TO BE AN ENGINEER

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BY

Lieut.-Colonel J. R. W. MURLAND

B.Sc. (Eng.), A.C.G.I., A.M.Inst.C.E., A.M.I.E.E., A.M.I.I.A.

5th Royal Inniskilling Dragoon Guards

Sometime Development Officer Electricity Board for Northern Ireland

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PREFACE

MODERN ENGINEERING covers a vast field; it has many ramifications which can only be known to the specialists in each sphere of activity, and I have not attempted to deal with these separately or in detail. The underlying principles and systems of training in all branches of the engineering profession have much in common, however, and I have tried to concentrate on these aspects, which are of general application to all engineers.

Nothing in this book presumes to be an effective substitute for the personal advice and guidance which each young engineer should seek from his seniors in the profession; there is much to be learnt from those who have gone before, and they are only too willing to help and advise the young entry. But, whatever books are studied and whatever advice is obtained, the course and progress of any engineering career must depend on the individual; this fact cannot be evaded, and it will recur as a constant theme in the chapters which follow.

Several people, on reading the MS., have said that I have been too conservative in my estimates of an engineer's financial prospects. I remain impenitent, for I am convinced that it would be most unfair to present a picture of an 'El Dorado' with huge salaries for all, when these can only be attained by a tiny minority in the profession. The leaders of any profession can always command fees beyond the reach of the ordinary practitioner. The engineering profession, however, does offer to its followers the prospect of an interesting career with a very comfortable livelihood.

Frequent mention will be made of Professional Institutions, and particularly of the Institutions of Civil, Mechanical, and Electrical Engineers. I cannot state too clearly that these Institutions are in no way responsible for the views expressed in this book, which are my own, and for which I accept the sole responsibility.

Those who have encouraged and guided my own career are, of course, the real authors of this book, which would have little value without their influence. I shall be satisfied if I have succeeded in passing on even a small part of their great wisdom.

J. R. W. M.

May 1945

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I AM especially indebted to my wife and to Captain E. F. Deane, who have toiled through the MS. and then the proofs of this book; they have saved me from many errors and not a little hard work. So many organizations and individuals have ungrudgingly given me assistance that it is hard to thank all of them adequately. Many of them have allowed me to quote from their publications, and these quotations are acknowledged in the text where they occur. I would particularly like to acknowledge the kindness with which my importunities were borne by: the Secretaries of the Institutions of Civil, Mechanical, Electrical, and Gas Engineers; the Secretary of the Institute of Industrial Administration; the Director of the National Institute of Industrial Psychology; the Secretary of the Engineering and Allied Employers' National Federation; the Director of Publications, H.M. Stationery Office; Birmid Industries, Ltd.; the Secretary to the Senate of the University of London; Mr. P. I. Kitchen, Principal of the Rugby College of Technology and Arts; and Mr. G. A. Hall of the British Thomson-Houston Co., Ltd.

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CHAPTER I

WHAT IS ENGINEERING?

IT IS the purpose of this book to describe and signpost the more important paths which lead to a successful engineering career. Were it possible to analyse the careers of the many thousands of engineers in this country, it would be found that few of them had reached their present positions by exactly the same route; individual abilities, circumstances, and desires had all combined to make each career distinct. There are, however, some features common to all engineering careers, and it is these which, on analysis, will provide the much-needed signposts to guide all who would follow.

Carrying this analogy a little farther, the position is similar to that of a man who is going on a long cross-country journey by car. He does not equip himself with large-scale maps showing every hedgerow and by-way; he would require dozens of such maps, and he could never see a clear picture of his journey as a whole. Obviously his need is for a small-scale map showing only the important roads and landmarks on his route. But, in planning his journey, the traveller must first be quite clear and definite about his destination; his journey has a purpose; it is not merely a sight-seeing tour.

It is similarly necessary to clarify the precise meaning of 'an engineering career'. This is, unfortunately, somewhat complicated by the vagueness with which the terms 'engineering' and 'engineer' are used to-day. These terms must be defined here, not as a matter of abstract etymology, but in order to make clear the precise scope of this book and to describe its objects and limitations.

Probably the best, and certainly the most famous, general definition of engineering is that given in the Royal Charter of Incorporation of the Institution of Civil Engineers:

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

a definition which is as accurate to-day as it was in 1828 when the charter was granted. There are two points about this definition which should be emphasized: it excludes military engineering by implication, for nobody could contend that the application of engineering technique to war is 'for the use and convenience of man', and secondly it is all-embracing, in that there is no branch of modern engineering which it does not cover.

The development of engineering science and technique has taken place almost entirely since the granting of the Royal Charter to the Institution of Civil Engineers. In those days it was possible for a competent engineer to be the master of every branch of his profession, and it is notable in the history of engineering that the great engineers of the early nineteenth century were all responsible for works of an extremely varied character. An outstanding example is I. K. Brunel, whose name is associated with many of the greatest engineering achievements of his time; in addition to his great work for the Great Western Railway, these included a great number of bridges which are still in use to-day, and the steamship *Great Eastern*, whose only fault lay in being some fifty years in advance of her time. Since then the scope of engineering has widened enormously, and it is now essential for an engineer to specialize in some particular branch of his profession; no man to-day can be competent in every sphere.

The fascinating story of the development of engineering during the past hundred years or so is, broadly speaking, the story of the Industrial Revolution. In so far as this revolution was due to a single cause, it resulted from James

Watt's invention of the steam engine in the latter half of the eighteenth century. To-day the steam engine is largely obsolescent as a source of power, and has been replaced by large steam-turbine units which generate electricity for distribution throughout the country, by smaller steam-turbine units for single factories and industrial plants, and by various forms of the internal-combustion engine. The latter, probably the most outstanding engineering development of the last sixty years, has itself given rise to a number of separate and distinct branches of engineering; it is only necessary to think of modern road transport and of the aeroplane to realize its far-reaching effects.

Of the many developments in engineering during the last hundred years, two must be mentioned whose importance cannot be exaggerated: the first is that of electrical science. A century ago electricity was little more than a scientific toy having some practical use in the field of communications which started with the first public telegraph line (between Paddington and West Drayton) in 1838–39. It is not too much to say that the later applications of electricity, for lighting (in 1876), and subsequently for power, have revolutionized engineering, and have given rise to one of the largest industries of the civilized world.

The other important development has been that of engineering materials, without which little could have been achieved. Again numerous examples could be quoted; the most notable is probably that of steel-making, which derives mainly from the invention of the Bessemer process in 1856. Self-hardening steel followed in 1868, and high-speed steel at the turn of the century. Since then stainless steel has been invented and developed, and this is only one of a large family of special steels now available to engineers. More recently the aircraft industry has been responsible for the vastly increased use of light non-ferrous metals and their alloys, the full uses of which have as yet scarcely been touched upon. Lastly, the increasing use of plastics in engineering has greatly accelerated since the first Great War, and it is certain that development is still in its comparatively early stages. Surveying this great range of materials now available to engineers, it is hard to realize how limited was the choice available to the pioneers at the beginning of the last century.

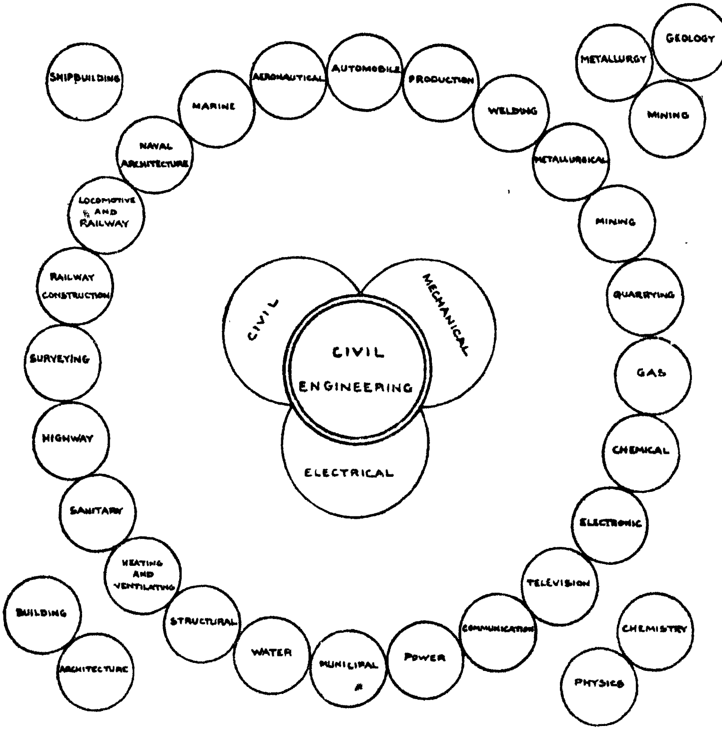
With the development and expansion of engineering, there arose a need for Institutions which would enable engineers to discuss and compare their experiences and which would form centres for the various specialized branches of the engineering profession. There were already precedents in the scientific world (notably the Royal Society and the Geological Society of London), and the first engineering professional institution, the Institution of Civil Engineers, was founded in 1818; ten years later it received its Royal Charter of Incorporation, from which the definition of engineering has already been quoted.

It is necessary at this point to clarify the meaning of the word ' civil ' as applied to engineering. There are two distinct meanings in use to-day, a not uncommon feature of English words. The Institution of Civil Engineers is, under its charter, an institution of those who practise ' the art of directing the great sources of power in Nature for the use and convenience of man '—that is, of all engineers other than military. The word ' civil ' is used with this meaning by the Institution, whose members, as will be seen later, are drawn from all branches of the engineering profession. The more modern and general meaning of the word ' civil ' (as applied to engineering) is ' that branch of engineering which is concerned primarily with constructional works ', these latter including water-supply schemes, harbours, bridges, and the like. Their irreverent colleagues in other branches of engineering sometimes refer to these ' civil ' engineers as ' muck-shifters ', which, though impolite, is a fairly correct description of at least the early stages of most constructional projects.

It is important to appreciate this distinction between the two usages of the word ' civil ', particularly when considering the question of membership of the professional institutions. The difference can easily be remembered by the fact that in its widest meaning the use of the word is almost entirely limited to the Institution of Civil Engineers, whilst in its narrower sense the word is widely used throughout the profession.

The other two main branches of engineering are represented by the Institution of Mechanical Engineers (founded in 1847) and the Institution of Electrical Engineers (founded as the Society of Telegraph Engineers in 1871). These, with the Institution of Civil Engineers, are rightly considered to be the senior and most important institutions in the profession. Since then many other professional institutions have been founded, each covering some specialized branch of engineering. These other institutions, together with those engineering and scientific societies which have some association or connexion with the engineering profession, are listed in Appendix I, with the dates of their original foundations. A study of Appendix I will give a very good idea of the wide field covered by the engineering profession to-day, and this is indicated diagrammatically in Fig. 1. It will, of course, be realized that this picture of the field of modern engineering inevitably cannot be completely comprehensive, but it will serve to illustrate how many and various are the ramifications of the profession.

In this diagram, Civil Engineering (using the word ' civil ' in its widest sense) is in the centre as representing all branches of the engineering art, and its three main offshoots, Civil (in the restricted sense), Mechanical, and Electrical Engineering, are shown as deriving from it. Around this are twenty-four further distinct branches, and these in turn



The central circle represents 'Civil Engineering' in the all-embracing sense of the Charter of the Institution of Civil Engineers. This may broadly be subdivided into 'Civil' (in the more modern and restricted sense), 'Mechanical' and 'Electrical' Engineering.

The twenty-four circles surrounding the four central circles each represent a branch of engineering practice. Outside these are eight circles representing trades, arts, and sciences which are so closely linked with certain branches of engineering as to be almost indistinguishable from them.

FIG. 1.—THE ENGINEERING AND ALLIED PROFESSIONS.

(Based on the list of Societies and Institutions in Appendix A.)

are associated with other trades, arts, and sciences so closely that precise distinction is scarcely possible. This rough outline will serve to indicate how much is implied by the word 'engineering', and it will be clear from the outset that anyone who contemplates a career in the engineering profession will not only have an extremely wide choice, but will also have to limit himself to acquiring a full knowledge of a comparatively restricted sphere.

The difficulty of defining an 'engineer' with any exactness is as great as that of defining 'engineering', but for somewhat different reasons. Unfortunately the word 'Engineer' is generally used as applying to anyone from a man at the very head of the engineering profession to those self-styled engineers whose activities are limited to the retailing of electric lamps in a small shop or repairing (most indifferently) an occasional wayside puncture. The word is also used to refer to the craftsmen and other manual workers in the engineering industry, a usage which is almost entirely confined to the trade unions. For example, the members of the Amalgamated Engineering Union [1] are generally referred to as 'engineers'. In the United States the matter is further complicated by the general use of the term 'engineer' with the meaning which is attached to 'engine-driver' in this country.

There seem to be two general schools of thought on this question. One of these would like to see the use of the word 'engineer' restricted to those with professional qualifications—that is, used in a similar manner to the word 'doctor'. As recently as February 1944, the President of the Society of Engineers suggested the setting up of a representative council to consider (*inter alia*) the possible limitation of the use of the title 'engineer'.[2]

[1] The largest and most important trade union in the engineering industry, founded in 1920 by the amalgamation of a number of smaller unions.

[2] The only limitation which now exists is on the word 'chartered';

It is unlikely that any general restriction of the word 'engineer' could be brought into effect, as its use is so general; the tendency to-day seems to be in the direction of a more definite classification of the many people who are now generically described as engineers. The Post-war Planning Committee of the Institution of Electrical Engineers recently submitted their second report to the Council of the Institution on 'Education and Training for Engineers'; in this report the Committee say:—

> 'The technical personnel of the electrical engineering industry fall naturally into three main groups. . . . The first and largest group consists of the craftsmen, men whose skill is essentially manual. The second group includes the technicians, whose skill lies in the practical application of a knowledge of engineering technique which is limited to a particular field; the group embraces draughtsmen, erection engineers, technical assistants, and senior testers. The third and last group, a comparatively small one, consists of professional engineers with ability to direct progress and to devise methods for the solution of the problems which arise in connexion with every new development, and to control the application of these methods in accordance with scientific principles.'[1]

It is felt that this classification into craftsmen, technicians, and professional engineers is probably the most satisfactory for the present purpose, recognizing as it does that an 'engineer' can be a member of any one of the three groups. In this book it is assumed that the ultimate objective is to become a professional engineer as defined in the I.E.E. report quoted above. This objective has been chosen for the

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this can be used only by corporate members of a professional institution incorporated by charter—e.g., a 'chartered electrical engineer' must be a member or associate member of the Institution of Electrical Engineers.

[1] This extract is reproduced by permission of the Institution of Electrical Engineers.

reason that, in the early stages of training, it embraces to some extent the two other groups of craftsmen and technicians; the group in which a particular individual will ultimately arrive depends entirely on his own personal qualities and abilities.

It is still necessary to define a 'professional engineer' more precisely in order to clarify the objective and to lay down the requirements rather more rigidly than the definition already given. For the purpose of this book, a 'professional engineer' is therefore considered to be one who has been elected a corporate member of one of the three major engineering institutions—that is to say, one who is a Member or Associate Member of any one of the Institutions of Civil, Mechanical, or Electrical Engineers.

In all three institutions there are various grades of membership, as follows :—

Institution of Civil Engineers	Institution of Mechanical Engineers	Institution of Electrical Engineers
Honorary Member	—	Honorary Member
Member	Member	Member
Associate Member	Associate Member	Associate Member
—	Companion	Companion
Associate	Associate	Associate
—	—	Graduate
Student	Student	Student

At this stage it is unnecessary to define each of these grades of membership. It will suffice to point out that members are engineers with greater experience than Associate Members, and it is rare for any individual to be elected to membership without having first been elected to associate membership. Having said, therefore, that the objective of an engineering training should be the attainment of corporate membership of one of the three major institutions, it is clear that in practice this amounts to the attainment of associate membership.

It was pointed out at the beginning of this chapter that there are many and various routes to the objective of becoming a qualified engineer, and it is hoped that the following pages will offer some guidance to those who may be rather bewildered and perhaps uncertain of the best way to start on their journey. Before deciding to start on the journey at all, it is only natural to inquire what advantages, if any, are to be gained by becoming a qualified professional engineer; in other words, what are the prospects (financial and otherwise) in an engineering career? This question of prospects, which is the subject of the next chapter, is a most important one, especially as the training for an engineer is a long one and may involve an appreciable financial outlay.

CHAPTER I

THE ENGINEER'S PROSPECTS

FROM its relatively simple beginning in the eighteenth century, engineering development has been accelerating continuously, and the profession as we now know it is little more than 150 years old. Although this is an insignificant period in the evolution of our present civilization, it is notable that only in the last fifty years have the greatest and most important innovations emerged. This statement is, of course, a very broad generalization, and there are some few outstanding exceptions to it. The important thing to realize is the great acceleration of development which shows not the slightest sign of decreasing; on the contrary, it continues to increase.

Technical progress was particularly noticeable during the Great War of 1914–18. We have just reached the end of an even greater struggle, which was predominantly a war of machine-power, as its predecessor was predominantly one of man-power. This suggests—and the suggestion is amply confirmed by such information as has already been released—that technical progress during, and as a result of, the recent war has been immeasurably greater than that which took place between 1914 and 1918. Taking the long view, there is little doubt that we have only entered the fringe of possible technical development, and we may look forward in the future to an unprecedented expansion in every sphere of engineering.

In the more immediate future, reconstruction, replacement, and expansion will be the three main national drives. They will demand all the technical abilities which the country can muster, and they will provide more engineering opportunities than perhaps there have ever been before. These matters are closely linked with major political questions of the day, and in many directions the picture of future activity is obscured (at the time of writing) by the absence of definite statements of national and international policy. However, the general outlines are becoming visible, and their possibilities will be worth examining briefly.

It is quite clear that our most urgent post-war need is for houses, and a vast building programme is already planned to start as soon as military requirements allow. This programme is additional to the temporary houses which are even now being erected to meet the serious deficiency. At first sight, the provision of houses might seem to be a matter primarily for architects and builders rather than engineers, but it must be remembered that a house consists of much more than walls and a roof. Even these are primarily engineering products in the case of the much-publicized 'pre-fabricated' houses. The provision of such services as water, drainage, electricity, gas, and roads often involves engineering works of considerable magnitude. The numerous fittings essential to the modern house, however simple its construction, are all engineering products; they involve the services of designers, manufacturers of both raw materials and finished articles, production engineers, and those whose concern is the manufacture of tools and equipment. Much research has already been carried out on the design of houses and their accessories, which makes it probable that the house built five years hence will bear little resemblance in detail to those we now know, and in this transition the part to be played by engineers can only be a most important one.

We have been at war for more than five years, and during that time very little replacement has been carried out in industry. Machinery, machine-tools, and equipment of all kinds have become worn out and in many cases obsolete; in the near future all these things must be replaced. In many instances they must be re-designed to suit modern requirements, then manufactured, and finally installed in the factories, for only thus will our industries be up-to-date and capable of satisfactorily meeting international competition.

It has been reiterated on many occasions that, if we are to maintain the standard of living which we had achieved in the years immediately before the war, we must expand our export trade to the fullest possible extent. This expansion, too, will largely be an engineering responsibility. In addition to the replacement and modernization of plant which has just been mentioned, there must be a wide programme of research into new products, methods, and materials, and the results of these researches must be translated into goods which can be marketed in all parts of the world.

Mention of research raises a question which should be clarified at once: research is generally regarded as being the province of the pure scientist, and it is often thought that the engineer only comes into his own at the stage where the results of research are being put into practice. This picture gives a very false idea of the situation. The functions of the scientist and the engineer are far more inter-dependent and overlapping than this conception would suggest. Research, it is true, is more generally carried out by scientists, but it is also carried out by engineers; similarly, when the results of some particular research are being put into practice, the services of the scientist are required as well as those of the engineer. To use a military analogy, the relationship between scientists and engineers is similar to that which exists between infantry and tanks in battle; each one is completely dependent on the other, and both must have an acute realization of each other's powers and limitations; they are a team, and not merely two separate entities working towards the same end.

For the present purpose, the important implication of the post-war programme lies in the obvious need for trained engineers. During the war the shortage of engineers was acute both in the Services and in industry, and for the past five years it has been necessary to take certain special steps to ensure that as many trained men as possible have been made available where they were most required. It must not be thought that the end of the war will see any surplus of trained engineers. The tasks still to be done are as great, if not greater, than those already accomplished, and it is already clear that, among many shortages, the dearth of trained engineers will be by no means the least. The many distinct and specialized branches of engineering will each and all require trained men to meet the strenuous demands of the future.

This demand for engineers in the post-war years is as certain as the fact that night follows day, but anyone now starting on an engineering career must wonder whether his services will be required for a longer period than that of immediate post-war reconstruction, replacement, and expansion. It was stated at the beginning of this chapter that we have probably only entered the fringe of possible technical development. This is more than a probability, it is a certainty; and it is this continuously accelerating development which will demand the services of more and more engineers as our civilization becomes increasingly mechanized.

Even in the rather limited sphere of communications, for example, it is almost impossible to visualize the changes which will undoubtedly take place in the next twenty-five years or so. Many developments were stopped at the outbreak of war, when our resources were diverted to military needs. The resumption of this work obviously will not be as planned in 1938 or 1939, for much, still secret, has been done meanwhile; the application of war-time discoveries and inventions will radically change many things which are regarded as established commonplaces. This is not the place to make detailed predictions of 'the shape of things to come', and it is sufficient here to emphasize that there will be few departments of life which will not feel the impact of technical progress.

These are, admittedly, generalities, but they are pointers to the future of engineering as a whole. From whatever standpoint the future is viewed, it is only possible to see continuous accelerating expansion and the consequent need for engineers in every branch of the profession. The would-be engineer can start confidently along such a road, and he (or she) can be certain of taking part in far-reaching developments in 'the art of directing the great sources of power in Nature for the use and convenience of man'.

In addition to a broad survey of future developments and opportunities, it is also necessary to examine the rewards which may be offered by the engineering profession to those who make it their chosen career. More bluntly, the question must be asked: 'What am I likely to earn if I qualify as an engineer and make the most of my abilities and opportunities?' The answer to this question is: 'Anything from £400 to £2000 a year, or even more, depending only on the abilities of the individual, and the uses to which those abilities are put.' Engineering is very far from being a profession with fixed salary scales for all its members whatever their personal calibre.

It may be helpful to consider some senior engineering appointments of which details can be obtained. Twenty-two such appointments are listed in Tables 1 and 2 (on pages 16 and 17). In Table 1 are ten posts in the Government service, with the personal qualifications of the holder and the salary applicable to each appointment. Table 2 gives details of twelve appointments, which have been extracted from the advertisement columns of the daily Press and engineering journals during 1944; in each case the abilities and qualifications required and the salary offered are noted.

TABLE I

DEPARTMENT	APPOINTMENT	QUALIFICATIONS OF HOLDER	SALARY (£ PER ANNUM)
Admiralty	Director, Electrical Engineering Dept.	F.C.G.I. M.I.E.E.	1900
,,	Civil Engineer in Chief	M.Eng. M.Inst.C.E.	1900
Ministry of Health	Chief Engineering Inspector	B.Sc. M.Inst.C.E. M.I.Mech.E.	1650
Ministry of Works	Asst. Director of Works (Mech. & Elect. Eng. Division)	B.Sc. M.Inst.C.E. M.I.Mech.E. M.I.E.E.	1450
Crown Agents for the Colonies	Engineering Contracts Department	A.M.Inst.C.E. M.I.Loco.E.	1150–1450
Ministry of Home Security	Chief Engineer	M.Inst.C.E.	1400
Department of Health for Scotland	Chief Engineer	A.M.Inst.C.E.	1200–1400
General Post Office	Controller of Research	Ph.D. B.Sc. M.I.E.E.	1250–1350
Office of the High Commissioner for India	Director of Inspection	M.I.E.E. M.Inst.E.I.	1000–1200
Department of Agriculture for Scotland	Chief Engineer and Surveyor	F.S.I. A.M.Inst.C.E. M.R.San.I.	900–1100

TABLE 2

APPOINTMENT	QUALIFICATIONS REQUIRED	(SALARY (£ PER ANNUM)
Chief Engineer, Port of Basrah	Qualified Civil Engineer, with all-round experience, including dock and harbour work, and able to supervise electric power and water supply	2088
Works Manager, Heavy Precision Engineering Works	Fully qualified and able to organize production through all stages; conversant with all latest machine practice, possess considerable ability, drive, and imagination	1500
Manager, Electrical Contracting	First-class technical qualifications, wide knowledge of installation design, estimating, and general business experience (preferably in contracting field)	up to 1500
Borough Engineer and Surveyor, County Borough of Southampton	Not over 50 years of age, A.M.Inst.C.E., or holding the Testamur of the Institution of Municipal and County Engineers	1200–1350 plus car allowance
Superintendent, Engineering Division, National Physical Laboratory	Considerable research experience in engineering, and a broad outlook on the possibilities of research applied to industry	up to 1250
General Works Manager, Wood and Metal manufacturing	Good education, degree or equivalent preferred, and first-class experience in large works; will be required to control all manufacturing activities, and experience in all phases of industrial administration is essential; executive ability is of primary importance	1200
?	Well-qualified Mechanical Engineer with extensive executive experience in production work Age not over 45	up to 1200

TABLE 2—(*continued*)

APPOINTMENT	QUALIFICATIONS REQUIRED	SALARY (£ PER ANNUM)
Chief Electrical Engineer and Manager, City of Chichester	Qualified Engineer not over 45 years of age, experienced in the management and administration of an electricity undertaking	1013 plus car allowance
Chief Engineer Turbo-alternator manufacture	Wide design and practical experience in the mechanical and electrical engineering fields, including detailed experience of Turbines at some period; age preferably not over 45 and an honours degree or equivalent is desirable	1000 upwards
Chief Engineer, Machinery Manufacture	Full knowledge of production and able to adapt himself to specialized manufacture of small automatic machinery; strong character and plenty of drive, possessing organizing ability and capable of developing manufacture	approx. 1000
Research Manager	Honours degree in engineering or physics, and industrial research experience in active co-operation with Design Department Age 35 to 45	750–1000
Deputy Borough Engineer and Surveyor and Deputy Planning Officer, Borough of Barking	Corporate Member of the Institution of Civil Engineers and of the Institution of Municipal and County Engineers	660–810

The salaries range from £660 to £2088 a year, and the appointments represent, in general, the higher levels which may be attained in the engineering profession. It may be observed that only one of the appointments (that of Chief Engineer, Port of Basrah, in Table 2) is abroad. Appointments abroad, and especially in tropical countries, are normally more highly paid than the equivalent jobs at home. There is consequently some temptation, particularly to young engineers in the early stages of their career, to accept some post abroad because of the higher salary offered. On this point two words of caution are necessary: first, standards of value are very different in other countries, and it may well be found that £2000 in a particular country has only the purchasing power of £1000 at home; secondly, a high standard of physique is essential for anyone working in an extreme climate.

The Government appointments in Table 1 call for little comment; as would be expected, the holders possess high technical qualifications, and each of them is a corporate member of one of the three major professional institutions. Each appointment in Table 2 also calls for technical qualifications and practical experience in the particular sphere of engineering concerned. This matter will be discussed more fully in Chapter IV, but it may be noted that in all cases corporate membership of the appropriate institution would satisfy the technical requirements. The two research jobs in the list are possible exceptions to this statement, as qualifications in pure science would be acceptable alternatives if accompanied by the required practical experience.

It will be observed that four of the posts in Table 2 are for engineers under forty-five years of age, and applicants for one must be less than fifty. This does not warrant any generalization on the question of ages and higher appointments, but it may be assumed that any engineer who has not acquired the necessary qualifications and experience before reaching forty-five is unlikely to be of the calibre demanded for these posts.

The appointments listed in Tables 1 and 2 have been selected as generally typical of senior positions in various branches of the engineering profession. They do not by any means represent the most highly paid posts open to engineers, but it must be emphasized that appointments in this country carrying salaries greater than £1500 a year are rare and represent heights to which only a few of the most able men can attain. At the lower end of the scale there are innumerable engineering appointments at salaries ranging from £400 to £1000 a year, and the majority of qualified engineers in this country probably fall into this group. Such appointments can be regarded either as steps towards more highly paid posts, or as ends in themselves; the choice must rest with the individual.

TABLE 3

Post	Age on taking up post (years)	Duration of post (years)	Salary (£ per annum)
Apprenticeship	20	3	100
First appointment as Junior Engineer	23	2	200
Second appointment as Junior Engineer	25	3	300
Third appointment as Junior Engineer	28	2	400
First appointment as Senior Engineer	30	5	500
Second appointment as Senior Engineer	35	5	750
Third appointment as Senior Engineer	40	?	1000

Note.—The figures in this table are also shown diagrammatically in Fig. 3, page 76.

It is almost impossible to outline, even approximately, the various stages in the average engineer's progress towards a senior appointment. Table 3, above, gives some very rough-and-ready estimates, based on pre-1939 salary scales, which may serve as a general guide. It is impossible to estimate the level at which these salaries will stabilize after the war, though it is certain that they will be higher than the pre-1939 values given in the table. The figures in Table 3 assume the attainment of a post worth £1000 a year at forty, which is probably slightly higher than the average expectation; higher appointments than this are, as has been mentioned, limited in number, and few engineers possess the abilities and experience which they call for.

All professions offer their own particular rewards to their members, and in these the engineering profession is especially rich. Engineering is essentially creative. Whatever difficult job has to be done, or however unpleasant an immediate task, there will always be the sure and certain satisfaction of seeing the contribution which it makes to the final achievement; the satisfaction of saying: 'I was responsible for so-and-so.' It is the satisfaction of the creative artist, and there is nothing like it to make a man realize that he and his job, however insignificant, matter in the greater scheme of things. This is one of the rewards which are more valuable than any salary cheques, and no survey of an engineer's prospects would be adequate without some mention of them. To appreciate the creative satisfaction in engineering is not to advocate 'work for work's sake'; the upholders of this pernicious doctrine are either fools or liars. The labourer remains worthy of his hire, and is anything but debased in his acceptance of the material reward, while enjoying the greater and less tangible.

It is trite to say that the wider an individual's experience the more he realizes how very little he knows. The truth of this can be emphatically confirmed by any truthful practising engineer, and it is essential for every engineer to appreciate that his training is a continuous process throughout his career. So many make the mistake of thinking that their training is a short period to be passed over as quickly as possible at the beginning of their careers. Only by the most diligent and continued application is it possible to obtain the wide knowledge (and the art of applying it) which is so essential to a successful career.

As our present society comes to rely more and more on mechanical things, so an ever-increasing number of people will become mechanically minded, and will appreciate the scope which an engineering career offers. At the same time, the certain expansion of the engineering sphere in future years will call for increasing numbers of qualified engineers. In practical terms, these facts mean that, while the scope is limitless, at the same time there is not likely to be any falling off in the competition for engineering appointments. In consequence, success will come first to those who stand out from among their fellows, whether by natural ability, hard work, or some other outstanding characteristic.

To sum up briefly, it can confidently be said that the prospects offered by an engineering career are excellent, and that the rewards (both tangible and intangible) are more than adequate. The progress to be made by each individual will depend only on himself, his efforts, and his abilities. There is no room for idleness, lack of enthusiasm, or for those who think that a career means getting two days' pay for half a day's work.

CHAPTER III

DECIDING TO BE AN ENGINEER

IF AN analysis could be made of those who have failed to make good in an engineering career, it would probably be found that the majority were totally unsuited to engineering in any form, and that they were vocational misfits. This question of individual suitability for a given career is a complex one, and it is only in recent years that the matter has received close attention and study. In the past, the choice of a career has too often been governed by factors which have little or nothing to do with the matter; misguided parental pressure, ignorance of possible openings, false assessment of abilities by teachers and parents, geographical proximity to a particular industry, and similar influences, have all contributed their quota of vocational misfits.

As the subjects of vocational selection and guidance receive more and more attention, there arises an unfortunate tendency to assume that, by means of a short interview and some simple tests, every round peg can be fitted infallibly into a round hole. This is a very false conception of the methods of vocational guidance, and is far from representing the true position. For the present purpose, it is important to know whether modern knowledge can offer a method of assessing the suitability of a given individual for an engineering career, and, more particularly, whether the totally unsuitable can be detected before they embark on such a career at all. An early and accurate assessment of this kind would be invaluable, not only to the individual aspirant, but also to the engineering profession generally. The usual haphazard method of choosing a career results in considerable wastage, as the unsuitable are weeded out at various stages of their training.

Intelligence tests have undoubtedly come to stay, but there is still much misapprehension about them. On the one hand, there is a general tendency (perhaps most marked in the older generation) to pooh-pooh the whole thing, and to deny that any information of value can be gained from such tests. On the other hand, there are enthusiastic optimists who proclaim that appropriate tests can not only determine the career for which the victim is best suited, but also the particular branch in which he or she should specialize.

In this field much important work has been carried out by the National Institute of Industrial Psychology. The Director of the Institute recently gave the author the following summary of the present position :—

> ' We consider that sufficient experimental work has now been carried out to demonstrate the value of psychological tests as aids in the assessment of the individual's capacities, but tests can only provide part of the information and account must always be taken also of temperament, interests and attainments.'

Apart altogether from the possibility of specialized vocational guidance (to which further reference will be made later), parents and teachers have a great responsibility which they are all too prone to neglect. They can observe the natural inclinations of a child, the subjects in which the greatest abilities are displayed, and those traits of character which show themselves from earliest youth. These indications in themselves may often be sufficient to suggest a suitable career, or at least they may show up the obviously unsuitable. Musical and artistic tendencies, for example, are generally shown at an early age, and the wise will encourage any such outstanding abilities, although this should never be done at the expense of that general background of knowledge which is so necessary in all careers.

It is most difficult to define those youthful tendencies which indicate a clear bent for engineering. Perhaps the most valuable are an inquiring mind for all subjects, combined with unquenchable enthusiasm for things scientific or mechanical; and if there is also some degree of manual dexterity, so much the better. At school the best subjects will probably be science and mathematics, accompanied by an intense interest in radio, automobiles, railways, aircraft, and the like. Everyone does better at school in those subjects in which he is most interested, and teachers should take the greatest care to arouse and maintain interest in a broad range of subjects which will give the essential background of general knowledge. A knowledgeable and enthusiastic scientist at the age of twelve is severely handicapped if he has reached this point at the expense of all other subjects; it is not too much to say that to select a child's career in his early youth is to handicap him for life.

The wishes of parents are rarely helpful in determining suitable careers for their children. Wishful thinking or a misplaced desire for the child to follow in his father's footsteps frequently condemns promising children to lives for which they are totally unsuited. Against this, the influences of heredity are often strong, and the son of an engineer may frequently inherit from his father just those abilities which will ensure for him the prospect of a successful engineering career. A clear and definitely expressed wish on the part of the child, however, is generally an excellent indication of the most suitable career, and parents can best assist their children by discussing all possible careers with them fully and sympathetically; in doing this it is necessary for parents to suppress any private desires they may have for the child to be a genius in some sphere selected by themselves, without considering the child's wishes and abilities.

It should be possible in some cases for parents and teachers to see, at this stage, if a child is obviously suited for a particular career; more often it will be possible to decide those careers for which the child is obviously unsuited. These, however, will be the exceptions. In the majority of cases, parents and teachers will not be able to make any decision because the child does not show either marked signs of special abilities or any preference for one career rather than another. In every one of these instances the services of a trained psychologist who has specialized in vocational guidance are invaluable; he can confirm the choice in those cases where it appears to be so obvious, and he can indicate the most suitable professions for those who seem to have no special leaning in a particular direction. It is the author's opinion that nobody (whatever their age) should embark on an engineering career without first obtaining a trained psychologist's confirmation of their choice.

In this connexion it will be helpful again to quote the Director of the National Institute of Industrial Psychology, who says:—

> '. . . those interested in obtaining advice from a psychologist on their suitability for an engineering career should get in touch with us. Facilities for obtaining this type of advice are rather limited at present, but certain education authorities employ psychologists on their staff, and we should be pleased to assist any inquirers to the best of our ability.'

This speaks for itself, and anyone who wishes to consult a psychologist to obtain advice should write to: The Director, The National Institute of Industrial Psychology, Aldwych House, London, W.C.2.

The next point which requires consideration is the standard of scholastic attainment necessary for those now determined to be engineers. For the present purpose, it is assumed (see Chapter I, page 9) that the objective of every would-be engineer is to become a corporate member of a professional institution; this involves (among other things) passing an examination of approximately degree standard,[1] and the need to pass this examination, in its turn, implies a certain minimum standard of knowledge when leaving school.

Unfortunately, examinations offer the only means of assessing the standard which any individual has reached. Although there are many obvious disadvantages inherent in the examination system, there is no adequate alternative, and the system is very unlikely to be superseded for a long time. The Matriculation, School-leaving Certificate, and Oxford and Cambridge School Certificate examinations all provide suitable measures of scholastic ability. It is therefore possible to say that for an engineering career the preliminary requirements are: a good general secondary education up to Matriculation or School Certificate standard with qualifications in mathematics, science, English, and at least one other language.

Before leaving this subject of standards of general education mention must be made of the Common Preliminary examination conducted by the Engineering Joint Examination Board. This Board was formed by eight of the most important professional institutions 'for the purpose of examining, by means of tests in general education, such candidates for studentship and other grades as those institutions may refer to it'. Candidates for associate membership (the objective of all would-be professional engineers) must pass this Common Preliminary examination or obtain exemption from it. The examination comprises five papers, as follows: one in English, two in mathematics, and two selected from elementary mechanics, elementary physics, elementary chemistry, and a language other than English. Exemption is granted to those who have passed the Matriculation examination of (*inter alia*) all those British Universities listed in Appendix VI, or have obtained a School Certificate with certain prescribed passes and credits. The Common

[1] The exact requirements are considered in detail in the next chapter.

Preliminary examination is of special importance to those who are proceeding to the associate membership examination of a professional institution without going to a University or taking a University degree; those who are going to a University (or are taking the External Degree of the University of London—see Chapter V, page 49) must, of course, take the appropriate Matriculation examination.

Anybody who has reached the standard of general education outlined above has thus not only demonstrated sufficient academic ability to warrant embarking on an engineering career, but has also reached the first stage towards the subsequent professional examinations.

This naturally leads to the question: what is the most suitable age to leave school? There is no clear-cut answer to this question, and, like many other problems which arise during an engineering career, it is only possible to say that it will depend on individual circumstances. The family budget may demand that on reaching the age of fifteen [1] the young person should proceed at once to what is officially called 'gainful employment'. That is not to say that education must cease in these circumstances, and many successful engineering careers have been founded on apprenticeships which started at the age of fourteen.

On the other hand, many may continue their whole-time education up to the age of seventeen or eighteen, by which time, if they have not reached Matriculation or School Certificate standard, it is unlikely that they are really suited to be professional engineers. The majority who stay on at school, however, will have proceeded to the Higher Leaving Certificate or the Higher School Certificate examinations,

[1] Section 35 of the Education Act, 1944, raised the statutory school-leaving age to fifteen on 1 April 1945, but shortly after the Act received the Royal Assent (on 3 August 1944) this date was changed to 1 April 1946, owing to shortage of teachers and accommodation. This section of the Act also provides that the leaving age will be rased to sixteen as soon as it is practicable to do so.

and this takes them yet another stage further towards their professional qualifications.

There is one point which is frequently overlooked by those who take a Higher Certificate examination at school, and which should perhaps be mentioned here. Provided the Higher Certificate is obtained with endorsements in the appropriate subjects, it will qualify the holder for exemption from the Intermediate Engineering examination at the Universities, and consequently for direct entry into the second year of a University course.[1] If full advantage of the Higher Certificate is to be obtained, it is clearly of vital importance to take the examination in those subjects which will qualify for the desired exemption. The requirements of the University of London for the External Intermediate examination in Engineering are given in Appendix V; the requirements of other Universities will be similar, and reference should be made to the particular University regulations for details.

It cannot be said that it is better to remain at school after the age of fifteen, and, where there is a choice in the matter, everything will depend on the individual. Some boys will reap more advantages from entering industry at fifteen; others are perhaps not sufficiently developed at that age, and in such cases they can advantageously remain at school for another two years or so. Often the choice must be governed by family or financial considerations rather than the needs of the individual. One thing, however, is certain: nobody has ever failed to become an engineer just because he left school at a particular age. Success depends on much more than a correct guess at the optimum age at which to leave school.

It is extremely important to avoid excessive specialization at the school stage, although this ideal will seldom be completely

[1] See also footnote on page 47, Chapter V.

attained. Any sign of mechanical ability or of a desire to make a career in engineering will inevitably mean that greater interest is taken in those school subjects which bear more directly on engineering matters. Combined with this, there is the unfortunate necessity to meet competition both in the classroom and in examinations. Invariably the easiest way to meet this competition is to concentrate on those subjects where the greatest interest lies to the detriment of other subjects which are in fact no less important. The successful counter-action of these tendencies must be in the hands of the teachers, who themselves will be tempted to encourage brighter pupils in the subjects in which they show the most promise.

The principal aim at school should be the acquisition of a sound general (but not merely superficial) knowledge of as many subjects as possible, with only the slightest bias towards those branches of learning (such as science and mathematics) which seem to be more closely related to engineering than the others. To acquire an adequate knowledge of any subject, the most useful stimulus is a keen interest in it, which, in turn, most easily arises from an inquiring attitude of mind towards anything and everything. The individual who is continually asking questions of himself and others will soon find that he possesses a miscellaneous but extremely valuable store of information, ranging perhaps from the simple mechanics of things around him to more abstruse matters, such as the principles of government, both local and national.

It is appreciated that this question of early specialization has been much discussed and that there are many widely differing ideas on the subject. The advice not to specialize during the school period is given here solely from the standpoint that a broad general knowledge will be invaluable to any engineer later in his career, and, further, that it will be more valuable than any slight additional technical knowledge which might be gained by concentrating on a narrow range of subjects while at school.

One further aspect of the early career of an engineer must be touched upon—namely, that of games and similar outside interests. Whatever branch of engineering may finally be chosen, there is no doubt that men will have to be handled as well as things. It is therefore essential that any activity which will aid this should be encouraged to the utmost. Again, it is appreciated that the question of whether the art of handling men can be taught is a most vexed one. It may, however, be stated in general terms that anyone can learn a great deal about his fellow-men (and hence about handling them) by the simple process of being in contact with them in as many differing circumstances as possible. At school, undoubtedly the best way of acquiring this knowledge is to indulge to the full in all possible out-of-school activities; the selection of these activities must, of course, depend on the individual's tastes and interests, but games of all kinds, debating societies, study groups, Boy Scouts, cycling clubs, and many others will come into this category.

It is a particularly British characteristic to attach special importance to proficiency at games, but, while this is sometimes carried to absurd lengths, the underlying reason is clear and sound. Many young engineers with most excellent technical qualifications have been surprised, and sometimes rather hurt, that in an interview for some appointment they have been asked their achievements in games. It is not the employer's purpose to seek out (say) a first-class cricketer; the employer does know, however, that the good games player has of necessity had some experience of his fellow men, and that consequently he is potentially more fitted to handle and deal with men than one who has not played games at all, but has devoted his entire time and interests to more academic pursuits.

One further most necessary qualification remains to be mentioned: physical health. An engineering career is arduous, especially in its early stages, and, unless good health is enjoyed, it may be found difficult to carry out the exacting tasks which will be encountered. This is not to say that one hundred per cent physical perfection is essential, but merely to sound a note of caution that any lack of physical health or stamina may prove a handicap and deprive the individual of his best chances.

CHAPTER IV

THE TECHNICAL QUALIFICATIONS OF AN ENGINEER

THE general attributes which should be possessed by anyone entering the engineering profession have been discussed in the previous chapter, and it will now be helpful to examine briefly the special qualifications which every engineer must have before he can truthfully describe himself as such. For this purpose it has already been decided (see Chapter I, page 9) to define an engineer as a corporate member of either the Institutions of Civil, Mechanical, or Electrical Engineers, and, for the young engineer, associate membership (the junior grade of corporate membership) is taken as the criterion.

The technical qualifications of an engineer are in consequence chiefly determined by the requirements for associate membership of these three institutions. These requirements are so important, forming as they do the basis of any professional engineer's career, that it is considered advisable to quote them in full. By permission of the Institutions of Civil, Mechanical, and Electrical Engineers, the appropriate by-laws governing associate membership are therefore reproduced below:—

(I) *The Institution of Civil Engineers* (By-Law 4)

Associate Members shall comprise every person who has been elected into the class of Associate Members, so long as his name is on the Roll as such.

Every candidate for election into the class of Associate Members shall possess the following qualifications, that is to say,

(i) *Age.*—He shall be more than twenty-five years of age.

(ii) *Occupation.*—He shall be actually engaged at the time of his application for election in the design and/or in the construction of such works as are comprised within the profession of a Civil Engineer as defined by the Charters. Any candidate who, at the time of his application for election, is employed either (*a*) as a teacher of engineering in a college which has a regular course of study approved by the Council extending over at least three years leading to a degree recognized by the Council as exempting from such parts of the Associate Membership Examination as they may from time to time direct, or (*b*) in engineering research, may be regarded as employed 'in the design' of engineering work.

(iii) *Examinations.*—He shall have passed the Preliminary and the Associate Membership Examinations of the Institution. The Council may exempt a candidate therefrom to the extent to which he has passed other examinations recognized by them.

(iv) *Training and Experience.*—He shall, moreover, have one of the following groups of qualifications lettered respectively (D), (E), (F), (G), and (H), that is to say,

> (D) He shall have been trained for at least three years in a manner satisfactory to the Council as an articled pupil or apprentice or as an assistant under agreement under a Civil Engineer practising in any of the branches of Civil Engineering as defined by the Charters; and he shall have had in addition two years' experience in the design or in the construction of such works as are comprised within the profession of a Civil Engineer. At least one year of the foregoing period of five years shall have been spent in an Engineer's office and at least one year in or upon engineering works.

(E) He shall have been trained for at least three years in a manner satisfactory to the Council as an articled pupil or apprentice or as an assistant under agreement under a Civil Engineer practising in any of the branches of Civil Engineering as defined by the Charters; and he shall have had in addition one year's experience in the design and/or in the construction of such works as are comprised within the profession of a Civil Engineer.

At least one year of the foregoing period of four years shall have been spent in an engineer's office and at least one year in or upon engineering works. He shall in addition have pursued a regular course of study for two years in an engineering college accorded recognition by the Council.

(F) He shall have followed in an engineering college a regular course of study approved by the Council, extending over at least three years, leading to a degree recognized by the Council as exempting from such parts of the Associate Membership Examination as they may from time to time direct, and shall have obtained that degree, and he shall have had in addition at least two years' training of a character satisfactory to the Council as an articled pupil or apprentice or as an assistant under agreement under a Civil Engineer practising in any of the branches of Civil Engineering as defined by the Charters; and he shall have had, in addition,

(1) One year's experience in the design or in the construction of such works as are comprised within the profession of a Civil Engineer, or

(2) One year in an engineering college of post-graduate engineering study approved by the Council, or

(3) One year of engineering research of a kind satisfactory to the Council.

At least one year of the foregoing period of three years' training and experience shall have been spent in an engineer's office, and at least one year in or upon engineering works.

(G) He shall have followed in an engineering college a regular course of study approved by the Council, extending over at least three years, leading to a degree recognized by the Council as exempting from such parts of the Associate Membership Examination as they may from time to time direct, whether he has taken the degree or not; and he shall have had in addition at least four years' experience of a character satisfactory to the Council in the design or in the construction of engineering works as an assistant under a Corporate Member.

At least one year of this period of four years shall have been spent in an engineer's office, and at least one year in or upon engineering works.

(H) He shall have had at least seven years' experience in the design or in the construction of engineering works of a character satisfactory to the Council as an assistant to a Corporate Member.

At least one year of this period of seven years shall have been spent in an engineer's office, and at least one year in or upon engineering works.

In the case of a mining engineer, for the purposes of this section, work in the general manager's office may be regarded as equivalent to work in an engineer's office, and training or experience gained wholly in the mine, or mainly in the mine and partly in works ancillary thereto, may be regarded as equivalent to training or experience obtained in or upon engineering works.

Evidence of the candidate's pupilage, apprenticeship, or training as an assistant under agreement must be afforded by the production of the indentures or a certified copy thereof, or of a certificate according to the Form AA in the Appendix hereto, given by the candidate's employer or immediate superior, who must be a practising Civil Engineer.

(II) *The Institution of Mechanical Engineers* (By-Law 13)

An Associate Member shall be a person not under twenty-five years of age who, in the opinion of the Council, is qualified to act as a Mechanical Engineer, having passed the Associate Membership Examination prescribed by the Council's Examination Rules for the time being or such other exempting examinations as may from time to time be approved by the Council under such Rules, and having produced evidence to the satisfaction of the Council that he—

(a) has been regularly trained as a Mechanical Engineer, and

(b) has had sufficient practical experience in mechanical engineering.

Provided that a candidate who is not under thirty-three years of age and who has not passed one of the above-mentioned examinations but has produced evidence to the satisfaction of the Council that he has received a good general and scientific education and has been employed for a sufficient period in a responsible position in engineering science or practice, may be required to pass such section or sections of the Associate Membership Examination, or in lieu thereof to submit such thesis as the Council shall determine.

(III) *The Institution of Electrical Engineers* (By-Law 12)

Every candidate for election or transfer to the class of Associate Member shall satisfy the Council—

(a) Either that he—

(i) Is at least twenty-six years of age;

(ii) And has been trained and has had responsible experience as an electrical engineer [1] according to one of the alternative typical groups of qualifications lettered respectively (A), (B), (C), and (D) in the Schedule set out below (*see* page 39), provided that the periods of training and experience of a candidate for Associate Membership shall include in the required total of seven years at least two years' experience in a responsible position as an electrical engineer;

(iii) And is engaged in or associated with any branch of engineering at the time of his application; provided that temporary unemployment shall not be deemed a disqualification;

(iv) And has passed an examination or possesses an educational qualification approved by the Council.[2]

(b) Or that he—

(i) Is at least thirty years of age;

(ii) And has had at least five years' experience in a responsible position as an electrical engineer; [1]

(iii) And is engaged in or associated with any branch of engineering at the time of his application;

[1] In addition to complying with the Examination requirements of the Institution, candidates for Associate Membership are required to have held a responsible position as an electrical engineer for a period of at least two years. This 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.

[2] The examination and educational qualifications are set out in the Associate Membership Examination Regulations. The Council have power to waive the examination, but exercise this power only in most exceptional cases and in no case if the candidate is less than forty years of age.

provided that temporary unemployment shall not be deemed a disqualification;

(iv) And (unless in special cases the Council decide otherwise) has passed an examination or possesses an educational qualification approved by the Council.[1]

SCHEDULE

Alternative Qualifications	Full Daytime College Course	'Sandwich' Course	College Apprenticeship or Workshop Course	Full Apprenticeship or Training, with Part Time Course	Responsible Experience as an Electrical Engineer	Total
(A)	3 yrs.	—	2 yrs.	—	2 yrs.	7 yrs.
(B)	3 yrs.	—	—	—	4 yrs.	7 yrs.
(C)	—	—	—	5 yrs.	2 yrs.	7 yrs.
(D)	—	4 yrs.	1 yr.	—	2 yrs.	7 yrs.

Although the by-laws are here quoted in full, it is essential that all intending candidates for associate membership should communicate with the Secretary of the Institution concerned. Not only will they then receive the latest and most up-to-date regulations together with the necessary proposal forms, &c., but they will also be given every possible assistance and advice as may be applicable to their own cases. The addresses of the three institutions are as follows:—

The Institution of Civil Engineers
Great George Street
London, S.W.1.

[1] The examination and educational qualifications are set out in the Associate Membership Examination Regulations. The Council have power to waive the examination, but exercise this power only in most exceptional cases and in no case if the candidate is less than forty years of age.

The Institution of Mechanical Engineers,
Storey's Gate
St. James's Park
London, S.W.1.

The Institution of Electrical Engineers,
Savoy Place
Victoria Embankment
London, W.C.2.

It is important to notice in By-law 4 of the Institution of Civil Engineers the words: 'Civil Engineer as defined by the Charters'—that is, one who practises '. . . the art of directing the great sources of power in Nature for the use and convenience of man. . . .' This means that membership of the Institution of Civil Engineers is open to those suitably qualified in any branch of engineering falling within this definition, for the institution does not confine its activities or its membership solely to civil engineering in the restricted sense of constructional works.

The requirements of the three institutions are generally similar in that they call for:—

(*a*) a minimum age limit of twenty-five (for the Civils and Mechanicals) or twenty-six (for the Electricals).

(*b*) a standard of theoretical knowledge, defined by the passing of the associate membership examination or by obtaining approved exemption from that examination.

(*c*) practical experience in the branch of engineering concerned, this practical requirement varying according to circumstances.

In acquiring the necessary practical experience, much will depend on the career of each particular individual, and on the branch of engineering in which he is engaged. The institution by-laws are so framed that almost every type of engineering career is catered for; some of the various possibilities are considered more fully in Chapters V and VI.

The associate membership examinations of the three institutions differ somewhat in arrangement as well as in subject-matter. This may be seen from Appendix III, in which are tabulated the requirements of the three examinations, together with those of the External B.Sc. (Eng.) Degree examination of the University of London. It will be seen that the A.M.Inst.C.E. and A.M.I.Mech.E. examinations are in three sections, ' A ', ' B ', and ' C ', and the A.M.I.E.E. examination is in two sections, ' A ', and ' B '. For the A.M.Inst.C.E. and A.M.I.E.E. examinations there is a ' Joint Section A ', which is common to candidates for membership of both institutions, and ' Section B ', which is separate for each institution. The Sections ' A ' and ' B ' of all three examinations are approximately equivalent, although there are differences in the subjects to be taken.

' Section C ' of the A.M.Inst.C.E. examination is special to that institution, and the requirements are quoted in full in Appendix IV (page 124). Briefly, this section consists of :—

(*a*) The submission of a report outlining the candidate's engineering training and experience,

which must be accompanied by :—

(*b*) certified evidence of practical experience in design calculations and quantities, specification of materials, testing, or similar work.

If the report and evidence are acceptable, the candidate will have :—

(*c*) an oral examination,

followed by :—

(*d*) a written examination (three hours), in which he must write an essay on a specified subject within his professional experience.

The final assessment will be made on the combined result of the report, oral examination, and essay.

' Section C ' of the A.M.I.Mech.E. examination consists of an examination paper on ‘ Workshop Organization and Management ’; a similar subject, ‘ Engineering Organization and Economics ’, is part of ‘ Section B ’ of the A.M.I.E.E. examination, which normally has no ‘ Section C ’, although, at their discretion, the Council may require any candidate to sit for this section. It may be said that it is exceptional for the Council of the Institution of Electrical Engineers to exercise their discretion in this matter.

The standard of the associate membership examinations may be gauged from the syllabus of the Institution of Civil Engineers, which is reproduced in full in Appendix IV. The syllabuses of the Institutions of Mechanical and Electrical Engineers are not reproduced owing to considerations of space, but the appropriate subjects form part of the A.M.Inst.C.E. examination as applicable to mechanical or electrical engineers, and will therefore give a general guide to the requirements.

Exemptions from Sections ‘ A ’ and ‘ B ’ of all three examinations may, in general, be obtained by possessors of a suitable technical qualification of approximately degree standard. It is not possible to list all the examinations which are approved by the three institutions as exempting from these sections; alterations and additions are continually being made, and it is essential to consult the latest and most up-to-date list. Anyone who is in doubt as to whether his own particular qualifications are acceptable for exemption should write to the institution concerned for confirmation. In certain circumstances a thesis may be submitted as an alternative to sitting for the A.M.I.Mech.E. or A.M.I.E.E. examinations. Full particulars and the conditions governing the submission of theses should, where necessary, be obtained from the institution concerned, as they are rather beyond the scope of this book.

In special cases exemption from ‘ Section C ’ of the A.M.I.Mech.E. examination is possible; here, too, particulars should be obtained from the institution. There is no exemption from 'Section C' of the A.M.Inst.C.E. examination, which must be taken by all candidates for associate membership.

The practical experience necessary for associate membership of the three institutions is outlined in the by-laws which have been quoted. Two factors enter into the assessment of any candidate's practical experience: the length and the quality of that experience. The Institution of Electrical Engineers require 'responsible experience as an electrical engineer', and it should be taken that the important word 'responsible' is also to be understood in the requirements of the other two institutions.

In the past the point has been raised that 'responsible' engineering appointments were open only to corporate members of the institutions, while such experience was itself essential to the attainment of corporate membership. This difficulty is more apparent than real, for there are many appointments of considerable responsibility for which corporate membership of an institution is not a stipulated requirement. Further, candidates for associate membership may be quite confident that the Councils of all three institutions, in examining the details of candidates' experience which are submitted to them, will give credit for the full worth of whatever practical experience those candidates may have had. In the Institution of Electrical Engineers there is a grade of membership known as 'Graduates', who are academically qualified for associate membership, but who have not yet gained the necessary 'responsible experience as electrical engineers'.

There are many different ways in which a career can be planned after leaving school so that the necessary academic and practical knowledge are obtained. These will be examined in the next three chapters, which are concerned with training to be an engineer and with careers after training.

CHAPTER V

TRAINING TO BE AN ENGINEER

IT HAS been seen that all engineering training must be both theoretical and practical, the general requirements of the professional institutions calling for theoretical training to approximately degree standard, a period of practical training as an apprentice or pupil, and a further period in a position of some responsibility. As already pointed out, there are several ways in which the first stages of this theoretical and practical training may be obtained; experience in a position of responsibility will follow after the initial qualifications have been obtained. The differences between the various possible methods lie almost entirely in the sequence which is adopted, although other more personal considerations will affect the method chosen by any particular individual.

This question of the sequence of training has, for many years, been the subject of discussions among engineers, and even to-day there is some disagreement about the best method to be adopted. One thing, however, is quite definite: theory or practice alone cannot, in any circumstances, be sufficient. This is a different state of things from that which existed in the earliest days of engineering, when there were practically no facilities for theoretical instruction. Then the art was much more empirical than it is now, and it could be acquired only by practical experience. Towards the end of the eighteenth century one of the most famous of the early engineers, Thomas Telford, described his own training in these words:—

> 'If civil engineering is still preferred, I may point out that the way in which both Mr. Rennie[1] and myself

[1] An equally famous engineer of the same period, perhaps best remembered as the builder of the first Waterloo Bridge.

proceeded, was to serve a regular apprenticeship to some practical employment—he to a millwright and I to a general house-builder. In this way we secured the means, by hard labour, of earning a subsistence; and, in time, we obtained, by good conduct, the confidence of our employers and the public; eventually rising into the rank of what is called civil engineering. This is the true way of acquiring practical skill, a thorough knowledge of the materials employed in construction, and last but not least, a perfect knowledge of the habits and dispositions of the workmen who carry out our designs.'

There could be no better advice offered to a young engineer than this last sentence, expressing as it does the whole essence of the qualifications which a good engineer should possess.

Returning to present-day systems of training, the first thing to be considered is whether the theoretical training should precede or follow the practical training, or whether they should be carried on at the same time. Several possibilities present themselves, of which the following are typical:—

1. A whole-time engineering course devoted solely to the acquisition of theoretical knowledge, followed by an apprenticeship or other such period of practical training.

2. The reversal of this—i.e., a period of practical training immediately after leaving school, followed by a whole-time course to obtain the necessary theoretical knowledge.

3. The 'sandwich' system, in which periods of theoretical and practical training are alternated.

4. A period of practical training during which an engineering course is taken at evening classes, one day or half-day every week being usually devoted to classes in addition.

It is felt strongly that there is a need for all these systems, and that the selection of the most suitable must rest with the individual. For these reasons, it is considered that little benefit would result from discussing their possible merits and demerits in detail. Some mention must, however, be made of a disadvantage inherent in any system in which practical training precedes theoretical. To illustrate this, it may be supposed that, on leaving school, a boy proceeds to serve an apprenticeship in the engineering industry, and he will presumably attend some suitable evening classes during this period; on the completion of his apprenticeship he embarks on a full-time engineering course of University standard, which he starts on the same level as boys who have just left school and who have decided that they will undertake their academic training first. There is a danger that he may have lost something of his power to absorb academic teaching, and he may find himself handicapped in comparison with those who have only just left school and who have not yet got out of the way of being taught in classrooms. It is probable that of the four methods of training mentioned this has always been the least popular, and, unless special circumstances demand otherwise, it is preferable to complete the theoretical training before starting on the practical.

In expressing this view, it must be emphasized that it is purely a personal one. Opinion has for long been divided on the relative merits of theoretical training before, during, or after practical training, and it is only fair to point out that many educationists would disagree with the author's opinion on this question.

This disadvantage in delaying the theoretical training is particularly applicable to those who will be starting their engineering careers after several years in one or other of the Services. In fact, the fear that they have forgotten how to learn may deter many of them from embarking on any career requiring an academic training. To throw up the idea of an engineering career on this account is to magnify a known snag into an insuperable obstacle; the existence of the snag should by all means be recognized, and advantage taken of this recognition to avoid it as far as possible. There are a number of counter-measures which can be taken. One of the best is probably a refresher course, many of which are to be available under Service arrangements;[1] a preliminary course at a technical college selected as being well within the individual's capabilities, an equivalent correspondence course (see pages 56 and 57), or suitable introductory reading, would each be of great assistance. These preparatory measures need not take a long time; in most cases a few months should suffice to restore the abilities which have been submerged in the strange life of war-time. Having done this, ex-Servicemen will have one priceless asset: invaluable experience in a hard school, with its resulting wide knowledge of men. Their fellow-students straight from school will have much leeway to make up in this respect in the increasingly competitive field of engineering.

Whenever an individual's circumstances permit, it is recommended that he should start his engineering career by taking a full-time course of University standard; this will normally require three years.[2] The Universities in Great Britain and Northern Ireland which award degrees in engin-

[1] It is not possible to give full details of Service demobilization courses. Those interested may obtain full particulars from their commanding officers.

[2] The ground covered in the three-year period will depend on the academic standard reached by the individual on leaving school. If he has passed the Matriculation examination (or obtained exemption from it by virtue of a School Certificate), he will take the Intermediate examination at the end of the first year, and the Final examination at the end of the third year. If, however, he has passed the Intermediate (or obtained exemption from it by virtue of a Higher Certificate—see Chapter III, page 29) before entering the University, he will take the Final examination at the end of the second year, making the third year available for post-graduate study. It should be mentioned that Universities insist on three complete years' work before a degree is awarded, even though the Final Degree examination is passed at the end of the second year.

eering are given in Appendix VI, and at these Universities it is always possible to select a degree course suited to the needs and circumstances of the individual. The financial aspects are discussed later, in Chapter VII, but meanwhile attention may be drawn to various other factors which will influence the choice :—

(*a*) Geographical positions of the University and of the student's home.

(*b*) The possibility of obtaining one of the many scholarships now available which enable their holders to go to a University.

(*c*) The branch of engineering in which the student proposes to make his career ; certain Universities tend to specialize in particular branches, usually associated with local industries, and their degrees in consequence have a particular value in those branches of engineering :

(*d*) The status of the degree in the engineering world ; the value of each degree is nicely appreciated by the engineering profession, and it is important that a student should obtain a qualification which will have the highest possible standing ;

(*e*) If a course on the 'sandwich' system is required, the choice of a University will be more limited ; the best-known courses of this type are those at the Universities of Glasgow, Liverpool, and Sheffield ;

(*f*) Personal considerations, such as traditional family association with a University, the wish to go to the University with special school-friends, and other similar reasons ; it is well not to give too much weight to these personal factors in making the final decision, as there are others which are, in the long view, more important.

Before making any decision, it is essential to get the benefit of the best advice which it is possible to obtain. At the very least, everyone should consult his school headmaster and an experienced engineer who has been through the same mill himself, and it is unnecessary to add that he must of course discuss the whole question with his parents. After carefully weighing this advice in the light of his personal ambitions and abilities, it will be found that the problem of selection will almost certainly solve itself.

It is perhaps unfortunate that specialization must be introduced at this early stage in an engineering career, but, with a very few exceptions, University engineering courses each deal with a particular branch of engineering (e.g., civil, electrical, or mechanical). The first year of a course is usually common to all branches, but after that the course becomes increasingly specialized. In some cases further specialization is necessary before the completion of the course; for example, the final year of an electrical engineering course is generally sub-divided into 'power' and 'communications', and the student must decide before the beginning of that year which he is going to take. The disadvantage of this need for early specialization is greatly offset by the fact that the various branches of engineering have much in common. The mechanical engineering student, for instance, must have a working knowledge of electricity and of many aspects of civil engineering. More important, the fundamental principles remain the same whatever the branch of engineering, and it is these principles which matter at this stage rather than their specialized application.

So far no mention has been made of the External Degree in Engineering awarded by the University of London, which stands in a class by itself. The examination for this degree may be taken without attending any course at the University of London or at any other University as such, and the majority of these degrees are obtained by students at the many technical colleges throughout the country which have been approved by the University of London for the purpose of this degree. It is a great advantage of the external engineering degree that a student may sit for the examination after a part-time course taken at evening classes while he is obtaining practical experience in his daily work and is also beginning to earn.

The arrangement of the External B.Sc. (Eng.) Degree Examination is given in Appendix III, where it may be compared with the associate membership examinations of the professional institutions. Some extracts from the University of London Regulations governing the degree are reproduced in Appendix V, which will indicate something of its scope and of the requirements which must be met by intending candidates. The technical colleges in Great Britain and Northern Ireland which have been approved by the University of London for the purpose of the degree will be found in Appendix VII.

It must not be thought that a University degree is the only academic qualification recognized by the professional institutions for the purpose of exemption from their associate membership examinations. There is the extremely important system of 'National Certificates' and 'National Diplomas' which represent the attainment of certain defined standards of engineering knowledge. These certificates and diplomas are awarded by the Institutions of Civil, Mechanical, and Electrical Engineers in conjunction with the Ministry of Education. They may be taken at the majority of technical colleges, schools, and institutes throughout the country, the only requirement being that the syllabus of each course is subject to the approval of the appropriate professional institution and of the Ministry. Appendix VII lists the various technical colleges, schools, and institutes which offer National Certificate and Diploma courses, and indicates the courses which are available at each.[1]

[1] Owing to the great interest which exists in all branches of aeronautical engineering, the technical colleges, schools, and institutes at which day courses and evening classes in this subject are available are also indicated in Appendix VII.

There are two types of National Certificate, and two types of National Diploma, as follows :—

1. The *Ordinary* National Certificate, which is awarded on the results of a *part-time course* usually requiring three years for completion.
2. The *Higher* National Certificate, which is awarded on the results of an *advanced part-time* course normally requiring two further years after the Ordinary National Certificate.
3. The *Ordinary* National Diploma, which is awarded on the results of a *full-time course* requiring two or three years.
4. The *Higher* National Diploma, which is awarded on the results of an *advanced full-time course* normally occupying a minimum of three years.

The regulations for the associate membership examinations of the various professional institutions provide for exemption from portions of the examinations depending on the subjects in which the candidate has passed in his National Certificate or Diploma examinations. It is important, before starting on a National Certificate or Diploma course or, for that matter, on *any* engineering course, to ascertain whether the successful completion of the course qualifies for exemption from all or part of the appropriate associate membership examination ; it is always advisable to refer the matter to the secretary of the institution concerned, who can advise in any case of doubt. This point is given special emphasis, as many students have been disappointed by failing to obtain exemption from parts of the associate membership examinations, after they had been led to believe (when they first started their courses of training) that they would do so.

It will be clear that the National Diploma courses offer alternatives to University degree courses, and they are, generally speaking, of a somewhat lower standard, although a student successful in the Higher National Diploma might well be able to pass the External University of London degree examination. The National Certificate courses are primarily designed for those who must obtain their theoretical instruction at evening classes, with perhaps a day or half-day during the week in addition, and it has become customary for engineering firms to insist that their apprentices attend such courses during the period of their apprenticeships. It is also possible, by working at evening classes, to reach the standard of the External Degree examination, which as a rule can be taken at the end of five years after leaving school (with matriculation or the equivalent) and starting apprenticeship.

At first sight it might appear that a five-year apprenticeship with attendance at evening classes, leading to the National Certificates, and possibly to the External Degree, would be the best method of gaining both theoretical and practical experience; the scheme is attractive, not only for financial reasons, but also because the whole training can be completed in five years, which is a shorter time than is normally required to go to a University and subsequently to serve an apprenticeship. Many people have embarked on such a system of training, but singularly few have succeeded in attaining their objectives, especially when these have included taking the External Degree examination.

As an expression of purely personal opinion, the author would never advise anyone to adopt this method unless it was absolutely unavoidable. In spite of its apparent virtues, the scheme suffers from two serious disadvantages: first, the physical strength necessary to work in a factory for five years as an apprentice and concurrently to attend evening classes leading up to a degree examination is far greater than the vast majority possess, and there have been many failures solely due to impaired health and lack of sufficient physical stamina. Secondly, in order to succeed, it is essential for the average student to keep his nose firmly pressed onto the grindstone throughout the five years; he simply cannot afford to devote more than the smallest proportion of his spare time to any pursuits other than working for his examinations. This results inevitably in a restriction of the student's outlook, which must prove a very serious handicap as his career proceeds.

At the risk of being thought an iconoclast, the author considers that an individual with fewer academic qualifications (nothing more, for example, than an Ordinary National Certificate), but with a practical knowledge of people and of the world he lives in, will always be of greater value as an engineer (both to himself and to others) than one who has obtained the highest academic qualifications at the expense of his knowledge of the world. The words 'at the expense of' are important. Anyone who combines high academic qualifications with a sound knowledge of the world has the ball at his feet; with the addition of practical engineering experience, his career is assured. Nor is this expression of opinion intended in any way to decry the great value of evening classes and their vital place in engineering training. It is only desired to emphasize that there are other things to be considered in training for an engineering career besides the acquisition of academic knowledge. If it is found that a particular part-time course requires the whole of an individual's spare time, it will be well worth his while to defer taking the examination rather than to lose opportunities of acquiring that general knowledge of people without which he can never reach the more important posts in the profession.

This point was emphasized in a recent paper on 'The Training and Qualities of the Future Gas Engineer' by Mr. G. C. Pearson, M.Inst.C.E., M.Inst.Gas.E., Chief Engineer of the Birmingham Corporation Gas Department. He said:—

'The attainment of success in any administrative position obviously requires more than technical ability alone. A man must possess a quality of leadership and the power to get work done; he must be able to deal with all situations from the viewpoint of calm commonsense and must possess courage. An optimistic outlook is of help. A man without these attributes would not be a success as a Gas Engineer but he can be useful in the Industry as a specialist.' [1]

If the word 'gas' were deleted from the last sentence of this acute appreciation, it would apply to any branch of engineering, and it expresses a truth which must be realized fully by all who intend to make a success of their engineering careers.

In recent years the science of management and administration has been closely studied, and it has now long passed the stage where its practice was entirely empirical. Like engineering, a sound training in administration must include much practical experience based on a sound knowledge of the underlying theoretical principles. A knowledge of administration is becoming more and more a part of the essential equipment of every engineer, a fact which has been recognized in the examinations for the A.M.I.Mech.E. (Section C) and the A.M.I.E.E. (Section B).[2] There is also an increasing tendency for Universities to give some instruction in administration as part of their engineering courses; at Cambridge University, for example, a series of eight lectures on management was arranged for third-year engineering tripos students as long ago as 1930. These lectures were introduced at the instigation of Professor C.E. Inglis, F.R.S., M.Inst.C.E., M.I.Mech.E. (lately Professor of Mechanical Sciences at Cambridge University), who said, during a

[1] This extract is reproduced by permission of the Institution of Gas Engineers.
[2] See Appendix III.

discussion on education and training at the Institution of Electrical Engineers some years ago :—

> ' Some preliminary instruction in industrial management should be given at a university, but that instruction should be regarded only as the introduction, and intensive training in the subject should be deferred until experience has given a background and a reality to the problems which confront management.'

An introduction to the principles of management and administration can well be obtained at evening classes in all cases where the academic engineering training has already been completed (e.g., those who have obtained a University degree and are serving their apprenticeships). The study of administration in this way really forms part of apprenticeship training, and will be referred to again in the next chapter.

In this discussion of theoretical engineering training and the ways in which it can be obtained, no mention has been made of correspondence courses. These courses are extensively advertised in the Press, and it would be well to have a clear idea of their virtues and limitations. For engineering training their most important limitation lies in the absence of all the laboratory and practical work which is an essential feature of University and technical college courses; the absence of laboratory work may mean, to take an extreme case, that a student who has failed in a particular examination after a technical college course may have had a better training than one who has passed the same examination after only a correspondence course. (In passing, it may be mentioned that it is a condition of a number of examinations that each candidate shall produce evidence of specified practical work.) On the other hand, it is claimed that a correspondence course makes the services of highly qualified teachers available to a greater number of students than would otherwise be possible, and it should be recognized that there is much truth in this claim when the teachers are highly qualified.

In the author's opinion, the greatest appeal of a correspondence course lies in its admitted efficiency as an ' examination-passing device ' ; anyone who has failed to pass an examination after a full- or part-time course of the usual type would benefit greatly by taking a suitable correspondence course before again sitting for the examination. Correspondence courses have also great value as refreshers, at the present time particularly for Service men who want to regain their 1939 academic standard. They are also, of course, extremely useful for those who cannot, for some reason, attend at a University or technical college.

With these exceptions, it is recommended that a University or technical college course in preference to a correspondence course should be taken for the purpose of obtaining the academic training required for a professional engineering career. It is not possible to list all the many and various engineering correspondence courses available ; the addresses of three correspondence colleges from among a large number which offer courses for the various associate membership examinations are, however, given below for the convenience of those who may be particularly interested :—

The British Institute of Engineering Technology
Shakespeare House
17–19 Stratford Place
London, W.1.

The Technological Institute of Great Britain
Temple Bar House
London, E.C.4.

The National Institute of Engineering
148–150 Holborn
London, E.C.1.

As the author has had no personal experience of correspondence courses, it must be emphasized that, in giving these three names, no particular recommendation is to be inferred, nor is any reflection whatever implied or intended to the many other organizations which may offer similar courses.

It may now be convenient to summarize the several ways in which the theoretical knowledge necessary to qualify for associate membership of a professional institution may be acquired. There are full-time courses at Universities leading to engineering degrees ; full-time courses at technical colleges leading to the National Diplomas or to the External London Degree ; and part-time courses leading to the National Certificates and also to the External Degree. Certain special cases may call for correspondence courses of various standards. Whichever of these routes may be chosen, the ultimate objective of qualifying as a professional engineer should never be lost sight of.

CHAPTER VI

TRAINING TO BE AN ENGINEER
(continued)

IN THE institution requirements for associate membership there is a distinction between 'practical training' and 'practical experience' (see Chapter IV, pages 33–39), the latter being obtained in a responsible position as an engineer after training has been completed. The present chapter is concerned with practical training, which generally takes the form of an apprenticeship or pupilage; the question of practical experience after training will be discussed in Chapter VIII.

Although the system of training in any particular case must depend on individual choice and circumstances (e.g., the sequence of theoretical and practical training considered in the previous chapter), it is possible to examine some of the more usual systems and to discuss their main features. The two most important for the present purpose are:—

(*a*) A full-time engineering degree course at a University or technical college, followed by a two- or three-year apprenticeship; this type of apprenticeship will be referred to as a 'student' apprenticeship, though it is sometimes also spoken of as a 'graduate apprenticeship'.

(*b*) A five-year apprenticeship on leaving school at seventeen or eighteen, and at the same time taking a part-time course leading to a degree or National Certificate; this type of apprenticeship will be referred to as a 'technical' apprenticeship.

Of those who come into this latter group, a number may never reach the standard required to become professional engineers; on the other hand, the group will include those who have started their apprenticeships as craftsmen on leaving school at fifteen, and who have shown such ability that they are proceeding to part- or full-time degree courses. The two groups may thus fairly be said to include the majority of those who will ultimately become professional engineers.

In serving an apprenticeship, whether it be 'student' or 'technical', there is certain basic knowledge which each individual must acquire. This basic knowledge is all-important; it includes the use of tools, the handling of the simpler machine-tools, the correct reading (and subsequently the making) of engineering drawings, the properties of the engineering materials in general use, and the basic manufacturing and constructional processes in the working of those materials. Knowledge of these things is common to all branches of engineering, although the balance between the different items will vary. For example, mechanical engineers will be more concerned with (say) machine-tools and manufacturing processes than with constructional work; for civil engineers, of course, this will be reversed, and in addition they will be concerned with many engineering materials, such as masonry, concrete, &c., of only secondary interest to mechanical engineers.

It is vital for every engineering apprentice and pupil to realize that in serving his apprenticeship he is being given a great opportunity to acquire practical knowledge; the use which he makes of that opportunity is entirely up to himself. An apprentice should at all times try to obtain the widest possible knowledge and experience of every aspect of engineering with which he comes into contact; he should always be asking himself 'why is so-and-so done in such-and-such a way?', and, having asked the question, he should only be satisfied with a definite and complete answer to it. His sources of information will be legion, varying from questions of his fellow-workmen to (in rare cases) library references, and the answer he seeks will usually be the summation of many small items gleaned from several sources.

This questioning attitude is epitomized in the advice given by a famous firm to all their newly-joined apprentices: 'Use your eyes, your ears, and your notebook.'

Before making any arrangements for an engineering apprenticeship, it is necessary to appreciate the relationship between engineering firms and their apprentices or pupils. An apprenticeship is based on a legal agreement between the firm and the apprentice (and his parent or guardian if he is under twenty-one), by which the firm undertakes, *inter alia*, to teach the apprentice, who on his part undertakes certain obligations to the firm. The document setting out these undertakings is known as an 'indenture'; a typical example, reproduced by permission of the Engineering and Allied Employers' National Federation, is given in full in Appendix X.

The agreement is phrased in legal language, but its essentials may be summarized as follows:—

The employer (or firm) agrees to:

(*a*) keep the apprentice in his service for a stated period,
(*b*) teach the apprentice his trade,
(*c*) observe certain prescribed conditions of employment, and
(*d*) pay the apprentice the agreed wages.

The apprentice agrees:

(*a*) to observe the prescribed conditions of employment,
(*b*) to obey the employer and promote his interests,
(*c*) not to reveal secrets of the employer's business,
(*d*) not to damage the employer's property,
(*e*) not to absent himself except with permission or when ill, and,
(*f*) not to take part in any labour dispute.

Either party can terminate the agreement should its provisions not be observed by the other.

At the end of the apprenticeship the employer will give the apprentice a certificate stating that he has served satisfactorily for the period of the apprenticeship ; frequently this certificate may be endorsed on a copy of the indenture which is given to the apprentice, and details of the work he has done, together with a statement of his special abilities, may often be added as well.

While an individual may select the firm to which he applies to be taken on as an apprentice or pupil, it is for the firm to decide whether or not it will accept him. There is no free choice of firms comparable to the choice of (for example) Universities. Obviously, the higher the reputation of the firm, the greater will be the competition to be accepted by it ; preliminary inquiries should always be made on this point, for the trade reputation of a firm may be a poor guide to its reputation for training apprentices.

Some selection must, of course, be exercised by the would-be apprentice before he makes application to a firm ; this will be necessary before he leaves either his school (for a technical apprenticeship) or University (for a student apprenticeship). The guiding factors will be generally similar to those which governed the choice of a University (see Chapter V, page 48), and it is again essential to get the best advice which it is possible to obtain before making a decision. It is not possible to list in this book the may hundreds of firms who accept apprentices for training, but most Universities and technical colleges have lists of suitable firms, and it is usually most convenient to make application for an apprenticeship through them.

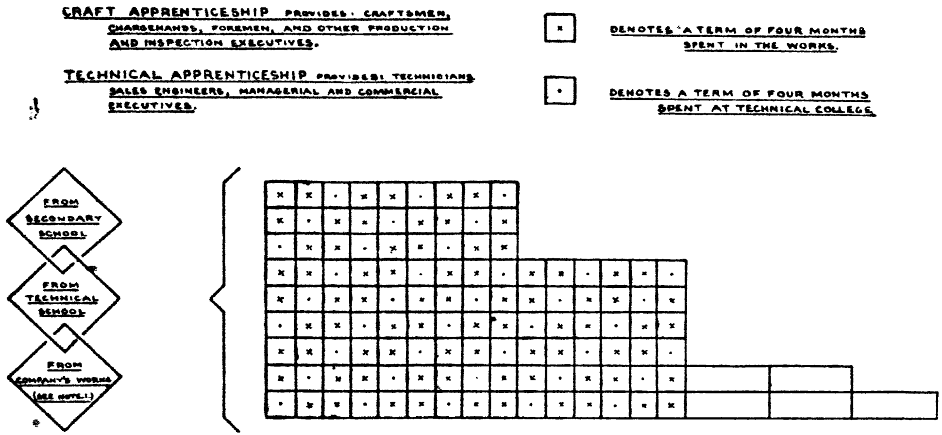
It may sometimes be possible to get an introduction to a particular firm where it is desired to serve an apprenticeship ; such introductions may be from directors or executives of the firm itself, or from someone who has a close connexion with the firm. A good introduction is an excellent beginning, but it does not compel the firm to accept the applicant as an apprentice; this may sound obvious, but a surprising number of young men seem to think that an introduction means just that. It is not denied that an introduction may carry considerable weight, but the firm will exercise its normal choice just the same, and it will not accept applicants whom it considers unsuitable. Any apprentice who has been accepted and who was specially introduced to his employer is under a particular obligation to do more than his very best; to put it mildly, it is most discourteous to his sponsor not to put forth his best efforts, or to give the slightest cause for complaint during his apprenticeship.

Having been accepted by a firm, it is usual for an apprentice to serve a probationary period of three or six months; at the end of this time either the apprentice or the employer may terminate the arrangement for any reason, or else the formal indenture may be completed. This probationary period has the great advantage, from the point of view both of the firm and of the apprentice, that misfits can transfer to some other sphere of activity without wasting their time in the engineering industry if they find that they are unsuited to it. Such cases should be rare, particularly if a qualified psychologist has been consulted at the outset of the individual's career.

Apprenticeship arrangements vary considerably in different firms. Some firms (the minority) are very casual, doing little more than giving the apprentice some crumbs of opportunity to learn, and leaving the rest to the apprentice himself. On the other hand, many firms have extremely well-organized arrangements, with definite syllabuses of works training and a department dealing solely with apprentices and their problems. A firm such as this is a major educational establishment in itself, having as its objective the production of a steady stream of qualified engineers of every grade and calibre. The closest association is maintained between the apprentice organization in the firm, the local technical colleges, and the Universities. The arrangements are such that planned schemes of training are available for all requirements, and it is always specially ensured that every apprentice can receive the highest standard of training for which his own individual capabilities fit him. There is naturally considerable competition to be accepted as an apprentice by a firm of this kind, but no effort or trouble is too great to achieve acceptance, and the young engineer who succeeds in this may count himself as among the fortunate ones.

Fig. 2 shows an example of an organized apprenticeship scheme, designed to train craftsmen and technicians on the 'sandwich' system; two-thirds of the apprentice's time is spent in the works and one-third at a technical college. It will be noticed that 'student' apprenticeships as such are not catered for, but there is provision both for the technical apprentice to proceed to a University and for the craft apprentice to transfer to the technical course, from which he, too, can proceed to a University. As already mentioned, a scheme of this kind must depend for its successful operation on the closest liaison between the firm and the local technical colleges, and it is not too much to say that the best apprentice training can be obtained only where such liaison exists. The scheme shown in Fig. 2 is operated by Birmid Industries, Ltd., and it is described in detail in their brochure, 'Training for the Metallurgical Engineering Industries', from which the diagram is reproduced.

Those who plan their careers so that they go to a University after leaving school and then to serve a student apprenticeship must decide how they will spend the long vacations while they are at the University. (This, of course, refers to normal conditions, when the long vacation is approximately fourteen weeks between June and October.) Although it is possible to spend the long vacations doing nothing in particular, competition is such that the loss of



	AGE	16	17	18	19	20	21	22	23
ALTERNATIVE COURSES	CRAFTSMEN	TECHNICAL COLLEGE OR CITY AND GUILDS CERTIFICATE COURSE			TECH COLLEGE OR CITY AND GUILDS (FINAL)		FOUNDRY SCHOOL	VISITING COURSE (SEE NOTE 2)	- - -
	TECHNICIANS	NATIONAL CERTIFICATE (ORDINARY)			NATIONAL CERTIFICATE (HIGHER)		FOUNDRY SCHOOL, VISITING COURSE, OR UNIVERSITY		

NOTES :—1. App rentices are recruited from secondary schools, technical schools, and from junior employees who are attending continuation schools.
2. A visiting course is taken at the works of another company.

FIG. 2.—OUTLINE OF A TYPICAL APPRENTICE TRAINING SCHEME.
(Reproduced by permission of Birmid Industries, Ltd., from their training booklet.)

nine months at the University stage might well prove a handicap for many years. The usual thing is to go into some engineering works for three months each summer, and there to obtain that basic practical knowledge which is so important. If this practical training is obtained with the same firm as the subsequent apprenticeship is served, an allowance will be made for the time served during vacations, thus reducing the period of the final apprenticeship.

On the other hand, vacation work may be done with a different firm each year, and this has the advantage of giving a broader experience. Time thus spent may not be allowed to count towards a subsequent apprenticeship, which would have to be served in full. If the student can afford to travel each year, he could devote his long vacations to acquiring a practical knowledge of languages, which are bound to be of great value to him later. Another possibility—perhaps the best of all—is to spend the long vacations obtaining practical experience in several branches of engineering related as remotely as possible to the student's own chosen branch, and if possible abroad; for example, an electrical engineer might spend one long vacation at sea and another on railway construction. By doing this he would prove for himself at an early stage of his career the old truth that interesting and important things are always happening on the other side of the hill, and he would also be widening his knowledge of people and of the world.

In whatever way the student spends his vacations he will have to make his plans considerably in advance. The guiding principle in making these plans should be to employ his available time in broadening his general knowledge and outlook to the best advantage; if this is done, the details of what he does are not important. The way not to spend vacations is either doing nothing or concentrating on some narrow specialized field in which he cannot see the wood for the trees.

The young engineer who serves a student apprenticeship will also be faced with the problem of evening study during his period of service. Most firms insist that their student apprentices attend evening classes at the nearest technical college, some of them specifying the subjects which the apprentice must study, and others leaving the choice of subjects entirely to the apprentice himself. These free evenings during a student apprenticeship provide a magnificent opportunity for the young engineer to acquire some knowledge of those subjects which are not normally taught in University engineering courses but which will be invaluable later in his career. These subjects include commercial and industrial law, economics, statistics, accountancy, cost and works accountancy, industrial organization and administration, labour management, and the like. No special guidance can be given on the choice of subjects, as this must rest with the individual, and must depend on his special abilities, inclinations, and future career.

It will be clear that at some point during his apprenticeship every young engineer must decide the line along which he will specialize. Obviously, practical training as an apprentice should be arranged quite differently for one who is destined for the commercial side of engineering than it would be for one choosing the manufacturing side. Specialization has already been mentioned several times, coupled with a warning against specializing in the early stages of an engineering career, and once again a similar warning must be given. Specialization should be avoided until the individual has settled down in his apprenticeship for (say) six months, and a longer period is advised in the case of five-year apprenticeships. The apprentice will find that, as he gradually acquires a knowledge of the industry, he will have little difficulty in deciding for himself the branch to which he is particularly drawn. As soon as this decision is reached he should firmly make up his mind to concentrate on this particular branch; his practical training will consequently be directed along definite lines, and no time will be wasted in acquiring unnecessary knowledge. In saying this it must be emphasized that no general knowledge is ever unnecessary; what must be avoided is the acquisition of detailed knowledge which will never again be required. It is also advisable to remember that knowledge consists less of knowing facts than of knowing where facts can be found and of being able to assess them at their real worth.

No attempt can be made here to examine the minor differences in the practical training required for various branches of engineering. Constructional work (of primary importance to civil engineers, although applicable to most other types of engineering as well) and research, however, are branches for which the practical training must differ from that already outlined. The differences lie only in the arrangement of the training; they do not affect in any way the underlying principles which have been discussed.

The practical knowledge required by a constructional engineer can, of course, be obtained only by doing such work and by spending the greater part of the time available for training on as many kinds of constructional work as possible. The basic groundwork (practical knowledge of tools, materials, methods, processes, &c.) is still essential, and this may be acquired in a consulting engineer's office or in the factory where the equipment is built; the constructional work—that is, the erection of the equipment on the site—will then follow. Most constructional jobs can be studied from two points of view: that of the consulting engineer responsible for the work, or that of the contracting firm who are carrying out the work. A particular individual can, of course, be apprenticed to only one of these, but for student apprentices it will be especially valuable to devote the long vacations to work with contracting firms, subsequently serving an apprenticeship to a consulting engineer. Alternatively, this sequence might be reversed; the important thing is to obtain experience of both aspects of constructional work.

For a research engineer the highest possible academic qualifications are required, and he should have an ' honours ' degree in his particular branch of engineering. After graduating he will probably remain at the University for a further year (or more in special cases) doing post-graduate research work leading to a higher degree, such as the M.Sc. or Ph.D. At the end of his University training it is usual to obtain an appointment as a junior research worker in his chosen field, and after some years, in which he can enlarge his practical knowledge and experience, he may consider himself to be a qualified research engineer.

It will be noticed that training on these lines does not include any period in a factory or works acquiring the essential basic practical knowledge (of tools, materials, methods, processes, &c.). The need for this knowledge will depend on the sphere in which the particular individual has specialized. If his bent is towards purely academic research, the need for this knowledge is not great; on the other hand, if he inclines to more practical industrial research,[1] it is advisable for him to obtain this groundwork of practical engineering. The best way to do this is probably to serve a student apprenticeship with some large firm which has its own research department. Like all other student apprentices, he will obtain, at the beginning of his apprenticeship, a practical knowledge of the basic essentials of engineering; the remainder of his apprenticeship can then be spent in the inspection department, the testing laboratories, and the

[1] This division of research into ' academic ' and ' industrial ' very much over-simplifies the real position, which is complex and does not lend itself to easy classification; it is only necessary here to distinguish two aspects of research work for which the training will generally follow different lines.

research department, where he will have practical experience of the many aspects of industrial research.

It has been said that an engineering student at his University or technical college learns how things should be done, and that he must then serve an apprenticeship to learn how they really are done. There is much truth in this, and it is certain that no apprenticeship is worthy of the name if it fails to make a young engineer realize how little he knows. Anyone who has taken an engineering course and has served an apprenticeship should be well grounded in the basic principles and should have a wide knowledge of where and how detailed information on any particular aspect of his work can be obtained accurately and quickly. He has completed his engineering training and has had some small practical experience of the work of his chosen profession; he has not, however, had any experience as an engineer, and the next phase of his career must be devoted to obtaining that experience. Before proceeding to examine this phase, it is necessary to consider the important question: 'How much does all this cost?' It is only too easy to plan an ambitious engineering career starting with the best training available, but all such plans must be modified according to the financial resources of each individual. The next chapter will therefore be concerned with these financial details, which may be unpleasant, but which cannot be ignored.

CHAPTER VII

MAINLY FINANCIAL

THE FACT that this book is being written during the abnormal conditions resulting from the war particularly affects anything which may be said on the subject of the costs and expenses of an engineering training. It is extremely difficult to predict the probable trends of training costs after the war, and consequently it is necessary to base this chapter primarily on pre-war figures and estimates. In general, however, this should not be misleading, as comparisons between various schemes of training will remain roughly the same, although the absolute figures of cost may require alteration in the light of post-war conditions and values.

In Appendix VI an attempt has been made to give the approximate cost of a complete engineering degree course at the various Universities in Great Britain and Northern Ireland. The figure given in each case is, of necessity, approximate, and represents the cost of tuition, University and examination fees, &c., for the full period (usually three years) of a degree course; the figure does not include books, stationery, personal expenses, or board and lodging. It is obvious that the total cost of a University training must depend largely on the amounts spent on these latter items, which amounts must, in turn, depend almost entirely on the individual.

If it is possible for a student to attend a University within a reasonable distance of his home, then the important item of board and lodging may, for practical purposes, be omitted. This will not, of course, be possible in all cases, and where it is necessary to obtain board and lodging in the University town, the costs will vary considerably. Oxford and Cambridge are primarily residential Universities, and the students there live in college or in lodgings approved by the University authorities. At other Universities a certain number of students can be accommodated in University hostels, or, alternatively, they may live in lodgings under their own arrangements.

Some guidance in the matter of comparative costs may be obtained from the figures recently suggested by the Ministry of Education to Local Education Authorities as suitable amounts for awards and grants under Section 81 of the Education Act 1944.[1] The Ministry suggest that the 'maintenance element' of an award should not exceed the following amounts per annum:—

	£
At Oxford or Cambridge Universities	175
At London University	160
Elsewhere	140

or, where the student lives at home:—

	£
At London University	90
Elsewhere	75

These amounts do not include tuition fees. From these figures it may be inferred that (in the Ministry's opinion) the additional cost of living away from home is approximately £70 per annum in London and £65 per annum elsewhere, for the periods of the University terms.

These figures are given as a guide to probable costs. The qualifications required to obtain an educational award of this kind and the procedure to apply for one are beyond the scope of this book. It may be said, however, that grant of an award will depend on the ability of a particular student, probably

[1] This section empowers Local Education Authorities (*inter alia*) to grant scholarships and similar awards for further education after the compulsory school-leaving age (e.g., at Universities).

assessed by the results of an examination such as the Higher School Certificate. The amount of the award will be determined by the financial situation of the student, up to the suggested maxima given above. The regulations governing awards are laid down by the Local Education Authority, to whom application should be made for all particulars.

University fees vary greatly, from a minimum of £63 for the complete course to a maximum of slightly over £200 (see Appendix VI). The amounts necessary for books and stationery will also show considerable variations from one University to another, the average probably lying between £5 and £10 a year.

Personal expenses must depend solely on the individual, although they will be governed largely by the standards set by his fellow-students. In this respect the various Universities again show considerable differences, but the absolute minimum outlay under this head is probably about £25 a year. It must be pointed out here that nothing is more difficult than to live on an allowance for personal expenses which is lower than the average of other students. It is essential for each individual to cut his coat according to his cloth, and it is better for him to go to some other University where the standard of life among the students is more within his means, than that he should be handicapped throughout his University career by the need to spend only sixpence while his friends are prepared to spend a shilling.

In general terms, therefore, it can only be said that the cost of a University training (including provision for board and lodging) may be anything from £125 to £400 a year, according to the University and to the personal needs and standards of the individual. These are very wide limits, and before finally deciding on a University it is most important that the prospective student should not only obtain full details of tuition fees and other essential expenses from the Registrar of the University concerned, but also that he should make a particular point of discussing the matter with someone who is (or has recently been) a student there; only in this way will he be able to estimate what his University life will cost.

The fees at technical colleges, schools, and institutes are, generally speaking, very much lower than those of a University, although they may show considerable variations from one to the other. In the example given in Appendix VIII, for instance, the total fees for a part-time degree course extending over seven years [1] are only £8 15*s*., and to this must be added a small amount for books and stationery.

Whole-time students at technical colleges almost invariably live at home, and this, of course, helps to reduce their expenses considerably. Students serving an apprenticeship at a works or factory within easy reach may also live at home; alternatively, they may have to live in lodgings convenient to the works, with a consequent increase in their expenditure. These various possible arrangements, depending as they do solely on individual circumstances, make it very difficult to give any figures of costs which might be helpful. Again the figures suggested by the Ministry of Education may be taken as a rough guide; remembering that the University year is only some twenty-five to thirty weeks, the amount of £65 a year may be doubled to give an estimate of £130 a year as the cost of living away from home.

It will be noted that no mention has been made of the cost of clothes, vacations, and the like, which involve further expenditure during the training period. They are matters in which each individual must suit himself, but it is important that they should not be omitted from any personal budgets or estimates.

[1] This seven-year course is designed for those leaving school at fifteen without having passed the matriculation or equivalent examination. The course is divided as follows:—

Matriculation	2 years
Intermediate	2 ,,
Final	3 ,,

For those returning from the Services a special scheme, known as the 'Further Education and Training Scheme', has been introduced. This scheme is designed to give financial assistance in obtaining or completing a specialized professional training. Full details are given in Appendix XI, which is a copy of the official leaflet on the scheme issued by the Ministry of Labour and National Service. It will be noted that certain conditions must be fulfilled, and the amount of the grant made to any individual under the scheme will depend on his particular requirements and on his existing financial resources. Those wishing to take advantage of the scheme should make sure that they fulfil the conditions laid down (see Appendix XI), and should then apply in writing to: The Appointments Department, The Ministry of Labour and National Service, Sardinia Street, London, W.C.2.

The cost of an engineering apprenticeship must next be considered. From this point of view apprenticeships may be classified broadly into five groups:—

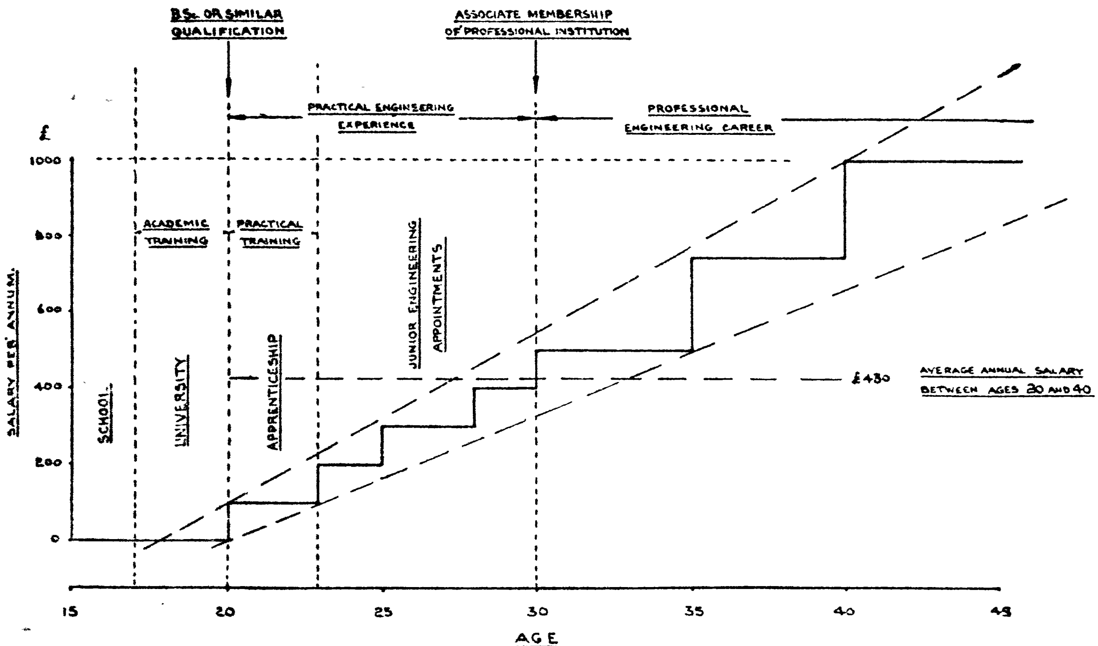
1. The apprentice is paid throughout his apprenticeship, the scale of wages rising at the end of each year of his apprenticeship. (See the typical form of apprenticeship indenture in Appendix X.)
2. The apprentice is paid throughout his apprenticeship at a fixed rate.
3. The apprentice is not paid at all.
4. The apprentice is required to pay a premium to the firm with whom he is serving his apprenticeship, this premium being returned during the apprenticeship in the form of wages.
5. The apprentice is required to pay a premium which is not returnable, and he does not receive wages.

Before examining these groups in greater detail, it is necessary to consider the point of view of a firm which undertakes to train an apprentice. When the apprentice first starts work he is a distinct liability, and any payment which is made to him must be regarded by the firm as expenditure which it hopes to recover by having a fully trained man at a later stage. Conversely, towards the end of his apprenticeship the apprentice is probably doing work for the firm which is worth considerably more than the wages which the apprentice is receiving. This serves to make up for the earlier years when the payment of wages represented a loss to the firm.

Engineering firms are not philanthropic institutions. They do not train apprentices solely for the benefit of those apprentices, but primarily so that they will have a continuous supply of trained men from which to fill technical and executive posts within their own organizations. In pursuing this aim there is, of course, a certain amount of wastage, as a number of apprentices will leave the firm at the end of their apprenticeships or shortly afterwards; firms generally compensate for this wastage by training more men than they would normally absorb, and, if necessary, by engaging engineers who have served their apprenticeships elsewhere.

The payment of a premium by the apprentice may perhaps be regarded as rather old-fashioned, and certainly this arrangement is becoming less usual in the engineering industry as time passes. It is more frequent among consulting engineers, who often require a premium from their pupils. In some cases the apprentice receives wages, and thereby gets some monetary return for the premium, but in other cases the premium represents a training expense for which the return is the training received.

In general, it may be said that the majority of engineering firms require apprentices and are prepared to pay them during their apprenticeships; unless therefore a premium is going to show its return in the form of specially good training, the young engineer is recommended to serve his apprenticeship



NOTE:—The salaries shown are approximate only and are based on 1939 values. Post-war salary levels will certainly be higher, but their stable values cannot yet be estimated.

FIG. 3.—DIAGRAM SHOWING THE POSSIBLE EARNINGS DURING AN ENGINEERING CAREER

where he will be paid something, if only a little, during that period.

The wages paid to student apprentices who have completed University courses before starting their apprenticeships vary with different firms. At the present time (1945) they are about £3 to £5 per week, though these amounts may include special war allowances. It is impossible to estimate the level at which such wages will stabilize after the war; it is certain, however, that they will be higher than those obtaining before the war (as quoted in Chapter II, page 20, and in Fig. 3), though perhaps not as high as those which are being paid to-day.

From the firm's point of view these wages represent a loss during the early part of the apprenticeship, but it is regained by the work done towards the end of the period, as already discussed. Apprentices entering a factory or works immediately after leaving school are normally paid a small initial wage, which rises by annual increments until, in their final year, they are earning as much or slightly more than a student apprentice.

It is now possible to consider the total expenditure incurred by a young engineer who has completed both his theoretical and practical training. For this purpose it is of interest to estimate this expenditure by taking the most liberal figures for each item involved. The estimate would then be roughly as follows:—

	£
Tuition and other University fees	215
Books and stationery	40
Board and lodging (300 weeks at 50s.)	750
Personal expenses (300 weeks at 40s.)	600
Travelling (say)	45
Apprenticeship premium	150
TOTAL	£1800

This represents an average expenditure of £300 a year for six years. It will be said at once that these figures are excessive, but costs considerably above the average have been taken for each item; put in another way, the best possible engineering training, together with considerable personal comfort, could be obtained for this sum, and it should be realized that the vast majority of engineers get a first-class training for very much less than this.

The important thing to appreciate about the cost of an engineering or any other professional training is that it is an investment in the individual. From this point of view, the average salary which an engineer may be expected to earn for the rest of his life may be regarded as the return on the original outlay for education and training. Taking the figures of Table 3 in Chapter II (page 20), the average earnings in the twenty years from twenty to forty are £430 a year, which is not a bad return on an original investment of under £2000.[1] This view of training costs perhaps over-simplifies the issue and takes insufficient account of several important factors. It is fundamentally the correct view, however, and it puts the seemingly onerous costs of an engineering training into their true perspective.

No mention has yet been made of the expenses incurred by joining one of the professional institutions as a junior (student or graduate) member, or of the fees payable to the institutions for taking their examinations, for obtaining exemption from all or part of an examination, or, finally, for becoming an associate member. The necessity for these expenses is a matter for the individual to decide, though at some stage in his career they will be essential. The entry fees and annual subscriptions for both members and associate members of the Institutions of Civil, Mechanical, and Electrical Engineers are given in Appendix XII, and details of

[1] As a matter of interest, £2000 would buy a life annuity of £75 6*s*. 8*d*. for a man aged twenty-five.

the examination and other fees may be obtained from the secretaries of the three institutions if required.

Most professional institutions allow members to commute their annual subscriptions by the payment of a lump sum, a facility of which very few members take advantage. The difficulty in commuting an annual subscription is that it should be done as early as possible in an engineer's career; unfortunately, this is just the time when it is least convenient to find the sum necessary, and, as a result, commuting remains a rare practice. In the author's opinion, all those who can afford to do so would be well advised to commute their annual subscriptions, but this is a counsel of perfection, and for most of us it is perhaps best to regard annual subscriptions to professional institutions as a small part of the working expenses of a professional engineer without which he would not have the same status or opportunities for higher employment.

CHAPTER VIII

CAREER AFTER TRAINING

THE SUCCESSFUL completion of his theoretical and practical training is rightly a landmark in the career of every engineer. It represents the end of a most important stage on his journey, and it justifies feelings of the greatest satisfaction. When these feelings have been adequately expressed, according to individual temperament, the moment has arrived to draw up a personal balance sheet. The assets will be the solid foundation of training, together with the personal abilities and drive of the individual; on the other side, the chief liability is the disconcerting fact that an engineering training, however good, does not of itself make an engineer. The balance sheet at this stage will therefore always show a large deficit, a deficit of experience, further experience, and still more experience.

An engineering training can be compared to a building site in the heart of a city. Such a site is extremely valuable, but its value depends on the use to which it is put; the owner can easily make or mar it by the structure he builds and by the purpose to which he applies it. On the full realization of these salutary facts and their implications will depend all future success.

The immediate need, when training has been completed, is usually 'to get a job'.[1] It will not be a highly-paid job, and its value will lie in the experience which it offers rather than the salary which it commands; but it will be a job in which, probably for the first time, the young

[1] In making this statement, and throughout this chapter, it is assumed that there is no compulsory National Service. This assumption does not affect the general principles discussed, although it may influence some minor details.

engineer is fairly launched on his own, and in which he will find the beginnings of independence. Before discussing the several ways of setting about 'getting a job', it is necessary to examine an important question of personal policy.

Briefly, each individual must at this stage decide whether it is better to start now in the firm with which he would like to make his whole career, or else to take a job with the intention of using it primarily as a stepping-stone to other and better jobs elsewhere. The deliberate choice of the first of these alternatives means experience restricted to one organization and promotion depending nominally on ability, but more probably on the rate of retirement of seniors. On the other hand, to accept a job with the full intention of leaving it when something better turns up somewhere else is to ensure a wider experience over the years and, more important, an invaluable flexibility of outlook.

As described, these two alternatives are extremes, and there are many paths which lie between them. Sooner or later, however, the choice will present itself in principle to every engineer, and the final decision must be based on purely personal considerations. Some people are steady and settled by nature; they put firm roots into the ground wherever they may be, and they dislike being uprooted. Others are born to be wanderers (or perhaps the better word is adventurers in its best sense) and are happy only if they have complete freedom to pack up and go to the other side of the world when they feel like it. The happy compromise is probably to combine both, wandering in the early years, when ties are few, and later settling down in some senior responsible post. Risking a broad generalization, the author considers that, unless he has held at least three different appointments in the ten years immediately after the end of his training, an engineer is unlikely ever to reach the highest position in his profession. This view is based entirely on the opinion that wide experience (both of men and of engineering technique) has a higher market value than the best experience obtainable in any one organization; there are obviously many exceptions to this general contention, but these do not necessarily invalidate it.

The easiest way of obtaining a first appointment after training is to join the staff of the firm with whom the apprenticeship was served; in this matter there is no need for any outside assistance, and anyone who has served an apprenticeship should know all the possibilities in this direction by the time his period of service has finished. For other appointments personal introductions are of the greatest value, but, it must be repeated, an introduction is not a guarantee of an appointment; at best it can only ensure favourable consideration for it.

Appointments can also be obtained through the various University appointments boards, the Appointments Department of the Ministry of Labour and National Service, or the recently formed Professional Engineers Appointments Bureau. Most Universities have an appointments board which is concerned with the placing of graduates in suitable posts, and which has two special advantages in carrying out this work: by its close association with the University, an appointments board can assess accurately the achievements, abilities, and character of a graduate, and it also has close contacts with those employers who customarily recruit their staffs from that particular University. As a result of these two factors, University appointments boards are often in a better position to find suitable posts for their graduates than other appointments organizations. University appointments boards can be of particular assistance to young people just leaving the University after taking their degrees, and most of the work of a University appointments board is in dealing with these cases.

The Appointments Department of the Ministry of Labour and National Service is divided into two branches [1] both of which may concern engineers at various stages of their careers. These branches are :—

(*a*) The Central (Technical and Scientific) Register, which is centrally located in London and deals with all fully qualified professional engineers.

(*b*) The Appointments Register, which is decentralized in thirty-one offices throughout the country, and deals with all engineers whose qualifications are not sufficient to warrant their inclusion in the Central Register.

Both branches are also concerned with other professions as well as engineering, but this aspect of their work requires no further reference here. The purposes of the Appointments Department are to place applicants in suitable posts and to offer to employers a service which will enable them to fill vacancies on their staffs with men who have appropriate qualifications. In the placing of qualified men and women who are demobilized from the Services, the Appointments Department has a special duty which is rightly regarded by the Ministry of Labour and National Service as of prime national importance.

Fully qualified engineers requiring appointments should apply to be placed on the Central (Technical and Scientific) Register. Applications should be made to :—

The Ministry of Labour and National Service
Appointments Department
Sardinia Street
Kingsway
London, W.C.2.

[1] Details of the present organization, together with recommendations for the future, will be found in the Report on Higher Appointments by the Committee set up by the Minister of Labour and National Service in July 1943. The report was presented to Parliament in January 1945 (Cmd. 6576).

Engineers who are not yet fully qualified, or are in any doubt about their position, should apply to the nearest office of the Appointments Branch, whose addresses are given in Appendix XI (page 175).

It was decided early in 1945 to set up a Professional Engineers Appointments Bureau, under the auspices of the Institutions of Civil, Mechanical, and Electrical Engineers, but with an organization quite separate from these Institutions. The Bureau is a non-profit-making body with objects generally similar to those of the Appointments Department of the Ministry of Labour and National Service, but restricted to the fields of civil, mechanical, and electrical engineering.

Applications to be registered at the Bureau for employment may be made by qualified engineers who are members of any of the three institutions. The address of the Professional Engineers' Appointments Bureau is :—

13, Victoria Street
Westminster
London, S.W.1.

Applying for a job is not itself a particularly easy matter. Some employers (and all appointments organizations) require a form to be completed giving details of age, general education, technical education, practical training, and subsequent experience. Other employers merely require 'details of training and experience' or 'a chronological list of posts held, with salaries'. Application forms usually have too little space in the 'training' and 'experience' sections, and it is often impossible to include all the relevant information, however much it may be condensed ; nothing relevant should be omitted on this account, and a separate continuation sheet, should be attached to the form when necessary. Conversely, where no form is used there is a tendency to write long, rambling accounts full of small details which can have no bearing on the matter being described; to do this is fatal, as the reader will at once think (quite correctly) that the applicant is by nature vague and verbose. Descriptions of training and experience should be concise and to the point, while omitting no essential information.

For a written application or an interview there is only one golden rule: tell the plain unvarnished truth about your career and experience; do not exaggerate, and, in an interview, be yourself—don't put on an act. Every employer knows what it is to receive an application from some young engineer (aged perhaps twenty-three) in which the latter's present appointment is described as 'Assistant Managing Director', and every employer would at once assume that the correct description of the appointment is probably 'deputy assistant to the assistant managing director', a very different matter! It is permissible, in giving an account of practical experience, to emphasize those features of the experience which are particularly applicable to the appointment which is being applied for. This can be done without exaggeration, and is merely a matter of making the most of genuine qualifications; it is very far removed from pretending to have qualifications which, if they exist at all, are only in the imagination.

Those who have spent the last few years in one or other of the Services will be faced, in applying for an appointment, with the special problem of describing their Service experience correctly. It is worth remembering that Service rank may not of itself be of any particular importance. There are many appointments in the engineering world for which a staff-sergeant with the necessary experience will be much more suitable than a colonel who only thinks he has that necessary experience. Anyone who has been employed in the Services in some technical capacity should find it easy to describe his work and experience. Those whose Service experience has been entirely military would be best advised to state the ranks which they have held and the responsibilities involved. Details should be given of any courses which they may have taken either in military subjects or in order to prepare themselves for their return to civilian life. Some application forms may call for a statement of ' the number of men controlled by the applicant '. Such information from Service applicants can be very misleading, as it is possible not only to hold a subordinate position in command of a considerable number of men, but also to hold an extremely high and responsible position in actual command of very few men indeed. Whatever the circumstances, the application should give details of the individual's precise duties, in addition to the numbers of men he has had under his command or control; by doing this, it is not likely that any misunderstanding will arise.

An interview is always a nerve-racking business for the applicant for a job, and it is difficult to offer any advice to the victim. Questions should be answered quickly, concisely, and above all accurately, and some attention should be paid to personal appearance; it is not advisable to be interviewed in clothes recently used for washing a car. This warning is not unnecessary, for there are people who seem to think they should attend for an interview looking as sloppy as possible, presumably on the principle that it is the man who matters and not the clothes. A prospective employer will not, it is true, be impressed by appearance alone, but he will undoubtedly draw his own conclusions from untidiness, carelessness, or dirt. To conclude these very brief suggestions on interviews, there are some further simple rules: don't fidget; don't lounge in your chair; look towards the interviewer, and not all round the room; don't smoke unless you are offered a cigarette; speak in your natural voice and only when you are spoken to; finally, avoid nervous movements, such as fiddling with a ring or watch-chain.

A word of warning may be necessary on the subject of academic qualifications. There is sometimes an unfortunate tendency to regard an academic qualification (be it an ordinary National Certificate or an Honours Degree) as a sort of passport entitling its possessor to specially accelerated progress up the professional ladder; this tendency is perhaps most marked among those who obtain their qualification by part-time work outside their normal employment. It cannot be said too emphatically that an academic qualification confers no rights whatever on its possessor; it merely proves to those who may be concerned that he has at some time reached a known standard of learning. It is not disputed that a qualification will probably make its possessor eligible for certain appointments for which he would otherwise not be acceptable, but progress always depends on the characteristics and abilities of the individual, and not on the mere fact that he possesses some qualification or other. There was recently some correspondence in the technical Press from several young (and apparently disgruntled) engineers who by hard work acquired certain qualifications while in their present appointments. They were then dissatisfied when they realized that the day on which they obtained their qualifications was not the day on which their employers gave them immediate promotions to higher appointments. The possession of the qualifications may have made them more eligible for certain posts; it has not automatically qualified them for such posts. In saying this, there is no intention whatever of belittling the value of technical qualifications; in fact, it is the aim of this book to show the need for technical qualifications in an engineering career. The matter is mentioned only to restore the proper perspective, and to prevent any future disappointments which might arise from similar causes. So long as young engineers realize that their progress depends entirely on themselves and not on their qualifications, they will be in no difficulty.

An engineering career, after training has been completed, should be planned ahead as far as possible. In order to do this, each individual should select for himself the goal at which he is aiming; his plans can then be made to attain this goal as rapidly and efficiently as possible. This may appear to contradict the advice not to specialize given earlier in this book, and some further explanation is now necessary. For a number of reasons it is not advisable to specialize in the early stages of engineering training. First, the student has not got nearly enough experience to know precisely what he wants to do in the future; secondly, the more general his engineering training the better, so that his subsequent career is planned on a broad general foundation rather than on a narrow specialized one; thirdly, it is vital for any engineer to cultivate and retain as wide an outlook as possible—a difficult thing to do when pursuing a career which has been narrowly specialized from its beginning.

This picture changes when training has been completed. It is quite impossible for any one individual to be proficient in all branches of engineering. He must therefore specialize in some particular branch or aspect of the subject, so that he may obtain the maximum amount of knowledge and experience within his chosen sphere. Obviously the special sphere of activity must be chosen as soon as possible after training, or during the later stages of training. By then an engineer will have a broad general foundation for his career, and he will have had sufficient practical experience to appreciate the many facets of his profession and to choose that one which best suits his own particular talents. There is a vast field from which to choose; in each technical branch of engineering there are, generally speaking, five broad divisions, which may be described as Consulting, Manufacturing, Construction, Research, and Public Service. In Fig. 1 (page 6) twenty-four distinct technical branches can be identified, so that there are some 120 spheres of engineering activity on this basis, and somewhere among them every engineer will find his own particular metier.

An examination of any list of engineers who hold important appointments (for example, the tables in Chapter II, on pages 16–18) will show that a number of them are members or associate members of more than one professional institution. The young engineer may perhaps wonder if he should at the outset join as many institutions as he can. Apart from the additional expense entailed by doing this, little would be gained; there is no purpose to be served by becoming a member of any institution unless professional interests warrant it, and in the early years of an engineering career membership of one institution will satisfy all requirements. At a later stage, when interests are more definitely focused, it may well be desirable to join another institution which is concerned with a more specialized field. For example, a railway engineer would probably be a member of the Institution of Civil (and/or Mechanical) Engineers, and also of the Institution of Locomotive Engineers. Above all, membership of dubious organizations should be avoided like the plague. For obvious reasons they cannot be named, but there are organizations whose membership (with, of course, some imposing letters for use after the member's name) is open to anyone who is even remotely connected with engineering and who chooses to apply for it. These organizations are only too well known in the engineering profession, which accords them the recognition which is their due.

Engineers are often members of societies and institutions which are primarily concerned with subjects in some way applicable to one of the many phases of engineering.[1] For instance, the qualifications of a corporate member of the Institution of Mechanical Engineers who is also a corporate member of the Institute of Cost and Works Accountants suggest that he has specialized in factory costing and accountancy,

[1] A list of such societies and institutions is given in Appendix II.

with particular reference to the mechanical engineering industry. This raises the general question of 'double qualifications', such as engineer-barrister, engineer-accountant, engineer-statistician, &c. Holders of such double qualifications are, of course, rare, and it will be appreciated that the necessary training takes very much longer and costs considerably more than the training in one profession only. For anyone who can undertake the additional training and who has the essential ability and strength of character, a double qualification offers very substantial rewards.

At all levels competition in the engineering profession is keen, and will probably become keener within the next decade; this is particularly true for the higher appointments in all spheres. Every engineer must watch the trends in his own special branch most carefully; he must make every effort to foresee future developments and prepare for them in advance. The surest way of getting an appointment is to have an extra something which the other applicants cannot offer, so each individual must always make the best of his own training, experience, and natural abilities.

CHAPTER IX

SUMMING UP

THE OPENING sentence of Chapter I said ' it is the purpose of this book to describe and signpost the more important paths which lead to a successful engineering career '. Many of these paths have now been explored, and it is possible to see the complete picture of an engineering career in its correct perspective. Two outstanding facts emerge from this picture: first, each individual must choose for himself the path which will best suit his own circumstances, abilities, ambitions, and inclinations. Secondly, whatever path is chosen, there must be certain features common to all careers, if these are to be at all successful.

These features common to all careers, baldly enumerated, are :—

(*a*) The temperament and interests likely to make an engineer.

(*b*) A general education to matriculation standard.

(*c*) Theoretical training to approximately degree standard.

(*d*) Practical training.

(*e*) A broad outlook, with a knowledge of the world and of one's fellow-men.

(*f*) Practical experience, and plenty of it.

All these are essential, and a deficiency in any one of them will mean failure to become a fully qualified professional engineer. Deficiencies, however, do not necessarily involve failure to make good in engineering; there are many who will make thoroughly competent technicians, while falling short of the full ' professional engineer ' standard.

In cases where there is completely free choice of the manner and sequence of training, it is suggested that the best system is a full-time University course with practical training in the vacations, followed by an apprenticeship with some firm of engineers of repute. During the apprenticeship it should be possible to decide the particular sphere of engineering best suited to the individual, and from then onwards specialization can be introduced. As soon as adequate experience has been obtained, application should be made for associate membership of the appropriate professional institution, of which the young engineer ought already to be a student member.

The early stages of an engineering career may be disappointing from the point of view of earnings. The possible earnings during an average career (based on the system of training outlined in the previous paragraph) are shown diagrammatically in Fig. 3. The figures used are based on the assumption that a salary of £1000 a year (1939 values) will be earned at the age of forty; these figures have previously been quoted in discussing prospects (see Table 3, Chapter II). It will be noted that the average earnings for the twenty years between the ages of twenty and forty are £430 a year. As an engineer progresses in his career, he will tend to remain longer in each successive appointment, and at the same time his salary will tend to increase by greater amounts with each new appointment; these tendencies are shown by the 'steps' in the salary line in Fig. 3. For simplicity, salaries are shown as constant throughout each appointment; in practice they are usually subject to small increases from time to time. This would, of course, raise the 'average annual salary' slightly, but not by any significant amount.

There is no doubt that it is possible, given the right type of personality and a few weeks' training, to earn very much more at the age of (say) twenty-three by selling some household appliance on a commission basis. To those who consider this to be a satisfactory career, it is only possible to say that they would be much better to continue selling the household appliance and leave engineering to others.

It must now be obvious that an engineering career involves a great deal of hard work. This must be accepted from the outset, and it may be stated categorically that unless the individual is prepared to work hard, to continue working hard, and to go on working hard after that, he would be wise not to embark on an engineering career at all. Against this, it must not be forgotten that each job should be in itself a source of great pleasure and satisfaction; here again it may be said emphatically that those who do not find pleasure in engineering work had much better not try to become engineers.

Throughout this book undue emphasis has perhaps been laid on the purely practical and mundane aspects of salaries and prospects, largely because these can be assessed in tangible terms. Doing an interesting and enjoyable job well must always give a deep satisfaction which cannot be measured in such terms, and in these rewards the engineering profession is especially rich. Engineering also offers a further great attraction, which lies in the fact that it is on the threshold of far-reaching developments which can be only vaguely realized at the present time. Civilization already depends to a great extent on the work of the engineer and the scientist, and it will become increasingly dependent on them in the future.

When discussing the early stages of training, special emphasis was laid on the importance of starting with a broad general knowledge, of not limiting a career by specializing too soon, and of obtaining a knowledge of people and of the world. These points are important because a broad outlook is impossible unless proper attention is given to them. The value of a broad outlook has already been stressed, and the need for it is increasing as the engineering profession assumes greater responsibilities to the community in general.

It has been said that nothing can stand in the way of a man who possesses a sense of humour, a sense of proportion, and a good digestion. Add to this a sound knowledge of some chosen branch of engineering, and there are so many worlds to conquer that one lifetime is too short.

APPENDIX I

ENGINEERING AND SCIENTIFIC SOCIETIES AND INSTITUTIONS

(*see* Chapter I, page 5)

Note.—The date given in each case is that of the original foundation. In practically every instance these Societies and Institutions were incorporated at a later date.

The Royal Society	1660
The Royal Institution of Great Britain . . .	1799
The Geological Society of London . . .	1807
The Institution of Civil Engineers	1818
The British Association	1831
The Royal Institute of British Architects . .	1834
The Institute of Builders	1834
The Institution of Mechanical Engineers . .	1847
The Society of Engineers	1854
The Institution of Engineers and Shipbuilders in Scotland	1857
The Institution of Naval Architects . . .	1860
The Institution of Gas Engineers	1863
The Royal Aeronautical Society	1866
The Chartered Surveyors Institution . . .	1868
The Iron and Steel Institute	1869
The Institution of Electrical Engineers . . .	1871
The Institution of Municipal and County Engineers	1873
The Physical Society	1874
The Royal Institute of Chemistry . . .	1885
The North East Coast Institution of Engineers and Shipbuilders	1884
The Junior Institution of Engineers . . .	1884
The Institute of Marine Engineers . . .	1889
The Institution of Mining Engineers . . .	1889
The Institution of Mining and Metallurgy . .	1892

The Institution of Sanitary Engineers	1895
The Institution of Water Engineers	1896
The Institution of Heating and Ventilating Engineers	1897
The Society of Model and Experimental Engineers	1898
The British Standards Institution	1901
The Faraday Society	1903
The Institution of Automobile Engineers	1906
The Institute of Metals	1908
The Institution of Structural Engineers	1908
The Illuminating Engineering Society	1909
The Institution of Locomotive Engineers	1911
The British Engineers Association	1912
The Association of Consulting Engineers	1913
The Institute of Petroleum	1913
The Radio Society of Great Britain	1913
The Institute of Quarrying	1917
The Institute of Fire Engineers	1918
The Institute of Physics	1918
The Women's Engineering Society	1919
The Society of Consulting Marine Engineers and Ship Surveyors	1919
The Institution of Engineering Inspection	1919
The Institute of Transport	1919
The Newcomen Society	1920
The Institution of Chemical Engineers	1922
The Institute of Welding	1923
The British Institution of Radio Engineers	1925
The Television Society	1927
The Institute of Highway Engineers	1930

APPENDIX II

SOME SOCIETIES AND INSTITUTIONS REPRESENTING PROFESSIONS WITH WHICH ENGINEERS MAY COME INTO CONTACT IN THE ADMINISTRATIVE SPHERE

(*see* Chapter VIII, page 89)

Note.—As in Appendix I, the date given in each case is that of the original foundation.

The Royal Statistical Society	1834
The Institute of Chartered Accountants	1880
The Society of Incorporated Accountants and Auditors	1885
The Royal Economic Society	1890
The Chartered Institute of Secretaries	1891
The Institute of Labour Management	1913
The Institute of Cost and Works Accountants	1919
The National Institute of Industrial Psychology	1921
The Institution of Production Engineers	1921
The Institute of Industrial Administration	1922
The Institute of Public Administration	1922

APPENDIX IV

DETAILED SYLLABUS OF THE A.M.Inst.C.E. EXAMINATION

(Reproduced by permission of the Institution of Civil Engineers)

N.B.—No Candidate may enter for Section B until he has passed in Joint Section A.

JOINT SECTION A

Conducted by the Institution of Civil Engineers and the Institution of Electrical Engineers

Candidates will be required to enter for all six subjects in Part I and Part II at one sitting.

Part I (Common to both Institutions) :—

1. English (unless passed in the Common Preliminary Examination or its accepted equivalent).
2. Mathematics.
3. Applied Mechanics.
4. Applied Heat (with Light and Sound).
5. Principles of Electricity.

Part II :—Theory of Structures *or* Theory of Machines.

Evidence of laboratory work in the subjects Applied Heat and Principles of Electricity, in the form of a certificate from the Principal or Teacher, or the actual laboratory note books and reports may be called for in the case of candidates residing or working within a ten mile radius of a technical college equipped with the requisite apparatus and conducting classes in these subjects. Candidates not so situated must produce evidence that these facilities are not available without entailing an unreasonable journey.

A set of specimen question papers of each subject may be obtained on application to the Secretary, price two shillings.

ENGLISH

(*a*) An essay on a subject of current interest or related to the history of engineering.

(*b*) An exercise in précis writing.

(*c*) Exercises in ability to write letters and reports.

(*d*) A concise description, without sketches, of some simple mechanism in everyday use.

(*e*) Other questions may be set to test knowledge and command of English.

MATHEMATICS

Algebra. Indices; the exponential theorem; logarithms; arithmetical and geometrical series; the binomial theorem and its application to approximations; graphical representation of functions; graphical solution of equations; determination of laws connecting variables.

Co-ordinate Geometry. The rudiments of plane geometry, including the simpler properties of conic sections referred to rectangular axes, but excluding the general equation of the second degree.

Trigonometry. The solution of plane triangles; the representation of directed quantities by vectors; the summation of vector quantities; the functions of the sum and difference of two angles, with derived formulæ; simple trigonometrical equations; Demoivre's theorem and its application to trigonometrical series; exponential values of sine and cosine.

Differentiation and Integration. Differentiation of simple functions; differentiation of products and quotients of two functions and of a function of a function; applications to maxima and minima, curvature and expansion in a series; integrations of simple functions; graphical methods of integration; applications of the integral calculus to the evaluation of plane areas, surfaces, volumes, moments of inertia, mean values and root mean squares; simple cases of Fourier's series; simple linear differential equations.

APPLIED MECHANICS

Statics. Forces acting on a rigid body; moments of forces; composition and resolution of forces; the laws of solid and fluid friction; mechanical advantage and efficiency of simple machines; conditions of equilibrium, with application to simple framed structures and beams; bending-moment and shear-force diagrams.

Hydrostatics. Pressure at a point in a liquid; centre of pressure on an immersed plane area; equilibrium of floating bodies; metacentre.

Kinematics (of Motion in a Plane). Velocity and acceleration of a point; relative motion; acceleration of a point moving in a circular path with uniform speed; simple harmonic motion: velocity-ratio diagrams of simple mechanisms; instantaneous centre.

Kinetics. Force, mass, impulse, momentum, work, energy, power; moment of momentum, moment of inertia, their relations and measurements; conservation of energy; conservation of linear momentum; rectilinear motion of a body under a force (constant or variable); equation of motion of a particle; motion of a body in a circular path with uniform speed; balancing of rotating masses; rotation and oscillation of a body about a fixed axis.

Hydraulics. Pressure and velocity change along a stream-line; Bernoulli's theorem; flow through an orifice.

Strength of Materials (Elementary). Hooke's law; Young's modulus; Poisson's ratio; modulus of rigidity; analysis of stress; theory of simple bending; theory of torsion of solid and hollow round shafts.

APPLIED HEAT (WITH LIGHT AND SOUND)

Part I:—Heat and Properties of Matter.

Thermometry. Measurement of temperature; pyrometry;

platinum-resistance and gas thermometers; thermocouple; radiation pyrometer.

Heat Effects. Expansion; change of state; specific heat; latent heat. Heat and energy; mechanical equipment. Conduction, convection and radiation, transmission of heat through simple bodies.

Thermodynamics. The first and second laws of thermodynamics; mechanical equivalent of heat; the gas laws of Charles, Boyle, Avogadro, Dalton and Joule (internal energy); absolute temperature; the two specific heats; use of the gas constant R; internal and external energy; distinction between gases and vapours; phenomena of the critical state; total heat of wet, dry and superheated steam; dryness fraction of steam; use of steam tables; isothermal and adiabatic expansion and compression; constant-volume; constant-pressure; isothermal and adiabatic changes in relation to steam and internal combustion engines; the P/V diagrams for constant-volume (Otto), constant-temperature (Carnot) and constant-pressure cycles; calculations of pressure, volume and temperature throughout the cycles; elementary principles of engines, turbines and boilers.

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

Properties of Matter. Concept of molecules. Principle of equipartition of energy. Elementary outline of kinetic theory of gases; agitation velocity. Outline of the structure of atoms, simple crystals and metals and of simple chain and ring type organic molecules. Elasticity and plasticity of materials. Viscosity of gases and liquids; dependence on temperature. Surface tension.

Part II:—Light and Sound.

Light. Reflection at plane and spherical surfaces. Refraction; thin lenses; combination of lenses. Spectrum and colour; the spectrometer. Dispersion through a lens;

achromatic combination; the telescope and microscope. Measurement of light intensity; units; flux; illumination and brightness; photometers. The wave theory of light; interference, the bi-prisms, Newton's rings. Polarization of light and double refraction.

Sound. Wave motion. Velocity in air, solids and liquids. Superposition of sound waves; beats; resonance. Measurment of sound intensity and units. Reflection and refraction of sound. Stationary vibrations; nodes and anti-nodes. Vibrations of columns of air, strings and diaphragms.

To satisfy the examiners candidates must not confine their answers to one Part only.

PRINCIPLES OF ELECTRICITY

Current Electricity. Simple primary and secondary cells; units of current, e.m.f. and resistance; Ohm's law; calculation of resistance; temperature coefficient; Kirchhoff's laws; Wheatstone bridge; simple potentiometer and its applications; units of energy and of power and their relationships in the electrical, thermal and mechanical systems; efficiency calculations.

Electrostatics. Field strength, potential, capacitance; units of capacitance and quantity.

Magnetism, Electromagnetism and Electromagnetic Induction of E.M.F. Magnetic field, lines of force and field strength; force on current-carrying conductor in magnetic field and between long parallel conductors; properties of iron and steel (B, H, μ); calculation of ampere-turns for a composite magnetic circuit; induction of e.m.f.; self and mutual inductance; energy stored in field; hysteresis; iron losses.

Alternating Currents. Values of sinusoidal current and voltage; vector representation; simple circuit calculations involving combinations of resistance, inductance and capacitance; single-phase power and power-factor; the

3-phase circuit, including simple calculations for star and delta connected circuits, processes of rectification.

Electromagnetic Machinery. Elementary principles of simple types of d.c. and a.c. machines and of transformers.

Measuring Instruments. Construction, action and application of principal types of ammeters, voltmeters and wattmeters.

Thermionics. The vacuum diode and its use as a rectifier; static characteristics of vacuum triode valve; elementary description of cathode-ray tube.

THEORY OF STRUCTURES

Graphic and analytic methods for the calculation of bending moments and of shearing forces, and of the stresses in individual members of framework structures loaded at the joints; plate and box girders; incomplete and redundant frames; stresses suddenly applied and effects of impact; resistance of struts; effect of different end-fastenings on their resistance; combined strains; calculations connected with statically indeterminate problems, as beams supported at three points, etc.; travelling loads; riveted and pin-joint girders; rigid and hinged arches; strains due to weight of structures; theory of earth-pressure and of foundations; stability of masonry and brickwork structures.

Stress-distribution in reinforced concrete beams, assumptions in simple bending theory, moments of resistance of rectangular and T beams with single reinforcement. Design of beam-and-slab cross-sections. Compression reinforcement and its effects. Shearing stress and shear reinforcement. Adhesion, grip length. Columns with vertical loads. Vertical and lateral reinforcement. Column bases. Reinforced concrete walls.

THEORY OF MACHINES

Kinematics of machines; kinematic chains; inversion of kinematic chains; virtual centres; vector-diagrams of displacement, velocity, and acceleration; acceleration of the connecting rod for a uniformly-rotating crank; acceleration of the cross-head; conditions for an equivalent dynamical system; belt drives; rope drives; chain, screw and toothed gearing; wheel trains; epicyclic trains; friction and efficiency of machines; ball and roller bearings; clutches and friction drives; brakes and dynamometers; Froude's hydraulic brake; crank-effort diagrams; the turning couple; flywheels; fluctuation of energy; governors; primary balancing of engines and machinery; balancing of the forces; balancing of the couples; lubrication; testing of lubrication oils; strength and proportions of machines in simple cases; valve gears; Stephenson's link motion; Walschaert's link motion; cams; the motor-car clutch, gear box, back axle gearing, the differential, the universal joint; methods of attaching a wheel to an axle; the Ackermann steering gear; the motor-car engine; the sleeve-valve engine.

SECTION B

N.B.—No Candidate may enter for Section B until he has passed in Joint Section A.

1. Engineering Drawing. (Two papers, 3 hours each.)
2. Engineering Materials. (One Paper, 3 hours.)
3. *Three* subjects—*a*, *b* and *c* from any ONE of the following nine Groups. (One paper in each subject, 3 hours):—

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* Theory and 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* Theory and 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* Theory and 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* Theory and Design of Structures.

Group IX

(Aeronautical Engineering)

a. Aeronautics.
b. Machine Design *or* Theory and Design of Structures.
c. Thermodynamics and Heat-Engines, *or* Electrical Machinery, Principles and Practice.

Subject 1

ENGINEERING DRAWING

Working drawings of 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 one of the following sections :—

(*a*) *Structural Steelwork* e.g. Roof principles, girders, cranes, stanchions, foundations.

(*b*) *Reinforced Concrete* e.g. Piles, tanks, retaining walls, floors.

(*c*) *Machines* e.g. Engine Details—cylinders, pistons, crossheads, flywheels, valves, governors. Hydraulic Machines—riveters, pumps. Gearing, clutches.

Fully dimensional working drawings may be required of some part or parts of the designs.

Subject 2

ENGINEERING MATERIALS

(*Chemical and Physical Properties*)

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, cast iron, cement, bricks, and plastics ; technique of concrete-making and the properties of concrete ; properties of timber, plywood, and plastics ; road and run-way making materials and their preparation ; bituminous surfacings ;

fuels, and the products of combustion; water treatment for engineering purposes; corrosion, weathering and disintegration.

Subjects in Groups I to IX

THEORY AND DESIGN OF STRUCTURES

While candidates will not be expected to memorize details of clauses, they should have a general knowledge of the more important British Standard Specifications, Codes of Practice and Regulations governing the design of Structures. In particular candidates should know how the simplified formulas used in design have been derived, how to choose and combine design loads and to select working stresses. A qualitative appreciation of the more recent work in Soil Mechanics will be expected of the candidate.

Designs may be required for some of the following structures of steel, mass or reinforced concrete, or other appropriate materials.

Buildings

Shed buildings with symmetrical trusses, valley beams, stanchions, and wind bracing; details of riveted, bolted, or welded connexions.

Hangars, multi-storey building frames, and portal frames with welded connexions, subjected to vertical and horizontal loads.

Bridges

Girder, triangulated truss, arched and portal framed bridges in steel or reinforced concrete.

Structural Elements

Steel stanchion bases and grillages.

Beams, columns, column bases and foundations, beam and slab floors, in reinforced concrete.

Walls and piers in plain and reinforced brickwork.

Timber trusses with connexions using nails, screws, bolts, glued plywood gussets or metal connectors.

Other Structures

Retaining walls.

Storage tanks and other water retaining structures.

Dams.

Transmission towers.

NOTE.—Candidates will be expected to show competency in making dimensioned hand sketches in good proportion. Drawing instruments may be used, but drawing boards will not be provided or required. British Standard Tables 4 *and* 4(*a*) *will be provided for Candidates taking this subject.*

SURVEYING AND APPLIED GEOLOGY

Surveying

The theory, structure, and adjustments of the principal surveying and levelling instruments, and the principles of their employment under various conditions; errors of observation and their elimination.

Chain surveys; compass, dial, and theodolite surveys, including the adjustment of the closing errors; plane-tabling; tacheometry.

Levelling and contouring: setting-out of engineering works, e.g., by triangulation from a carefully measured base-line; curve-ranging. Mining surveying and simple hydrographical surveying; principles of photographic and air surveying.

Applied Geology

A general survey of the chief rock-forming minerals and of the more important rock types; changes in the earth's surface, the operation of the agents of denudation, transport, and deposition; jointing; faulting; folding; metamorphism; earthquakes; landslips.

Methods used in the determination of the relationships and ages of the stratified rocks; the sequence of stratified rocks in Britain and their mode of formation; geological maps and their interpretation; the work and facilities of the Geological Survey.

Economic minerals, their distribution and mode of occurrence.

The nature, location, and characters of the chief rock and mineral materials of economic utility, such as building, roofing, and road-making materials, cements, fuels, ores, clays, sands, and refractories.

Exploration methods; field survey: trial pits and headings; augering; boring; magnetic, seismic, gravitational, and electrical methods.

Water-supply: surface supplies, underground water, the siting of dams and reservoirs, catchment-areas.

Geological considerations in the location of works of engineering construction, foundations, excavations, tunnels, drainage.

HYDRAULICS

The laws of the flow of water through orifices, Venturi tubes, and flumes, and over notches and weirs.

Laws of fluid friction.

Steady flow in pipes or channels of uniform section.

Vortex motion.

Losses at sudden enlargements or contractions, bends, and control devices.

General phenomena of flow in rivers.

Determination of the discharge of streams and rivers.

Principles of dynamic similarity; use of models; scale effect.

Water-hammer and surge.

Impulse and reaction of jets of water on fixed and moving vanes.

Transmission of energy by fluids.

Principles of hydraulic machines—pumps and turbines.

Flow of underground water; yield of wells and galleries.

BUILDING CONSTRUCTION

In studying the problems covered by the following outline syllabus for the Building Construction paper, special attention should be paid to the principles underlying the forms of construction and their employment. The questions set in the paper will require a scientific approach. Though acquaintance with practical detail is essential, it is regarded as more important in this paper to know the real requirements of a particular problem and the basic principles whereby a solution can be obtained rather than to have a knowledge of the many practical solutions which have been used in the past. In considering constructional forms, attention must be paid to the methods of erection and their organization.

Foundations and sub-ground level construction; support and drainage of large excavations, including construction tunnelling; underpinning and shoring; demolitions; foundations for walls and piers; treatment of sloping sites; pile foundations; rafts; retaining walls; water-resisting construction.

Load-bearing walls in brick and masonry construction; composite walls; cavity construction; parapet walls; arch construction; centering; formwork for concrete; site work on steel and reinforced concrete framed structures; attachment of panel walls; external finishes.

Steel, reinforced concrete and other materials in roof and floor construction; floor finishes; coverings to flat and pitched roofs; roof drainage.

Internal walls and partitions; surface finishes to internal walls and ceilings; doors and windows; staircases, lifts and lift planning; fire-resistant construction; acoustical treatment of large rooms and auditoria; sound insulation.

The layout and co-ordination of engineering services; heating systems and equipment, ventilating systems and equipment, performance tests; electric power-supply and lighting to buildings, acceptance tests; sanitary equipment and drainage, hot and cold water-supplies.

A 'Supplementary Note for candidates taking the Building Construction Paper' can be obtained on application to the Secretary.

MACHINE DESIGN

Analysis of forces in simple mechanisms.

Calculation of dimensions of simple elements subjected to tension, compression, and shear, e.g., bolted connexions in shear and tension; shaft couplings; bolting for pipe flanges and pressure-vessel covers; shaft keys; cottered connexions; riveted joints; simple welded joints.

Design of parts subjected to pure bending or pure torsion, e.g., pin connexions; simple structural and machine beam members; levers; shafting; springs.

Design of parts subjected to combined bending, torsion, and direct stress, e.g., cranked members; eccentrically loaded connexions (bolted and riveted).

Design involving applications of kinematics, e.g., gears and gear wheels; nut and screw mechanisms; cams; lubrication; design of bearings for given loads; use of ball and roller journal and thrust bearings; influence on design of fatigue and stress concentrations.

NOTE.—Candidates will be expected to show competency in making dimensioned hand sketches in good proportion. Drawing instruments may be used, but drawing-boards will not be provided or required.

THERMODYNAMICS AND HEAT ENGINES

The laws applied to a perfect gas; universal and particular gas-constants; molecular heats; compression and expansion of gases with constant specific heats; internal energy, external work; Joule's Law; the Carnot cycle with air as the working agent; the Carnot cycle with vapour as the working agent; reversibility; conditions for maximum efficiency; absolute temperature; entropy and entropy–temperature diagrams; air-compressors and air-motors; refrigerators; and :—

Applied Thermodynamics

Either (*a*) Steam plant; calorific values of solid and liquid fuels, their measurement and calculations; formation of steam at constant pressure; the steam tables; wet steam; superheated steam; the effect of throttling; measurement of dryness; boilers; heat-transfer; boiler trials; flue-gas analysis; calculation of actual and theoretical air-supply; indicators and indicator-diagrams; losses determined from the indicator card; compounding; the Rankine cycle; entropy–temperature and total-heat–entropy diagrams for steam and their uses; the flow of steam through nozzles; impulse and reaction turbines; condensing plant; turbine trials; the regenerative and reheat cycles; feed-water systems; heat-balance and thermal efficiency for both reciprocating engines and turbines.

Or (*b*) The internal-combustion engine; calorific values of liquid and gaseous fuels, their measurement and calculation; combustion; combustion-equations and calculations connected therewith; air-measurement; exhaust-gas analysis; ideal cycles and standards; actual engine cycles; the indicator diagram; optical indicators; actual temperature of the charge at various points in the cycle; the effects of dissociation and variable specific heats; turbulence;

mixture-strength, power and efficiency; detonation; super-charging; volumetric efficiency; gas-producers; suction-gas-producers; a general knowledge of gas, oil, and petrol engines; methods of governing; fuel-injection; type of combustion-chamber of compression-ignition oil-engines; heat-balance sheets; friction and pumping horse-power; testing of internal-combustion engines and the apparatus used.

NOTE.—Abridged Callendar Steam Tables (Fahrenheit units) will be provided in the Examination Room for the use of Candidates taking Thermodynamics and Heat-Engines, who will be expected to use these Tables in the solution of thermodynamical problems.

HEATING AND VENTILATING

(*a*) *Heating*

Metabolism and comfort; heat-transmission by convection and radiation; thermal conductivity of building materials and types of construction; insulation of buildings and apparatus; heat requirements in buildings; efficiencies and economics of various forms of heating; panel systems; thermal storage; provision in building for heating installation; steam and hot-water boilers and their accessories; feed-water treatment; fuels and combustion; mechanical stokers; natural and mechanical draught; pumps and pump drives; radiators, pipes, and fittings; feed, expansion, and venting arrangements; calorifiers; indirect heaters; unit heaters; statutory provisions relating to heating; principles and design of hot-water and steam heating systems; balancing; zoning and controls; guarantees, testing, and regulation; district heating; drying; principles and design of hot-water service installations for residential and commercial premises, institutions, laundries, &c.

(*b*) *Ventilation*

Properties of air; standards of ventilation; atmospheric humidity; total heat of air; psychrometric charts; natural ventilation; systems of plenum heating and mechanical ventilation; air filters, washers, and heaters; air distributing systems; duct construction; dampers, regulators, and registers; principles, methods, and applications of air conditioning, including refrigeration; provision in building for ventilation system; statutory provisions affecting ventilation; selection and specification of fans; fan performance; fan drives; prevention of noise and vibration; design of ventilation systems; testing and regulation; indicating and recording instruments; automatic and other controls; dust and fume removal; deodorizing; special problems in ventilation—kitchens, laundries, garages, factories, assembly halls, &c.

ELECTRICAL MACHINERY, PRINCIPLES, AND PRACTICE

General

Fundamental principles of energy conversion in electrical machinery; e.m.f.'s of rotation and pulsation; active and reactive components of currents; properties of materials used in electric and magnetic circuits.

Armature Windings

Types and arrangement of single-phase, polyphase and commutator windings; effect of flux distribution, slot arrangement, coil span and distribution of windings on waveform; symmetrical windings; m.m.f.'s of field and armature windings; stator and rotor leakage.

Synchronous Generators and Motors

Construction, salient and non-salient pole types; performance, voltage regulation and excitation; parallel operation of generators; stability, hunting, and overload capacity; behaviour of synchronous motors; methods of starting; uses of synchronous motors for power-factor correction and as low-power-factor reactance.

Transformers

Construction and principles of action; single and three-phase connexions; transient phenomena; parallel operation; voltage control; insulation and cooling; induction and moving-coil regulators.

Induction Machines

Construction and principles of action; production of rotating magnetic field; rotor windings; relation between input, mechanical power and electrical power in rotor; simple circle diagram; starting and speed control; capacitor motors; synchronous and compensated induction motors; phase advancers; induction generators.

Direct-Current Generators and Motors

Construction; function of commutator; methods of excitation; load characteristics; commutation phenomena; voltage control of generators; parallel operation of generators; speed control of motors; cross-field machines.

Alternating-Current Commutator Motors

Principle of action of single and polyphase, series and shunt motors; commutation and power factor; methods of starting and speed control; comparisons with other types of motor.

Converting Machinery and Rectifiers

Functions; current and voltage relations; rotary convertors, commutation, voltage control, power-factor control, starting, and inverted operation; motor-convertors; motor generators; frequency changers; mercury-arc rectifiers, construction and principle of operation, voltage regulation and grid control; copper oxide rectifiers, construction, and principles of operation.

Cooling of Electrical Machines

Nature of losses; methods of dissipating heat; coolers and cooling media—hydrogen coolers; limits imposed by maximum safe working temperature.

Testing of Electrical Machinery

Nature of tests and methods of checking performance of the various types of machines.

Design

Brief outline of the salient points of the design of the different types of electrical machines as affected by the conditions under which they operate; specifications to meet operating conditions.

Miscellaneous

Field of application of the various types of electrical machines.

Causes of vibration and noise in electrical machines; balancing of rotating parts; sound insulation.

Special features of fractional horse-power and domestic electric motors.

Foundations and supports for electrical machinery.

ELECTRICAL TRANSMISSION

Principal systems of distributing electrical energy.

Choice of operating voltage.

Efficiency and losses in conductor systems.

Theory of alternating-current lines.

Transformer connexions.

Voltage regulation and control of reactive kilovoltamperes.

Operation of interconnected power stations.

Causes of transient currents and voltages.

Calculation of short-circuit currents.

Types of circuit breaker and principal methods of feeder protection.

Design of insulators and methods of protection against voltage rises.

Mechanical design of overhead lines.

Types of underground cable.

Layout of high-voltage switching station, of transforming, and of traction substations.

ELECTRICAL COMMUNICATIONS

(*a*) Self- and mutual-inductance; capacity; meaning of 'resistance' at high frequencies; units.

(*b*) Vector diagrams, Heaviside complex variable methods for dealing with undamped sinusoidal currents; application to simple A.C. bridges and networks.

(*c*) Principles of wave-motion, wave-length, and frequency, frequency-range of sound and electrical waves.

(*d*) Principles of telegraph and telephone transmitter and receiver; elementary ideas on long lines (excluding general mathematical theory); 'characteristic impedance', impedance matching, the decibel as a power ratio.

(*e*) The oscillatory circuit, series and parallel resonance (undamped oscillations only, excluding spark or shock excitation): resonance curves; 'Q', 'dynamic impedance', calculation of numerical values for circuit with given L, C, R, &c.; determination of Q from resonance curve.

(*f*) The thermionic valve (excluding theories of thermionic emission), characteristic curves, meaning of μ, ρ, g, with knowledge of order of magnitude for specified common types; calculation of constants from given curves.

(*g*) Common 'equivalent circuit' for valve; application to voltage amplifiers, power amplifiers, oscillators—under linear operating conditions only.

(*h*) Use of screen-grid tetrode and pentode to overcome effects of inter-electrode capacities; valves with 'variable mutual conductance' characteristics.

(*i*) Non-linear conductors and rectification. Harmonics and 'sum and difference' frequencies in output of valve worked on curved part of characteristics; thermionic diode, grid, and anode rectifiers and valve voltmeters treated non-mathematically.

(*j*) Simple rectifier and smoothing systems for supply of small direct currents from single-phase A.C. source. 'De-coupling' of anode and grid feeds in multi-valve apparatus.

(*k*) Principle of 'superheterodyne'; frequency-changer valves.

(*l*) Non-mathematical treatment of cathode ray oscillograph, time-bases, and simple applications to engineering problems.

(*m*) In addition, not more than two questions of a descriptive nature may be set on recent developments not specified above.

(*n*) Candidates will be expected to be able to draw diagrams of connexions of simple circuits, and to indicate suitable orders of magnitude of components; to sketch characteristic and wave-form curves; and to describe laboratory experiments.

PRINCIPLES OF MINING

The acquisition and tenure of mining rights and mining ground; location of mineral deposits by vertical boring and the types of appliances used; geophysical prospecting; methods of sinking, lining, ventilating, and lighting mine shafts; underground developments in the vicinity of the shafts; construction and operation of winding, pumping, hauling, and ventilating machinery, together with problems in mechanics which each entails; the application, with particular reference to safety, of electricity and compressed air to underground operations; construction and operation of mining machinery used in the cutting, drilling, conveying, and loading of coal; principles of mine illumination and methods of lighting working places, roads, and shaft insets; the breaking down of mineral by blasting and other means, and the regulations designed to prevent accidents in the process; working of stratified and unstratified mineral deposits, together with the means adopted to secure the adequate support of roads, excavated areas, and undercut mineral; methods of boring against old workings containing water under pressure; spontaneous combustion; physics, chemistry, and physiological effects of mine atmospheres, dust, and high air-temperatures; explosions of firedamp and coal-dust and the use and limitations of mine rescue apparatus; the crushing, sizing, cleaning, and treatment of the raw mineral; coal screening and washing, practice, methods, and appliances.

MINING METALLURGY

Separation of Minerals

Purposes for which employed; physical properties made use of; ratios of enrichment and recoveries obtained; costs; metallurgical considerations; washing, sorting, and picking; types of ores so treated; appliances used; breaking, crushing, and grinding machines used; types of machine and function; theory of crushing; crushing systems; sizing; wet and dry screening; water-sizing or classification, theory, and practice; water concentration; jigs, tables, vanners, buddles, slime tables, rag frames, blanket strakes, sluices; 'sink and float' processes; magnetic separation, theory, machines, applications in practice; flotation, principles and applications; reagents; machines; recent developments; electrostatic, dielectric and pneumatic separation; decrepitation; heat disintegration; magnetizing; roasting; weathering; unsolved problems in mineral separation or dressing.

Mill design; principles; lay-out; flow-sheets; sampling; tonnage and recovery calculations; operating costs.

Laboratory testing; use of the pan, the infrasizer, elutriators and heavy liquids in determining the amenability of ores to concentration; froth flotation separation tests; magnetic separation tests.

Preparation of Metals

The nature and objects of metallurgical processes; the physical properties of metals; character, composition, testing, and uses of various fuels; pyrometry; calorimetry; manufacture of coke and charcoal, methods of using fuel; refractory materials used in the manufacture of fire-bricks, crucibles, and retorts; their composition, properties, and use; classification of furnaces; description of types for roasting, sintering, calcining, and smelting; simple furnace building; stacks; furnaces for small-scale work; fluxes and slags; composition; properties; functions in smelting; outline of the metallurgy of silver, lead, zinc, and copper, with special reference to the effects of impurities; metallurgical requirements for simple treatment; recoveries; costs; influence of the flotation process on metallurgical practice; hydrometallurgical or leaching processes for copper, silver and gold; the metallurgy of gold; electrolytic processes for gold, zinc, and nickel; a general knowledge of the manufacture of iron and steel and of the composition and properties of the more widely used grades of steel and alloy steel.

APPLIED CHEMISTRY

Either (*a*) *Air, Water, Sewage, Ferrous and Non-ferrous Metals, Building Materials, and Paints. Air.*—Composition and physical properties; nature and sources of impurities; principles of ventilation and air-conditioning; methods of removal of dust, fog, and objectionable gases and vapours; principles of methods of collection and examination of gases and suspended impurities. *Water.*—Chemical and physical properties; classification of natural waters; purification of water for domestic and industrial processes; storage; filtration; disinfection; treatment by activated carbon; copper sulphate to remove algal growths; treatment of small quantities for drinking; hard and soft waters; methods of softening water; the bacteriological and chemical testing of water. *Sewage.*—Domestic sewage and trade wastes; examination, treatment, and disposal. *Ferrous and non-ferrous metals.*—Corrosion of iron and steel in soils, buildings, and reinforced concrete; methods of protection; corrosion of lead, copper, and aluminium in soils and buildings. *Building materials.*—Production, properties, and hardening of lime and gypsum mortars; manufacture of Portland cement; the setting, hardening, and physical and mechanical properties of normal and rapid-hardening Portland cements; Portland blast-furnace, pozzuolanic, and aluminous cements; production, properties, and uses of cements; clay bricks, manufacture and properties; natural stone; granites, slates, limestones, and sandstones; effect of weathering; natural and artificial bitumens and asphalts used in constructional work; timber; differentiation of hardwoods and softwoods; action of other building materials, acids, and alkalies on wood; principles of wood-preservation. *Paints.*—Ingredients of oil paints and varnishes; paint products, properties, uses, deterioration on exposure to weather; application of paint to wood, metal, plaster, and cement.

Or (*b*) *Combustion, Fuel, Gas Manufacture, Oils and Lubricating Oils. Combustion.*—Principal reactions in combustion of solid, liquid, and gaseous fuels; ignition-temperatures; limits of inflammation; flame-speed; gaseous explosions. *Solid, liquid, and gaseous fuels.*—Sources; composition; analysis; calorific value. *Gas manufacture.*—Destructive distillation of wood and coal at high and low temperatures; hydrogenation; nature and recovery of products and by-products; analysis of purified gas and determination of calorific value. *General properties of oils and fats.*—Common animal, vegetable, and mineral oils, their general chemical properties and differentiation; drying and non-drying oils; standard physical and chemical methods of oil-testing; turpentine and resin; petroleum; distillation of crude oil and separation of commercial products; standard methods of testing; lubricants, solid, liquid, and semi-solid; general principles of lubrication; standard methods of analysis.

(*A more detailed Syllabus may be obtained on application to the Secretary.*)

STABILITY AND RESISTANCE OF SHIPS

The principles of buoyancy, stability and oscillation for floating bodies, with special application to ships, and methods of calculation and experiment; principles of the structural strength of ships; the straining forces acting upon ships afloat and ashore; methods of calculation for strength and stiffness; nature of the wave-forming and other resistances experienced by ships moving through water; stream lines; methods of model experiments on resistance; influence of forms and proportions upon resistance; mechanical theory of propellers and relative efficiency of various kinds of propellers; estimates of horse-power for assigned speeds; manœuvring of ships under the action of rudders or propellers.

GAS ENGINEERING

General design, construction, control, maintenance, and principles of operation of gas works plant, as follows:—

Coal handling plant; retort house plant; coke handling plant; carburetted water gas plant; coke ovens; gas condensers; exhausters; wet purification; dry purification; benzole plants; gas drying plants; station meters; gas holders; gas boosting and compressing plant; station governors; ancillary plant; distribution.

Besides the design and construction of plant, candidates would be expected to understand the process going on within the plant, to appreciate how the various designs affect the process, and the products resulting from it; methods of determining the purity and calorific value of gas and characteristics of by-products.

AERONAUTICS

Wind tunnels; pitot-static head; measurements of pressure-distribution; aerodynamic balances; lift, drag, moments, centre of pressure, and their coefficients; resistance of flat plates and streamline bodies; downwash.

Performance calculations; relative physical properties of atmosphere; speed, climb, ceiling; controls and longitudinal balance; simple manœuvres; autorotation; stability and types of instability; elementary theory of airscrews.

Types of aircraft structures and component parts; common materials of construction and their properties; bracing systems; accelerometers; load-factors and factors of safety; conventional load systems for stress calculations theorem of three moments; laterally loaded struts; torsion of fuselages; strain-energy analysis of redundant structures; thin sheet construction; full-scale testing of aircraft structures and components.

Coefficients of viscosity; Poiseuille's experiments; principles of dynamical similarity; Reynolds' number; Bernoulli's theorem in two dimensions, including effect of compressibility; elements of potential flow; relation between lift and circulation; Joukowski's geometrical aerofoil transformation; elements of Prandtl's aerofoil theory; elements of boundary-layer theory.

ELECTRICAL INSTALLATIONS

Wiring Systems: I.E.E. Regulations for the Electrical Equipment of Buildings; Electricity Commissioners' Regulations for Securing the Safety of the Public and for Ensuring a Proper and Sufficient Supply of Electrical Energy; Home Office Electricity Regulations under the Factories Act.

Economics of distribution in buildings; protective systems and earthing; rupturing capacity of switches and fuses; transformers, rectifiers, and converting machines; power factor correction; motors, with special reference to speed variation, torque, and starting current; electricity tariffs and their application to the economic use of electricity and the effect of load factor; electric heating devices; electric lamps and the theory and practice of illumination; testing of installation systems, of motors and other electrical machinery and apparatus; electrical communication systems, fire protective systems, electric clocks; the correlation of the use of electricity with heating and ventilating.

SECTION C

In order that every Student or candidate for election to Corporate Membership of The Institution may satisfy the Council that he has taken full advantage of his training with a view to thereby qualifying to become a Corporate Member of The Institution every candidate is to be examined in accordance with the following rules.

1. Every candidate will be required to submit an account

of his engineering training and experience in a document of some 2000 to 3000 words. This will be written in the form of a Report in the first person dealing in general with some of the actual work carried out under the personal supervision or knowledge of the candidate, as well as with problems and difficulties which have confronted him and which have made particular impression on his mind. The Report should strictly avoid any semblance to a mere list or catalogue of work executed.

2. A candidate who has been engaged on works of engineering construction will be required to submit with the Report:—

(*a*) Calculations for design and drawings of an item of permanent or temporary constructional work, and

(*b*) A Bill of Quantities relating to various classes of constructional work.

A candidate trained in any other branch of Engineering (i.e., Mechanical, Electrical, Chemical Engineering) will be required to produce evidence of having had practical experience in some such matters as:—

(*c*) Specification of materials and tolerances.

(*d*) Carrying out tests on the properties of materials, accuracy of workmanship and performance of plant and machines.

A candidate who is a 'bona fide' research worker may alternatively submit a thesis dealing with a particular research work in Applied Science related to Engineering, actually carried out by him. Before preparing such a thesis he is advised to ascertain whether the subject chosen and the conditions under which the research was conducted are acceptable to the Council for the purpose.

3. In connexion with the evidence to be produced under items 1 and 2 above, a certificate in a prescribed form must

be submitted, signed by the Engineer under whom the work was carried out, stating that it was done by the candidate in the ordinary course of his employment.

4. Provided the Report is found to be acceptable the candidate will be examined orally. At the conclusion of the oral examination, the candidate will be required to write an essay on a specified subject within his professional experience. Three hours in the examination room will be allowed for the writing of the essay.

5. The candidate will be assessed on the combined result of the Report or Thesis, Interview, and Essay.

APPENDIX V

EXTRACTS FROM THE REGULATIONS FOR THE INTERMEDIATE EXAMINATION IN ENGINEERING AND FOR THE EXTERNAL B.Sc.(Eng.) DEGREE EXAMINATION OF THE UNIVERSITY OF LONDON

(Reproduced by permission of the University of London)

Notes

1. The extracts which follow are reproduced from the 'Regulations relating to Degrees in Engineering for External Students' by permission of the University of London.

2. The extracts cover the more important points in connexion with the Intermediate Examination in Engineering and the External B.Sc. (Eng.) Degree examination. It is essential, however, for anyone who proposes to take a course leading to the degree examination to study the complete Regulations and Syllabus. These may be obtained at any of the approved Technical Colleges (see Appendix VII), or from :—

The External Registrar
The University of London.

3. The address of the University of London is :

Senate House,
London, W.C.1.

ADVISORY SERVICE FOR EXTERNAL STUDENTS

Persons desirous of entering upon a course of study with the intention of obtaining a degree as External Students of the University of London may consult the External Registrar with a view to deciding how to relate their proposed studies either to their present or proposed professional occupation or to some intellectual interest which they wish to develop on academic lines. Advice may be obtained both as to the degree which would be most suitable in the student's individual circumstances, and as to the selection of particular branches of learning and special subjects.

Normally it is expected that External Students will make their own arrangements as to courses of study; but those who find any difficulty in doing so are invited to consult the External Registrar, who will advise as to those facilities for instruction already in existence by the help of which External Students can carry out their contemplated studies.

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Enquiries of a preliminary or general nature will be considered by the External Registrar and answered without fee; but where schemes of study are provided for the use of students a fee will become payable.

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All communications from students seeking the Registrar's advice will be treated as confidential and replies will be given only on the understanding that they will be treated by the student as confidential and as personal to himself.

. . . . .

Students desiring advice or guidance of any kind must in the first place complete an enquiry form, obtainable on application by postcard; submission of this form to the Registrar does not commit the enquirer to the payment of any fee. Students in a position to call personally at the University should complete the enquiry form and ask for an appointment.

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INTERMEDIATE EXAMINATION IN ENGINEERING

Qualifications for Admission

To be admitted to the Intermediate Examination in Engineering every External Student must (*a*) have passed the Matriculation Examination or been exempted therefrom not later than the preceding January in the case of a June Intermediate nor later than the preceding June in the case of a November Intermediate; and (*b*) have registered as an External Student preparing for the Intermediate Examination in Engineering at least six calendar months before the last date of entry to the examination.

Scheme of Examination

1. The examination shall be a pass examination only. Candidates shall be examined in five subjects as follows:

(1) Pure Mathematics	Two papers.
(2) Applied Mathematics	One paper and a practical examination.
(3) Heat, Electricity, and Magnetism	One paper and a practical examination.
(4) Engineering Drawing	Two papers.

together with one of the following subjects:

(5) Sound and Optics	One paper and a practical examination.
(6) Chemistry	One paper and a practical examination.
(7) Geology	One paper and a practical examination.

2. The examination shall be conducted by means of printed papers and practical examinations as hereinafter set forth; but an oral examination may be held in any subject if the examiners deem it desirable.

3. Candidates shall not be approved by the examiners unless they have shown a competent knowledge in each of the five subjects taken.

4. No candidate offering an experimental science subject will be allowed to pass who fails to satisfy the examiners in the practical part as well as the written part of the examination in the subject chosen.

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Exemptions

1. A candidate who has passed a Higher School Examination may apply for exemption from the Intermediate Examination in Engineering, in whole or in part, as follows :—

(*a*) A candidate who holds a certificate or certificates awarded on a Higher School Examination recognized by the Ministry of Education as an approved second examination in Secondary Schools and is qualified to proceed to the External Intermediate Examination in Engineering may apply for exemption at that examination in respect of any subject or subjects of that examination corresponding to those endorsed on his Higher School Certificate or Certificates on the Main (Principal) or Additional Subject standard provided that the subjects from which exemption is desired comply with the regulations regarding the choice of subjects at the Intermediate Examination in Engineering.

(*b*) Such candidates will be required to pay the prescribed fee for the Intermediate Examination, whether exempted in whole or in part, and in the case of candidates who obtain partial exemption from the examination this fee will include one entry for examination in the remaining subjects.

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(*e*) A candidate may, if he so desires, complete his exemption qualification by passing in the required additional subjects at a subsequent Higher School Examination, provided the subjects offered correspond to the Intermediate subjects required by the regulations for completion. In this case all or both the subjects required must be passed at one and the same Higher School Examination.

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Fees

1. Every candidate entering for the Intermediate Examina-

tion in Engineering must pay a fee of six guineas to the External Registrar.

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B.SC. (ENGINEERING) EXAMINATION

1. The B.Sc. Degree in Engineering is open to candidates who enter for both Parts of the Final Examination. Successful candidates will be awarded First or Second Class Honours or a Pass Degree.

Qualifications for Admission

1. To be admitted to Part I of the B.Sc. Engineering Examination every External Student must (*a*) have passed the Intermediate Examination in Engineering at least one academic year previously, (*b*) have registered as an External Student preparing for Parts I and II of the B.Sc. Engineering Examination at least three calendar months before the last date of entry to Part I of the examination, and (*c*) have attended a course of study at an institution approved for the purpose by the University.

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4. To be admitted to Part II of the B.Sc. Engineering Examination every External Student must (*a*) have matriculated at least three academic years previously, (*b*) have passed Part I of the B.Sc. Engineering Examination, or have obtained permission to enter for it at the same time as he enters for Part II, (*c*) have attended a course of study at an institution approved for the purpose by the University, and (*d*) in the case of a candidate entering for both Parts I and II on the same occasion have registered therefor not less than 15 months prior to the last date of entry to the examination.

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6. Nevertheless, on special application, candidates who are not in attendance at an approved institution, but who produce evidence satisfactory to the Council for External Students that they have (*a*) had practical engineering

experience, or (*b*) followed a course of study that is substantially equivalent to the course of study otherwise prescribed, may be registered for the examination. This concession is valid only for four years subsequent to the date of granting, but may, on application, be renewed.

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Scheme of Examination

1. The examination is divided into two parts and each part consists of (*a*) a written examination, and (*b*) the examination of the candidate's course work. Normally candidates must pass Part I before they may enter for Part II of the examination. Candidates who have not attended an approved institution will be required to submit, in lieu of course work, except in Mathematics, records of practical work and subsequently to undergo in London an oral-practical examination.

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3. All candidates must offer and pass in the five subjects of Part I of the examination, and four subjects of Part II of the examination. Candidates attending an approved institution must have their choice of subjects for Part II approved by the authorities of that institution. Candidates not in attendance at an approved institution must have their choice of subjects approved by the Council for External Students. The subjects of the examination shall be as follows:

Part I

(1) Strength and Elasticity of Materials and Theory of Structures	One 3-hour paper
(2) Theory of Machines	One 3-hour paper
(3) Applied Heat and Mechanics of Fluids	One 3-hour paper
(4) Applied Electricity	One 3-hour paper
(5) Mathematics	One 3-hour paper

Part II

Four of the following:—

(6) The Mechanics of Fluids	Two 3-hour papers
(7) Surveying	Two 3-hour papers
(8) Applied Thermodynamics	Two 3-hour papers
(9) Principles and Design of Electrical Machines	Two 3-hour papers
(10) Electrical Power	Two 3-hour papers
(11) Electrical Measurements and Measuring instruments	Two 3-hour papers
(12) Telecommunications	Two 3-hour papers
(13) Theory of Machines	Two 3-hour papers
(14) Theory of Structures	Two 3-hour papers
(15) Strength and Elasticity of Materials	Two 3-hour papers
(16) Mathematics	Two 3-hour papers

4. The standard of the examination in Part I is to be that which would normally be required of a whole-time student over a course extending over one year subsequent to passing the Intermediate Examination in Engineering.

5. In setting the papers of any of the subjects of this examination the examiners will assume that the candidate possesses a knowledge of the Differential and Integral Calculus.

6. In each subject of the examination except Mathematics the examination will include, in addition to the written papers, examination of the student's course work, and the examiner shall be at liberty to test any candidate by means of *viva voce* questions.

7. No candidate shall pass who does not obtain such proportion of the aggregate marks in all subjects, and also such proportion (but lower) of the total marks in each of such subjects taken separately as shall satisfy the examiners.

8. The marks obtained in Part I of the examination will be

combined with those obtained in Part II for the purpose of the classification of Honours.

9. In each subject a reasonable choice of questions shall be allowed.

10. Candidates permitted to enter for the examination without attendance at an approved institution will be required to submit records of practical work, except in Mathematics, and subsequently to undergo in London an oral-practical examination, and will be required to pay an additional fee of seven guineas for this examination. This test will not exceed six hours, and will consist of an oral examination on the candidate's practical work and in addition, at the discretion of the examiners, a practical examination in an Engineering Laboratory.

Note.—No exemptions from any part of the examination are allowed.

. . . . .

Course Work and Practical Work

1. Except in Mathematics course work in all subjects is an essential part of the examination, and candidates cannot pass the examination unless their course work satisfies the examiners. Candidates are warned that if they submit no course work in a subject they will be regarded as having failed in that subject.

2. The course work submitted in any subject must be carried out at a duly recognized institution and be certified by the candidate's teacher or teachers in that subject.

. . . . .

6. Special importance will be attached to technical facility in drawing, designing, field work, or other practical operations which cannot be tested in an examination by questions. Tutorial or Class Exercises are *not* considered as constituting course work.

. . . . .

10. Candidates who have been permitted by the Council

for External Students to enter without attendance at an approved institution will be required to make a declaration that any practical work they submit is their own work.

. . . . .

13. In the case of part-time students or students working on the sandwich system, an institution may submit along with the course work a detailed report with regard to the work such students have done outside the institution in training for, or in the practice of, the Engineering profession provided that the principal or a teacher of the institution is able, from his own knowledge, to certify the authenticity of such work.

14. An institution may apply on behalf of any of its students at the time of registration for exemption from course work in any subject on the ground of exceptional professional experience and ability.

15. No definite number of hours of course work is prescribed but the amount of course work must be equivalent to that done during a normal two-year full-time course of study.

. . . . .

Fees

1. The fees for the B.Sc.(Eng.) Examination are as follows :—

	£	s.	d.
Whole examination	7	17	6
Part I alone	4	4	0
Part II alone	3	13	6
Re-examination in referred subject at Part I	2	2	0
Supplementary subject	2	2	0

Candidates taking this examination at overseas centres will be required to pay a fee of eight guineas.

2. Candidates taking the oral-practical examination will be required to pay an additional fee of seven guineas or three-and-a-half guineas for each part.

APPENDIX VI

UNIVERSITIES IN GREAT BRITAIN AND NORTHERN IRELAND WHICH AWARD DEGREES IN ENGINEERING

THE LIST below gives, in alphabetical order, the Universities in Great Britain and Northern Ireland which award degrees in engineering. Where necessary, colleges are given in parentheses; in some cases the Engineering School of a University is at a technical or other college and not at the University itself.

In each case a figure is given of the *approximate* cost of tuition for a complete engineering degree course excluding books, stationery, personal expenses, board and lodging, for which reliable estimates are not possible.

	£
Aberdeen	125
Belfast (at the Municipal College of Science and Technology)	70
Birmingham	200
Bristol (Technical College of the Society of Merchant Venturers)	160
Cambridge, see Note 2 overleaf.	
Durham (King's College, Newcastle-upon-Tyne)	130
Durham (Sunderland Technical College)	60
Edinburgh (at Heriot Watt College)	120
Glasgow (at the University)	120
Glasgow (at the Royal Technical College)	120
Leeds	160
Liverpool	200
London (Imperial College of Science and Technology)	200
London (King's College)	200
London (Queen Mary College)	100
London (University College)	200
Manchester (Owens College)	130
Manchester (Manchester College of Technology)	140

Oxford, see Notes 1 and 2 below.	£
Sheffield	140
St. Andrews (at University College, Dundee)	120
Wales (University College, Bangor), see Note 1 below	70
Wales (University College, Cardiff)	90
Wales (University College, Swansea)	70

NOTES

1. Courses in civil, electrical, and mechanical engineering are available in all cases except at Oxford (in 'Engineering Science' only) and at University College, Bangor (electrical engineering only).

2. As Oxford and Cambridge are essentially residential Universities, it is impossible to quote figures of costs which would be comparable with those given for the other Universities.

As a guide, it may be estimated that the cost of tuition and residence at either Oxford or Cambridge is £250 to £300 per annum, but the exact amount will depend largely on the student's way of life while in residence.

3. In addition to the four colleges listed above under the University of London, the following are recognized by the University for the purpose of the *Internal* B.Sc.(Eng.) Degree :—

Battersea Polytechnic.
Northampton Polytechnic, Finsbury.
West Ham Municipal College.
Woolwich Polytechnic.

4. The technical colleges, schools, and institutes recognized by the University of London for the purpose of the *External* B.Sc.(Eng.) Degree are quoted in Appendix VII.

APPENDIX VII [1]

LIST OF TECHNICAL COLLEGES, SCHOOLS, AND INSTITUTES IN GREAT BRITAIN AND NORTHERN IRELAND

(*a*) AT WHICH APPROVED COURSES FOR NATIONAL CERTIFICATES AND DIPLOMAS IN CIVIL, MECHANICAL, AND ELECTRICAL ENGINEERING ARE CONDUCTED;

(*b*) RECOGNIZED BY THE UNIVERSITY OF LONDON FOR THE PURPOSE OF THE EXTERNAL B.Sc.(Eng.) DEGREE;

(*c*) AT WHICH DAY COURSES AND EVENING CLASSES IN AERONAUTICAL ENGINEERING ARE AVAILABLE.

Notes

In the list of technical colleges, schools, and institutes which follows, letters are used to indicate the various courses offered, thus:—

A. Ordinary National Certificate in Civil Engineering
B. „ „ „ Mechanical Engineering
C. „ „ „ Electrical Engineering
D. „ „ Diploma in Mechanical Engineering
E. „ „ „ Electrical Engineering
F. Higher National Certificate in Civil Engineering
G. „ „ „ Mechanical Engineering

[1] The information in this Appendix is reproduced by permission of the Institutions of Civil, Mechanical, and Electrical Engineers, the University of London, and the Temple Press, Ltd.

H. Higher National Certificate in Electrical Engineering
J. ,, ,, Diploma in Mechanical Engineering
K. ,, ,, ,, Electrical Engineering
L. Recognized by the University of London for the purpose of the External B.Sc.(Eng.) Degree
M. Day course in Aeronautical Engineering
N. Evening Classes in Aeronautical Engineering.

The list of technical colleges, schools, and institutes is arranged alphabetically in three sections:

I. England and Wales
II. Scotland
III. Northern Ireland

Every effort has been made to incorporate the latest information in this Appendix, but conditions are continually changing and all details should be verified by personal inquiry; this will confirm that the courses listed are still available.

I. ENGLAND AND WALES

ACCRINGTON Technical School	B
ACTON Technical College	B, C, D, E, G, H, L
ASHFORD Technical Institute	B, C, G
BARNSLEY Mining and Technical College	B, C, G, H
BARROW-IN-FURNESS Technical College	B, C, G, H
BATH Technical College	B, C
BATLEY Technical College	B
BEDFORD Technical Institute	A, B, C, F
BIRKENHEAD Technical School	B, C, G, H

BIRMINGHAM Central Technical College .	B, C, D, E, G, H, L, N
,, Aston Technical College .	B, C, G, H
,, Bordesley Green Evening Engineering School. .	B, C
,, Handsworth Technical College	B, C, G, H
BLACKBURN Municipal Technical College	B, C, G, H
BLACKPOOL Technical College . .	B, C
BOLTON Municipal Technical College .	B, C, G, H
BOOTLE Municipal Technical College .	B, C
BOURNEMOUTH Municipal College . .	B, C, D, E, H, J, K, L, N
BRADFORD Technical College . .	B, C, G, H, L
BRIGHOUSE Technical Institute . .	B
BRIGHTON Municipal Technical College	B, C, D, G, H, J, K, L
BRISTOL Merchant Venturers' Technical College	B, C, G, H, N
,, Bishop Road Evening Institute .	N
BURNLEY Municipal College . . .	B, C, G, H, L, N
BURY Municipal Technical College .	B
CAMBRIDGE Cambridgeshire Technical Evening Institute	B, C
CANNOCK CHASE Mining College . .	B, C
CARDIFF Technical College . . .	B, C, D, G, H, L
CARLISLE Technical Evening Institute .	B, C
CHELMSFORD Mid-Essex Technical College and School of Art	B, C, G, H
CHELTENHAM The North Gloucestershire Technical College	B, M, N
CHESTERFIELD Technical College . .	B, C, G, H
COALVILLE Mining and Technical Institute	B
CINDERFORD Forest of Dean Mining and Technical School Evening Institute .	C

COLCHESTER North-East Essex Technical College and School of Art . .	B, C
CONSETT Technical Institute . . .	B
CORBY Monotechnic Institute . .	B, C, G
COVENTRY Municipal Technical College .	B, C, G, H, L, M, N
COWES Evening Institute and Engineering School	B, C, G, N
CREWE Technical College . . .	B, C, G, H
CROYDON Polytechnic	B, C, G, H, N
CRUMLIN Mining and Technical College .	B, C, D, E, G
DAGENHAM South-East Essex Technical College and School of Art . .	B, C, G, H
DARLINGTON Technical College . .	B, C, G
DARTFORD The County Technical College	B, C, G, H, L
DERBY Technical College . . .	B, C, G, H, L, N
DEWSBURY Municipal Technical College.	B, C
DOLCOATH Technical School . . .	B, G
DONCASTER Technical College . .	B, C, G, H, L
DOVER Technical Institute . . .	B
DUDLEY and Staffordshire Technical College	B, C, G, H
DURSLEY Technical Evening Institute .	B, C
EAST HAM Technical College . . .	B, C
ENFIELD Technical College . . .	B, G
ERITH Technical College . . .	B, C, G, H
FARNBOROUGH Royal Aircraft Establishment Technical School and Farnborough Technical Evening School .	B, G, N
FILTON Bristol Aeroplane Company's Works School	B, N
GAINSBOROUGH Technical School . .	B, G
GATESHEAD Durham Road Technical Evening Institute	B, C
GILLINGHAM Medway Technical College .	B, C, G, H, L

GLOUCESTER Technical College . . .	B, G, N
GRAVESEND Technical Evening Institute .	B, C
GUILDFORD Technical College . . .	B, C, D, G
HALESOWEN Technical School . . .	B
HALIFAX Municipal Technical College .	B, C, G, H, J, L
HATFIELD de Havilland Aeronautical Technical School	M, N
HEANOR Mining and Technical Institute .	B, C
HENDON Technical Institute	B, C
HORWICH Technical College	B, G
HUDDERSFIELD Technical College . .	B, C, G, H, J, L
HULL Kingston-upon-Hull Municipal Technical College	B, C, D, E, G, H, L, M, N
ILMINSTER Standard Telephones & Cables Ltd. Works' School	C
IPSWICH School of Engineering . . .	B, C, G
JARROW Secondary School Evening Institute	C
KEIGHLEY Technical College	B, C
KINGSTON-UPON-THAMES Technical College	B, C, G, H, N
LANCASHIRE AND CHESHIRE INSTITUTES, UNION OF [1]	A, B, C, F, G, H
LANCASTER Storey Institute Technical College	B, C
LEEDS College of Technology . . .	B, C, D, E, G, H
LEICESTER College of Technology and Commerce	B, C, G, H, L, N
LEIGH (Lancs.) Municipal College . . .	B, C, G, H
LINCOLN Technical College . . .	B, C, G, H, L
LIVERPOOL City of Liverpool Technical College	B, C, G, H, L

[1] A federation of Institutes conducting part-time classes (day or evening) in the geographical counties of Lancashire, Cheshire, Flintshire, Denbighshire, Caernarvonshire, the High Peak Parliamentary Division of Derbyshire, and the Isle of Man.

LONDON	Battersea The Polytechnic Institute	A, B, C, F, G, H, J, K, L, M, N
,,	The Borough Polytechnic Institute, Southwark	B, C, G, H
,,	Faraday House, Electrical Engineering College	L
,,	Finsbury Northampton Polytechnic Institute	A, B, C, F, G, H, J, L, M, N
,,	Hackney L.C.C. Hackney Technical Institute	B, C, G, H
,,	Lewisham L.C.C. South East London Technical Institute	B, C, G, H
,,	Paddington L.C.C. Paddington Technical Institute	B, C
,,	Poplar L.C.C. School of Engineering and Navigation	B, C, G, H, N
,,	St. Marylebone The Polytechnic Institute	B, C, D, G, H, J, K, L
,,	Wandsworth L.C.C. Wandsworth Technical Institute	B, C
,,	Westminster L.C.C. Westminster Technical Institute	A, B, F
,,	Woolwich Polytechnic Institute	B, C, G, H, J, K, L
LOUGHBOROUGH	College	B, C, G, H, L, M
LUTON	Technical College	B, G, N
MAIDSTONE	Technical Institute	B, C
MANCHESTER	Municipal College of Technology	B, C, G, H, L
,,	Newton Heath Technical School	B, C, N
,,	Openshaw Technical School	B, C
MANSFIELD	The County Technical College	B, C, H
MELTON MOWBRAY	and District County Technical College	B

MEXBOROUGH Schofield Technical College	B
MIDDLESBROUGH Constantine Technical College	B, C, D, E, G, H, J, K, L
NEWARK The County Technical College .	B, G
NEWCASTLE-UPON-TYNE Rutherford Technical College	B, C, D, E, G, H, L
NEWPORT (Mon.) Technical College and Institute	B, C, D, G, H
NEWTON-LE-WILLOWS Technical School .	B
NORTHAMPTON College of Technology .	C
NORTHWICH Verdin Technical College .	B, C, G
NORWICH City College and Art School .	B, C, G, H, L
NOTTINGHAM University College[1] . .	B, C, G, H, J, K, L
NUNEATON County Mining and Technical School	B, C
OAKENGATES Walker Technical College .	B, G
OLDHAM Municipal Technical College .	B, C, G, H
OXFORD Schools of Technology, Art, and Commerce	B, C, G
PLYMOUTH AND DEVONPORT Municipal Technical College	A, B, C, F, H, K, L
PONDERS END Technical Evening Institute	C, H
PORTSMOUTH Municipal College . . .	A, B, C, D, E, F, G, H, L, N
PRESTON Harris Institute	B, C, G, H, L
RADCLIFFE Technical College . . .	B, C
READING University of Reading . .	B
REDDITCH Technical Evening Institute .	B
REDHILL Technical College	B, C
ROCHDALE Municipal Technical School .	B, C

[1] It was recently reported in the Press that, under a proposed new scheme, the technical education functions of Nottingham University College will be transferred to a joint committee of the Derbyshire and Nottinghamshire County Councils and the Nottingham City Council, and a new technical college will be established. This scheme cannot of course come into operation for some time.

ROTHERHAM Technical College . .	B, C, G, H, L
RUGBY College of Technology and Arts .	B, C, G, H, L
ST. HELENS Municipal Technical College	B, C, G, H
SALFORD Royal Technical College . .	B, C, D, E, G, H, L
SHEERNESS Technical Evening Institute .	B, C, G, H
SHEFFIELD University of Sheffield (Dept. of Applied Science)	B, C, G, H
SHREWSBURY Technical College . .	B, C
SMETHWICK Municipal College . .	B, C, G, H
SOUTHALL Technical College . .	B, C, G, H, N
SOUTHAMPTON University College . .	B, C, G, H, L, M, N
SOUTHEND-ON-SEA Municipal College .	B
SOUTHPORT Technical College . .	B, C
SOUTH SHIELDS Marine School Evening Institute	B
SPENBOROUGH Technical Institute . .	B
STAFFORD County Technical College .	B, C, H
STAMFORD Technical School . . .	B
STOCKPORT College for Further Education	B, C, G
STOCKTON-ON-TEES Technical Evening Institute	B, C
STOKE-ON-TRENT North Staffordshire Technical College	B, C, D, G, H, L
STRETFORD Old Trafford Technical Evening Institute	B, C
STROUD and District Technical College .	B, G
SUNDERLAND Technical College . .	B, C, G, H, J, K, L
SWANSEA Technical College . .	B, C, D, E, G, H
SWINDON The College	B, G, L
TREFOREST School of Mines and Technology	B, C, G, H, J, L
TUNBRIDGE WELLS Technical Evening Institute	C

TWICKENHAM Technical College	B, C, G
WAKEFIELD Technical College	B, C, G
WALLSEND Technical Institute	B
WALSALL Technical College	B, C, H
WALTHAMSTOW South-West Essex Technical College and School of Art	B, C, D, G, H
WARRINGTON Municipal Technical School	B, G
WATFORD Technical School Evening Institute	B, C
WEDNESBURY County Technical College	B, C, G
WELLINGBOROUGH Technical Institute	B
WEST BROMWICH Kenrick Technical College	B, C
WEST HAM Municipal College	B, C, G, H, J, K, L
,, Great Eastern (L.N.E.R.) Mechanics Institute	B
WEST HARTLEPOOL Technical College	B, C, G
WEYBRIDGE Vickers (Aviation) Technical Day Classes	B
WHITWOOD Mining and Technical College	B
WIDNES Municipal Technical College	B, C, G, H
WIGAN and District Mining and Technical College	B, C, G, H, L
WILLESDEN Technical College	B, C, G, H
WIMBLEDON Technical College	B, C, G, H
,, College of Aeronautical Engineering	M
WOLVERHAMPTON AND STAFFORDSHIRE Technical College	B, C, D, G, H, L, N
WOLVERTON Technical College	B, C, G, H
WORCESTER Victoria Institute	B, C, G
WORKINGTON The Cumberland County Technical College	B, C
WORKSOP The County Technical College	B, C, H

WREXHAM Denbighshire Technical Evening Institute	B, C, H
YEOVIL Technical Institute	B, N
YORK Technical Institute	B, C, G, H

II. SCOTLAND

ABERDEEN Robert Gordon's Technical College	B, C, G, H, J, K, L
ARBROATH High School Continuation Classes	B
BATHGATE Lindsay High School Continuation Classes	B, C, H
BUCKHAVEN Mining and Technical School	B, C
COATBRIDGE Technical College	B, C, G, H
COWDENBEATH Fife Mining School	B, C, G, H
DUNDEE Technical College	B, C, G, H, J, K
DUNFERMLINE Lauder Technical School	B
EDINBURGH Heriot-Watt College	B, C, G, H, J, K, L
FRASERBURGH Continuation Classes	B
GLASGOW Royal Technical College	G, H, J, K, L
KIRKALDY Technical School	B, C, G, H
PAISLEY Technical College	B, C, G, H, L
WEST OF SCOTLAND COMMITTEE ON TECHNOLOGY (at various centres)	B, C, G

III. NORTHERN IRELAND

BALLYMENA Municipal Technical School	B
BELFAST Municipal College of Technology	B, C, G, H, L
LISBURN Technical School	B
LONDONDERRY Municipal Technical School	B, C
NEWRY Municipal Technical School	B
PORTADOWN Municipal Technical School	B

APPENDIX VIII

EXTRACTS FROM THE PROGRAMME OF THE RUGBY COLLEGE OF TECHNOLOGY AND ARTS[1], 1944–45

(Reproduced by permission of the Governors and Principal of the Rugby College of Technology and Arts)

FEES

SENIOR TECHNICAL AND ART SCHOOLS

1. COURSES

Year of Course	S1	S2	S3	A1	A2
Building, Commercial and Art (Evening)	10/–	12/6	15/–	15/–	15/–
Art (Day)	10/6	10/6	10/6 per half day		
Engineering	10/–	12/6	17/6	20/–	25/–
Housecraft	7/6	7/6	7/6	—	—

Year of Course	M1	M2	I1	I2	F1	F2	F3
Degree . . .	10/–	15/–	20/–	25/–	30/–	35/–	40/–

2. SINGLE SUBJECTS

Practical Science	20/– per class
Industrial Administration . .	10/– (A1), 15/– (A2), 20/– (A3)
Orchestra	7/6

3. GENERAL EDUCATION, including FOREIGN LANGUAGES

To members of courses and single subject classes	Free
To others	5/– per class or group

[1] The College is recognized by London University as an approved Institution for Final B.Sc.(Eng.) in the following subjects :—

Part I. Strength and Elasticity of Materials and Theory of Structures, Theory of Machines, Applied Heat and Mechanics of Fluids, Applied Electricity, Mathematics.

Part II. Mechanics of Fluids (A), Applied Thermodynamics, Principles and Design of Electrical Machines, Electrical Power, Electrical Measurements and Measuring Instruments, Strength and Elasticity of Materials, Mathematics.

NOTES :—

(*a*) The fee for any subject which forms part of a group Course is the same as for the whole Course, and in cases where subjects are taken from more than one Course the higher Course fee is charged.

(*b*) In the case of a selection of a Course and a Single Class, the Course Fee plus the Single Class Fee will be charged.

(*c*) Any Student who is less than 21 years of age on September 1st who, in the preceding Session—

(*a*) Obtained a 1st Class Pass, and

(*b*) Made not less than 90 per cent. of the possible attendances, will be admitted without fee to an approved Course for the whole of the succeeding year.

(*d*) A Student from one of the Junior Schools who joins a Department of one of the Senior Schools at the first opportunity will be admitted for half fee, or if he or she fulfils the conditions of paragraph (*c*) he or she will be admitted without fee.

(*e*) Any Student in difficult financial circumstances may submit an application for reduction of fees. Such an application should be made in writing, explaining the circumstances to the Principal.

COLLEGE OFFICE

The General Office for enquiries and juvenile employment matters is open on weekdays from 9.0 a.m. to 5.0 p.m., on Saturdays from 9.0 a.m. to 12.0 noon, and during term time from 6.30 p.m. to 9.0 p.m.

SENIOR TECHNICAL SCHOOL

ENROLMENT WEEK: SEPT. 11—15

TERMS

Winter .	September 18th—December 22nd inclusive
Spring .	January 11th—March 29th inclusive
Summer .	April 30th—July 27th inclusive

HOURS

Morning	8.45 a.m.—12.15 p.m.
Afternoon	1.30 p.m.—5.0 p.m.
Evening	7.0 p.m.—9.0 p.m.

Morning Assembly in Hall at 8.45 a.m.

CURRICULUM

PART-TIME DAY AND EVENING COURSES

The following is a list of Courses and Classes. Students attending one full day or more per week will add Physical Training and Modern Problems to the subjects indicated.

BUILDING

ORDINARY NATIONAL CERTIFICATE (B)

BS1, S2, S3. Construction. Mathematics. Geometry. Science.

TRADES. CARPENTRY AND JOINERY (J) PLUMBERS (Pb) BUILDERS' CLERKS (C1)

JS1, S2, S3, A1. Carpentry Theory. Carpentry Practical.
PbS1, S2, S3, A1. Plumbing Theory. Plumbing Practical.
C1S3. Quantities.

MECHANICAL ENGINEERING

ORDINARY NATIONAL CERTIFICATE (M)

MS1. Engineering Drawing. Mathematics. Mechanical Science. Electricity and Magnetism.

MS2. Engineering Drawing. Mathematics. Mechanical Science. Chemistry. Electrotechnology.

MS3. Applied Mechanics. Mathematics. Mechanical Science. Metallurgical Chemistry. Electrotechnology.

HIGHER NATIONAL CERTIFICATE (DESIGN MD)

MDA1. Mathematics. Theory of Machines. Electrotechnology. Thermodynamics.

MDA2. Hydraulics. Theory of Machines. Electrotechnology. Thermodynamics.

HIGHER NATIONAL CERTIFICATE (PRODUCTION MP)

MPA1. Strength of Materials and Theory of Machines. Metallurgy and Metrology. Jig and Tool Design. Machine Tools. Electrotechnology.

MPA2. Metrology. Jig and Tool Design. Machine Tools. Electrotechnology.

ENGINEERING

TRADES. MACHINE SHOP ENGINEERING (G). FOUNDRY AND PATTERNMAKING (F). SHEET-METAL WORK (T).

INTERMEDIATE (S)

GS1, FS1, TS1. Calculations and English. Sketching and Drawing. Workshop Science. Workshop Technology or Foundry and Patternmaking Practice, or Sheet Metal Work.

GS2, S3, FS2, S3, TS9, S3.	Calculations. Sketching and Drawing. Workshop Science. Workshop Technology or Foundry and Pattern-making Practice, or Sheet Metal Work.

FINAL (A)

GA1, A2, FA1, A2, TA1, A2.	Calculations. Sketching and Drawing. Workshop Science. Workshop Technology or Foundry and Pattern-making Practice, or Sheet Metal Work.

ELECTRICAL ENGINEERING

ORDINARY NATIONAL CERTIFICATE (E)

ES1.	Engineering Drawing. Mathematics. Mechanical Science, Electricity and Magnetism.
ES2.	Mechanical Science. Mathematics. Electrotechnology. Electrical Laboratory.
ES3.	Mechanical Science. Mathematics. Electrotechnology I. Electrotechnology II.

HIGHER NATIONAL CERTIFICATE (GENERATION EG)

EGA1.	Mathematics. Industrial Physics. Electrotechnology. Electrical Laboratory.
EGA2.	Electrical Machine Design. Thermodynamics. Power Station Design. Electrical Generation and Transmission.

HIGHER NATIONAL CERTIFICATE (UTILIZATION EU)

EUA1.	Mathematics. Industrial Physics. Electrotechnology. Electrical Laboratory.
EUA2.	Utilization of Electrical Energy. Industrial Physics. Manufacturing Technique. Electrical Distribution and Conversion.

SINGLE SUBJECT. Radio-Communication

FINAL B.Sc.(Eng.) (D)

DF1. Mathematics. Materials and Structures. Theory of Machines. Applied Electricity. Electrical Laboratory. Applied Heat and Mechanics of Fluids.

DF2. Mathematics. Materials and Structures. Theory of Machines. Applied Electricity. Electrical Laboratory. Applied Heat and Mechanics of Fluids.

DF3. Mathematics. Strength of Materials. Design of Electrical Machines. Electrical Power. Applied Thermodynamics.

SCIENCE

ORDINARY NATIONAL CERTIFICATE IN CHEMISTRY (Ch.)

Ch.S1. Inorganic Chemistry I., Physics I., Mathematics I.

Ch.S2. Inorganic Chemistry II., Physics II., Mathematics II.

Ch.S3. Inorganic and Physical Chemistry I., Organic Chemistry I., Physics III.

MATRICULATION AND PRELIMINARY PROFESSIONAL (DM)

DM1, M2. English. Mathematics. French. Chemistry. Electricity and Magnetism.

INTERMEDIATE B.Sc.(Eng.) (D)

DI1, I2. Drawing. Pure Mathematics. Applied Mathematics. Heat and Electricity. Sound and Optics, or Chemistry.

INTERMEDIATE B.Sc. (SCIENCE) (Sc.)

ScI1, 12. Pure Mathematics. Applied Mathematics. Heat and Electricity. Sound and Optics. Chemistry (Inorganic and Physical). Chemistry (Organic).

FINAL B.Sc. (SCIENCE) (Sc.)

ScF1, F2, F3. Mathematics. Physics. Chemistry (Inorganic and Physical). Chemistry (Organic).

SINGLE SUBJECTS Metallurgy. Post Graduate Chemistry.

COMMERCE AND GENERAL EDUCATION:—
COMMERCE

ORDINARY NATIONAL CERTIFICATE (C)

CS1. English. Arithmetic. Book-keeping. Business Economics. Economic History.
CS2. English. Arithmetic. Book-keeping. Business Economics. Economic Geography.
CS3. Statistics. Book-keeping. Business Economics.

PROFESSIONAL (C)

CA1. Book-keeping and Accounting. Economics. Commercial Law. Company Law. Costing.
CA2. Accounting. Secretarial Practice. Economics. Commercial Law. Company Law. Costing.
(During war-time the Professional subjects are planned tutorially to meet individual needs).

CLERKS (Cm)

CmS1.	English.	Arithmetic.	Book-keeping.
CmS2.	English.	Arithmetic.	Book-keeping.
CmS3.	Statistics.	Book-keeping.	

SHORTHAND TYPISTS (S)

SS1.	English.	Shorthand.	Typewriting.
SS2.	English.	Shorthand.	Typewriting.
SS3.	English.	Shorthand.	Typewriting.

INDUSTRIAL ADMINISTRATION (Ad)

AdA1.	Fundamentals of Industrial Administration.
AdA2.	Works' Management.
AdA3.	Technique of Industrial Administration.

GENERAL EDUCATION

FOREIGN LANGUAGES (L)

LS1.	French.	German.
LS2.	French.	German.
LS3.	French.	

GROUPS. English for Technical Students. General Economics. Orchestra. Ballroom Dancing. Talks, Discussions, Recitals.

NOTE.—The formation of additional Classes and Groups will be considered on request.

APPENDIX IX

TYPICAL SYLLABUS FOR THE FINAL YEAR OF THE ORDINARY NATIONAL CERTIFICATE COURSE IN ELECTRICAL ENGINEERING

(Reproduced by permission of the Governors and Principal of the Rugby College of Technology and Arts)

1. *Electrotechnology*, I

Magnetic properties of materials used in machines; magnetomotive force; discussion of the magnetic circuit; calculation of loss in iron.

Generation of e.m.f.; simple types of winding of generators and motors; armature reaction and commutation; types of lamps and principles of photometry.

2. *Electrotechnology*, II

Alternating-current phenomena; frequency; average and R.M.S. values; representation by vectors; inductance in D.C. and A.C. circuits, series and parallel; power factor; resonance; three-phase generation and transmission of power; simple theory of transformers.

3. *Utilization of Electrical Energy*

Characteristics, protection, and speed control of different types of industrial A.C. motors; phase advancing; commutator motors.

Ward-Leonard systems; special drives; propulsion of ships; automatic starting and control; photo-cell and thyratron control.

Illumination, modern systems; electrical welding; water heating and storage; electrolytic processes and industrial chemistry.

4. *Mechanical Science*

Properties of materials; tensile, compressive, and shear stresses; resilience; suddenly applied loads; stresses in thin cylinders.

Force diagrams and funicular polygons; roof trusses; beams; bending moments and shear force diagrams; resistance to bending; modulus of section; torsion.

Linear motion; circular motion; centrifugal force; hoop stresses; simple harmonic motion; balancing; relative velocity; flywheels.

Hydrostatics; hydraulics; notches and weirs; fluid friction; flow in pipes.

5. *Mathematics*

Sum and difference formulæ of trigonometrical expressions; solution of triangles; trigonometrical equations with their graphs; binomial expansions; determination of laws from two variables.

Methods of differentiation; standard forms; rules for the sum, product, and quotient of two functions; functions of a function; maxima and minima.

Methods of integration; standard forms; integration applied to areas, volume, centres of gravity, and moments of inertia.

APPENDIX X

TYPICAL FORM OF APPRENTICESHIP INDENTURE

(' Form " B " (as revised 1943) ' reproduced by permission of the Engineering and Allied Employers' National Federation)

DRAFT AGREEMENT

THIS AGREEMENT made the..............day of ....19.......BETWEEN A. B. (hereinafter called ' the Apprentice ') a minor of ....years of age on the..............day of..............19........of ....and C. D. (hereinafter called ' the Guardian ') of.................and E. F. (hereinafter called ' the Employer ') of.. WITNESSETH that with the consent of the Guardian testified by the latter's execution of this agreement the Apprentice has agreed to serve the Employer, and the Employer has agreed to accept and pay for such service upon the conditions hereinafter contained.

1. The Apprentice and the Guardian severally agree with the Employer as follows :—

(1) The Apprentice will as from the ....day of.............19.......serve the Employer for a total period of.............years of service, each year to consist of fifty-two working weeks calculated in accordance with the provisions of this agreement, which total period is hereinafter called ' the period of service '.

(2) The Apprentice will during the period of service—

(*a*) observe and be subject to the conditions of employment contained in the schedule annexed hereto ;

(*b*) obey the lawful orders of the Employer or his representatives ;

(*c*) promote to the best of his ability the interests of the Employer.

(3) The Apprentice will not during the period of service—

(*a*) reveal the secrets of the Employer's business;

(*b*) do or suffer to be done any damage or other injury to the property of the Employer or his customers;

(*c*) absent himself, except in the event of sickness, from the service of the Employer without his permission or consent;

(*d*) take part in any labour dispute which may arise between the Employer and any of his employees or in which the Employer and any of his employees may be involved, nor during the continuance thereof refuse to do any work which the Employer may lawfully require him to perform.

2. In consideration of the said obligations undertaken by the Apprentice and the Guardian, the Employer agrees with the Apprentice and the Guardian that, subject to the provisions of this agreement, he will for and during the period of service—

(1) receive the Apprentice into his service and, subject to the fulfilment by the Apprentice of the said obligations, allow the Apprentice to continue therein until the expiration of the period of service;

(2) observe the conditions of employment and pay to the Apprentice in respect of his service wages at the rates contained in the schedule annexed hereto;

(3) permit the Apprentice to enjoy the advantage of acquiring under the control of the Employer to such extent as is practicable, having regard to the conditions of work and of organization from time to time existing in the

Works or in the particular department thereof in which the Apprentice may be working, a practical knowledge of the trade of............. so far as from time to time that trade is being carried on in the Works or in such department and the capacity and proficiency of the Apprentice admits.

3. It is further expressly agreed by and between the Apprentice and the Guardian and the Employer as follows :—

(1) If the Apprentice shall wilfully disobey the lawful orders of the Employer or his representatives or shall persistently neglect or refuse to comply with the provisions of this agreement or shall grossly misconduct himself or shall habitually absent himself from work without the Employer's permission or consent, except in the event of sickness certified by a duly qualified medical practitioner, the Employer may without notice discharge the Apprentice from his service, in which event this agreement will forthwith be at an end.

(2) If by reason of being unable to obtain materials or in consequence of any accident or trade dispute or trade depression or of any cause beyond his control, the Employer finds it necessary from time to time to close down the Works or any particular Department thereof in which the Apprentice may at the time being be working, or to reduce the volume or alter the character of the work done in such Works or such particular department thereof so that the Apprentice cannot continue to be usefully employed or enjoy the facilities for acquiring a practical knowledge of the said trade, the Apprentice will not be entitled to claim to work, or enjoy such facilities, during such time as the Works or such particular department are closed down, nor to claim during such period of reduction of volume or alteration of character of work, to work or to enjoy such facilities save on such basis of short time as the

Employer may think it best to adopt; and during such period of closing down or short time the provisions of this Agreement will cease to apply either to the Apprentice and the Guardian or to the Employer in respect of any working time which the Apprentice by reason of such closing down or short time is not working. Provided that if in any one year of service the Apprentice be prevented under the operation of this clause from working for a total period exceeding four weeks or be required to work on short time during more than twelve weeks, the Apprentice and the Guardian may by notice in writing signed by both of them and addressed to the Employer determine this Agreement.

Signed by the Apprentice and the Guardian, and by or on behalf of the Employer as follows :—

A. B.	the Apprentice
C. D.	the Guardian
E. F.	the Employer

SCHEDULE REFERRED TO IN THE FOREGOING AGREEMENT

HOURS OF WORK

Working Week.

1. (1) The ordinary working week to be worked by the Apprentice will consist of such total number of working hours worked in such shifts or ordinary working days as from time to time constitute the ordinary working week in the Works in which the Apprentice may be working.

(2) When the Apprentice is working under clause 3 (2) of the foregoing

agreement on any basis of short time a shortened working week consisting of a less number of working hours than the full number in the ordinary working week, and/or a shortened working day consisting of a less number of working hours than the full number in the ordinary working day, such shortened week and such shortened day will respectively be deemed to be the ordinary working week and/or the ordinary working day so long as short time continues.

Computation of period of service.

2. (1) When in accordance with clause 3 (2) of the foregoing agreement the Apprentice has worked a shortened working week he will nevertheless be deemed to have worked a full ordinary working week, for the purpose of computation of his year of service.

(2) All days which the Apprentice is entitled to keep as holidays will nevertheless be counted as days on which he has worked, for the purpose of computation of his year of service.

(3) All working hours during which the Apprentice is absent from work by reason of sickness certified as provided in clause 6(*a*) of this schedule (not exceeding the total of the working hours contained in eight full ordinary working weeks) and all working hours during which he is absent from work with the permission or consent of the Employer will nevertheless be counted as hours in which he has worked, for the

purpose of computatation of his year of service.

Overtime. 3. (1) The Apprentice will, as and when requested so to do, work in excess of the hours contained in—

(*a*) the ordinary working day or the ordinary working week as the case may be, or

(*b*) the shortened working day or shortened working week when short time is being worked under clause 3(2) of the foregoing agreement,

such additional hours as the Employer, from time to time, subject to the Employment of Women, Young Persons and Children Act, 1920, and/or the Factories Act, 1937, and any Act amending the same, may lawfully require the Apprentice to work.

(2) When such additional hours are worked they will be counted as overtime in the manner and to the extent provided by the practice for the time being prevailing in the Works or in any department thereof in which the Apprentice may be working.

Night Work. 4. The Apprentice will, as and when requested so to do, work at night to such extent as the Employer, subject to the Employment of Women, Young Persons and Children Act, 1920, and/or the Factories Act, 1937, and any Acts amending the same, may lawfully require him to work.

Holidays and Sundays. 5. The Apprentice will be entitled to keep as a holiday all such days as are customarily kept as holidays in the Works, provided that the Employer may in cases of necessity, of which he will be the judge, and subject to the Employment of Women, Young Persons and Children Act, 1920, and/or the Factories Act, 1937, and any Acts amending the same, require the Apprentice to work on any such holiday or on any Sunday.

Lost time. 6. The aggregate of all working hours or portions of working hours which the Apprentice fails to work in any ordinary or shortened working week as the case may be in any year of service shall be worked by him before that year of service is deemed to have been completed. Provided that the Apprentice will not be bound so to work in respect of—

(*a*) any time during which he has been absent from work by reason of sickness (not exceeding the total of the working hours contained in eight full ordinary working weeks) if he produces to the Employer a certificate from a duly qualified medical practitioner that as a result thereof he has been unable to work;

(*b*) any time he has been absent from work with the permission or consent of the Employer or as provided by this Agreement.

WAGES

Rates of Wages.

7. (1) The Apprentice will be paid in respect of each ordinary or shortened working week for each hour he works in such ordinary or shortened working week respectively at the following rates according to his year of service:—

During the—

1st year of service			at the rate of......per hour worked.	
2nd	,,	,,	......	,,
3rd	,,	,,	......	,,
4th	,,	,,	......	,,
5th	,,	,,	......	,,

(2) These rates are in conformity with and are subject to variation in accordance with the terms of agreements made from time to time between the Engineering and Allied Employers' National Federation and the Trade Unions concerned regarding the wages of apprentices.

(*Note*—This paragraph may be omitted if so desired.)

(3) He will also be paid at the said rates for such working hours as he is unable to work in any ordinary or shortened working week on account of sickness up to a maximum in any one year of service of the total of the hours contained in eight full ordinary working weeks, provided his inability to work is in each case certified by a duly qualified medical practitioner.

(4) The Apprentice will, as and when required to do so by the Employer, work and accept remuneration based on piecework or any other system of payment by results on which the Employer may desire him to work, but, in such cases he will be paid as a minimum his time rate of wages.

Overtime and Night Work. 8. The Apprentice will be paid for overtime and night work on the respective bases on which overtime and night work are, for the time being, paid at the Works or in any department thereof in which he may be working.

Holidays. 9. The Apprentice will be paid for all hours he works on days customarily kept as holidays in the Works or in any department thereof in which he may be working, such addition (if any) to the foregoing rates as is usual at the time being at the Works.

GENERAL

Works Rules. 10. The Apprentice will conform to the conditions of employment and the rules which from time to time are in existence in the Works so far as they are not inconsistent with the express provisions of this Agreement and are applicable to the Apprentice.

Working conditions. 11. The Apprentice will work in or away from any Works of the Employer on new work, repair work or on any other work which the Employer may require, and with any class or classes of workmen which the Employer may select; and when the Apprentice is engaged on work away from such Works he will receive such allowances as are customarily paid (under the circumstances of the case) by the Employer.

Certificate. 12. When the Apprentice has served the Employer to the satisfaction of the latter for the full period of service a certificate to that effect will be given to the Apprentice by the Employer.

APPENDIX XI

DETAILS OF THE 'FURTHER EDUCATION AND TRAINING SCHEME' FOR THE PROVISION OF FINANCIAL ASSISTANCE TO MEMBERS OF THE SERVICES ON DEMOBILIZATION

THE SCHEME outlined below is authorized by the Minister of Labour and National Service, the Minister of Education, the Minister of Agriculture and Fisheries, and the Secretary of State for Scotland.

OBJECTS OF THE SCHEME

1. The war has interrupted the training and education of large numbers of young men and women who, at an age when they would normally be taking courses of further education or training for a business or professional career, have been engaged in work of national importance.

2. His Majesty's Government recognize that as a result there is a scarcity of persons fully trained for posts of importance in the professions, industry (including agriculture), and commerce. In particular, the supply of persons highly qualified in the humane studies such as history, philosophy, and the fine arts has been seriously curtailed. They have accordingly approved plans for providing financial assistance to enable suitably qualified men and women, on demobilization, to undertake or continue further education or training (i.e., beyond the secondary school standard).

PERSONS ELIGIBLE TO BENEFIT BY THE SCHEME

3. The Further Education and Training Scheme will apply to men and women alike, and in the following paragraphs the references to men include women, unless the context demands otherwise.

The scheme is primarily intended for the following categories :—

(i) (*a*) The Armed Forces (including their Auxiliary and Nursing Services).

(*b*) United Kingdom nationals with service in the Indian Armed Forces.

(*c*) Those who have volunteered for or been directed to work in the Coal Mines as an alternative to service in the Armed Forces.

(ii) Merchant Navy.
(iii) Civil Defence Services.
(iv) Police Auxiliaries.
(v) Civil Nursing Reserve.

The scheme is also available for suitable applicants whose further education or training has been prevented or interrupted by employment in work of national importance other than the types of service mentioned above. If at any time the training facilities for a particular profession or calling are limited, preference will be given to persons from the named Services.

4. The primary condition of eligibility will be proof of full-time effective service in work of national importance during the war. In addition to giving proof of such service an applicant will ordinarily be required to show that by reason of this service he

(*a*) has been unable to start training for a career, or
(*b*) has suffered interruption of training for a career, or
(*c*) is unable to resume his previous career, or
(*d*) requires a 'refresher' course to enable him to follow his previous career.

Normally the minimum period to constitute effective service is one year, but an applicant who has had less than one year's effective service can be considered if the shorter period of service has resulted in interruption of training amounting to a year or has resulted in a residual disability which prevents the applicant's return to his pre-service training or career. Part-time service will not satisfy the primary condition of eligibility unless that part-time service has led to a disability which has rendered him unable to follow his normal occupation. The tenure of a State Bursary, Language Scholarship, or Engineering Cadetship is deemed to satisfy the primary condition.

5. An applicant who, before the war, already held a post for which he had received adequate training, and who left that post to enter the services or to undertake temporary war-work, will not normally be regarded as eligible for training for a new profession unless, because of changed circumstances, he is denied the opportunity of resuming his pre-war career. In particular cases, however, applications made by men desiring to qualify for a profession on a higher plane will be considered provided that it is clear from their war record that they have shown or developed capabilities which would justify the expenditure of public money for the purpose.

6. There will be a number of men whose war-time service has been in itself the exercise of their chosen profession, e.g., men of the regular forces, the regular police and fire services. Such persons will, generally speaking, not be eligible for assistance under the scheme unless they have been discharged for medical reasons and have no career open to them other than one that requires training not already possessed.

7. Owing to economic pressure or other cause, a demobilized man may accept a post before applying for training. Such a man will not be debarred from consideration for an award solely by the fact that he has obtained employment.

8. An applicant will not be deemed ineligible solely by reason of the fact that he is an alien, if he satisfies the other

conditions; but in any field where accommodation and opportunity fall short of the demand, aliens will not be accepted to the exclusion of suitably qualified British subjects.

PERSONS SUITABLE TO BENEFIT BY THE SCHEME

9. The criterion will be whether an applicant is likely to be capable of completing with credit the course he desires to take. This implies a standard which will clearly vary according to circumstances. Previous attendance at a secondary school or its equivalent, although normally desirable, is not essential. Assistance will not be given to persons below the requisite standard of education to enable them to reach the standard required for admission to a particular course.

10. The applicant must show capabilities or potentialities sufficient to suggest that his training will justify expenditure of public money.

FURTHER EDUCATION AND TRAINING

11. By the phrase 'further education' is meant education beyond the secondary school standard. It may be divided into three categories:—

(1) Whole-time training at a University or other educational establishment, or in a profession or business where practical as well as theoretical training is required.

(2) Part-time training relevant to and taken in conjunction with paid employment.

(3) Refresher courses.

12. No hard-and-fast rule can be laid down as to the profession, business or industry for which assistance in training can be given. In general the criterion will be that a profession will be regarded as falling within the scope of the scheme if it requires the attainment of a recognized standard

of education as a condition of entry, or in the case of industry and commerce the occupation is one for which technical training or higher education will materially improve an entrant's prospects of advancement to a responsible or administrative position. Where neither of these conditions was *prima facie* fulfilled, e.g., in the Fine Arts, it would be for an applicant to make out a case for the expenditure of public funds on his training.

13. An applicant should normally indicate the profession or business for which he desires to train and the qualification he wishes to acquire. It must, however, be realized that his selection of career and course cannot be left to his undirected choice. There may be alternative types of training, some of which are more beneficial than others. Preference will be given to those likely to give the most satisfactory results. So far as careers are concerned, regard must be had to the absorptive capacity of professions or businesses and industry. For this purpose, advantage will be taken of the expert advice collected by an Inter-Departmental Committee presided over by Lord Hankey which has been considering the number of persons who should be encouraged to enter upon various kinds of further education and training having in mind the prospects of employment at home and abroad.

EDUCATION AND TRAINING GRANTS

14. When an award is made in respect of a course of full time training at a University, Technical College, or similar institution, it will take the form, subject in all cases to financial necessity, of the payment to the institution attended of fees incidental to the course, such as admission fees, and fees for tuition and examination, together with an additional payment to the applicant to cover maintenance. The amount of the payment for maintenance will vary according to the institution attended, and will be based on standard figures for maintenance costs at particular Universities, or Uni-

versities and other institutions of particular types, originally assessed by Committees of the Universities themselves. In all other cases the award to a successful applicant will take the form of a grant which may in addition to payments covering fees, tuition and books, include a payment for maintenance up to the maximum sum of £160 p.a.

15. In the case of married persons the award may include an additional sum not exceeding £110 p.a. in respect of a wife and £40 p.a. in respect of each child.

16. Applicants who apply for an exceptionally long or expensive training will be required to show special promise of a successful career. It may be that some candidates will wish to take courses at Dominions or other overseas Universities. This will be permitted in appropriate cases, subject to the approval of the authorities concerned. The amount of such awards will receive special and separate consideration.

17. The scheme will not provide for the payment of premiums to employers upon the acceptance by them of men or women for training.

18. Continuance of an award will be dependent upon satisfactory conduct and progress and will normally be conditional upon the passing of the ordinary examinations associated with the course, unless some good reason for failure, such as ill-health, can be shown.

ASSESSMENT OF AWARDS

19. In assessing the amount of the award which shall be paid to a successful applicant, the following general principles will be applied :—

(*a*) if the applicant is under 21 years of age at the date of the commencement of the award, and unmarried, his parents will be asked to state their income. If this is substantial, the amount of the award made to the applicant will be based on the assumption that the parents will make a suitable contribution to the cost of the applicant's further education;

(*b*) if the applicant is over 21 years of age, or is married (whether over or under 21) he will be asked to state the occupation of his father, and what contribution, if any, his parents or others are prepared to make towards the cost of his further education;

(*c*) a substantial proportion of the income, if any, of an applicant will be taken into account when assessing the grant payable to him, except that no account will normally be taken of personal disability pay or disability pension or war gratuity.

APPEALS TRIBUNAL

20. Appeals by applicants whose applications for grants have been refused may be referred to an Appeals Tribunal at the discretion of the Minister concerned.

APPLICATIONS

21. The scheme, it will be clear, cannot come into full operation until general release begins, but it has been decided that applications for consideration can be received immediately from certain limited classes. These are, in general, men and women who have been discharged from their war service through disablement or on medical grounds and who are not required by the Ministry of Labour and National Service to undertake other forms of national service.

22. An application for an award cannot be considered until the applicant has been released from his national service. It should be addressed to the nearest Appointments Office of the Ministry of Labour and National Service. The addresses are given below.

23. In the case of applicants resident in Northern Ireland applications should be sent to the Ministry of Education for Northern Ireland, Belfast.

OFFICES OF APPOINTMENTS DEPARTMENT

London . .	Sardinia Street, Kingsway, W.C.2. Holborn 4300.
Cambridge . .	2nd Floor, Lloyds Bank Chambers, Hobson St., Cambridge, Cambridge 55288.
Reading . .	23 Valpy St., Reading, Berks. Reading 4801–6.
Bristol . .	91 Pembroke Rd., Bristol 8. Bristol 38241.
Birmingham .	Patrick Motors Building, Broad St., Birmingham.
Nottingham .	Commerce Chambers, Upper Parliament St., Nottingham, Nottingham 46711–3.
Leeds . .	Lloyds Bank Chambers, Vicar Lane, Leeds. Leeds 3047.
Manchester .	Royal Exchange Buildings, Bank St., St. Ann's Square, Manchester 2. Blackfriars 5173–6.
Liverpool .	Cotton Exchange, Bixteth St., Liverpool. Central 7446.
Newcastle-on-Tyne.	153 Barras Bridge, Newcastle-on-Tyne 2. Newcastle-on-Tyne 22477–9.
Edinburgh . .	5 Rothesay Terrace, Edinburgh 3. Edinburgh 22121.
Glasgow . .	450 Sauchiehall St., Glasgow, C.3. Glasgow Douglas 7161.
Cardiff . .	8 Cathedral Rd., Cardiff. Cardiff 8327–31.

MINISTRY OF LABOUR AND NATIONAL SERVICE
ST. JAMES'S SQUARE, LONDON, S.W.1

March, 1945

APPENDIX XII

ENTRANCE FEES AND ANNUAL SUBSCRIPTIONS FOR MEMBERS AND ASSOCIATE MEMBERS OF THE INSTITUTIONS OF CIVIL, MECHANICAL, AND ELECTRICAL ENGINEERS

(Reproduced by permission of the Institutions of Civil, Mechanical, and Electrical Engineers)

I. THE INSTITUTION OF CIVIL ENGINEERS:

Entrance Fees:—	Members	£42
	Associate Members	£12 12s.

Annual Subscriptions:—

	London Area			Elsewhere in Brit. Isles			Abroad		
	£	s.	d.	£	s.	d.	£	s.	d.
Members	6	6	0	4	4	0	3	13	6
,, (retired) . .	3	13	6	2	12	6	2	12	6
Associate Members . .	3	13	6	2	12	6	2	12	6
,, ,, (retired) .	2	12	6	2	2	0	2	2	0

II. THE INSTITUTION OF MECHANICAL ENGINEERS:

Entrance Fees:—	Members	£6
	Associate Members	£3
Annual Subscriptions:—	Members	£4
	Associate Members	£3

III. THE INSTITUTION OF ELECTRICAL ENGINEERS:

Entrance Fees:—	Members	£5 5s.
	Associate Members	£3 3s.

Annual Subscriptions:—

	Gt. Britain and Northern Ireland			Abroad		
	£	s.	d.	£	s.	d.
Members	4	4	0	3	3	0
Associate Members	3	3	0	2	12	6

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