution Membership Examinations.

That these diplomas be awarded in respect of courses which, though mainly part time, shall include at least one year of full-time study.

That these diplomas be awarded as a result not only of examination success, but also of satisfactory completion of a course of study approved by the Education Department.

That a candidate must pass at the one time in all subjects of any year before proceeding to the next year of the course.

That examination-papers in all subjects be set, moderated, and marked by examiners approved by the Education Department.

(3) CONDITIONS OF ENTRY TO DIPLOMA COURSES

210. The Committee considers that the minimum educational qualification necessary to establish the diploma course on a sound basis is the University Entrance Examination. This initial requirement is admittedly somewhat higher than the preliminary qualification at present demanded of applicants for Institution membership (Section 6), but the Committee has recommended in Section 11 a raising of this preliminary qualification also. There is, in the Committee's opinion, no valid reason why the pre-requisite for the engineering profession should be any lower than that for other professional occupations such as accountancy, architecture, dentistry, law, medicine, and post-primary teaching. Moreover, the Committee is recommending the establishment of engineering scholarships to assist students of exceptional ability who may be following a diploma course to transfer to a degree course, if they wish to do so (Section 13 (III) of this report). It must be remembered, too, that from 1950 onwards the University Entrance Examination will have a wider range of subjects than at present.

211. The diploma courses which the Committee is recommending will be so closely linked up with the requirements of the appropriate branch of professional engineering that entry upon a course should be allowed only to students actually engaged in suitable engineering work. These classes will be established for diploma purposes only; to admit others would involve waste of effect on the part of the instructors and impair the effectiveness of the instruction.

212. In making its recommendation that the pre-requisite of a diploma course be University Entrance the Committee found it necessary to take into account the cases of older men who might not possess this qualification, but who might be anxious to embark upon a diploma course without further delay. The Committee considered admission on a provisional basis to be reasonable in such cases. The University of New Zealand grants candidates not under twenty-one years of age provisional admission to

certain degree courses, and confirms this admission when the candidate passes in three subjects of his degree. Engineering is not one of these so that applicants admitted to a diploma course provisionally would not be able to transfer subsequently to a degree course. They would, however, save at least one year and probably more in commencing their diploma course, and their admission could be confirmed if subsequent progress warranted it.

RECOMMENDATIONS—

That the pre-requisite of a diploma course be University Entrance either by accrediting or examination.

That entry upon a diploma course be permitted only to a student employed as a cadet, articled pupil, or apprentice under conditions approved by the Engineers Registration Board for this purpose.

That, in order that no hardship be inflicted upon men who develop later, men twenty-five years of age or over be admitted to the first year of a diploma course on a provisional basis, this provisional admission to be confirmed if the Principal of the Institution attended makes a favourable recommendation to that effect.

(4) PROVISIONS COVERING TRANSITION PERIOD

213. When the system of diploma courses is commenced it will be necessary to make provision for those students who have already made some progress towards the Institution Membership Examinations. The Committee considers that such students should, if they so desire, be permitted to transfer to diploma courses. As will be seen from the suggested prescriptions set out in Part IV, the subjects and subject content of the first three years of the diploma course are similar to those of the corresponding subjects of Section A of the Institution Membership Examinations, so that there should be little difficulty in arranging for a transfer to the Diploma course at this stage.

RECOMMENDATION—

That during the transition period students who have already passed Section A of the Institution Membership Examinations and who make application to the Director of Education be credited with the first three years of the corresponding diploma course.

(5) TRANSFER TO AND FROM DEGREE COURSES

214. One reason for the establishment of diploma courses is that they are considered more suitable than degree courses for certain types of students. They also provide an avenue to the engineering profession for those students who, for one reason or another, find it impossible to attend a University School of Engineering. It will generally happen that a decision as to whether a particular student will enter upon a degree course or a diploma course will be made at the time of leaving post-primary school. This is a very important decision; but it would be folly to imagine that it will always be wisely made. There will probably be cases where lack of information, poor judgment as to the student's real ability, or an unwise first selection of employment may mean that a student selects the type of course which is not suitable for him. It is in the interests both of the youth himself and of the community that such errors should be corrected.

215. For these reasons the Committee considers that, though the diploma and degree courses are differently organized and employ different methods, they should not be separated so rigidly that transfer from one to another should be impossible. No great measure of transfer is likely to take place in practice; but the Committee considers that provision should be made for outstanding students enrolled in diploma courses to change to a degree course and to receive at least some credit for the work

already accomplished. It is therefore of opinion that the University of New Zealand should consider granting credits up to a maximum of all subjects of the Engineering Intermediate Examination to men of exceptional ability who have completed with distinction the third year of the diploma course. Reference to the prescriptions suggested for this course, and set out in Part IV, will show the scope of the work covered. So strongly does the Committee believe in the desirability of this provision that it recommends in Section 13 the award of a strictly limited number of scholarships for exceptional students. The University Senate may wish to limit the granting of credits to those who are selected as scholars. At stages later than the third diploma year transfer would be increasingly difficult and is not recommended.

216. It would be less difficult to arrange for transfers in the reverse direction. There are always likely to be some students who find the degree course too difficult, or who cannot devote their whole time to study. A man could unhesitatingly be credited towards the diploma in any subject which he has passed at the degree stage.

RECOMMENDATION—

That provision be made for cross-credits to students who transfer from the degree course in engineering to the corresponding diploma course, or vice versa.

(6) PRACTICABILITY OF THE SCHEME

217. The Committee considers that, in future, no great difficulty would be experienced in providing the necessary instruction in all subjects of the first three years of the diploma courses in civil, electrical, and mechanical engineering in the technical schools in the four main centres. This is already being done for the subjects of Section A which correspond closely with the proposed diploma subjects of the first three years, although in one or two of these schools further equipment is required.

218. The Committee is of the opinion that, outside of the main centres, the necessary instruction in the subjects of the first two years should be given through the Technical Correspondence School, but that arrangements should be made for practical work in those subjects requiring it. A short concentrated period at the end, say, of each term would enable this to be done. The method is admittedly not ideal, but seems the best way possible. The Committee considers that in practical subjects correspondence instruction leaves much to be desired.

219. The provision of bursaries at the end of the second year, which is recommended elsewhere, would enable students to attend full time at a technical school in one of the four main centres for the third year's instruction and thus fulfil the condition laid down earlier in this section that at least one year of the diploma course should be full time.

220. The subjects of the fourth and fifth years of all courses are more closely related to the practical requirements of the engineering profession than are the subjects of the first three years, which are to be regarded as preparatory only. The necessary instruction in the fourth- and fifth-year subjects requires in most cases more equipment than at the earlier stage. Moreover, the numbers of students will be smaller owing to wastage earlier in the course and owing to the transfer of some of the most promising students to degree courses.

221. The technical schools are not finding it easy at present to secure engineering instructors, but this is one aspect only of the present shortage of professional engineers, and the difficulty should in due course be overcome if the Committee's proposals for increasing the supply are put into successful operation.

222. Discussion of the practicability of the scheme for diploma courses inevitably brings up the question of time off for study. All witnesses who were questioned on the

point were emphatic that some time would have to be made available during the day. The Committee's proposals may be studied in more detail in Part IV, but briefly they involve—

(*a*) An average of about eight hours per week day lectures (some of which may be on a Saturday) during the school session, for each of the four part-time years :

(*b*) The release for one school session of those students who have successfully completed the first two part-time years of the course so that they can take the third full-time year :

(*c*) The release of a few of the most able of those mentioned in (*b*) for a further school session to give them an opportunity of taking in one full-time year the fourth and fifth years which will normally be taken part time. Such students would have two years' part time as in (*a*) instead of four :

(*d*) In some cases the transfer of students to main centres where there are facilities for them to complete the fourth and fifth years part time.

223. All this undoubtedly calls for sacrifices and co-operation from employers and employees alike. It may be assumed that employees will see the personal advantages to be gained by entering on diploma courses and will make their plans accordingly. The advantages to employers and to the country as a whole are not so direct, but they are just as real. The Committee sees no need to labour this point. The success of the diploma courses in England shows conclusively that employers are prepared to co-operate in any reasonable way in the training of their engineering cadets. The gratifying experience of the Auckland Technical School in 1948, referred to in para. 116, indicates that what is true in England in this respect is true also in New Zealand.

224. The following summary, which should be read in conjunction with Part IV, sets out in tabular form the principal means of instruction for diploma students.

Means of Instruction for Diplomas

——	Main Centres.	Comments.
First two years (part time)	At technical schools in the four main centres and any other centre which may be approved for this purpose	Otherwise through Technical Correspondence School, with provision for practical work.
Third year (full time) ..	At technical schools in the four main centres	Bursaries to enable attendance at technical schools in the four main centres.
Fourth and fifth years (part time)	At technical schools in the four main centres	Cadets should arrange for a transfer to one of the four main centres.

RECOMMENDATIONS—

That the necessary facilities be provided in the technical schools at Auckland, Wellington, Hutt Valley, Christchurch, and Dunedin for instruction in the various subjects of the diploma courses, if these facilities are not at present available, as an initial step in the establishment of technological institutions.

That for candidates outside approved centres instruction be provided through the Technical Correspondence School for all subjects of the first two years of the diploma course, and that arrangements be made for laboratory work in those subjects requiring it.

That bursaries be provided to enable selected students who have completed the first two years of the diploma course to proceed to the third year.

(7) RELATION WITH THE PROFESSION

225. It must be emphasized that the diploma courses will derive much of their importance from the fact that students will be drawn from those who are already engaged in some branch of engineering, whether in a Government Department, a local government authority, or in a private firm. Such students will require a somewhat different method of teaching from that suitable for University students. For one thing, they will be critical of theory that does not have relation to engineering practice as they know it. It is of the utmost importance for this, if for no other reason, that the courses should be constantly geared to the requirements of engineering occupations. There are other sound educational reasons for having such technical courses of study continuously under review. Engineering is a rapidly developing profession, and teachers who become immersed in the problems of teaching can easily lose touch with reality. Though this would be bad at the University level, it is much worse when the classes are composed of those who have some personal experience of the practice of engineering. Further, the courses that the Committee recommends can be undertaken satisfactorily only if employers are prepared to release selected employees for some hours each week. They cannot be expected to do so with any enthusiasm unless they have confidence in the courses laid down and the teachers to whom their employees will be sent.

226. The technical schools offering diploma courses should have the assistance of advisory committees on which there should be strong representation of leading engineers in touch with many fields of engineering. The Seddon Memorial Technical College and the Wellington Technical College, to give two examples, have active committees. An extension and strengthening of this practice is strongly recommended; indeed, your Committee would go so far as to recommend that the setting-up of such advisory committees be a condition of the approval of diploma courses by the Education Department.

227. Advisory committees should be free to make representations to the governing body of each approved school on any matters relating to diploma courses, and their advice should be sought on all matters pertaining to the correlation of theoretical instruction with the practical training of the young engineers attending the school.

RECOMMENDATION—

That it be a condition of the recognition of a technical school for purposes of diploma courses that it set up one or more functional advisory committees for the branches of engineering covered by its courses.

228. In Section 10, while discussing degree courses, the Committee stressed the necessity of providing some means whereby both the degree and diploma courses should be kept under review, and for this purpose advocated the setting-up of a Council of Engineering Education. The constitution and functions of this Council are set out in Section 14. Here it is only necessary to add that the Council should be brought into being as soon as possible, preferably not later than the date at which the diploma courses are commenced.

(8) RECOGNITION OF DIPLOMAS

229. The Committee is definitely of the opinion that the successful establishment of the diploma system is contingent upon the recognition of diplomas by the Engineers Registration Board. Before giving this recognition the Board would naturally wish to be completely satisfied with the courses, the subject prescriptions, the conditions, and the examination standards. The Committee recommends, therefore, that there should be the closest association between the Education Department and the Engineers Registration Board in all matters relating to diplomas in professional engineering, that the necessary regulations should be approved by the Engineers Registration Board before being gazetted, but that the diplomas be issued under the authority of the Education Department.

230. The Committee feels certain that the successful establishment in New Zealand of a system of diplomas in professional engineering on the basis recommended would quickly lead to their recognition and acceptance by overseas Institutions.

RECOMMENDATIONS—

That the Education Department and the Engineers Registration Board co-operate in drawing up prescriptions and conditions for qualifying examinations for diplomas in professional engineering, as circumstances warrant, and in conducting or arranging for these examinations.

That diplomas in professional engineering be issued under the authority of the Education Department.

That any necessary regulations be prepared and administered by the Education Department after approval by the Engineers Registration Board.

13. BURSARIES, SCHOLARSHIPS, LOANS, AND OTHER FORMS OF FINANCIAL ASSISTANCE

(1) GENERAL POLICY

231. Perhaps the greatest single problem which the Committee has had to consider is how to obtain a sufficient intake to provide for the 120 professional engineers who will be required annually for some time to come. The statistics in so far as they are available have been considered in Section 8. In this section it is proposed to set out the steps which the Committee considers should be taken to make certain that no suitable entrants to the profession are lost to it purely through lack of financial resources to complete the necessary course.

232. It is interesting to note that one of the causes of the increases in the rolls at the University Schools of Engineering has been the number of returned servicemen who, by taking advantage of the generous bursaries of the Rehabilitation Department, are qualifying for a profession that would in the ordinary course be denied to them. It would seem, therefore, that a similar policy for civilians might well have the effect of increasing the number of engineering students. In fact, some such action is made necessary for the engineering profession by the action taken to increase the numbers in other professions.

233. As indicated in Section 8, the anticipated requirement of trained professional engineers is, say, 75 graduates and 45 non-graduates annually. The provision of bursaries under more generous conditions than at present exist is considered necessary for both types of students, for somewhat different reasons, in so far as the effect on the supply of engineers is concerned. The provision of bursaries to diploma students, in order that they may take at least one full-time year, is necessary if the scheme is to be successful. It will have the effect of producing trained engineers more quickly by reducing the period hitherto taken to qualify. The provision of bursaries to degree students will increase the supply by ensuring that no one is debarred purely on financial grounds.

(2) ASSISTANCE AT PRESENT AVAILABLE

234. It may be as well at this stage to indicate briefly in general terms the assistance at present available from public funds to any one who wishes to become a professional engineer. It should be mentioned that most bursary schemes contain detailed provisions designed to cover special cases. The list below does not attempt to cover all these points.

Table J—Bursaries and Scholarships Available to Engineering Students from Public Funds at University Colleges

Name.	Tenure.	Value.	Qualifications Required.
1. (*a*) Ordinary National Bursary	4 years	Fees up to £20 per annum	University Entrance or Endorsed School Certificate or Higher Leaving Certificate (now obsolete).
1. (*b*) Ordinary National Bursary	4 years	Fees up to £20 per annum, plus £20 per annum (must be a full-time student)	Higher School Certificate.
2. National Boarding Bursary	4 years	Fees up to £20 per annum, plus £50 per annum boarding-allowance	Competitive. Sixty-five annually on results of University Entrance Scholarship Examination.
3. Special Bursaries in Engineering NOTE.—These are the only bursaries available exclusively to engineering students.	5 years	Fees up to £20 per annum, bursary allowance of £10 per annum, £40 per annum boarding-allowance where justified	Competitive. Fifteen annually. Minimum qualification, University Entrance and course with engineering bias.
4. University Junior Scholarships	4 years	Full fees, scholarship allowance of £80 per annum, plus boarding-allowance of £45 per annum where justified	Competitive. Ten annually to highest candidates in University Entrance Scholarship Examination.
5. University National Scholarships	Same as above		Competitive. Twenty annually to next twenty students on U.E.S. list.

235. The above list excludes special bursaries such as war bursaries and others of limited application. It should be noted that of those that are competitive the special bursaries in engineering are the only ones specifically for engineering students. It may be mentioned, too, that in no case is there any restriction placed on the future movements of a boy when he has completed his course. These scholarships and bursaries differ in this essential respect from a number of so-called bursaries awarded by different authorities under varying conditions and having different values but requiring in each case an undertaking to work for the authority concerned at the conclusion of the period of study.

236. It is perhaps inevitable when labour is scarce that inducements to recruitment will be offered to an extent and in ways not at all likely to occur in normal times. The general effects of this development lie well beyond the Committee's order of reference, but there is one point on which it wishes to express its views.

237. The present tendency of Government Departments, in particular, to appoint young men to their staff and then send them to the University is one that commends itself to the Committee, and reference will be made to it later. Nor is there any objection to the practice of requiring these cadets to enter into a bond to serve their employer at the end of their training. It was perhaps inevitable that, for want of a better word, the term " bursary " would be used in this connection. There is, however, the danger of hiding a distinction that ought to be maintained. It may be very hard to draw the line in particular cases, especially in this country where many bursaries are awarded to part-time students, but the principle is still clear that a bursary ought to be regarded as an opportunity of completing one's education rather than as a training for a specific

organization. As such it ought to be awarded without any of the restrictions of the kind referred to in this paragraph. While, therefore, the Committee favours the scheme of granting assistance to engineering cadets, it is strongly of the opinion that the way must be left completely open for others who wish to be quite free to go where they choose when they qualify.

The terms "scholarship" and "loan" which also appear in this section are sufficiently clear not to require any clarification.

(3) PLANS FOR IMPROVEMENT

238. It is hoped that the above discussion will help to remove some of the confusion that undoubtedly exists and so make the specific recommendations of the Committee easier to follow. These recommendations are summarized immediately below and are then dealt with in more detail in turn—

(i) An increase in the number and the value of the Education Department's Special Bursaries in Engineering.
(ii) The extension of the system of University college training of engineering cadets.
(iii) and (iv) The establishment of bursaries and scholarships for students studying for diplomas in professional engineering or associate membership examinations.
(v) An increase in the number of post-graduate scholarships in engineering.
(vi) Provision for loans for engineering students.

(i) Education Department's Special Bursaries in Engineering

239. At the present time the Education Department awards a number of bursaries in special fields, including engineering. As will be seen by reference to No. 3 of Table J, the value of these special bursaries is comparatively low. They were established from time to time to encourage students to enter fields of occupation in which there tended to be insufficient entrants. Initially the standard required was not high. The quality of applicants for engineering bursaries in the past few years has been so high, however, that the limit of fifteen annually could have been considerably increased without any noticeable lowering of standard.

240. It has been pointed out that the special bursaries in engineering are the only bursaries open solely to engineering students entering upon a University course. They were introduced to increase the number of degree students at a time when the number of graduates required was very much lower than it is to-day. It is reasonable to ask that this key bursary should now be made sufficiently attractive to compete with incentives offering in other professions and that more bursaries be made available. Nor is it unreasonable to argue that all students who succeed in obtaining a B.E. degree prove themselves worthy of assistance. On the assumption that 75 will graduate each year, there are at least 75 worthy of assistance among those who embark on an engineering course. Even allowing for the fact that some students may obtain assistance from other sources, there should be provision for at least 40 engineering bursaries annually. It is possible that the present conditions are not sufficiently attractive to ensure such a large number of first-class applicants. The Committee has no wish to encourage participation in an undignified scramble, but it considers that the engineering bursary should be made at least as attractive as those for other professions.

Recommendation—

That the number of engineering bursaries be increased from 15 annually to a minimum of 40, with provision for a further number if sufficient good applicants are forthcoming, and that the total value of the bursary be not less than £110 per annum including boarding-allowance where payable.

241. In Section 9 the Committee recommends that intending entrants for the engineering degree course should spend at least one year in the Sixth Form of a post-primary school subsequent to qualifying for University Entrance. This the Committee regards as most necessary if the student is to be sufficiently well grounded in the fundamental subjects of mathematics and the physical sciences and is to reach a reasonable standard in English and other cultural subjects before proceeding to the University.

RECOMMENDATION—

That, other things being equal, special bursaries in engineering should be awarded for preference to candidates who have been accredited for or have passed the University Entrance Examination and have spent an additional year in the Sixth Form of a post-primary school.

(ii) THE EXTENSION OF THE SYSTEM OF UNIVERSITY COLLEGE TRAINING OF ENGINEERING CADETS

242. Some Government Departments find it worth while to send to the Schools of Engineering cadets already on their staff. The conditions under which this is done vary, but in at least one Government Department employing a large number of professional engineers the full benefit of a University course is lost by the policy of restricting the period to two years. This appears to be a short-sighted policy and the Committee accordingly recommends :—

RECOMMENDATION—

That cadets considered worthy of training at the University should be given every encouragement to complete the B.E. degree.

243. The policy referred to above also appears to have unfortunate results in another direction. Post-primary-school pupils who wish to become professional engineers are not appointed as engineering cadets and so have no guarantee that they will be able to enter the profession. Many able boys turn towards other professional occupations offering direct approach to those professions and greater initial inducements. On the other hand, the Committee notes with interest the growing tendency of some Government Departments to appoint a young man to the staff and send him to the University as a full-time student on the understanding that he will work for his Department during the long vacations. This is of particular relevance to the engineering profession because it embodies some of the requirements of the sandwich schemes which have many desirable features. It is considered that this scheme should be extended and that local bodies and private firms should be encouraged to make similar arrangements for their staff.

RECOMMENDATION—

That, as a means of inducing able young men to enter the engineering profession, Government Departments and other organizations be encouraged to offer cadetships under conditions requiring the cadet to attend courses for the B.E. degree as one of the terms of appointment.

(iii) BURSARIES FOR DIPLOMA STUDENTS

244. The Committee has already recommended that full-time attendance for at least one year should be required of all students following courses for Diplomas in Engineering, or during the interim period, for the Institution Membership examinations (Sections 11 and 12). The proposals for the diploma course require that the third year be full time. Students taking these courses will include some who could not afford to take a degree course even with the assistance of a bursary. For the reason above it is unlikely that

the new proposals will prove acceptable to trainees unless some provision is made for a bursary during the full-time year. As the Committee is firmly convinced that the full-time year is essential, it follows that a bursary for diploma students in their third year is an integral part of the Committee's plans for the improvement of engineering education. The Committee considers that the awards must be on such a scale and of such a value that all candidates who have satisfactorily completed the first two years of the course will be able to undertake the third year. This implies that provision should be made for additional payments to married men. It is hoped that employers will readily grant leave facilities during the tenure of the bursary. It has no doubt, too, that some employers will see fit to supplement the bursary allowance.

245. It will be remembered that in Section 9 the Committee set out the arguments for and against University training for all professional engineers and indicated that it would be necessary for some years to train a proportion of engineers by means of courses leading to diplomas in professional engineering. The previous paragraph follows logically from the recommendation in para. 124. Under present conditions the need to train more engineers quickly (so long as this is done without reducing the standard) and the desirability of providing more adequate courses for students who are studying Institution examinations under difficulties justify a considerable expenditure on diploma bursaries. Once this stage has passed, however, there ought to be a continually increasing trend towards the University. Assistance to those taking a diploma course should then be restricted by limiting the number of awards. The Committee had in mind a progressive reduction in the number of awards, but it feels that no good purpose would be served by such preciseness in the formal recommendation, as the position will be watched by the Council of Engineering Education.

RECOMMENDATIONS—

That, in order to assist in increasing the efficiency of engineering education for non-degree students, bursaries be established available to all deserving students who are entering on the full-time year of the course for the Diploma in Professional Engineering; that the term of the bursary be one year, with the possibility of an extension for a further year in exceptional and strictly limited cases; and that the value of the bursary be £100 per annum, inclusive of any fees that may be payable, plus £40 per annum boarding-allowance, where justified, plus £100 per annum for married men, payment to be subject to receipt of satisfactory reports each term from the Principal of the school attended.

That the number of diploma bursaries be unlimited until the awards at the end of 1954 to give approved students already taking non-University courses every encouragement to complete their qualifications and that thereafter no more than 30 bursaries be awarded annually.

That during the interim period students who have completed Section A of the Institution Membership examinations be considered eligible for the above bursaries under the same conditions.

(iv) ENGINEERING SCHOLARSHIPS

246. With the existing facilities for education in this country it is seldom that the lad of exceptional ability is not discovered and given the opportunity of continuing his studies to the highest level in the normal manner. Every now and then, however, cases occur of students whose capabilities remain unnoticed until a relatively late age. This happens in engineering, where, for example, a boy's passion for mere dabbling with mechanical things may well hide for the time being a mind capable of revelling in the higher intricacies of engineering mathematics. There can be no doubt that every encouragement to transfer to the University should be given to any such person who happens to be following a diploma course. The Committee proposes, therefore, that

scholarships should be established to meet the needs of this very small but extremely important group. It is not intended that more than one or two such scholarships should be awarded in any one year, and it may well happen that some years may elapse without any awards being made. The machinery to enable such a student to transfer to a degree course has already been discussed in paras. 214–216. He would normally enter the University at the first professional year of the B.E. degree so that the term of the scholarship ought to be for three years to enable him to complete the three professional years, with the possibility of extension to a fourth year so that he could take an honours degree if he developed as might be expected.

RECOMMENDATIONS—

That engineering scholarships be established to enable students of exceptional ability who have completed the third year of the diploma course in professional engineering to transfer to the B.E. degree course.

That the tenure of such scholarships be three years, with the possibility of extension to a fourth year, and that they be awarded with the same value and under the same conditions as the University Entrance Scholarship, but that an additional £100 per annum be paid to a married man.

(v) POST-GRADUATE SCHOLARSHIPS IN ENGINEERING AND TRAVELLING SCHOLARSHIPS

247. The Committee considered that every encouragement should be given to those capable of undertaking advanced study or research into problems which can be investigated in this country. It felt that scholarships should be established open to engineering graduates of any recognized University, and tenable at one of the University schools of engineering in this country. In the award of these scholarships preference should be given to candidates who have had some professional experience. To meet the needs of New Zealand students who might wish to prosecute their studies overseas it is proposed that an additional University Travelling Scholarship in Engineering be awarded.

RECOMMENDATIONS—

That two post-graduate scholarships in engineering be awarded annually tenable only in New Zealand, but open to graduates of any recognized University; that these scholarships have a value of £300 per annum and be tenable for one year, with the possibility of extension to a second year.

That the number of University Travelling Scholarships in Engineering be increased to two annually.

(vi) LOANS FOR ENGINEERING STUDENTS TAKING THE DEGREE COURSE

248. In view of the recommendations made by the Committee for an improvement in the bursary system, loans may appear unnecessary. The bursary is not intended, however, to cover all expenses, but merely to assist, and some students may require further financial assistance. Moreover, not all engineering students will secure bursaries. Some further provision appears, therefore, to be very desirable not only for engineering students, but for others who require this assistance. A limit of £100 per annum for three years might be placed upon the amount granted by way of loan. It is suggested that it should be provided, interest free, by the Government under suitable guarantee for repayment.

249. It was pointed out to the Committee that the Government salary rate for the sixth year of service is £325, for the tenth year of service is £425 and for a B.E. is £425. A student, therefore, who employs the first five years in securing his B.E.

degree (the first two years for the intermediate part time) obtains on appointment a salary £100 higher than if he had not secured this qualification and can readily repay the loan from his salary in the next few years.

RECOMMENDATION—

That a system of loans be established to assist deserving students who may be unsuccessful in securing bursaries or scholarships or who may require financial assistance over and above the value of the bursary or scholarship to enable them to pursue an engineering degree course.

(4) GENERAL EFFECT OF RECOMMENDATIONS FOR FINANCIAL ASSISTANCE

250. The system of bursaries and other financial assistance is based on the general proposition that, for the more academic student who proves his merit at the post-primary school, considerable assistance is available by one means or another from that stage onwards to enable him to take a University course. It is hoped that the assistance at present granted will be increased, but the point made here is that something already exists. The more practical student will prove his ability and his determination in the first two years of the diploma course, during which he will be engaged in industry and part-time study. Financial assistance for this class is thus deferred, but when it comes it is substantial and, for a student of exceptional ability, the prizes are high.

251. The Committee considers that money spent on diploma bursaries will be well worth while. It would be loath, however, to see a situation arise in which students who might otherwise take a degree course with success, decide to take the diploma course because the financial assistance appears more attractive and the time, effort, and money involved are less. Such a decision would be extremely short-sighted, and it is hoped that the majority of students and their parents will realize the over-all desirability of taking the degree course. If it is found by experience in the next few years that the attractions of the various forms of financial assistance do not in fact produce the desired balance, particularly if it happens that there is any trend away from the degree course, then steps could be taken by the Council of Engineering Education to effect an adjustment.

14. COUNCIL OF ENGINEERING EDUCATION

252. The need for keeping the University schools of engineering and the technical schools in constant touch with the engineering profession has already been mentioned in Sections 10 and 12. The University schools of engineering and the main technical schools have advisory committees which include amongst their members practising engineers of experience. The Committee was impressed with the interest shown by some of these men, and considers that co-operation of this kind should be encouraged.

253. At the national level, however, there is at present no organized body able to give special attention to the courses of study, examination requirements, and educational qualifications of the profession. The Senate and the Academic Board of the University of New Zealand deal with the degree courses in engineering and the University statutes relating thereto. Neither of these bodies, however, provides the kind of opportunity that the Committee considers desirable for close observation of trends in engineering and for inquiry into ways of keeping abreast of new developments. Moreover, it is highly desirable that the proposed diploma courses in professional engineering should be related to degree courses and that both should be constantly under review. The need for close co-operation between the various authorities concerned in the training of professional engineers and the engineering profession has been mentioned frequently throughout this report.

254. The Committee has shown that there are several branches of engineering for which little training is at present available, and it is probable that other needs will arise from time to time. The engineering profession plays a most important part in our

national economy and its healthy development is a matter of national concern. It is no reflection on the profession, the University, or the Education Department to say that there has been in the past some lack of co-ordination of effort. It appears to the Committee that the time has arrived for a better understanding of their common purpose. The Committee therefore makes the following recommendations:—

RECOMMENDATIONS—

(1) *That there be established a Council of Engineering Education.*

(2) *That the Council be constituted as follows:—*

(a) *Two members appointed by the Minister of Education.*
(b) *The Vice-Chancellor of the University of New Zealand.*
(c) *Two members appointed by the Senate of the University of New Zealand.*
(d) *One member appointed by the New Zealand Secondary Schools' Association.*
(e) *One member appointed by the New Zealand Technical School Teachers' Association.*
(f) *Three members appointed by the New Zealand Institution of Engineers.*
(g) *One member appointed by the Engineers Registration Board.*

(3) *That the term of office of appointed members be three years, but that they be eligible for reappointment.*

(4) *That the Council have power to appoint one additional member.*

(5) *That the functions of the Council be—*

(a) *Generally to make recommendations to the Minister of Education on matters relating to the education of professional engineers.*
(b) *To make, after consultation with the faculties of the University Engineering Schools, recommendations to the Senate through the Academic Board on any matter relating to engineering education, and in particular with respect to courses of study, examinations, and the educational and practical qualifications of professional engineers; and, further, to make recommendations to the Education Department on any matters relating to diplomas in professional engineering, and in particular concerning the courses of study and examinations for these diplomas.*

(6) *That the Senate should not make or alter any statute relating to the courses of study, examinations, and degrees in professional engineering until it has first received and considered any recommendations made by the Council of Engineering Education; and, further, that the Education Department should not make or alter any regulation relating to courses of study and examinations for diplomas in professional engineering until it has first received and considered any recommendations made by the Council.*

255. No attempt has been made in these recommendations to draw up a complete set of rules for the Council. In broad outline, the Committee considers that the Council should be a body composed of men of the highest possible attainment and wide experience. It is hoped that in selecting its members those responsible will see that there is a fair representation of the teaching institutions concerned with the training of professional engineers. Partly for this reason, and to ensure that no important field of experience is neglected, the proposed Council is given power to appoint one additional member. The selection of a chairman will be of the greatest importance. On the whole, the Committee feels that the Council should have power to elect its own chairman, though it realizes that not all members would be prepared to undertake this responsibility. What is important is that the person selected should be of such distinction as to enjoy the complete confidence of the University, the technical schools, and the profession.

256. If these recommendations are accepted, some alteration in the University of New Zealand Act may be required, particularly as the Committee is of opinion that reference to the Council should in some matters be mandatory. The Council as recommended is not simply a passive body; it will have the right to suggest changes and to tender advice. The Committee hopes, too, that such a Council will be concerned with broad principles rather than minute detail.

15. RECOGNITION OF STATUS OF ENGINEERS' ASSISTANTS

257. It was clear from the evidence submitted to the Committee that there is a demand for some recognition of status for engineers' assistants. Evidence to this effect was given by the Engineers' and Assistants' Association, Inc. The Committee regards the establishment and continued activities of this and similar associations as desirable and recognizes the importance of their members to industry and to the engineering profession. The qualifications of the membership, however, are varied, and will in many cases depend more on length of experience than on examination certificates. This Committee does not regard the establishment of any form of certificate for this group as coming within its functions, but it desires to commend the matter to the Hon. the Minister for his sympathetic consideration.

16. SPECIFIC FINDINGS OF THE CONSULTATIVE COMMITTEE

258. Your Committee's answers to the questions which you placed before it are set out below :—

Question (i) : What are the most satisfactory courses to be undertaken at the post-primary stage by prospective entrants to the engineering profession ?

259. The Committee's answers to this question are set out fully in Section 9. They cover the entire post-primary course. The following conclusions were reached :—

(*a*) That for intending engineering students there should be no specialization before the end of the School Certificate year (page 31).

(*b*) That for these entrants instruction at the post-primary stage in technical engineering subjects is not essential (page 31).

(*c*) That even at the post-certificate stage concentration on mathematics and the physical sciences should not exclude English and other cultural subjects (page 31).

(*d*) That intending entrants for the engineering degree course should spend at least one year in the Sixth Form subsequent to qualifying for University Entrance (page 31).

260. A sound grounding in mathematics and the physical sciences is, of course, essential for intending engineering students, whether for degree or diploma. For Institution Membership examinations the present minimum pre-requisite is the School Certificate examination passed in the subjects of the Common Preliminary, but the Committee is recommending that the pre-requisite be now University Entrance.

Question (ii) : Is the present standard of entrants to degree and diploma courses in engineering satisfactory ?

261. An investigation by the Scientific Man-power Committee* showed that between 1936 and 1946 inclusive there was a greater proportion of winners of University Entrance Scholarships among students following an engineering degree course than in any other faculty, while the Education Department states that the highest quality of students applying for its special bursaries occurs among those seeking entrance to the University Schools of Engineering. The Committee is of the opinion, therefore, that engineering gets at least its fair share of the best pupils leaving the post-primary schools.

* Scientific Man-power Resources of New Zealand, Government Printer, 1948, at page 19.

262. There is, unfortunately, no common standard whereby the quality or ability of students entering University for the first time may be judged. The Committee therefore endeavoured to approach the general problem by a comparison of the wastage of students from engineering courses with the wastage from all courses. The following table makes this comparison :—

Table K—Examination Wastage for B.E. Candidates Compared With Wastage in All Degree and Diploma Courses

—	1945.		1946.		1947.	
	All Courses.	B.E.	All Courses.	B.E.	All Courses.	B.E.
Total number of candidates ..	6,937	336	9,705	537	10,060	604
Total number successful ..	5,580	275	7,592	455	8,001	525
Total number unsuccessful ..	1,357	61	2,113	82	2,059	79
Percentage unsuccessful ..	19	18	22	15	20	13

263. These figures indicate that the engineering students are more successful than the average University student. Question (ii) can be answered in part, then, by stating that the standard of entrants to degree courses in engineering is considered satisfactory.

264. You have asked also in this question whether the present standard of entrants to diploma courses in engineering is satisfactory. The Committee has interpreted this as referring to any non-degree courses. There is at present nothing similar to the diploma courses recommended in Section 12. The principal courses existing are those leading to membership of one or other of the British Institutions of Engineers. The minimum standard of entry to these examinations is lower than the University Entrance Examination, which is the lowest standard acceptable to the Committee. The complementary answer to Question (ii), then, is that the present standard of entrants to diploma courses in engineering is not satisfactory.

Question (iii) : To what extent, if any, should instruction in professional engineering subjects be provided in the technical schools ?

265. The answer to this question will be found in Sections 9, 11, and 12. While there is a weight of evidence that ultimately all civil and electrical engineers, at least, should be graduates, the Committee realizes that for some years it will still be necessary to train a proportion of professional engineers by means of courses leading towards diplomas in professional engineering. It will therefore be necessary to provide facilities for instruction in the subjects of these examinations in certain of the technical schools.

266. The Committee is of the opinion that complete facilities should be provided at the technical schools at Auckland, Wellington, Hutt Valley, Christchurch, and Dunedin if they are not at present available, and for the first two years of the diploma course at any other centre which may be approved for the purpose.

Question (iv) : Are the present facilities (staffing, accommodation, and equipment) at the University colleges or at the technical schools sufficient for the numbers of students offering ?

and,—

Question (v) : If the answer to (iv) is in the negative, what improvements are required ?

267. The answers to these questions are set out in Sections 10 and 12. Briefly, they are that the present facilities, especially at the University schools of engineering, have been far from adequate to deal effectively with the big influx of students that has occurred during the last few years. Moreover, these facilities are insufficient to handle the numbers which it will be necessary to train in the future to meet this country's requirements. Although the problems of the technical schools have not been so pressing, the establishment of diploma courses will make new demands on them. The main respects in which improvements are required are indicated in the following recommendations :—

(*a*) That the question of building a new engineering school at Canterbury be considered to be one of the greatest urgency, that steps should be taken to secure a suitable site, and that the building be given a high priority (page 43).

(*b*) That the equipment of the Auckland University College School of Engineering be improved and that further equipment be provided to permit the extension of the courses in civil and electrical engineering to the final year of the B.E. course (page 44).

(*c*) That the staffing at both University schools of engineering be sufficiently liberal to permit of a reasonable amount of research being undertaken (page 48).

(*d*) That the necessary facilities be provided in the technical schools at Auckland, Wellington, Hutt Valley, Christchurch, and Dunedin for instruction in the various subjects of the diploma course, if these facilities are not at present available, as an initial step in the establishment of technological institutions (page 56).

Question (vi) : What instructional courses in engineering subjects should be provided by the Technical Correspondence School ?

268. This question is answered by the two following recommendations :—

(*a*) That to meet the needs of those who in the interim period will still be sitting external examinations, instruction be provided through the Technical Correspondence School, and that arrangements be made for laboratory work in those subjects requiring it (page 51).

(*b*) That for candidates outside approved centres instruction be provided through the Technical Correspondence School for all subjects of the first two years of the diploma course and that arrangements be made for laboratory work in those subjects requiring it (page 56).

Question (vii) : What weaknesses, if any, exist in the present standard of instruction available at any stage ?

269. The Committee received some criticism of the instruction available at the two University schools of engineering. This criticism, however, mainly arose from the conditions under which the schools have had to carry on their work in recent years. For this reason the Committee has made specific suggestions for improving accommodation, equipment, and staffing. It is of opinion that, if these improvements are not accomplished as soon as possible, the quality of graduates must decline.

270. The Committee thinks that the present system of allowing overlapping of professional years is not in the best interests of the students and considers that for deserving students there should be supplementary special examinations. It believes, too, that the University course should be restricted as soon as possible to those students proceeding to a degree in engineering.

271. In Section 10 attention is drawn to certain branches of engineering for which there is little or no adequate instruction available. In particular, the Committee recommends the addition of courses in locomotive engineering, refrigeration engineering, and telecommunications.

272. The Committee considers that some of the courses laid down for Institution membership examinations could, with advantage, be made more specifically applicable to New Zealand conditions, and has recommended the institution of diploma courses with sufficient flexibility in the prescriptions to overcome this disadvantage.

273. The order of reference of the Committee also permitted it to inquire into and make recommendations on any other matters which the Committee considered relevant. The Committee has done this where necessary. The problem of the supply of engineers, for example, has been considered in some detail in Section 8, and in Section 13 recommendations are made about forms of financial assistance considered necessary or desirable.

274. The Committee is conscious, however, of the impossibility of dealing adequately in such a report as this with many important aspects of engineering education. The above report sets out what the Committee considers desirable by way of formal education and training for an engineer. It should be pointed out, however, that this constitutes only a foundation for the successful engineer and merely equips him for entry to the profession. His study and training must continue for many years of his practising professional life if he is to keep abreast of the many changes and improvements which are continually taking place in the engineering world. It must be pointed out also that, although the Committee has set out courses and proposals for improving engineering education, there are many qualifications necessary for a successful engineer which cannot be taught directly in any engineering school. Such characteristics as honesty, integrity, initiative, judgment, common-sense, accuracy, industry, and knowledge of men are considered by many executives to be of equal, if not greater, importance than the technique and practice of the technical side of the profession of engineering. Whilst a full discussion of this aspect may be outside the scope of this report, the Committee is convinced that it ought not to be overlooked. The Committee, for its part, has had such considerations in mind in its recommendations which aim at making the fundamental education of a professional engineer as broad as is reasonably possible.

PART III

SUMMARY OF RECOMMENDATIONS

1. *Section 8: Supply and Demand*

That the number of professional engineers be increased to 850 per million of the population in ten years' time, and thereafter, as opportunity offers to 950 per million during the following fifteen years. (Page 30.)

2. *Section 9: By What Way Should a Professional Engineer Qualify?*

(1) That for intending engineering students there should be no specialization before the end of the School Certificate year. (Page 31.)

(2) That for these entrants instruction at the post-primary stage in technical engineering subjects is not essential. (Page 31.)

(3) That, even at the post-certificate stage, concentration on mathematics and the physical sciences should not exclude English and other cultural subjects. (Page 31.)

(4) That intending entrants for the engineering degree course should spend at least one year in the Sixth Form after qualifying for University Entrance. (Page 31.)

(5) That in future all civil and electrical engineers should qualify by way of a University degree. (Page 35.)

(6) That the policy for development in mechanical engineering be based on the assumption that there will be a demand for some years for engineers who obtain their professional qualifications while employed in industry. (Page 35.)

(7) That for some years a proportion of professional engineers should be trained by means of courses leading towards Diplomas in Professional Engineering. (Page 34.)

3. *Section 10: Courses Leading to Degrees in Engineering*

(1) That the question of building a new engineering school at Canterbury be considered to be one of the greatest urgency, that steps be taken to secure a suitable site, and that the building be given a high priority. (Page 43.)

(2) That the equipment of the Auckland University College School of Engineering be improved and that further equipment be provided to permit the extension of the courses in civil and electrical engineering to the final year of the B.E. course. (Page 44.)

(3) That as the present prescriptions in mathematics for University Entrance and University Entrance Scholarships are too narrow, the University of New Zealand be strongly urged to broaden them. (Page 41.)

(4) That, as soon as the necessary facilities can be made available at technical schools or technological colleges for other students in engineering, the University engineering course be restricted to those students proceeding to a degree in engineering. (Page 46.)

(5) That if at any time further restriction is necessary, having regard to the number of engineering graduates which the Dominion can reasonably be expected to absorb, selection of students for this purpose be made at the end of the Engineering Intermediate Course. (Page 41.)

(6) That optional subjects (locomotive engineering and refrigeration engineering) be added to the list of subjects for the third professional examination for the degree of Bachelor of Engineering (Mechanical). (Page 46.)

(7) That a subject (telecommunications) be added to the list of subjects for the third professional examination for the degree of Bachelor of Engineering (Electrical), and that this subject be optional with hydraulics and pneumatics. (Page 46.)

(8) That the University of New Zealand consider the institution of supplementary examinations for the professional years of the B.E. degree. (Page 45.)

(9) That the University of New Zealand be asked to investigate the question of establishing a Master's Degree in Engineering. (Page 46.)

(10) That the Schools of Engineering provide, from time to time, short post-graduate courses in special branches of engineering in which important recent developments have taken place. (Page 47.)

(11) That means be provided to permit engineering teachers at the University schools of engineering, and the technical schools to return periodically to active practice. (Page 47.)

(12) That the possibility of engineering specialists giving short lecture courses be explored, and that greater use be made by the University schools of engineers who would lecture on a part-time basis and practise part time. (Page 47.)

(13) That there be a greater amount of co-operation between University college engineering staffs and engineers under whom students are carrying out practical work to ensure that students are making the best possible use of the time spent in practical work. (Page 47.)

(14) That the staffing at both University schools of engineering be sufficiently liberal to permit of a reasonable amount of research being undertaken. (Page 48.)

4. *Section 11 : Courses leading to Institution Membership Examinations*

(1) That the Engineers Registration Board ensure that the minimum standard of entry to the engineering profession in New Zealand be University Entrance either by accrediting or examination, and that intending students be strongly advised to include both mathematics and the physical sciences among the subjects taken at the Sixth Form stage. (Page 49.)

(2) That for a limited period men who have the necessary preliminary qualifications and who can produce evidence that they have already entered upon an approved course as students for one of the recognized institutions should be regarded as eligible for bursaries on terms similar to those recommended for diploma students. (Page 50.)

(3) That to meet the needs of those who in the interim period will still be sitting external examinations, instruction be provided through the Technical Correspondence School, and that arrangements be made for laboratory work in those subjects requiring it. (Page 51.)

(4) That while having due regard to the necessity of keeping faith with students who have begun courses for other examinations, the technical schools be organized as soon as possible to provide exclusively for the courses for the diplomas in professional engineering as set out in Section 12 of this report. (Page 51.)

5. *Section 12 : Establishment of a System of Diplomas in Professional Engineering*

(1) That the Education Department institute a system of Diplomas in Professional Engineering of a standard at least equal to that of the present Institution Membership Examinations. (Page 53.)

(2) That these diplomas be awarded in respect of courses which, though mainly part time, shall include at least one year of full-time study. (Page 53.)

(3) That these diplomas be awarded as a result not only of examination success, but also of satisfactory completion of a course of study approved by the Education Department. (Page 53.)

(4) That a candidate must pass at the one time in all subjects of any year before proceeding to the next year of the course. (Page 53.)

(5) That examination-papers in all subjects be set, moderated, and marked by examiners approved by the Education Department. (Page 53.)

(6) That the pre-requisite of a diploma course be University Entrance either by accrediting or examination. (Page 54.)

(7) That entry upon a diploma course be permitted only to a student employed as a cadet, articled pupil, or apprentice under conditions approved by the Engineers Registration Board for this purpose. (Page 54.)

(8) That, in order that no hardship be inflicted upon men who develop later, men twenty-five years of age or over be admitted to the first year of a diploma course on a provisional basis, this provisional admission to be confirmed if the Principal of the institution attended makes a favourable recommendation to that effect. (Page 54.)

(9) That during the transition period students who have already passed Section A of the Institution Membership Examinations and who make application to the Director of Education be credited with the first three years of the corresponding diploma course. (Page 54.)

(10) That provision be made for cross-credits to students who transfer from the degree course in engineering to the corresponding diploma course, or *vice versa*. (Page 54.)

(11) That the necessary facilities be provided in the technical schools at Auckland, Wellington, Hutt Valley, Christchurch, and Dunedin for instruction in the various subjects of the diploma courses, if these facilities are not at present available, as an initial step in the establishment of technological institutions. (Page 56.)

(12) That for candidates outside approved centres instruction be provided through the Technical Correspondence School for all subjects of the first two years of the diploma course, and that arrangements be made for laboratory work in those subjects requiring it. (Page 56.)

(13) That it be a condition of the recognition of a technical school for purposes of diploma courses that it set up one or more functional advisory committees for the branches of engineering covered by its courses. (Page 57.)

(14) That bursaries be provided to enable selected students who have completed the first two years of the diploma course to proceed to the third year. (Page 56.)

(15) That the Education Department and the Engineers Registration Board co-operate in drawing up prescriptions and conditions for qualifying examinations for diplomas in professional engineering, as circumstances warrant, and in conducting or arranging for these examinations. (Page 58.)

(16) That diplomas in professional engineering be issued under the authority of the Education Department. (Page 58.)

(17) That any necessary regulations be prepared and administered by the Education Department after approval by the Engineers Registration Board. (Page 58.)

6. *Section 13: Bursaries, Scholarships, Loans, and Other Forms of Financial Assistance*

(1) That the number of engineering bursaries be increased from 15 annually to a minimum of 40, with provision for a further number if sufficient good applicants are forthcoming, and that the total value of the bursary be not less than £110 per annum including boarding allowance where payable. (Page 60.)

(2) That, other things being equal, special bursaries in engineering should be awarded for preference to candidates who have been accredited for or have passed the University Entrance Examination and have spent an additional year in the Sixth Form of a post-primary school. (Page 61.)

(3) That cadets considered worthy of training at the University should be given every encouragement to complete the B.E. degree. (Page 61.)

(4) That, as a means of inducing able young men to enter the engineering profession, Government Departments and other organizations be encouraged to offer cadetships under conditions requiring the cadet to attend courses for the B.E. degree as one of the terms of appointment. (Page 61.)

(5) That in order to assist in increasing the efficiency of engineering education for non-degree students, bursaries be established available to all deserving students who are entering on the full-time year of the course for the Diploma in Professional Engineering; that the term of the bursary be one year, with the possibility of an extension for a further year in exceptional and strictly limited cases; and that the value of the bursary be £100 per annum, inclusive of any fees that may be payable, plus £40 per annum boarding-allowance, where justified, plus £100 per annum for married men, payment to be subject to receipt of satisfactory reports each term from the Principal of the school attended. (Page 62.)

(6) That the number of diploma bursaries be unlimited until the awards at the end of the year 1954 to give approved students already taking a non-University degree course every encouragement to complete their qualifications and that thereafter no more than 30 bursaries be awarded annually. (Page 62.)

(7) That during the interim period students who have completed Section A of the Institution Membership examinations be considered eligible for the above bursaries under the same conditions. (Page 62.)

(8) That engineering scholarships be established to enable students of exceptional ability who have completed the third year of the diploma course in professional engineering to transfer to the B.E. degree course. (Page 63.)

(9) That the tenure of such scholarships be three years, with the possibility of extension to a fourth year, and that they be awarded with the same value and under the same conditions as the University Entrance Scholarship, but that an additional £100 per annum be paid to a married man. (Page 63.)

(10) That two post-graduate scholarships in engineering be awarded annually tenable only in New Zealand but open to graduates of any recognized University; that these scholarships have a value of £300 per annum and be tenable for one year, with the possibility of extension to a second year. (Page 63.)

(11) That the number of University Travelling Scholarships in Engineering be increased to two annually. (Page 63.)

(12) That a system of loans be established to assist deserving students who may be unsuccessful in securing bursaries or scholarships or who may require financial assistance over and above the value of the bursary or scholarship to enable them to pursue an engineering degree course. (Page 64.)

7. *Section 14: Council of Engineering Education*

(1) That there be established a Council of Engineering Education. (Page 65.)

(2) That the Council be constituted as follows:—

(*a*) Two members appointed by the Minister of Education.

(*b*) The Vice-Chancellor of the University of New Zealand.

(*c*) Two members appointed by the Senate of the University of New Zealand.

(*d*) One member appointed by the New Zealand Secondary Schools' Association.

(*e*) One member appointed by the New Zealand Technical School Teachers' Association.

(*f*) Three members appointed by the New Zealand Institution of Engineers.

(*g*) One member appointed by the Engineers Registration Board. (Page 65.)

(3) That the term of office of appointed members be three years, but that they be eligible for reappointment. (Page 65.)

(4) That the Council have power to appoint one additional member. (Page 65.)

(5) That the functions of the Council be—

(*a*) Generally to make recommendations to the Minister of Education on matters relating to the education of professional engineers.

(*b*) To make, after consultation with the faculties of the University Engineering Schools, recommendations to the Senate through the Academic Board on any matter relating to engineering education, and in particular with respect to courses of study, examinations, and the educational and practical qualifications of professional engineers; and, further, to make recommendations to the Education Department on any matters relating to diplomas in professional engineering, and in particular concerning the courses of study and examinations for these diplomas. (Page 65.)

(6) That the Senate should not make or alter any statute relating to the courses of study, examinations, and degrees in professional engineering until it has first received and considered any recommendations made by the Council of Engineering Education; and, further, that the Education Department should not make or alter any regulation relating to courses of study and examinations for diplomas in professional engineering until it has first received and considered any recommendations made by the Council. (Page 65.)

PART IV

DIPLOMAS IN PROFESSIONAL ENGINEERING

PROPOSED COURSES AND SUBJECT PRESCRIPTIONS

The Committee sets out in this part of its report the courses and special prescriptions for the diplomas in professional engineering recommended in Section 12. The prescriptions cover the three branches of engineering—civil, electrical, and mechanical—in which the greatest numbers of engineers are required. They have been drawn up after discussion with experts in the different subjects and have been carefully considered by sub-committees of the main Committee. If the recommendations for the institution of diplomas are accepted, further discussion of the details of the courses will be desirable in order to make sure that they are completely in line with New Zealand conditions. It may be necessary from time to time to establish diploma courses in other branches of engineering. The Committee has made no attempt to lay down any specific requirements for such branches, but it considers that the scheme outlined in this part of the report would be useful as a model for any such future courses.

I. Courses and Subjects

The figures in the following table indicate the *number of seventy-five minute periods weekly* which should be devoted to each subject in each year of the course. These periods include the times which should be devoted to practical work.

It will be noted that the *first and second year courses are identical in all three branches*, but that the civil and electrical courses differ slightly from the mechanical in the third year, and that in the fourth and fifth years all three courses differ greatly.

Civil, Electrical, and Mechanical Engineering

First year (part time)—	Day.	Evening.
Applied Mechanics I (*a*)	2	1
*Chemistry	..	2
Drawing (*a*)	1	..
Mathematics I (*a*)	2	..
*Physics (*a*)	1	1
	6	4

*Note.—Exemption granted if candidate has reached University Entrance standard.

Second year (part time)—	Day.	Evening.
Applied Mechanics I (*b*)	1	..
Drawing (*b*)	1	..
Mathematics I (*b*)	2	..
Physics (*b*)	2	2
Workshop Practice I	..	2
	6	4

Third year (full time)—	Civil.	Electrical.	Mechanical.
Applied Electricity	3	5	..
Applied Heat	5	5	5
Applied Mechanics II	2	2	2
Engineering Drawing and Design I	2	2	4
Mathematics II	4	4	4
Strength of Materials I	3	3	3
Theory and Design of Structures I (*a*)	2	2	..
Theory and Design of Structures I (*b*)	2	..	..
Workshop Practice II (*a*)	..	..	2
Workshop Technology	..	..	3
	23	23	23

Civil Engineering

Fourth year (part time)—	Day.	Evening.
Engineering Drawing and Design II (*a*)	2	..
Engineering Materials	..	3
Hydraulics (*a*)	1	..
Surveying and Applied Geology (*a*)	..	2
Surveying and Applied Geology, Field	3	..
Theory and Design of Structures II (*a*)	2	..
	8	5
Fifth year (part time)—		
Hydraulics (*b*)	3	..
Surveying and Applied Geology (*b*)	..	2
Surveying and Applied Geology, Field	3	..
Theory and Design of Structures II (*b*)	2	2
	8	4

Electrical Engineering

Fourth year (part time)—	Day.	Evening.
Electrical Engineering (four papers)	6	4
Engineering Drawing and Design II (*b*)	2	2
	8	6
Fifth year (part time)—		
Power Supply (four papers)	6	4
Or—		
Line Communication (four papers)	6	4
Or—		
Radio Communication (four papers)	6	4

Mechanical Engineering

Fourth year (part time)—	Day.	Evening.
Engineering Drawing and Design II (*c*)	2	..
Heat Engines (*a*)	1	..
Strength of Materials II (*a*)	..	2
Theory of Machines (*a*)	1	..
Workshop Practice II (*b*)	..	2
*Optional Subject (*a*)	2	..
	6	4

Fifth year (part time)—

	Day.	Evening.
Heat Engines (*b*)	..	2
Industrial Administration	..	1
Strength of Materials II (*b*)	..	1
Theory of Machines (*b*)	2	..
*Optional Subject (*b*)	2	..
	4	4

*One chosen from—
- Engineering Chemistry
- Heating and Ventilating
- Hydraulics
- Locomotive Engineering
- Marine Engineering
- Physical Metallurgy
- Refrigeration Engineering

In each of these subjects there are two prescriptions, (*a*) being the fourth and (*b*) the fifth year prescription.

II. Prescriptions

(Arranged in alphabetical order)

N.B.—Unless otherwise indicated there will be only one paper of three hours' duration in each subject.

Applied Electricity

Principles of the application of electricity to engineering. An outline of the generation, transmission, and utilization of electrical energy with elementary underlying theory.

Elementary principles of simple types of A.C. and D.C. machines and transformers.

Construction, action, and application of principal types of ammeters, voltmeters, and wattmeters. The vacuum diode valve and its use as rectifier. Static characteristics of vacuum triode valve. Elementary description of cathode-ray tubes.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Applied Heat

Calorimetry, heat quantity, specific heats.

The first and second laws of thermodynamics. The gas laws of Charles, Boyle, Avogadro, Dalton, and Joule (internal energy); absolute temperature. Use of the gas constant R; internal and external energy; gases and vapours; phenomena of the critical state; total heat of wet, dry, and superheated steam; dryness fraction of steam; entropy; use of steam tables; isothermal and adiabatic expansion and compression; heat added = increase of internal energy plus work done; application to constant-volume, constant-pressure, isothermal and adiabatic changes, the P/V diagrams for the following cycles: Otto, Carnot, Joule, Ericsson, Stirling, Rankine, Atkinson. Calculation of pressure, volume, and temperature throughout the cycles.

Calorific value of fuels; higher and lower values; quantity of air required for combustion of carbon and hydrogen.

The indicator card for the reciprocating engine; mean effective pressure; diagram factor; horse-power, indicated and brake.

Viscosity of gases and liquids, and its dependence on temperature; surface tension and its variation with temperature.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Applied Mechanics I (a)

Statics.—Units of measurement of force; simple stress, strain: Hooke's law; Young's modulus of elasticity; composition and resolution of forces in one plane; levers; moments and couples; centre of gravity; equilibrium of a particle and a rigid body under forces in one plane; forces in simple frames; friction; simple machines.

Dynamics.—Uniform and uniformly accelerated motion in a straight line; relations between force, mass, and acceleration; speed-time graphs; uniform circular motion; centrifugal force; impact forces; energy and the principle of work; power; units and dimensions.

Fluid Mechanics.—Pressure on plane areas immersed in a liquid; principle of Archimedes; centre of pressure; the barometer; specific gravity and density.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Applied Mechanics I (b)

Statics.—Moments and couples; levers; stability. Machines. Application of equilibrium to framed structures and beams; modulus of rigidity; torsion; bending; simple bending moment and shear force diagrams.

Friction.—Kinetic friction; tractive force of a locomotive; rolling friction; angle of rest.

Dynamics.—Simple harmonic motion; pendulum. Relative motion, vector and scalar quantities; motion on an inclined plane. Impulse; momentum; change of momentum; moment of inertia; conservation of energy; conservation of linear momentum.

Fluid Mechanics.—Hydraulic press, jack, lift, crane. Bernouilli's theorem; flow through an orifice.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least fifteen hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Applied Mechanics II

Statics.—Application of funicular polygon to roof trusses, structures. Polygon of forces applied to cranes, winches, &c. Transmission of motion and power; belts, ropes, gearing.

Dynamics.—Further problems on rate of change of momentum; impact; further problems on motion in a plane; circular motion and harmonic motion; centrifugal force, balancing, balancing of rotating masses; reciprocation. Piston motion, quick returns, links, cams. Instantaneous centre. Rectilinear motion of a body under a constant or variable force; equation of motion of a particle. Rotation and oscillation of a body about a fixed axis.

Fluid Mechanics.—Centre of pressure on dams; metacentre; force of a jet of water; the water turbines: lift and force pumps. Hydraulic gradient, loss of head due to resistances.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Chemistry

Physical properties of gases; the laws of Boyle, Charles, and Avogadro; solubility and diffusion of gases.

Atomic theory; valency. Formulæ and equations. Chemical equivalents. Compounds; chemical reactions and their representation by equations. Periodic classification of the elements.

Oxygen and oxides; oxidation and reduction.

Acids, bases and salts. Solubility, crystallization and water of crystallization.

Hydrogen. Water. Reduction by hydrogen.

Carbon; oxides of carbon; carbonates and bi-carbonates.

Chlorine; hydrochloric acid; chlorides; potassium chlorate.

Nitrogen; nitric acid; nitrates; ammonia, liquefaction of ammonia; use of ammonia in refrigeration; ammonium salts. Sodium and potassium cyanide.

Sulphur; sulphuretted hydrogen; carbon di-sulphide; sulphides; oxides of sulphur; sulphuric acid and its preparation; sulphates.

Silica and silicates; the nature of glass and earthenware.

Metals and non-metals.

The occurrence, sources, and physical properties of sodium, calcium, magnesium, aluminium, zinc, iron, lead, copper. Their oxides and principal salts.

Physico-chemical properties of cast iron, steel, wrought-iron, and the simple non-ferrous alloys. Iron alloys.

Elementary thermo-chemistry.

Properties and uses of types of coal; coal-gas, producer gas, water-gas, carburetted-water gas.

Endothermic and exothermic reactions.

Electrolysis; meaning of pH. Electrolysis of aqueous solutions and fused electrolytes.

Metallic corrosion and its prevention. Protective coatings, paints, galvanizing and electro-deposited coatings.

Natural water; impurities and their effects on boilers.

Hardness in water, causes and removal.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Drawing (a)

Fundamental constructions in plane and solid geometry. Development of surfaces.

Construction of conic sections, cycloid, involute, helix, and spiral, and their practical applications.

Locus of a point in simple mechanisms.

Elementary oblique, isometric and perspective projections.

Conventional representation of screw threads.

Drawing of and knowledge relating to standard parts such as nuts, bolts, rivets, and keys.

Preparation of projected drawings of simple machine parts from pictorial views, and *vice versa*, both free hand and instrumental, including elementary sectional views.

NOTE.—New Zealand standard drawing office practice is to be adhered to in all details.

Drawing (b)

Scales and their correct use.

Methods of setting out engineering drawings.

Intersection of solids.

Development of simple pipe junctions; sheet and plate constructions.

Form of involute teeth in contact.

Conventional representation of gear wheels and trains.

Drawing and general knowledge of machine and constructional details such as:—

Riveted and welded joints, pipe joints, pulleys, couplings, bearings and simple types of valves and cocks.

Simple electrical fittings, including switches, cable terminals, and supports.

Drawings to include sectional views, introducing special types—for example, full and half sections and broken-out sections. Correct location of parts from centre lines or finished surfaces.

Auxiliary views.

Reading of first and third angle drawings and prints, and application of standard symbols and method of expressing tolerances.

A knowledge of the processes of making tracings and reproductions.

NOTE.—First angle projection will be used and asked for in the examinations, but it is expected that students shall be given instruction in the standard American or third angle projection during the course of their training.

Electrical Engineering. (Four papers—three hours each)

Paper (a): Electric Circuit Theory

Circuit calculations involving combination of resistance, inductance, and capacitance, three-phase circuit calculations, treatment of A.C. circuits by use of the symbolic notation, simple locus diagrams, harmonics, resonance in series parallel and coupled circuits, simple wave filters, star-mesh transformations, transient phenomena in simple L.C.R. circuits. Calculation of insulation resistance and capacitance of, and electrostatic stress in, concentric cable.

Paper (b): Electrical Machinery

The operating characteristics of series, shunt, and compound D.C. generators and motors and of alternators, synchronous motors and induction motors. Methods of motor starting. Principles of power factor correction. Vector diagram and equivalent circuit of the transformer, autotransformers, instrument transformers.

Rectifiers.—Characteristics and essential connections of thermionic, metal, and mercury arc rectifiers. Smoothing circuits.

Paper (c) Electronics

Dynamic characteristics of the vacuum diode and triode valves. Photoelectric cells, resistance and photoemission types.

Illumination.—Laws, units and standards of illumination, measurement, photometry. Polar curves. Mean hemispherical candle-power. Secondary illumination. Reflection factors. Light sources. Comparison of filament and discharge types of lamp for domestic, factory, office, and street lighting, colour of light source and its effect. Elementary spectroscopy. Fluorescent lamp circuits. Starting. Flicker. Illumination systems. Design and layout of illumination systems to meet specific requirements. Calculation of maximum and minimum illumination. Influence of lighting fittings, diffusers and reflectors. Glare and contrast. Control and switch points.

Materials.—The testing of iron including the separation of hysteresis and eddy current losses and the calculation of these losses. Characteristics of permanent and high-permeability magnetic materials.

The measurement of permitivity power factor and electric strength of insulating materials at power and audio frequencies.

Paper (d): Electrical Measurements

General theory. Basic laws of electrostatics and electromagnetism, and their application in instrument and measurement technology to the calculation of capacitance and electrostatic stress, magnetic field strength and magnetic forces. Self and mutual inductance, induced E.M.F. Eddy current loss; current penetration in conductors, and flux penetration in magnetic materials. Units and standards. Derivation of C.G.S. electrostatic and electromagnetic units; their dimensions and their relationship to practical units; the m.k.s. system. International units. Absolute measurements of current and resistance. Standards and substandards.

Instruments and accessories; materials and construction. The theory, design, construction, testing, and use of indicating, recording, and integrating instruments and meters. The theory and testing of instrument transformers. Moving-coil and cathode-ray oscillographs.

Measurements. Alternating current and direct current bridge and potentiometer measurements. Resonance methods of measuring effective resistance and reactance. Principal properties of, and methods of testing, magnetic, conducting, and insulating materials. Measurement of non-electrical quantities by electrical means.

The principles of measurements at power, audio, and radio frequencies of inductance, capacitance, resistance, voltage, current, power, and frequency.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least 120 hours' duration based on the prescriptions (*a*), (*b*), (*c*), and (*d*) above, and that his attendance and work have been satisfactory.

Engineering Chemistry (a)

Fuels and Combustion.—Elementary thermo-chemistry. Combustion. Air required. Products of combustion. Heat losses. Properties and uses of coal. Ultimate and proximate analyses. Calorific values. Liquid and gaseous fuels. The manufacture of coal-gas, water-gas, carburetted-water gas, coke-oven gas, producer gas. Domestic and metallurgical cokes.

Heat Transfer.—Heat transfer by radiation, conduction, and convection. Industrial furnaces.

Lubricants.—Oils and greases (animal, vegetable, and mineral), properties, requirements. Physical tests. Viscosity. Boundary and flooded lubrication.

Industrial Water-supply.—Permanent and temporary hardness. Boiler-feed water treatment. Water-treatment plant for boilers. Dye-houses and allied industrial equipment.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Engineering Chemistry (b)

Fuels and Combustion.—Further consideration of solid, gaseous, and liquid fuels. Methods of preparation and burning—*e.g.*, pulverized fuel, mechanical stokers, oil-burners. The calculation of flame and gas temperatures. Heat losses in gases. Furnace efficiency and factors affecting same. Pyrometers and other methods of temperature measurement. Gas analysis.

Lubrication.—Oil requirements of bearings, bearing friction, high speed and special bearings. The production of oils from crude petroleum. The preparation of greases.

Bearings.—Types of bearings. Bearing metals, recent developments, anti-friction bearings, porous bearings.

Plastics.—General outline of the types, production, and uses of the more common plastics, both thermo-setting and thermo-plastic. Compression, injection, and transfer moulding techniques, laminates, extrusion. The physical and chemical properties of engineering plastics.

Corrosion.—A general study of the problem of corrosion of engineering materials. Surface treatment of ferrous and non-ferrous materials by spraying, dipping, galvanizing, and plating.

Non-metallic Materials.—A general study of cement, concrete, mortars; clay, common and refractory bricks, paints, varnishes.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Engineering Drawing and Design I

(*a*) *Drawing.*—Drawings and general knowledge of details of any common part or appliance for an engine, machine, electrical fitting, or structural construction, such as connecting-rods, cross-heads, governors, pistons for both steam and internal-combustion engines, electrical machine parts, and structural frames.

(*b*) *Design.*—Analysis of forces in simple mechanisms, and structures.

Calculation of dimensions of simple elements subjected to tension, compression, shear, bending, or torsion—for example, belted connections, riveted joints; shaft couplings and keys; boiler shell and stays; levers, cottered connections, pin connections, cams, simple structural and machine beam members.

Engineering Drawing and Design II (a). (Two papers—three hours each)

Working drawings of civil engineering details from sketches or assembly drawings.

Assembly drawings from sketches or drawing of details.

The projection of additional outside and sectional views. The completion of drawings by the addition of simple suitable parts.

Designs worked out and prepared from data in the following sections:—

(*a*) *Structural Steelwork*—*e.g.*, roof trusses, girders, cranes, stanchions, and foundations.

(*b*) *Reinforced Concrete*—*e.g.*, piles, tanks, retaining-walls, floors.

Fully dimensioned working drawings to be made of some parts or part of the designs.

Engineering Drawing and Design II (b). (Two papers—three hours each)

Design involving application of kinematics—for example, screw mechanisms; gear wheels; cams.

Design of bearings for given loads; use of ball and roller journal and thrust bearings; lubrication. Design of machine and engine details such as pulleys, couplings, clutches, power-transmission drives, and pressure transmission.

The design and preparation of working drawings of electrical machine parts from outline data or sketches—*e.g.*, switches; starters for D.C. and A.C. motors; commutators and brush gear for electrical machines.

Candidates will be expected to show competency in making dimensioned hand sketches in good proportion.

Engineering Drawing and Design II (c). (Two papers—three hours each)

Design involving application of kinematics—for example, screw mechanisms; gear wheels; cams.

Design of bearings for given loads; use of ball and roller journal and thrust bearings; lubrication. Design of machine and engine details such as pulleys, couplings, clutches, power-transmission drives, and pressure transmission.

Simple jigs and fixtures.

Influence on design of fatigue and stress concentration.

Candidates will be expected to show competency in making dimensioned hand sketches in good proportion.

Engineering Materials

The chemistry, metallography, and mechanical properties of the commoner metals of industrial importance, with special attention to iron and steel; the chief alloys of these metals and the conditions under which they are formed; variation of properties by thermal and mechanical treatments; outlines of manufacture of steel, wrought iron, and cast iron. Methods of crack detection and use of x-ray for inspection.

Techniques of making cement, concrete, bricks, ceramics, and plastics, and their properties.

The properties and preservation of timber, including plywoods.

Road and runway making materials and their preparation; bituminous surfaces.

Fuels and the products of combustion.

Water treatment; corrosion; weathering and disintegration.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Heat Engines (a): Steam-engines

Thermodynamics.—Reversible and irreversible processes; entropy; temperature-entropy and total heat-entropy diagrams; Carnot, Rankine, regenerative and reheating cycles, heat pumps.

Steam Generators.—Smoke-tube and water-tube boilers; boiler fuels; combustion in boilers, furnaces and draught; air supply and regulation; flue gas analysis.

Reciprocating Steam-engines.—The incomplete Rankine cycle; action of steam in cylinder compounding; jacketing; effects of super-heating; Willan's law; testing procedure and equipment; indicators; combined diagrams; trial data and heat balances. Governors; reversing gears; valve diagrams.

Turbines.—Expansion in the impulse type and in the reaction type; steam flow through nozzles and blades; nozzle and blade dimensions; blade thrust; loss and leakage effects; stage efficiency; reheat factor; allocation of energy; trial procedure; velocity diagrams; velocity compounding; governing; temperature and entropy T ϕ, H ϕ diagrams.

Condensers.—Condensing-plant; jet and surface condensers; air and extraction pumps; air-ejectors; de-aerators; evaporators; feed heaters; the feed circuit, feed treatment.

Refrigeration.—Vapour compression machines, absorption machines, compression compound, refrigerants.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least fifteen hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Heat Engines (b): Internal-combustion Engines

Cycles.—Ideal cycles applicable to the internal-combustion engine, and their representation by pressure-volume and temperature-entropy diagrams; air standard efficiencies and their modifications by the properties of actual working substances.

Classification of Engines.—The classification and cycles of operation of gas-engines, petrol-engines, heavy-oil engines and turbines, and jet-propulsion engines.

Combustion in Engine Cylinder.—Process of combustion in compression-ignition and spark-ignition engines, with special reference to detonation in the latter.

Testing and Performance.—Apparatus and procedure; indicators; characteristics of indicator diagrams; fuel-consumption and heat-distribution; engine losses; accuracy of measurement; representation and interpretation of test results; volumetric efficiency; consideration of the performance of actual engines in relation to ideal conditions.

Air-compressors.—Positive displacement, centrifugal, and turbo-compressors.

Constructional Details.—The general construction of internal-combustion engines, carburettors, electrical ignition systems, fuel-pumps and injection systems; governing and power control; gas-producers.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Heating and Ventilating (a)

Heating.—Metabolism and comfort conditions. General consideration. Wet and dry bulb temperature. Effective temperature. Heat transmission by radiation, convection, and conduction. Thermal conductivity of building materials. Surface coefficients. Effect of wind and building exposure on heat transmission. The calculation of building heat losses. Consideration of a satisfactory temperature difference for New Zealand conditions. The insulation of buildings. The various systems of building heating. Choice of a suitable system. Steam and hot water boilers, feed treatment. Fuels. Fuel burning equipment. Calculation of air required for combustion. Heat losses in flue gases. Boiler efficiencies. General consideration of equipment used. Thermostatic control of heating systems.

Ventilation.—Standards of ventilation. Natural and mechanical ventilation. Fan types. Fan laws. Fan-rating tables. Ducts and grilles. The calculation of air quantities. Friction losses in ducts and grilles. Total and static head required at fan. Fan efficiencies and horse-power requirements. Fan construction and drives. Duct construction.

Heating and Ventilating (b)

Heating.—Estimation of radiator surface requirements for different types. Panel and other forms of low temperature heating. Water quantities. Pipe sizing and pipe losses. General layout of system. Pumps and circulators. Thermal electric storage systems. The heating of buildings by forced warm air systems. The domestic hot-water requirements of large buildings such as hospitals, institutions, blocks of flats, and offices. Steam requirements for kitchens in hospitals and institutions. The layout of D.H.W. systems.

Air Conditioning.—The physical properties of air, and air-vapour mixtures. The total heat of air, psychometric charts. The basic problems of air conditioning. Comfort conditions. Heating load in winter, cooling load in summer, sun load, occupant load. The simultaneous control of temperature and humidity. The calculation of air quantities, heating and cooling loads. Air-conditioning equipment: fans, filters, air washers, thermostatic control, extended surface heating and cooling coils. The mechanical production of cold. Types of refrigeration and methods of rating. The heat pump. Air conditioning and the control of humidity for specific manufacturing problems.

Economic Considerations.—Factors governing the choice of a suitable system of heating or air conditioning from economic considerations.

Hydraulics (a)

The development from basic principles of mechanics of the laws of fluid flow. Equation of motion and continuity. Bernouilli's Equation. Applications of the principles of conservation of mass and energy. The Venturi Meter. Flow of fluids through orifices and over notches. The experiments of Froude and Reynolds: Applications of the principle of dynamical similarity in respect of the viscous resistance of fluids.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least fifteen hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Hydraulics (b)

The flow of water through pipes and open channels. Backwater curves. Methods of gauging. The boundary layer. Hydraulic machines—turbines, centrifugal and reciprocating pumps, hydraulic ram, pressure-machines. Similarity and models. Dimensional analysis.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least sixty hours' duration based on the above prescriptions and that his attendance and work have been satisfactory.

Industrial Administration

Industrial Development—Formation and Development of Manufacturing Organizations

Sales Organization.—Types of different products. Market study in relation to technical development. Price determination. After service.

Design Organization.—Designing for production. Control of quality in designs. Organization of the design department and flow of work. Relationship of research to design. Organization and control of inspection activities. Estimating specifications, contracts, and costing.

Production Organization.—The organization and inter-relationship of the sections concerned with planning, estimating, rate-fixing, tool design and manufacture, material purchase and inspection, stores, manufacturing, progress, wage systems, bonus, piece work and time study, costing, works engineering, labour bureau, welfare, canteens. Routes of essential documents through the organization and of work through the shops; division of labour.

Factory Layout.—Ideal layouts of work and offices, based on work and document routing. Practical modifications. Heating, ventilation, lighting, and power supply of workshops.

Factory Sites.—General considerations as to suitability of land, service, and local government regulations. Proximity to materials, labour, markets, and communications.

Management.—The art of directing human activities. Application of scientific method to management by reference to work of pioneers. Social responsibilities of management (*a*) to the community, (*b*) to those it directs. Position of management relative to capital and labour. Training for management, relative values of theory and experience. Graduation of potential managers through operative and staff grades. Supervision, selection of staff; qualities. Modification of theoretical organizations to take account of individuals.

Labour.—Trade-unions; their development and legal status. Trade-union regulations regarding employment. Negotiations with unions. Works committees. Shop stewards. Selection and training of operatives. Vocational guidance tests. Apprenticeship schemes. Engagement of labour. Labour turnover. Discharge of labour. Discipline and handling of personnel. Effect of long hours and monotony on efficiency. Attitude of labour to status and working conditions. National and local agreements between employers and trade-unions. Arbitration Court, conciliation, tribunals, and awards. Industrial fatigue. Accident causes and prevention.

Industrial Legislation.—Review of the development of industrial legislation; the underlying aims and objects. The Factories Act; detailed knowledge of the current New Zealand Act and of the more important statutory Orders in so far as the engineering industry is concerned. Workers' Compensation Acts, strikes, stop-work meetings, and lockouts.

Line Communication. (Four papers—three hours each)

Papers (a) and (b); Theory and Measurements

Basic equation of the uniform transmission-line. Attenuation and phase constants. The neper and the decibel. Characteristic impedance. Reflection and transmission cœfficients, at a termination. Loaded lines. Equivalent π and T networks. More advanced treatment of electrical network and transmission-line theory. Electromagnetic and electrostatic interference in lines, transposition, balancing of cables, phantom circuits. Waveguides.

Principles of operation and characteristics of thermionic valve amplifiers, oscillators, modulators, and demodulators, frequency changers and rectifiers.

Telegraph transmission; signal distortion; frequency band-width related to speed of signalling. Composite circuits; principles of multi-channel working over a single circuit using alternating current.

Telephony; characteristics of the instruments involved in the conversion of sound energy to electrical energy, and *vice versa*; sound-levels. Frequency bands required for various classes of service. Repeaters; echo-suppressors. Principles of carrier working.

Methods of measurement of amplifier gain and of the attenuation and phase constants and of the characteristic impedance of lines, cables and filters.

Papers (c) and (d) : Equipments and Circuits

Manual and machine telegraph terminal apparatus for land-line and submarine cable. Photo-telegraphy. Telegraph repeaters, including regenerative and electronic types. Principles of manual and automatic exchange switching and of subscribers' apparatus. Principles of exchange layout and cabling ; junction signalling. Routiners and routine testing. Trunking and grading. Layout and operation of multi-exchange areas. Multi-channel carrier systems. Local distribution schemes ; flexibility schemes.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least 120 hours' duration based on the prescriptions (*a*), (*b*), (*c*), and (*d*) above and that his attendance and work have been satisfactory.

Locomotive Engineering (a)

Types of locomotives.

Factors governing the selection of locomotives for different purposes, tractive force, adhesion and resistance, determination of leading dimensions, cardinal points of design, boilers including brick arches, boiler mountings, and steam-using auxiliaries including injectors, feed-pumps and feed-water heaters, lubricators, dynamos, steam-heating, regulator, boosters, mechanical stokers and oil-firing. Superheaters, spark-arresters, ash-pans, dampers, grates, smoke-boxes, blast pipe, and chimney.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Alternatively, a candidate in this subject will be required to present a certificate from his employer, and approved by the Principal of the institution attended, that he has spent a minimum of three months engaged upon the construction, repair, and maintenance of locomotives.

Locomotive Engineering (b)

The engine, including bogies, cylinders, valves and valve gears, pistons, cross heads, connecting and coupling rods, wheel-centres, tires, crank-pins, axles, axle-boxes, lubrication, compound expansion, frames, springs including compensating gear, brakes, flexibility on curves. Tanks, bunkers and tenders, superstructure. Mechanical equipment of electric locomotives and electric stock. Internal-combustion locomotives and rail cars. Testing of locomotives. Locomotive depots and maintenance of locomotives.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Alternatively, a candidate in this subject will be required to present a certificate from his employer, and approved by the Principal of the institution attended, that he has spent a minimum of six months in all engaged upon the construction, repair, and maintenance of locomotives.

Marine Engineering (a)

Steam-engines.—Types, constructional details and working principles of both reciprocating engines and turbines. Determination of i.h.p. adjustment of irregularities disclosed by indicator diagrams. Turbine gears. Valve gears. The principle of working and calibration of dynamometers and torsion meters. Types of marine boilers and their constructional details, superheaters, economizers, air-preheaters, soot-blowers, and ash-handling. Coal and oil firing. Types of oil and coal used. Boiler testing. Principles and constructional details of air and circulating pumps. Feed, bilge, sanitary, and ballast pumping systems. Evaporators, feed-water heaters, condensers, and fans. Turbo-electric drives and their control.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based upon the above prescription and that his attendance and work have been satisfactory.

Alternatively, a candidate may be granted exemption from the laboratory work if he has spent a minimum of three months in either a power-station, and/or in a vessel at sea, and/or in an engineering workshop approved by the Principal and engaged upon the construction and repair of marine engines and boilers.

Marine Engineering (b)

Internal-combustion Engines.—Types, constructional details and working principles of propelling and auxiliary internal-combustion engines. Fuels and fuel injection systems. Air-compressors. Starting and reversing arrangements. Diesel-electric drives.

Layout of engine-rooms, steering engines, winches, thrust bearings, and hydraulic couplings. Electrical machinery and installations used on ships. Refrigeration plant and systems.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based upon the above prescription and that his attendance and work have been satisfactory.

Alternatively, a candidate may be granted exemption from the laboratory work if he has spent a minimum of three months in either a power-station, and/or in a vessel at sea, and/or in an engineering workshop approved by the Principal and engaged upon the construction and repair of marine engines and boilers.

Mathematics I (a)

Algebra.—Theory of quadratics. Indices; the exponential theorem. Logarithms, decimal and natural systems, practical applications, conversion. Arithmetical and geometrical series. Binomial theorem and its application to approximations.

Co-ordinate Geometry.—Point and straight line in one plane; distance between two points; simple loci; equations of straight lines; conversion from one form into another; distance between point and straight line; angle between two straight lines.

Trigonometry.—Solution of triangles. Identities; trigonometrical equations. Inverse circular functions.

Calculus.—Functions and limits; gradient; derivatives of simple functions from first principles; application to maxima and minima.

Mathematics I (b)

Algebra.—Functions, graphical representation; solution of equations by graphs; determination of laws connecting variables (from table of given experimental data). Elementary use of determinants. Use of nomograms.

Co-ordinate Geometry.—Conic sections; derived equations of circle, ellipse, parabola, and hyperbola in rectangular co-ordinate and parametric form. Simple properties of conics.

Trigonometry.—Complex numbers; vectors; De Moivre's theorem; graphical representation of complex numbers and vectors (Argand diagram).

Calculus.—Further rules of differentiation; application to expansion in a series; theorems of McLaurin and Taylor; integration of simple functions; graphical methods of integration of simple functions; Simpson's rule; integration by parts and by expansion in a series.

Mathematics II

Co-ordinate Geometry.—Equations of tangents and normals to a given curve (by use of differentiation). Curvature and radius of curvature (with derived formula). The properties of the cycloid, involute, and catenary curves with practical application.

Trigonometry.—Hyperbolic functions; inverse hyperbolic functions; relationship to circular and logarithmic functions; application of De Moivre's theorem to trigonometrical series.

Calculus.—Partial differentiation; application to differentials and approximations. Convergance of series; Newton's interpolation formula. Applications of integration to arcs, areas, surfaces, volumes, moment of inertia, radii of gyration, centroids and centres of gravity, mean values, and root mean squares.

Fourier's series.

Differential equations; simple linear of first and second order; formation of differential equations from given conditions.

Distribution of errors; Gaussian law.

Physical Metallurgy (a)

Iron and Steel.—The production of pig-iron from its ores. Different types of pig-irons. The requirements of a satisfactory foundry practice, with particular reference to melting. Ladle additions. The effect of silicon and other alloying elements on cast iron. High-duty cast irons. The production of low-carbon steels by Bessener, open hearth and electric furnace methods. Rolling-mill practice. Forging and other hot working processes.

Elementary consideration of the structure of metals. Crystals, grains, grain size. Thermal equilibrium diagrams. Eutectics, solid solutions, phase change, binary alloys. The iron-carbon equilibrium diagram. Mechanical properties of the ferrous metals. Physical testing machines and procedure.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Physical Metallurgy (b)

Further consideration of the structure of metals. Microphotography and interpretation of results. Plasticity, creep, fatigue, and corrosion.

The effect of alloying elements in the iron-carbon alloys. Classification and uses of alloy steels. The heat treatment of steel. Carburizing and nitriding.

The more common alloys of copper, tin, zinc, nickel, aluminium, and magnesium. Binary and tertiary alloys. Heat treatment, ageing.

Foundry practice for ferrous and non-ferrous materials. Foundry sands. Die-casting, precision investment casting. Powder metallurgy.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Physics (a)

Properties of Matter.—Mass, force, weight. Velocity and acceleration; composition and resolution of vectors. Work, energy, power. Principle of moments; the balance. Elasticity; Hooke's law; Young's modulus.

Heat.—Expansion of solids, liquids, and gases. Compensation for expansion; utilization of expansion. Common thermometers, pyrometers, thermocouples, resistance pyrometers. Conduction, convection and radiation of heat. Relations between pressure, volume, and temperature of a gas; absolute temperature. Heat units. Calorimetry. Change of state; specific heat; latent heat, vapour pressure, dew-points. Determination of melting and boiling points. Regelation. Refrigeration.

Electricity and Magnetism.—Effects of electric current. Primary and secondary cells. Potential difference and electromotive force. Ohm's law. Electrical units of current, e.m.f., and resistance. Electricity and chemical change; electrolysis. Potentiometers. Wheatstone bridge. D.C. measuring-instruments. Units of energy and power and their relationships.

Production of electric charges. Electric fields. Electrostatic units. Field strength, potential, capacitance. Properties of magnets; use of alloy steels; magnetic fields, lines of force; field strength.

Light.—Propagation of light. Reflections at plane and curved surfaces. Refraction, index of refraction. Mirrors. Thin lenses; combination of lenses. Photometers. Measurement of light; units of intensity, flux, illumination and brightness. The prism; deviation; minimum deviation; dispersion.

Sound.—Sound as wave motion. Transverse and longitudinal waves. Velocity of sound in air, solids, liquids. Superposition of sound waves; reflection and refraction of sound; resonance. Interference, beats. Determination of frequency.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Physics (b)

Heat.—Heat and energy; mechanical equivalent of heat. Gas laws. Isothermal and adiabatic expansion. P/V diagrams.

Electricity and Magnetism.—Magnetic moments. Intensity of magnetization. Magnetic properties of iron and steel. Calculation of ampere turns for magnetic circuits. Electro-magnetic induction, direction and magnitude of e.m.f.; self and mutual inductance. Hysteresis; measurements of field strength and plotting of B/H curve.

Elements of A/C wave form; phase displacement, amplitude, frequency, generation of a sinusoidal e.m.f. A/C measuring instruments. Effects of inductance and capacitance.

Transmission, modulation, and reception of electro-magnetic waves. Action of diode and triode valves. Photo-electric cells. Conduction of electricity through gases. Cathode rays and x-rays.

Light.—The spectrum; colour, spectrum analysis, spectrometer.

Achromatic combination. Optical instruments, telescope, microscope, projector.

Wave theory. Interference; the bi-prism, Newton's rings. Polarization of light; double refraction. Velocity of light.

Sound.—Forced vibrations. Stationary vibrations; nodes, antinodes. Vibrations of columns of air. Vibrations of strings; the monochord. Musical instruments. The phonograph. The microphone.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least sixty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Power-supply. (Four papers—three hours each)

Paper (a) : Generation

Essential connections of main cables and control cables between generators, switchgear, and transformers ; main switchgear sectionalizing arrangements and use of reactors. Action of oil-filled, air-blast, and other types of circuit-breakers. Neutral earthing arrangements, earthing resisters and transformers. Control of voltage, frequency, and reactive loading. Parallel operation of generators. Calculation of short circuit kVA and breaking requirements of switchgear. Protective systems for generators, transformers, and bus-bars. Generator synchronizing equipment. Exciter systems, stability and control.

Transmission.—Electrical principles of the design and testing of overhead transmission-lines. Voltage distribution on insulators and insulator strings. Cable testing. Principles of operation of unearthed systems, solidly earthed systems, multiple earthed systems and Peterson coil earthed systems. Method of protection of transmission-lines, location of faults, calculation of fault currents, voltage drop and voltage rise, charging current and corona. Surges. Lightning and surge protection, sag and tension calculations, spacing of conductors, vibration, types of support, maintenance of lines and accessories.

Paper (b) : Distribution and Distribution Systems

Layout of distribution systems in cities, urban and rural areas. Use of single-phase, three-phase, and D.C. distribution. Diagram of connections of switchgear, isolators, and transformers in a substation. Voltage regulating devices and methods of power-factor adjustment. Testing and fault location in networks. Voltage regulation. Choice of conductor sizes. The operation of fuses and circuit breakers. Underground cables, types, temperatures, and spacing, Calculation of line drop by vector and symbolic methods. Effect of low-power factor. Earthing. Substation design, location, ventilation, and fire protection. Pole substations. Maintenance of substations, transformer and switchgear.

Paper (c) : Consumers' Installations

Principles, supply characteristics, and design of power, lighting, heating, and ventilating installations. Rectifiers. Battery-charging installations. Fundamental characteristics of D.C. and A.C. motors. Selection of types for different duties and requirements. Starting torque. Speed-variation, overload capacity, power factor, types of enclosure. Electric furnaces, welding-plant, electrolytic plant. Lifts and control equipment.

Conductors, switchgear, and protective installation. Supply characteristics and essential connections of electric cookers and hot-water installations. Layout of hot-water systems (space-heating, water-heating, hot-water services). Comparisons with other sources of power. Metering and tariff.

Paper (d) : Electrical Apparatus, Plant, and Machinery

Meters and Instruments.—The application, testing, and maintenance of meters, relays, and instruments.

Transformers.—Types and characteristics. Voltage control. Tap-changing equipment. Regulation. Parallel operation. Testing. Determination of efficiency. Heating. Equivalent circuit. Vector diagram. Symbolic methods, auto transformers, instrument transformers. Induction and regulating transformers.

Induction and Synchronous Induction Machines.—Types and characteristics. Speed control and pole-changing. Starting. Synchronizing. Testing. Determination of efficiency. Heating. Vector diagram. Windings.

Synchronous Machines.—Types and characteristics. Voltage control. Regulation, parallel operation starting. Synchronizing. Testing. Determination of efficiency. Heating. Vector diagram. Windings. Synchronous converter. Induction alternator.

D.C. Machines and A.C. Commutator Machines.—Types and characteristics. Voltage control. Regulation. Parallel operation. Speed-control (including Ward-Leonard). Starting. Testing. Determination of efficiency. Heating. Commutation. Windings.

Mercury-arc-Rectifiers.—Theory of operation, starting and voltage control. Number of phases. Transformer connections. Testing. Harmonics and smoothing equipment.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least 120 hours' duration based on the prescriptions (*a*), (*b*), (*c*), and (*d*) above and that his attendance and work have been satisfactory.

Radio Communication. (Four papers—three hours each)

Papers (a) and (b) : Theory and Measurements

More advanced treatment of A.C. network theory.

Class A, B, and C amplifiers. Push-pull operation. Forms of feed-back. Valve and metal rectifiers; smoothing; voltage doubling. Sine-wave and relaxation oscillators; frequency stabilization; generation of micro-waves.

Methods of modulation, amplitude, phase, frequency and pulse, and of demodulation; frequency changing. Transmission-line system for use at high radio frequencies; general theory, reflection effects; matching methods. Waveguides.

Principles of electromagnetic wave propagation and of effects arising in propagation.

Voltage and current distributions, radiation resistance and polar diagrams of simple antennæ. Principles of direction-finding; antenna systems for D.F. purposes; causes of error and their elimination.

Cathode-ray oscillography; methods of controlling focusing, brilliance and deflection; simple time-base circuits.

Methods of measurements of the characteristic impedence, attenuation and phase constants of high frequency transmission lines.

Papers (c) and (d) : Equipment and Circuits

Dielectric and magnetic materials suitable for use at radio frequencies. Radio telegraph, radio telephone, and television transmitters; characteristic features. High- and low-power modulation; carrier suppression; power-supplies.

Receivers; superheterodyne and super-regenerative types; selectivity and gain control; terminal equipment for connection of radio telephone circuits of the landline network. Causes of and methods of suppressing radio interference.

Broadcasting and directional transmitting arrays; receiving aerials; principles of mechanical design.

Simple examples of cost comparison.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least 120 hours' duration based on the prescriptions (*a*), (*b*), (*c*), and (*d*) above and that his attendance and work have been satisfactory.

Refrigeration Engineering (a)

Reversed heat engine cycles; Carnot, Joule, and Rankine.
The compression refrigerating cycle.
The properties of main refrigerants used.
The absorption cycle.
Refrigerating machines and equipment; compressors, condensers, valves, and piping for typical industrial undertakings using carbon dioxide and ammonia.
Methods of cooling; brine and brine system air cooling.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based upon the above prescription and that his attendance and work have been satisfactory.

Alternatively, a candidate may be granted exemption from the laboratory work if he has spent a minimum of three months in an industrial refrigerating-plant approved by the Principal or in an engineering workshop engaged on the construction and operation of refrigerating machines and equipment.

Refrigeration Engineering (b)

Temperature-entropy, total heat-entropy, and pressure-enthalpy diagrams for refrigerants.
Wet and dry compression, multiple compression.
Applications of refrigeration. Ice-making, liquefaction of air. Cold storage.
The heat pump.
Heat transfer; insulation of cooling-chambers.
Air cooling and conditioning.
Household refrigerators; electrolux system: dry ice; silica gel cooling systems.
Erection, operation, and testing of refrigerating plants. Safety-devices and fire protection.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based upon the above prescription and that his attendance and work have been satisfactory.

Alternatively, a candidate may be granted exemption from the laboratory work if he has spent a minimum of three months in an industrial refrigerating-plant approved by the Principal or in an engineering workshop engaged on the construction and operation of refrigerating machines and equipment.

Strength of Materials I

Simple stresses in tension, compression, shear, and torsion. Elasticity. Hooke's law. Stress due to temperature change. Bending and shearing force diagrams. Centroids and moments of inertia of plane figures. Stresses in simple beams. Bolted, welded, and riveted joints in shear and tension. Ropes, chains, and slings. Stress in thin-walled cylinders and spheres. Empirical formulæ for struts and columns. Slenderness ratio. Stress and deflection of close-coiled springs. Elementary consideration of the physical properties of cast iron and mild steels. British standard specification for iron and steel. British standard test pieces. Testing machines for tension, compression, and bending. Test procedure. Stress-strain diagrams. The testing of rope, chain, and welded joints to Marine Department requirements.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Strength of Materials II (a)

The deflection formula for simple beams by methods of double integration and moment-area. Built in and other statically indeterminate beams. Super-position. Shear force distribution in beams. Laminated leaf and coiled springs. Composite beams. Elementary consideration of reinforced-concrete beams. Combined stresses in two dimensions only. Mohr's Circle. Principal stresses.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Strength of Materials II (b)

Members subjected to combined bending, torsion, and axial loading. Euler's column theory. Rational column formulæ. Eccentric loading. Stress and strain in thin and thick-walled cylinders. Further consideration of statically indeterminate beams. Curved beams. Strain energy theory.

Further consideration of the properties of ferrous and non-ferrous metallic materials. The iron-carbon equilibrium diagram. Heat-treatment. Impact, hardness, fatigue, and creep testing. The choice of a rational working stress.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least fifteen hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Surveying and Applied Geology (a). (Two papers—three hours each)

Paper (a) : Surveying

The theory, structure, and adjustments of the principal surveying and levelling instruments, and the principles of their employment under various conditions ; errors of observations and their elimination. Chain surveys ; compass, dial, and theodolite surveys, including the adjustment of the closing errors ; plane-tabling, tacheometry.

Paper (b) ; Applied Geology

A general survey of the chief igneous, sedimentary, and metamorphic rock types, and the more important rock-forming minerals of which they are composed. Properties of rocks which render them specially suitable for purposes of construction, and typical localties from which supplies of economic value are obtained. Denudation by physical agents at the earth's surface, and the transport and deposition of sediments. Landslips, earthquakes. The common intrusive forms of igneous rocks ; lava flows.

Common geological structures and their representation on geological maps and sections ; unconformity, folds, faults, joints.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least sixty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Surveying and Applied Geology (b). (Two papers—three hours each)

Paper (a) : Surveying

Levelling and contouring ; setting-out of engineering works, triangulation and adjustments ; precise levelling ; curve-ranging. Mining surveying and simple hydrographical surveying ; principles of photographic and air surveying, and its developments. Elements of spherical trigonometry and geodetic survey.

Paper (b) : Applied Geology

The order of the systems of rocks in geological time, and methods of determining the relative ages of strata. The general character and situation of the chief New Zealand formations and the broad conditions under which they were formed. The principle economic products derived from them, such as sands, clays, fuels, and refractories, cements, buildings and road making materials. The work and facilities of the New Zealand Geological Survey.

Water-supply, underground water, surface supplies and catchment areas, the siting of dams and reservoirs. Exploratory surveys at engineering sites ; trial pits and headings ; augering ; boring ; use of magnetic, gravitational, seismic and electrical methods.

Geological considerations in the location of works of engineering construction, including foundations, excavations, tunnels, drainage.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least sixty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Theory and Design of Structures I (a)

Conditions for equilibrium. Classification of structures into statically determinate and indeterminate. Graphical and analytical methods for the determination of reactions, bending moments and shear forces. Construction of bending moment and shear force diagrams. Graphical and analytical methods for the determination of stresses in framed, determinate structures and three-hinged arches. The simple beam ; bending, shear, slope, and deflection. Stability of masonry and brickwork structures. Design and analysis of simple, reinforced-concrete beams and columns.

Theory and Design of Structures I (b)

Further consideration of slope and deflection leading to statically indeterminate beams. Columns and standard formula. Influence lines. Analysis and design of reinforced-concrete slabs, beams with single and double reinforcement, tee-beams, columns and foundations. Design of riveted and welded joints, simple beams, plate and other built up girders, struts, simple trusses.

Theory and Design of Structures II (a)

Deflection of trusses analytically and graphically. Analysis of redundant structures by methods of strain energy and virtual work. Analysis of rigid frames by moment-distribution. Codes of practice and regulations governing the design of structures. Methods of choosing design loads and working stresses. Design of simple structures in steel, timber and concrete.

Candidates will be expected to show competency in making dimensioned hand sketches in good proportion.

Theory and Design of Structures II (b)

Further applications of moment-distribution. Slope-deflection and column analogy methods. Theory of arches. Use of models. Design of more complex structures.

Candidates will be expected to show competency in making dimensioned hand sketches in good proportion.

Theory of Machines (a)

Kinematics.—Pairings, Kinematic chains, mechanisms, inversion.

Methods of determining the relative velocities of parts in machines, by calculation and by graphic methods. Simple cases of acceleration diagrams.

Gears—theory of shape and action of teeth; simple, compound, and epicyclic trains. Worm gears.

Kinetics.—Inertia forces on elements of mechanisms; gearing—strength and durability. Use of British Standard Specification No. 436, 1940.

Engine turning moment diagrams; flywheels; governors. Balancing—rotating parts; primary balancing of reciprocating parts, including locomotive balancing and secondary balancing of "in line" engines.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least fifteen hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Theory of Machines (b)

Cams.—Harmonic, constant-velocity, and constant-acceleration types; displacement, velocity, and acceleration of follower. Inertia forces on cam followers.

Vibrations.—Body with single degree of freedom; torsional oscillations of shafts with attached masses. Transverse vibrations of beams. Whirling of shafts. Forced vibrations with viscous damping: use of vector diagram for determination of amplitude.

Gyroscope.—Theory and action.

Tractive effort and performance curves for vehicles.

Friction and Lubrication.—"Dry" friction; friction circle, plate and cone clutches screws and pivots.

Belt and rope drives.

Elementary qualitative treatment of boundary and film lubrication applied to journal and thrust bearings.

General characteristics of ball and roller bearings.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Workshop Practice

It is recommended that as far as possible in each stage the work attempted should be associated with a production job. For example, in the first year individual projects such as engineering tools should be provided to cover the operations set out in the syllabus.

In the subsequent stages more ambitious projects such as small drill presses, bench lathes and shaping machines would provide a good range of work to cover the syllabus. These projects may be either individual or group efforts.

Workshop Practice I

The syllabus of work to be attempted is set forth in the following sections:—

(1) The care and use of hand tools for marking out and bench work and elementary machine work.

(2) Marking out—

(*a*) A steel or cast-iron component for machining, in which the following operations are planned : facing by turning, milling or other general machining method, drilling, boring and counter-boring.

(*b*) A plate gauge demanding the use of height gauge, bevel protractor or combination set and other marking out equipment.

(3) Fitting and bench work—

(*a*) The fitting of two mating parts requiring the use of chisels, files, scrapers, drills, reamers, hand taps, stocks and dies, in which the important dimensions are to tolerances recognized in good class practice.

(*b*) The soldering, brazing and the welding of simple lap or butt joint with steel or copper plate.

(4) Elementary machine work, including the use of the drilling machine, lathe and shaping machine.

There will be no examination in this subject, but a candidate in the subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Workshop Practice II (a)

(See note heading syllabus in this subject in second year course)

The syllabus of work to be followed is set forth in the following sections :—

(1) The care and use of all hand tools and gauges for marking out and setting-up of machine shop work.

(2) *Tool-grinding*—The hand grinding of a representative selection of single-point tools to standard shapes and angles for specified machining operations.

Turning—Central lathe turning and boring, including chucking operations with both three- and four-jaw chucks. Taper turning. The cutting of a single-start Whitworth or square thread.

Milling—The milling of flat surfaces, and of vee-grooves, slots or key-ways in which the widths and spacings are to tolerances recognized in good class practice.

Shaping, Planing, or Slotting—The machining of flat faces, with vee-grooves, tee-slots, or other work requiring similar operations.

Grinding—

(*a*) External (parallel and taper) or internal (cylindrical) grinding.

(*b*) Surface grinding of parallel faces, to tolerances and finish recognized in good class practice.

Heat Treatment—The preparation and heat treatment of a typical selection of plain carbon or alloy steel cutting tools for hand or machine work.

There will be no examination in this subject, but a candidate in the subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Workshop Practice II (b)

(See note heading syllabus in this subject in second year of course)

The syllabus of work to be attempted is set forth in the following sections:—

(1) The marking off, setting up, and machining in a lathe, of a casting, forging, or fabricated part requiring at least two settings for accurate relationship of bores or surfaces. At least one of the operations should require the use of face and angle plate.

(2) Layout of operations, and setting-up of a typical multi-tool capstan or turret lathe, for the production of a part requiring, as far as possible, full use of the tooling available. Either collet or chucking capstan would be suitable.

(3) Machining to appropriate limits a number of parts forming an assembled unit, such as a "tool-maker's jack," embodying as many as possible of the following operations: surfacing, facing, recessing, boring and screw cutting (internal and external). The parts should be, as far as possible, of different materials.

(4) The machining of a component on a universal milling-machine in which a variety of operations and cutters is used. The work should include indexing and, if possible, some spiral milling.

(5) The grinding of a component on a cylindrical grinding machine, fitted with internal grinding attachment, in which internal and external grinding of parallel and taper work to toolroom limits is required, or, alternatively, work of equivalent standard on a surface grinder or tool and cutter grinder.

(6) The machining of a component (steel or cast iron), such as a simple milling fixture, requiring the following operations: planing or shaping, drilling, reaming, and counterboring.

(7) The assembly of a mechanism requiring accurate alignment, the fitting of bearings, and various drilling, reaming, tapping, and dowelling operations.

(8) The production of a set of workshop gauges comprising plug, gap and recess limit gauges, for checking a component to British standard specifications and recommendations. Suitable gauge blanks should be provided, but all heat treatment and finishing processes should be carried out.

(9) Manufacture of a simple press tool, such as a "drop-through" type blanking tool with fixed stripping plate.

The syllabus covers a wide range of operations, and, although it may not be possible to treat it completely in the time allowed, it is recommended that as much as possible should be attempted.

There will be no examination in this subject, but a candidate in the subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least thirty hours' duration based on the above prescription and that his attendance and work have been satisfactory.

Workshop Technology

(1) *Materials.*—The composition, physical properties, and engineering uses of the more common metals and their alloys, such as cast iron, wrought iron, malleable iron, mild steel, medium-carbon steel, copper, gunmetal, brass, phosphor bronze, bearing metals, and light alloys.

Tool steels, carbon and high-speed steels, and special tool alloys; their suitability for different kinds of tools.

Market forms of supply and relative costs—*e.g.*, castings, forgings, drop forgings, bars, sheets, plates, rods, wire.

(2) *Heat Treatment.*—The relation between heat treatment and the physical properties of plain carbon steels. The effect of carbon. Critical temperatures. Hardening, tempering, annealing, normalizing, and case-hardening. Types of furnaces. Temperature measurement and control. Quenching media.

(3) *Manufacturing Processes.*—An outline of the preparatory processes for forming materials—*e.g.*, pattern making, moulding, and casting; forging, spring-making, drop stamping and die-casting; rolling and drawing metal bars; dishing, drawing, and embossing sheet metal; sheet-metal work, including pressing, spinning, extruding; riveting and general principles of boiler-making; brazing and soldering; welding and cutting by arc and oxy-acetylene blow-pipe flame; gear-manufacture.

(4) *Measuring, Gauging, Inspection.*—General principles of interchangeable production and limit gauging. B.S.I. and N.Z. Standards. Systems of limits and fits for plain and screwed work. Tolerances, limits; clearance, interference, and transition fits. Tolerances associated with different machining operations.

Types of limit gauges. Advantages of adjustable gauges. Measuring equipment. Construction, care, and use of surface plates, straight-edges, squares, micrometers (external and internal), vernier calipers, and height gauges, dial gauges, rules, and protractors. Basic standard of length. Imperial standard yarn. International standard metre. Conversion factor. Standard and workshop end gauges; their accuracies and uses.

(5) *Cutting Tools.*—Cutting action of tools such as hand tools; lathe tools (including tipped tools); drills; reamers; milling cutters; dies; taps; tool angles for different materials and purposes; measurement of tool angles. Cutting speeds and feeds. Estimation of machining times.

(6) *Machine Tools.*—Fundamental principles in the production of machine surfaces. Copying or forming and generating. Principal features of construction and functions of the more important general purpose machines, such as lathes; sensitive, vertical, and radial drilling machines; shaping, slotting, planing, and boring machines; plain milling machines and accessories; capstan and turret lathes; grinding and lapping machines. Chatter and the use of steadies.

Lubrication. Types of lubricants. Types and uses of cutting oils and solutions. Selection and methods of application.

(7) *Safety Measures.*—Sources of danger and methods of protection. Types of guards and safety devices. New Zealand regulations.

(8) *Operation Planning.*—Planning the operation layout, and estimation of floor-to-floor times for simple machined parts.

A candidate in this subject will be required to present a certificate from the Principal of the institution attended that he has carried out a course of practical work of at least forty-five hours' duration based on the above prescription and that his attendance and work have been satisfactory.

APPENDICES

APPENDIX 1—LIST OF INSTITUTIONS AND ORGANIZATIONS GIVING EVIDENCE

Auckland University College—
- Council.
- Dean and staff of School of Engineering.
- Engineering Students' Society.

British Institution of Mechanical Engineers (through Local Honorary Secretary).

Canterbury University College—
- Council.
- Dean and staff of National School of Engineering.
- Engineering Students' Society.

Christchurch Technical College.
Education Department.
Engineers and Assistants' Association.
Engineers Registration Board of New Zealand.
Hutt Valley Memorial Technical College, Petone.
King Edward Technical College, Dunedin.
New Zealand Institute of Industrial Management.
New Zealand Institute of Marine and Power Engineers.
New Zealand Institute of Refrigeration.
New Zealand Institution of Engineers.
New Zealand Post and Telegraph Department's Engineers' Association.
New Zealand Secondary Schools' Association.
New Zealand Technical School Teachers' Association.
Post and Telegraph Department.
Professional Engineers' Association of New Zealand.
Seddon Memorial Technical College, Auckland.
Wellington Technical College.

The Committee is also indebted to a number of professional engineers and other interested persons who gave evidence in their private capacity.

APPENDIX 2—THE DEGREE OF BACHELOR OF ENGINEERING (B.E.) *

(Extracted from the New Zealand University Calendar, 1948, pages 194–202)

NOTE.—Students who propose to take the B.E. degree should include the following subjects in their school courses: English, Mathematics, and Physics or Chemistry or Mechanics:—

I. Every candidate for the Degree of Bachelor of Engineering must matriculate and thereafter follow the prescribed course of study (keeping terms in accordance with the Statute "Terms and Lectures") and pass the examinations hereinafter prescribed.

II. Subject to the provisions of the Statute "Conduct of University Examinations," every candidate for an Intermediate Examination shall send in his name to the Registrar, together with the fee, not later than the tenth day of June preceding the examination.

III. Subject to the provisions of the Statute "Conduct of University Examinations," every candidate for a professional examination shall send in his name to the Registrar, together with the fee, not later than the tenth day of May preceding the examination.

IV. Subject in each case to the provisions of the Statute "Conduct of University Examinations," the fee for examination shall be that prescribed in the Statute "Fees."

* NOTE.—Candidates who in 1944 have already entered on the course for the Degree of Bachelor of Engineering and who desire to complete under the regulations in force in that year shall be allowed up to and including the examination of 1949 to do so.

COURSES

V. A candidate who has satisfied the requirements in a subject of a University examination where the standard in the subject was not lower, and where the prescription in the subject was substantially the same as it was for the Bachelor of Engineering when the candidate entered upon the Engineering Course, shall be exempt from examination in that subject for the Degree of Bachelor of Engineering.

A candidate for the Degree of Bachelor of Engineering (Mechanical or Civil) who has passed Electrical Engineering I shall be granted exemption in the subject Applied Electricity, provided he has performed to the satisfaction of his teacher the complete course of laboratory work prescribed for Applied Electricity.

(A candidate taking B.Sc. and B.E. concurrently or a candidate proceeding to B.Sc. degree after having passed the examinations for the B.E. degree should read Section VII of the Statute "The Degree of Bachelor of Science.")

VI. The following optional subjects from the course for the degree of Bachelor of Commerce may be taken under the conditions herein provided.

In the Mechanical or Civil Courses (Second Professional), instead of Engineering Mathematics III a candidate may present either Economics I, or Book-keeping and Accounts I and Mercantile Law I, provided that a candidate who selects the latter option will be allowed no option from B.Com. subjects in the Third Professional Examination.

If a candidate has taken Engineering Mathematics III in his Second Professional he may, in his Third Professional Examination, offer Economics I or Book-keeping and Accounts I and Mercantile Law I in place of Subject 5 if he is taking the Mechanical Course ; and in place of either Surveying III or Theory of Structures II if he is taking the Civil Course.

If a candidate has offered Economics I for his Second Professional in place of Mathematics III, he may offer Advanced Economics and Book-keeping and Accounts I and Mercantile Law I in place of subject 5 if he is taking the Mechanical course and in place of either Surveying III or Theory of Structures II if he is taking the Civil Course.

VII. A candidate may not proceed to a First Professional Examination either complete or in part until he has passed in all or all but one of the subjects of the Intermediate Examination.

VIII. A candidate may not offer any part of a Second Professional Examination until he has completed the Intermediate Examination, nor any part of a Third Professional until he has completed the First Professional.

IX. A candidate who has failed in one subject only of a First or Second Professional Examination may, if the Dean gives a certificate of approval, present himself in that subject together with the subjects of the succeeding complete Professional Examination.

X. Except as provided in Section IX, a candidate who requires to pass in one or two subjects to complete a Professional Examination, may, with the consent of the Dean, offer such subjects either alone or together with portion of the next succeeding Professional Examination, provided that the total number of subjects offered does not exceed the total number of subjects in such next succeeding Professional Examination and that the subjects offered shall include all the subjects of the previous Professional Examination in which he has not already been credited with a pass.

XI. Except as provided in Section XVII hereof, no candidate shall offer and no candidate may be credited with fewer than two subjects at a time, except when a subject is the last remaining one required to complete an examination, provided that a candidate for a Third Professional Examination who has to pass in only two subjects to complete the Examination may be credited with a pass in either of them.

XII. No candidate shall offer two stages of the same subject at the same time. Engineering Mathematics II is a further stage of Engineering Mathematics I, Engineering Mathematics III of Engineering Mathematics II, Heat Engines II of Heat Engines I, Engineering Drawing and Design II, (Mechanical, Electrical, Civil) of Engineering Drawing and Design I, Electrical Engineering II of Electrical Engineering I, Surveying II of Surveying I, Surveying III of Surveying II, and Theory of Structures II of Theory of Structures I, Mining II of Mining I, Mine Surveying II of Mine Surveying I, Mine Surveying III of Mine Surveying II, Metallurgy II of Metallurgy I.

XIII. A candidate for a Mechanical, Electrical, or Civil Degree who has failed in any subject of a Professional Examination must, before presenting himself for re-examination in that subject, follow a course of instruction to the satisfaction of the Professor of that subject. When a student has qualified to pass in any subject of a Professional Examination, but owing to failure in other subjects is unable to receive credit for this subject, he may be required by the Dean of the Faculty of Engineering, after consultation with the Professor in whose department the subject is taught, to receive further instruction before presenting himself again for examination.

PRACTICAL WORK

XIV. Before completing the First Professional Examination each student shall, except in circumstances approved by the Dean, have performed a course of practical workshop training to the satisfaction of the Dean. Before obtaining his degree, every candidate must present a certificate signed by the Dean of the Faculty of a recognized Engineering School that after meeting the University Entrance requirements the candidate has spent to the satisfaction of the Faculty, time in practical work as follows :—

1. Mechanical Engineering—nine months in approved workshops.
2. Electrical Engineering—six months in approved workshops and three months either in approved workshops or in approved practice.
3. Civil Engineering—six months in approved workshops and three months in approved practice.
4. Chemical Engineering—six months in approved workshops and three months in approved industrial works.
5. Mining Engineering—twelve months partly in metal and partly in coal mines.
6. Metallurgical Engineering—nine months in metallurgical works.

In the case of a student who has done practical work before entering on his course, the Faculty may, at its discretion, take this time into consideration in determining any further time required.

Candidates must also present a First Aid Certificate from the St. John Ambulance Association.

HONOURS IN ENGINEERING

(Mechanical—Electrical—Chemical—Civil)

XV. Every candidate for the Degree of Bachelor of Engineering with Honours must matriculate and thereafter follow the prescribed course of study during at least five years :—

(i) After a candidate has completed the Second Professional his progress will be reviewed and only if he has obtained high average marks in the First and Second Year Professional Examinations and has been approved by the Faculty will he be allowed to proceed to the Honours course.

(ii) Before the award of Honours to a candidate, he shall submit a thesis giving the results of original work on some branch of engineering or on some approved experimental work.

(iii) The length of period for the preparation of the thesis shall normally be from February to November, inclusive, and the work shall be entirely under the direction of the Professor of the subject.

SUBJECTS OF EXAMINATION

Bachelor of Engineering—Mechanical, Electrical, Chemical, Civil

Intermediate Examination

XVI. The subjects of the Intermediate Examination shall be :—

1. Pure Mathematics, as for B.A. I. (Two papers.)
2. Applied Mathematics, as for B.A. I. (Two papers).
3. Physics, as for B.A. I. (Two papers.)
4. Chemistry, as for B.A. I. (Two papers.)

XVII. A candidate will be credited with any subject passed in the Intermediate Examination.

A candidate who has failed in this Intermediate Examination in Physics or in Chemistry, shall, before presenting himself again for examination in that subject, follow such a course of instruction in theoretical and practical work as may be required by the Professorial Board.

Note.—Terms in the subjects of this Intermediate Examination may be kept at any constituent College.

Professional Examinations

A. *Bachelor of Engineering—Mechanical*

XVIII. *First Professional Examination :—*

1. Engineering Mathematics II. (One paper.)
2. Chemistry of Engineering Materials. (One paper.)
3. Surveying I. (One paper.)
4. Descriptive Geometry. (One paper.)
5. Applied Mechanics. (Two papers.)

XIX. *Second Professional Examination :—*

1. Engineering Mathematics III. (One paper.)
2. Heat Engines I. (One paper.)
3. Applied Electricity. (One paper.)
4. Strength of Materials in Construction. (One paper.)
5. Engineering Drawing and Design I. (Two papers.)

XX. *Third Professional Examination :—*
1. Heat Engines II. (One paper.)
2. Hydraulics and Pneumatics. (One paper.)
3. Theory of Workshop Practice. (One paper.)
4. Engineering Drawing and Design II (Mech.). (One paper.)
5. One of the following :—

   Naval Architecture and Marine Engineering. (One paper.)
   Production Engineering and Works Management. (One paper.)
   Engineering Applied to Arts and Manufacture. (One paper.)
   Automotive Engineering. (One paper.)
   Aeronautical Engineering. (One paper.)

B. *Bachelor of Engineering—Electrical*

First Professional as for B.E. (Mech.).

XXI. *Second Professional Examination :—*
1. Engineering Mathematics III. (One paper.)
2. Heat Engines (one paper) or Theory of Structures I (one paper).
3. Electrical Engineering I. (One paper.)
4. Strength of Materials in Construction. (One paper.)
5. Engineering Drawing and Design I. (Two papers.)

XXII. *Third Professional Examination :—*
1. Hydraulics and Pneumatics. (One paper.)
2. Theory of Workshop Practice. (One paper.)
3. Engineering Drawing and Design II (Elect.). (One paper.)
4. Electrical Engineering II. (Two papers.)

C. *Bachelor of Engineering—Civil*

First Professional as for B.E. (Mech.).

XXIII. *Second Professional Examination :—*
1. Engineering Mathematics III. (One paper.)
2. Surveying II. (One paper.)
3. Applied Electricity. (One paper.)
4. Strength of Materials in Construction. (One paper.)
5. Theory of Structures I. (One paper.)
6. Engineering Drawing and Design I. (Two papers.)

XXIV. *Third Professional Examination :—*
1. Hydraulics and Pneumatics. (One paper.)
2. Engineering Drawing and Design II (Civil). (One paper.)
3. Principles of Civil Engineering. (Two papers.)
4. Surveying III (one paper) or Theory of Structures II (one paper).
5. Physical Geology. (One paper.)

D. *Bachelor of Engineering—Chemical*

First Professional Examination as for B.E. (Mech.)

XXV. *Second Professional Examination :—*
1. Engineering Mathematics III. (One paper.)
2. Applied Electricity. (One paper.)
3. Strength of Materials. (One paper.)
4. Engineering Drawing and Design I. (Two papers.)
5. Theory of Workshop Practice. (One paper.)
6. Chemistry II, as for B.A. (Two papers.)

XXVI. *Third Professional Examination :—*
1. Heat Engines. (One paper.)
2. Chemistry III, as for B.A. (Three papers.)
3. Applied Chemistry, as for B.Sc. (Two papers.)
4. Elementary Economic Geology. (One paper.)

XXVII. *Fourth Professional Examination :—*
1. Advanced Applied Chemistry. (Two papers.)
2. Hydraulics and Pneumatics. (One paper.)
3. Engineering Drawing and Design II (Mech.). (One paper.)
4. Industrial Microbiology. (One paper.)

E. *The Degree of Bachelor of Engineering With Honours*

Mechanical.—First, Second, and Third Professional Examinations as for B.E. (Mech.).

XXVIII. *Fourth Professional Examination :—*

1. Engineering Mathematics IV. (One paper.)
2. Advanced Properties of Materials. (One paper.)

Electrical.—First and Second Professional Examinations as for B.E. (Elect.).

XXIX. *Third Professional Examination :—*

1. Electrical Engineering II. (Two papers.)
2. Theory of Workshop Practice. (One paper.)
3. Hydraulics and Pneumatics. (One paper.)

XXX. *Fourth Professional Examination :—*

1. Engineering Mathematics IV. (One paper.)
2. Physics III, as for B.A. (Two papers.)

Civil.—First, Second, and Third Professional Examinations as for B.E. (Civil).

XXXI. *Fourth Professional Examination :—*

1. Engineering Mathematics IV. (One paper.)
2. Engineering Geology. (One paper.)

A candidate may take Engineering Mathematics IV together with the subjects of the Third Professional Examination and complete the course by taking the remaining Fourth Professional subject by itself.

Chemical.—First, Second, Third, and Fourth Professional Examinations as for B.E. (Chem.).

XXXII. *Fifth Professional Examination :—*

1. Engineering Mathematics IV. (One paper.)
2. Physical Chemistry, as for M.A. (One paper.)

Bachelor of Engineering—Mining, Metallurgical

Intermediate Examination

XXXIII. The subjects of the Intermediate Examination shall be—

1. Pure Mathematics, as for B.A. I. (Two papers.)
2. Applied Mathematics, as for B.A. I (two papers) or Geology, as for B.A. I (two papers).
3. Physics, as for B.A. I. (Two papers.)
4. Chemistry, as for B.A. I. (Two papers.)

XXXIV. A candidate who has failed in this Intermediate Examination in Physics or Chemistry or Geology shall, before presenting himself again for examination in that subject, follow such a course of instruction in theoretical and practical work as may be required by the Professorial Board.

Note.—Terms in the subjects of this Intermediate Examination may be kept at any constituent College.

Professional Examinations

F. *Bachelor of Engineering—Mining*

XXXV. *First Professional Examination :—*

1. Freehand Mechanical Drawing. (One paper.)
2. Descriptive Geometry. (One paper.)
3. Geology, as for B.A. I (two papers) or Applied Mathematics as for B.A. I (two papers), (the option not taken in the Intermediate Examination).
4. Mineralogy. (One paper.)
5. Surveying I. (One paper.)

XXXVI. *Second Professional Examination :—*

1. Ore Dressing. (One paper.)
2. Applied Mechanics relating to Mining. (Two papers.)
3. Heat Engines I. (One paper.)
4. Mechanical Drawing. (Two papers.)
5. Mining I. (Two papers.)
6. Mine Surveying II. (One paper.)

XXXVII. *Third Professional Examination* :—
1. Mining II. (Two papers.)
2. Mine Surveying III. (One paper.)
3. Economic Geology. (One paper.)
4. Petrology. (One paper.)
5. Applied Electricity (One paper.) Assaying (certificate only).

G. *Bachelor of Engineering—Metallurgical*

First Professional Examination as for B.E. (Mining).

XXXVIII. *Second Professional Examination* :—
1. Ore Dressing. (One paper.)
2. Applied Mechanics relating to Mining. (Two papers.)
3. Heat Engines I. (One paper.)
4. Mechanical Drawing. (Two papers.)
5. Metallurgy I. (Two papers.)

XXXIX. *Third Professional Examination* :—
1. Metallurgy II. (Two papers.)
2. Economic Geology. (One paper.)
3. Assaying and Laboratory Work. (Two papers.)
4. Applied Electricity. (One paper.)

APPENDIX 3—PROFESSIONAL SUBJECTS FOR THE BACHELOR OF ENGINEERING DEGREE AVAILABLE AT THE NATIONAL SCHOOL OF ENGINEERING, CANTERBURY UNIVERSITY COLLEGE

(Extracted from the 1948 Prospectus of the National School)

PROFESSIONAL EXAMINATIONS

First Professional Examination

Examination Subjects :—
1. Engineering Mathematics II. (One paper.)
2. Chemistry of Engineering Materials. (One paper.)
3. Surveying I. (One paper.)
4. Descriptive Geometry. (One paper.)
5. Applied Mechanics. (Two papers.)

Course Subjects.—Engineering Mathematics II ; Chemistry of Engineering Materials ; Surveying I, with Field Work ; Descriptive Geometry ; Applied Mechanics with Problems and Laboratory ; Elementary Fluid Mechanics ; Elementary Strength of Materials ; Elementary Theory of Workshop Practice ; Elementary Heat Engines ; Applied Electricity ; and Mechanical Drawing.

Second and Third Professional Examinations

A. *Mechanical—Second Professional Examination* :—
1. Engineering Mathematics III. (One paper.)
2. Heat Engines I. (One paper.)
3. Applied Electricity. (One paper.)
4. Strength of Materials in Construction. (One paper.)
5. Engineering Drawing and Design I. (Two papers.)

Course Subjects.—Engineering Mathematics III ; Heat Engines I, with Problems ; Applied Electricity Problems and Laboratory ; Strength of Materials, with Problems and Laboratory ; Properties of Materials ; Engineering Drawing.

A. *Mechanical—Third Professional Examination* :—
1. Heat Engines II. (One paper.)
2. Hydraulics and Pneumatics. (One paper.)
3. Theory of Workshop Practice. (One paper.)
4. Engineering Drawing and Design II (Mech.). (Fifteen days' paper.)
5. One of—
   - Naval Architecture and Marine Engineering. (One paper.)
   - Works Management and Production Engineering. (One paper.)
   - Engineering Applied to Arts and Manufacture. (One paper.)
   - Automotive Engineering. (One paper.)
   - Aeronautical Engineering. (One paper.)

Course Subjects.—Heat Engines II, with Problems and Laboratory ; Hydraulics, with Problems and Laboratory ; Theory of Workshop Practice ; Mechanical Drawing and Design ; Advanced Applied Mechanics and one optional subject as above.

B. *Electrical—Second Professional Examination* :—
1. Engineering Mathematics III. (One paper.)
2. Heat Engines (one paper) or Theory of Structures I (one paper).
3. Electrical Engineering I. (One paper.)
4. Strength of Materials in Construction. (One paper.)
5. Engineering Drawing and Design I. (Two papers.)

Course Subjects.—Engineering Mathematics III; Heat Engines, with Problems and Laboratory, or Theory of Structures I, with Problems: Electrical Engineering I, with Laboratory; Applied Electronics I, with Laboratory; Strength of Materials, with Problems and Laboratory; Properties of Materials; Engineering Drawing.

B. *Electrical—Third Professional Examination* :—
1. Hydraulics and Pneumatics. (One paper.)
2. Theory of Workshop Practice. (One paper.)
3. Engineering Drawing and Design II (Elect.). (Fifteen days' paper.)
4. Electrical Engineering II. (Two papers.)

Course Subjects.—Hydraulics, with Problems and Laboratory; Theory of Workshop Practice; Electrical Drawing and Design; Electrical Engineering II, with Problems and Laboratory; Applied Electronics II, with Laboratory.

C. *Civil—Second Professional Examination* :—
1. Engineering Mathematics III. (One paper.)
2. Surveying II. (One paper.)
3. Applied Electricity. (One paper.)
4. Strength of Materials in Construction. (One paper.)
5. Theory of Structures I. (One paper.)
6. Engineering Drawing and Design I. (Two papers.)

Course Subjects.—Engineering Mathematics III, Surveying II, with Problems, Field Work, and Camp; Applied Electricity Problems and Laboratory; Strength of Materials, with Problems and Laboratory; Properties of Materials; Theory of Structures I, with Problems; Engineering Drawing.

C. *Civil—Third Professional Examination* :—
1. Hydraulics and Pneumatics. (One paper.)
2. Engineering Drawing and Design II (Civil). (Fifteen days' paper.)
3. Principles of Civil Engineering. (Two papers.)
4. Surveying III. (One paper.)
5. Physical Geology. (One paper.)
6. Theory of Structures II. (One paper.)

Course Subjects.—Hydraulics, with Problems and Laboratory; Civil Drawing and Design; Principles of Civil Engineering; Surveying III, with Problems, and Project; Theory of Structures II, with Problems; Physical Geology.

D. *Chemical—Second Professional Examination* :—
1. Engineering Mathematics III. (One paper.)
2. Applied Electricity. (One paper.)
3. Strength of Materials in Construction. (One paper.)
4. Engineering Drawing and Design I. (Two papers.)
5. Theory of Workshop Practice. (One paper.)
6. Chemistry II, as for B.A. (Two papers.)

Course Subjects.—Engineering Mathematics III; Applied Electricity, with Problems and Laboratory; Strength of Materials, with Problems and Laboratory; Properties of Materials; Engineering Drawing; Theory of Workshop Practice; Chemistry II with Laboratory.

D. *Chemical—Third Professional Year* :—
1. Heat Engines. (One paper.)
2. Chemistry III as for B.A. (Three papers.)
3. Applied Chemistry as for B.Sc. (Two papers.)
4. Elementary Economic Geology. (One paper.)

Course Subjects.—Heat Engines, with Problems and Laboratory; Chemistry III, with Problems and Laboratory; Applied Chemistry, with Laboratory; Economic Geology.

D. *Chemical—Fourth Professional Examination* :—
1. Advanced Applied Chemistry. (Two papers.)
2. Hydraulics and Pneumatics. (One paper.)
3. Engineering Drawing and Design II (Mech.). (Fifteen days' paper.)
4. Industrial Microbiology. (One paper.)

Course Subjects.—Advanced Applied Chemistry, with Laboratory; Hydraulics, with Problems and Laboratory; Mechanical Drawing and Design; Industrial Microbiology; Theory of Structures (one term).

A. *Honours Mechanical—Fourth Professional Examination* :—
1. Engineering Mathematics IV. (One paper.)
2. Advanced Properties of Materials. (One paper.)

B. *Honours Electrical—Fourth Professional Examination* :—
1. Engineering Mathematics IV. (One paper.)
2. Electrical Engineering III. (One paper.)

C. *Honours Civil—Fourth Professional Examination* :—
1. Engineering Mathematics IV. (One paper.)
2. Engineering Geology. (One paper.)

D. *Honours Chemical—Fifth Professional Examination* :—
1. Engineering Mathematics IV. (One paper.)
2. Physical Chemistry, as for M.A. (One paper.)

PRACTICAL WORK

Faculty Requirements

Approval of the particular workshop or other place of practical work must be obtained from the Dean before the student commences work at the place. The total practical time can be worked out in a variety of shops if the student so desires and approval is obtained. Work done in the drawing office attached to a workshop, or in supervision of work, cannot be counted as workshop time.

This practical work, like laboratory work, is an essential part of all degree courses. The habit of close observations of—

1. Trade Practices,
2. Labour Conditions, Foremanship and Human Nature,
3. Details of Machinery and Equipment,—

should be formed very early in the student's career and will soon prove invaluable in later application of theoretical training, and eventually in the practice of the profession.

For each unbroken period of practical work in shop or approved practice the student should submit to the Dean a report on the work done and observed. This report will be retained by the school, and the student should prepare a duplicate if he wishes to keep a copy for himself. Each employer will be asked to submit a report on the student covering the period of his employment, stating the number of hours worked and the progress made. Time will be granted by the Faculty on the basis of the employer's report, and each 160 hours of work will be credited as one month, provided that no actual week's work will be credited as more than fifty hours.

Government Workshops

A limited number of students can, by arrangement with Government Departments, carry out their practical time at approved Government workshops, and this experience is recommended. As in other workshops, students are expected to attend full working-hours and are paid for their work. All arrangements must be made through the Dean.

APPENDIX 4—PROFESSIONAL SUBJECTS FOR THE BACHELOR OF ENGINEERING DEGREE AVAILABLE AT AUCKLAND UNIVERSITY COLLEGE SCHOOL OF ENGINEERING

(Extracted from the 1948 Prospectus of Auckland University College School of Engineering)

A. B.E. MECHANICAL, CIVIL, ELECTRICAL AND CHEMICAL

Subjects limited to certain courses only are indicated by brackets.

First Professional Course :—
Engineering Mathematics II.
Surveying I.
Descriptive Geometry,
Applied Mechanics.
Chemistry of Engineering Materials.
*Preliminary Heat Engines.
*Preliminary Engineering Drawing.
* Workshop.
* Workshop Technology (Chemical).
* Applied Electricity without laboratory (Electrical).

* No degree examination, but terms must be kept.

Second Professional Course :—

Engineering Mathematics III.
Strength of Materials.
Engineering Drawing I.
Applied Electricity (Mechanical, Civil and Chemical) or Electrical Engineering I (Electrical).
Theory of Structures I (Electrical and Civil) or Heat Engines I (Mechanical and Electrical) or Theory of Workshop Practice (Chemical).
* Workshop Technology or Chemistry II (Chemical).
Surveying II (Civil).

Third Professional Course (Mechanical) :—

Heat Engines II.
Hydraulics and Pneumatics.
Theory of Workshop Practice.
Engineering Drawing and Design II.
One of the following :—

- Naval Architecture and Marine Engineering.
- Production Engineering and Works Management.
- Engineering Applied to Arts and Manufacture.
- Automotive Engineering.
- Aeronautical Engineering.

Third Professional Course (Chemical) :—

Heat Engines I.
Chemistry III.
Applied Chemistry.
Elementary Economic Geology.

The Third Professional Course in Electrical and Civil Engineering is taken at Christchurch.

Fourth Professional Course B.E. Degree with Honours (Mechanical) :—

Engineering Mathematics IV.
Advanced Properties of Materials.
A thesis.

B. B.E. MINING AND METALLURGICAL

First Professional Course :—

Freehand Mechanical Drawing.
Descriptive Geometry.
Geology or Applied Mathematics.
Mineralogy.
* Preliminary Drawing.
* Preliminary Heat Engines.

Second Professional Course (Mining and Metallurgical) :—

Ore Dressing.
Applied Mechanics relating to Mining.
Heat Engines I.
Mechanical Drawing.
Applied Electricity.
Quantitative Chemical Analysis (Inorganic. Certificate only).

The Third Professional Course is taken at Dunedin.

---

*No degree examination, but terms must be kept.

APPENDIX 5—SECTION A EXAMINATIONS OF THE BRITISH INSTITUTIONS OF CIVIL, ELECTRICAL AND MECHANICAL ENGINEERS AND THE ENGINEERS REGISTRATION BOARD OF NEW ZEALAND (1948)

Civil.		Electrical.		Mechanical.	
Institution.	Registration Board.	Institution.	Registration Board.	Institution.	Registration Board.
English (*a*).	..	English (*a*).	..	English (*a*).	..
Part I 1. Mathematics. 2. Applied Mechanics. 3. Applied Heat (with Light and Sound). 4. Principles of Electricity. *Part II* 5. (*a*) Theory of Structures *or*, (*b*) Theory of Machines.	1. Mathematics. 2. Applied Mechanics. 3. Applied Heat (with Light and Sound). 4. (*a*) Principles of Electricity *or*, (*b*) Workshop Technology. 5. (*a*) Theory of Structures *or*, 5. (*b*) Theory of Machines.	1. Mathematics. 2. Applied Mechanics. 3. Applied Heat (with Light and Sound). 4. Principles of Electricity.	As for Civil.	1. Mathematics. 2. Applied Mechanics. 3. Engineering Drawing. 4. Two of the following— (*a*) Applied Heat. (*b*) Principles of Electricity. (*c*) Physics (Heat, Light, Sound, Electricity, and Magnetism). (*d*) Chemistry. (*e*) Workshop Technology. NOTE.—4 (*c*) not to be presented with 4 (*a*) or 4 (*b*).	As for civil, but substituting Engineering Drawing for 5 (*a*) or 5 (*b*).

(*a*) A candidate who has passed in English in the Common Preliminary Examination or in some other approved examination is granted exemption in this subject for Section A.

APPENDIX 6—SECTION B EXAMINATIONS OF THE BRITISH INSTITUTIONS OF CIVIL, ELECTRICAL, AND MECHANICAL ENGINEERS AND THE ENGINEERS REGISTRATION BOARD OF NEW ZEALAND (1948)

1. CIVIL

A. Institution of Civil Engineers

(i) Engineering Drawing.
(ii) Engineering Materials.
(iii) Three subjects (*a*), (*b*), and (*c*) from any one of the following nine groups :—

Group I—Constructional and Public Works Engineering—
(*a*) Theory and Design of Structures.
(*b*) Surveying and Applied Geology.
(*c*) Hydraulics or Building Construction or Machine Design.

Group II—Mechanical Engineering—
(*a*) Machine Design.
(*b*) Thermodynamics and Heat Engines.
(*c*) Hydraulics, or Design of Structures, or Heating and Ventilating, or Electrical Machinery, Principles and Practice.

Group III—Electrical Engineering—
(*a*) Electrical Machinery, Principles and Practice.
(*b*) Electrical Transmission or Electrical Communications.
(*c*) Machine Design, or Hydraulics, or Thermodynamics and Heat Engines, or Design of Structures.

Group IV—Structural and Building Engineering—
(*a*) Theory and Design of Structures.
(*b*) Building Construction.
(*c*) Surveying and Applied Geology or Heating and Ventilating or Applied Chemistry, or Electrical Installations.

Group V—Mining Engineering—
(*a*) Principles of Mining.
(*b*) Surveying and Applied Geology.
(*c*) Machine Design, or Mining Metallurgy, or Thermodynamics and Heat Engines, or Electrical Machinery, Principles and Practice.

Group VI—Chemical Engineering—
(*a*) Applied Chemistry.
(*b*) Thermodynamics and Heat Engines.
(*c*) Machine Design or Electrical Machinery, Principles and Practice, or Hydraulics.

Group VII—Shipbuilding and Marine Engineering—
(*a*) Stability and Resistance of Ships.
(*b*) Machine Design, or Design of Structures.
(*c*) Thermodynamics and Heat Engines or Electrical Machinery, Principles and Practice.

Group VIII—Gas Engineering—
(*a*) Gas Engineering.
(*b*) Applied Chemistry.
(*c*) Thermodynamics and Heat Engines, or Machine Design, or Design of Structures.

Group IX—Aeronautical Engineering—
(*a*) Aeronautics.
(*b*) Machine Design or Design of Structures.
(*c*) Thermodynamics and Heat Engines, or Electrical Machinery, Principles and Practice.

B. Engineers Registration Board

Civil—

1. Engineering Drawing.
2. Engineering Materials.

And *three* subjects from—

3. Theory and Design of Structures.
4. Surveying and Applied Geology.
5. Hydraulics.
6. Building Construction.

2. ELECTRICAL

A. Institution of Civil Engineers

(i) Electrical Engineering (Paper A).
(ii) Electrical Engineering (Paper B).
(iii) *One* of the following :—
Electricity Supply.
Electrical Installations.
Electrical Machinery.
Electrical Measurements.
Radio Communication.
Line Communication.

B. Engineers Registration Board

1. Engineering Drawing.
2. Engineering Materials.

And *three* subjects from—

3. Electrical Machinery, Principles and Practice.
4. Electrical Transmission.
Or,—
4. (*a*) Electrical Communications.
5. Machine Design.
Or,—
5. (*a*) Theory and Design of Structures.
Or,—
5. (*b*) Surveying and Applied Geology.
Or,—
5. (*c*) Hydraulics.

3. MECHANICAL

A. Institution of Mechanical Engineers

(i) Theory of Machines.
(ii) Properties and Strength of Materials.
(iii) *One* of the following :—
(*a*) Steam and the Steam Engine (Heat Engines I).
(*b*) Internal Combustion Engines (Heat Engines II).
(*c*) Hydraulics and Hydraulic Machinery.
(*d*) Electrotechnology.
(*e*) Metallurgy.
(*f*) Aeronautics.
(*g*) Metrology and Machine Tools.

B. Engineers Registration Board

As for Institution Examinations, with the addition of Industrial Administration taken in Section C of the Institution Examinations.

APPENDIX 7—REQUIREMENTS OF PRACTICAL TRAINING AND AGE-LIMITS FOR CORPORATE MEMBERSHIP (ASSOCIATE MEMBERS) OF BRITISH INSTITUTIONS (1948)

CIVIL

Minimum age, twenty-five years. Applicants must have had a period of training as an articled pupil, apprentice, or assistant under agreement. This period is usually five years in the case of a student who does not follow a University course, and is reduced in accordance with the extent of the course taken until, in the case of a graduate in Engineering, it becomes three years. In all cases at least one year must have been spent in an engineer's office and at least one year in or upon engineering works.

If the experience is not as an articled pupil, apprentice, or assistant under agreement the period required is seven years.

ELECTRICAL

Minimum age, twenty-six years. Practical training required. One of the following typical alternatives :—

Alternative Qualifications.	Full Daytime College Course.	"Sandwich" Course.	College Apprenticeship or Work Course.	Full Apprenticeship or Work Course.	Responsible Experience as an Electrical Engineer.	Total.
(A)	3 years ..	..	2 years ..	..	2 years ..	7 years.
(B)	3 ,, ..	..	..	..	4 ,, ..	7 ,,
(C)	..	..	..	5 years ..	2 ,, ..	7 ,,
(D)	..	4 years ..	1 year ..	..	2 ,, ..	7 ,,

NOTE.—The responsibility should in general be of such a nature as to require the candidate to exercise initiative, and should either—

(1) Involve individual technical responsibility ;
(2) Embrace technical research and/or development ; or
(3) Be of an executive nature involving the control of, and technical responsibility for, a number of technical assistants.

MECHANICAL

Minimum age, twenty-five years. Applicants must have been regularly trained as a mechanical engineer and have had sufficient practical experience in mechanical engineering. The Institution of Mechanical Engineers does not detail the training necessary or what is considered to be sufficient practical experience, but requires applicants to set out details on the application form, particularly those defining personal responsibility subsequent to training.

APPENDIX 8—ANALYSIS OF QUESTIONNAIRE

The principal information from the questionnaire is set out in Section 8, Supply and Demand. Set out below are the remaining questions asked and the figures obtained:—

—	Branch of Engineering.	Number with University Degrees in Engineering.	Number with A.M.I.N.E. but not Degrees.	Number Registered as Professional Engineers but not with Degree or A.M.I.N.E.	Totals.
4. How many professional engineers were appointed to your staff in 1947?	(*a*) New posts—				
	Civil ..	20	8	5	33
	Electrical	9	13	3	25
	Mechanical	6	7	1	14
	Others ..	..	..	..	..
	Totals ..	35	28	9	72
	(*b*) Replacements				
	Civil ..	21	11	7	39
	Electrical	7	3	..	10
	Mechanical	4	2	1	7
	Others ..	..	..	1	1
	Totals ..	32	16	9	57
5. Number of persons employed on work of a professional engineering nature.	(*a*) In 1928—				
	Civil ..	45	144	82	271
	Electrical	72	60	37	169
	Mechanical	13	26	9	48
	Others ..	3	4	..	7
	Totals ..	133	234	128	495
	(*b*) In 1933—				
	Civil ..	46	192	77	315
	Electrical	80	81	32	193
	Mechanical	18	35	6	59
	Others ..	4	4	..	8
	Totals ..	148	312	115	575
	(*c*) In 1938—				
	Civil ..	110	222	70	400
	Electrical	122	111	32	267
	Mechanical	43	46	8	97
	Others ..	5	5	..	10
	Totals ..	280	384	110	774
	(*d*) In 1943—				
	Civil ..	121	217	74	412
	Electrical	143	122	29	294
	Mechanical	42	48	12	102
	Others ..	5	7	6	18
	Totals ..	311	394	121	826

INDEX

NOTE.—References are normally to paragraphs; references to Sections and Appendices are prefixed "Sec." and "A." respectively.

Approximate Cost of Paper.—Preparation, not given ; printing (3,808) copies), £370.

By Authority: R. E. Owen, Government Printer, Wellington.—1949.

[*Price 2s. 3d.*]