Engineering technicians

Some problems of nomenclature and classification

H. W. French

unesco
Studies in engineering education 7
Titles in this series:

1. * Standards for Engineering Qualifications* (also published in French)
2. *Social Sciences and Humanities in Engineering Education* (also published in French and Spanish)
3. *The Continuing Education of Engineers / La formation continue des ingénieurs*
4. *Staff Development for Institutions Educating and Training Engineers and Technicians* (also published in French)
5. *The Design of Engineering Curricula* (also published in French and Spanish)
6. *Advances in the Continuing Education of Engineers*
7. *Engineering Technicians. Some Problems of Nomenclature and Classification* (also published in French; to appear in Arabic, Russian and Spanish)
8. *Strengthening Co-operation between Engineering Schools and Industry* (in preparation)
9. *The Environment in Engineering Education* (to appear also in Arabic, French and Spanish)
Preface

The question of nomenclature and classification regarding technicians, their education and functions as used around the world, has often given rise to controversy and misunderstanding. There are major differences in views on terminology, even in individual countries.

With this in view, Unesco felt that it would be useful to prepare a survey of current practice to help identify major difficulties and differences and give clearer insight into the problem. Prior to publication, the report was circulated to thirty-five experts in the field of engineering and technician education from both developed and developing regions of the world for their comments and suggestions. In the light of the comments received, it is felt that the report has to a major extent achieved this aim.

The report includes a critical analysis of the problem of nomenclature and classification of technicians and contains summaries of the systems for training technicians and technician engineers in many countries.

It is hoped that this publication will prove useful to those responsible for the planning and implementation of technician training programmes, to associations and institutions involved in the professional recognition of technicians, to employers in industry and to the technicians themselves.

The opinions expressed in this publication are not necessarily those of Unesco and the Organization is not responsible for the choice and presentation of the facts used to support or illustrate the ideas put forward.

Unesco extends its thanks to the author and all those who have contributed to this study.
Contents

Foreword

Part One

1. Introduction
   The occupational spectrum 15
   Craftsmen 15
   Engineers 16
   The technician area and its boundaries 17
   Levels of technician work 21

2. Definitions of technicians:
   Definition by occupational level 22
   Definition by function 24
   Occupational classifications and titles 28
   Definition by qualification 46

3. Associations of technicians and of technician-engineers
   General 52
   The Swiss register 52
   The Engineers Registration Board (United Kingdom) 53
   The FEANI comparability investigation 55
   The experience requirement 58

4. International minimal requirements for education and training
   Minimal educational requirements 60
   A 'broad banding' proposal 62

5. Titles—legal protection
   General 63
   The problem of title without experience 64
   Categories of legal conditions of title 64

6. Summary of recommendations and conclusions 66
Part Two

7. Introduction

8. Country summaries
   Argentina
   Australia
   Austria
   Belgium
   Brazil
   Canada
   Czechoslovakia
   Denmark
   Egypt
   France
   Federal Republic of Germany
   Ghana
   Greece
   Hong Kong
   Hungary
   India
   Indonesia
   Iran
   Iraq
   Italy
   Ivory Coast
   Japan
   Kenya
   Republic of Korea
   Malaysia
   Mexico
   Netherlands
   New Zealand
   Nigeria
   Pakistan
   Poland
   Spain
   Sweden
   Switzerland
   Thailand
   Union of Soviet Socialist Republics
   United Kingdom
   United States of America
   Zambia

Bibliography
Foreword

This report has been prepared as part of the regular programme of Unesco, concerned with the development and improvement of engineering and technological education. While it provides some information concerning the formation of technician-level personnel in thirty-nine countries, and also comments on such matters as the objectives of this formation, industry-education relations, the importance of professional associations, etc., its main purpose has been to consider the nomenclature applied to occupations at the technician-level, and to suggest possible means whereby the present confused terminology might, by agreement, be made more uniform. Since such an operation should result in similar names being applied to—and only to—similar jobs, at the same level, it follows that success can only be achieved if a methodology can be found for assessing the nature of, and the levels achieved in, the various means whereby technician-level personnel are educated and trained. To carry out this task accurately would involve the careful assessment of course content, time allocations, the nature and organization of practical training, etc. This would be an immense task; and while some of the generalizations about courses in this report do in fact derive from a consideration of actual education and training programmes in a number of countries, it is certainly not claimed that the investigations thus involved begin to approach such a detailed analysis.

What is claimed, however, as a result of the operation, is that (a) it should be possible, as part of an overall system of occupational classification, to provide job descriptions of technician-level occupations which would be generally satisfactory to industry in many countries; and to attach to such job descriptions a nomenclature which could readily be adapted to suit the languages of most member nations; (b) that technician-type work in most countries is at two clearly determined levels, and that it should be possible (but
IO Engineering technicians. Some problems of nomenclature and classification

perhaps not easy) to agree upon a nomenclature suitable for international adoption which would distinguish between these levels; and (c) that it should be possible to produce useful approximate criteria, short of the very detailed investigation needed for exact assessment, enabling decisions to be made as to whether particular courses produce technician-type personnel at the higher or at the lower level.

The report applies a set of possible criteria to the main technician-forming courses in the thirty-nine countries and 'grades' them accordingly. It is most important to note that this is done purely to show the feasibility of applying such a method. Since the criteria used are the writer's own, it follows that the result of applying them, while it may satisfy him, might not necessarily receive support from other people. But, in the writer's view, it does show that, if criteria could be agreed upon, such broad-band divisions could be made. A reasonably uniform nomenclature, indicating both the nature and the level of the various technician-type occupations, would then seem to be practicable.

To carry out a thorough investigation of technician 'formation' in thirty-nine countries would involve a great deal of work by many people. This report results from a few months' part-time work by one man—appropriately enough, since its object is simply to point a possible way, not to provide a detailed map of the route. Any shortcomings in the report will, it is hoped, be considered in the light of the limited objective of the operation and, consequently, the very modest facilities used in achieving it.

The author's thanks are especially due to those countries which kindly provided the information for which he asked. These were few, however, and much of the material used has been obtained from a variety of sources. Grateful thanks for assistance given are especially extended to: the European Federation of National Associations of Engineers (FEANI); the World Federation of Engineering Unions (WFEU); the European Society for Engineering Education (SEFI); the British Council (London headquarters); the Council of Engineering Institutions (CEI, London); the Institution of Electrical and Electronics Technician Engineers (IEETE, London); the Technical Education and Training Organization for Overseas Countries (TETOC, London); the Commonwealth Secretariat (London); the Great Britain East European Centre (London); the British Engineering Industry Training Board (Watford); the Organisation for Economic Co-operation and Development (OECD); and to many individuals who kindly provided information.

Naturally, a great deal of information came from books and papers, most of which are listed in the bibliography. However, the writer derived so much help from three particular publications that
he would like to express his special thanks to their authors. They are 
*Standards for Engineering Qualifications—A Comparative Study in Eighteen European Countries*, by Professor V. Broida, The Unesco Press, 1975; *Survey Training of Technicians in East European Countries*, by Dr P. G. Kochetkov, Unesco, 1977; and *Technician Education and Training Systems in the Colombo Plan Countries—A Comparative Study and Analysis of Current Issues*, by Dr L. Chandrakant, Colombo Plan Staff College for Technician Education, 1976. Thanks are also due to those who have commented on the original draft of the manuscript. Their remarks have enabled some mistakes to be eliminated, and a measure of updating to be achieved. Even so, given the rate at which changes are taking place in technical education in many parts of the world, it is inevitable that some details in Part Two will quickly become outdated—some perhaps even by the date of publication.

The author would also like to record his thanks to members of the Unesco Secretariat for their help and advice. However, any opinions expressed are entirely his own and do not purport to represent the views of the Organization.

H. W. F.
Part One
1. Introduction

The occupational spectrum

The range of technical occupations within the engineering industry may be represented as a continuous spectrum by a diagram of the type illustrated in Figure 1. The first of the two triangles, with its short side on the left of the diagram, represents manual and machine skills and techniques; the other triangle represents knowledge of scientific and engineering principles. A particular occupation may be represented by a vertical line, cut into two parts by the oblique line which is the side common to the triangles. The vertical line is so located along the base that the ratio of the two parts into which it is thus divided indicates the proportion of manual skills to technical knowledge required in the occupation which the line represents.

A machine operators job might well be represented by the line A-B, indicating that his work is virtually all manual, and involves negligible technical knowledge. At the other extreme, the line C-D could indicate the situation for a person engaged in research in mathematical methods of engineering analysis, involving a high degree of theoretical knowledge, but not requiring practical ability.

Craftsmen

Consider next the section marked 'craftsman (skilled worker). It shows, by length E-G, that such tradesmen make their contribution largely through the skill of their hands. They also require a measure of theoretical background, indicated by G-F; but it is usually limited, and often of an empirical nature closely related to the skills of the particular craft. It is sometimes referred to as 'job knowledge'.

---

The range of technical occupations within the engineering industry may be represented as a continuous spectrum by a diagram of the type illustrated in Figure 1. The first of the two triangles, with its short side on the left of the diagram, represents manual and machine skills and techniques; the other triangle represents knowledge of scientific and engineering principles. A particular occupation may be represented by a vertical line, cut into two parts by the oblique line which is the side common to the triangles. The vertical line is so located along the base that the ratio of the two parts into which it is thus divided indicates the proportion of manual skills to technical knowledge required in the occupation which the line represents.

A machine operators job might well be represented by the line A-B, indicating that his work is virtually all manual, and involves negligible technical knowledge. At the other extreme, the line C-D could indicate the situation for a person engaged in research in mathematical methods of engineering analysis, involving a high degree of theoretical knowledge, but not requiring practical ability.

Consider next the section marked 'craftsman (skilled worker). It shows, by length E-G, that such tradesmen make their contribution largely through the skill of their hands. They also require a measure of theoretical background, indicated by G-F; but it is usually limited, and often of an empirical nature closely related to the skills of the particular craft. It is sometimes referred to as 'job knowledge'.
However, it will be seen that these skilled craftsmen are represented on the diagram, not by a line but by an area. This indicates that within the range of engineering crafts, there is a difference between the proportions of manual skills to background knowledge required. A newly qualified turner might be represented by the left-hand edge. A master craftsman, perhaps having supervisory duties, and a correspondingly greater degree of background knowledge, by the right-hand edge.

Engineers

Let us move now to the section labelled 'engineer (university level)'. This clumsy title—and the reason for its clumsiness will quickly become apparent—is intended to incorporate the top-level band of technical personnel within the engineering industry, by whatever names they may be known in the different countries; for example, the 'Diplomingenieur' in the Federal Republic of Germany and in Austria; 'sivilingeniør' in Norway; 'mohandess' in Egypt; 'chartered engineer' in the United Kingdom; 'engenheiro' in Brazil and Portugal, etc. In the United States of America the title
is 'engineer'. But while this word, and its widely used near-equivalent in other languages, e.g. 'ingenieur', 'ingénieure', etc. is used in some countries to indicate this high technical level, in other countries it may describe an occupation requiring a lesser degree of knowledge and, perhaps, a greater extent of practical skill than one would expect to find in a 'university-level engineer'—a 'superior technician', in fact.

It will be observed that, like the 'craftsman' section, the 'university-level engineer' part of the diagram also covers an area, indicating a degree of difference between the proportions of practical facility and background knowledge required, as, e.g. between an engineer at the left-hand extremity and one at the right-hand edge. This arises from two causes. First, there are different types of engineers. A mechanical-production engineer will need to have had a good deal more study and practice in production processes than would be necessary for an engineer who heads a research group concerned with electronic circuitry. Secondly—and this is a point of both difficulty and delicacy—not all countries are agreed as to the breadth and depth of study necessary for a 'university-level engineer'; nor do all see eye to eye with regard to the extent of practical training needed. Thus, problems arise regarding the equivalence of qualifications. However, these are outside the main objective of this publication, although they have a bearing upon it.

The technician area and its boundaries

Our subject is the range of engineering activities which bridge the gap between the upper limit of the activities of craftsmen, and the lower limit of those of 'university-level engineers'. While the history of the craftsman goes back to the craft guilds of the Middle Ages (and, indeed, earlier) and engineering degree-level courses have existed for more than a century (much more, in some countries), the concept of the 'middle man', or 'technician' is a relatively new one. Few countries have recognized this level of work as a separate part of the engineering spectrum for more than fifty years; and the majority of countries for a very much shorter period. Indeed, some

have barely begun to make provision for the education and training of personnel at this level.

Further, development in some countries has occurred ad hoc, often by individual firms recognizing the need for particular intermediate-level personnel and making their own arrangements for training them. A lack of co-ordination between countries has led to nomenclature problems, which often produce misunderstandings. Sometimes names which are virtually the same in two countries may be applied to functions or to jobs, which are manifestly very different; or jobs which are virtually the same in different countries, be given names implying a considerable difference in levels of work. Indeed, confusion of this kind is not restricted to titles used in different countries. Because of the ad hoc development of the technician structure, inconsistencies can often be found between different firms in the same country.

A further degree of confusion arises because of problems at the boundaries of these job classifications. It will be seen that the 'technician area' in Figure 1 overlaps both the upper limit of the 'craftsmen' section and the lower limit of the 'university-level engineer' section. Let us consider first the craftsman overlap, which is the less troublesome of the two. It arises from two main causes. The first is the existence, at the higher levels of craftsmen's work (particularly the supervisory ones), of jobs which need much the same proportion of practical skill to background knowledge as do certain 'craft-related' technician positions. The second relates to a lack of clarity in job definition in some countries, in which, e.g. some firms might regard a particular job as a 'craft' while others may consider it as a 'technician' level. This happens particularly in those work areas where jobs merge at a not very clear boundary line. For example, it is not altogether easy to say at what point the diagnostic ability and background knowledge of a good motor vehicle mechanic becomes sufficient for him to be regarded as a motor vehicle technician. There are some who would say that this point is reached when the motor mechanic can pass the examinations which would qualify him as a motor vehicle technician. But this implies that 'titles' should be attached, not to the jobs being done, but to the qualifications of the persons doing them. Clearly, the two criteria ought to coincide but they do not always do so. This problem will be discussed more fully later. For the moment, let us move from the lower overlap in Figure 1 to the upper one, noting in passing that problems of nomenclature do exist at this lower overlap area. As the relevant chapters of Part Two show, there are two or three countries where the overlap results in a third (low) stratum of 'assistant technicians'.

The upper overlap does, in fact, raise many problems. At first sight, perhaps, it would appear that it need not. For example, an
Introduction

inquiry by the writer to the National Labour Market Board (Arbetsmarknadsstyrelsen) in Sweden received the reply that 'the kinds of technician mentioned in your letter work in all functions except where a university degree is required'. This is no doubt a clear, definite and satisfactory way of distinguishing between 'superior technicians' and 'university-level engineers' in Sweden. But it would not hold in the United Kingdom, where the 'university-level engineer' positions may be reached, not only through the universities, but by other paths also. Nor would it readily hold in the United States where the graduate of a four-year university-degree course in engineering is entitled 'engineer', and is thus a 'university-level engineer', while his counterpart who also successfully completes a four-year university-degree course, but in 'engineering technology', is termed an 'engineering-technologist' and is rated below the level of the 'engineer'. Thus he could be located towards the right-hand extremity of the 'technician' area in Figure 1. In the United Kingdom, the term 'technologist' implies a person qualified at the high level, i.e. the 'university-level engineer'. In Canada, however, as in the United States, 'technologist' means 'superior-level technician' (as it does also in Brazil, Zambia and a few other countries).

There are other countries where difficult distinctions have to be made between different levels of engineer-type titles. In the Federal Republic of Germany the Diplomingenieur (Dipl. Ing.) is undoubtedly a 'university-level engineer', but the Ingenieur graduiert (Ing. grad.) is at a level of qualification below that of Diplomingenieur. In Denmark there are four levels above the skilled worker, namely: tekniker, teknikumingeniør, akademisingeniør and sivilingeniør; and while the first undoubtedly comes within the 'technician area' of Figure 1, and the 'sivilingeniør' is certainly in the 'university-level engineer' category, the exact locations of the 'akademisingeniør' and the 'teknikumingeniør', since they must be below that of 'sivilingeniør' are not immediately obvious. They are dealt with in Part Two, in the section 'Denmark', page 91.

An additional complication is that, while most university-level engineering courses start more or less from the same point (i.e. the successful completion of a full secondary education at the age of about 18 or 19), they vary greatly in length. Thus, in the United Kingdom, where compulsory education starts at the age of 5, and a considerable measure of subject specialization occurs during the last two of the thirteen years of school education, an engineering degree can be obtained after only three years of full-time study at a university or equivalent-level establishment; and degree courses of the same duration exist in a number of other Commonwealth countries that have systems based on the British one. In most other countries, four years is normal, while many have degree courses
lasting five, five-and-a-half and even six years. The problem from the perspective of the technician is as follows. Suppose a country runs two engineering courses, both following the completion of a full secondary education. One course lasts five-and-a-half years and undoubtedly reaches the 'university-level engineer' standard. The second course lasts four years and is regarded in its country as a high-level technician qualification. But this course requires a year more of study than it takes to cover the academic requirements for the 'university-level engineer' qualification in the United Kingdom. There is here an apparent anomaly. It does not follow that the longer course should necessarily lead to the higher qualification. Other factors may well be involved—such as the content and nature of the earlier years of education; the number of hours per working year; whether a change of language is required; whether subsequent or concurrent training or experience is obligatory before the qualification is given; and, above all, how, and for what purpose, the course has been designed. Some of these points will arise later.

As with the lower level of overlap, there arises at the upper end of the technician spectrum the complication of firms specifying different levels of qualification for equivalent jobs, which results in similar posts being occupied by 'senior technicians' in one firm and by 'university-level engineers' in another.

One sometimes finds, too, that personnel with university-level qualifications may be employed in posts that are recognized as being merely of 'senior-technician' level. For example, an investigation carried out in the United Kingdom in 1969/70 by the Engineering Industry Training Board1 revealed that nearly 4 per cent of the technicians actually employed as such (that is, having finished training) were university graduates, or possessed equivalent qualifications. Some of these would be so employed in order to provide them with practical experience at this level before receiving higher appointments more appropriate to their qualifications. Sometimes a post might involve a 'mix' of responsibilities at different technical levels. Employment as 'higher-level technicians' may also arise from a mismatch between manpower needs and the production of successful students at the two levels, and the consequent problems of employment. Occasionally, it occurs that some people, despite high qualifications, do not have the attributes required for higher-level posts and are consequently retained at lower ones.

Levels of technician work

It will have been noted that reference has been made to 'superior-level technicians', 'senior technicians', etc. In the survey of thirty-nine nations on which this publication is based, thirty recognize two levels of technicians, and some of the remainder are considering doing so. This, of course, creates yet another source of confusion—namely, the distinction between 'junior' and 'senior' technicians, or whatever names are used to differentiate between them. These, as may be seen from Part Two, are many, such as 'technicien', 'technicien supérieur' in France and certain francophone countries (although in some of them, a number of titles tend to complicate the issue, such as 'agent technique', 'agent de maîtrise', 'technicien moyen', 'conducteur technique', 'assistant d'ingénieur', 'ingénieur-technicien', etc.). The confusion often arises because of differences between names used by employers and titles associated with state-recognized diplomas. In Austria, the 'lower-level' technician is called 'Techniker' and the upper-level one 'Ingenieur', the 'university-level engineer' having the title 'Diplomingenieur', as mentioned earlier. Italian technicians are called 'periti' and—a fairly recent addition—their senior technicians, 'periti superiori' (or, in more common parlance, 'superperiti'). (Incidentally, 'perito' provides a good example of linguistic confusion since a 'dictionary translation' of the word is 'expert', in both French and English. The problem is that not only does the word 'expert' mean something slightly different in those two languages, but in both it connotes a level of technical expertise which would generally be held to be above that of 'technician' or 'technicien'.

The equating of the words 'technician' and 'technicien' points to the task which needs to be done. There is, first, a need to examine the various names used by different countries to describe those who work in the 'technician area' indicated in Figure 1; and, as will be seen from Part Two these are both numerous and confusing. Further, because of the widespread practice of specifying two levels of technicians, it is necessary, as far as possible, to distinguish, among the titles listed in Part Two, those in the 'lower-technician' band from those who are properly in the upper one. This, of course, involves applying agreed-upon criteria to the entire range of engineering technician occupations. As an approach to this formidable task it is first necessary to examine accepted definitions of technicians.
2. Definitions of technicians

Definition by occupational level

The great variety of work carried out by the many types of technicians to be found in industry makes a short and comprehensive definition virtually impossible. Indeed, if a conference on some area of technician interest is unwise enough to begin by trying to achieve such a definition, it is likely to grind to a halt, and to remain in that condition for some time. This was realized at the conference on Education and Training of Technicians held at Huddersfield, United Kingdom, in 1966, under the auspices of the Commonwealth Education Liaison Committee, which reported that:

The conference quite deliberately rejected the temptation to attach a specific clear-cut meaning to the term 'technician' and accepted the impossibility of finding an acceptable definition which would cover the whole range of industry and commerce. It was recognized that, throughout the whole range of industry and commerce, there is a broad spectrum of occupations lying between the craftsmen, on the one hand, and the professional (or technologist) on the other; within this spectrum there are wide differences, both in subject interests and in degrees of expertise, which must be taken into account when planning educational and training programmes, but the whole band does represent a unique and distinguishable group of people who, whatever their specific functions, can be broadly classed as 'technicians'.

Of course, this 'definition', if such it can be called, generalizes over the whole gamut of technician activity, while this publication has the more limited and easier goal of dealing with the range of technician occupations within the field of engineering. But it is interesting, and perhaps amusing, to note that the conference's attempt to hurry past the problems of definition and thus to avoid the use of contentious words and titles does in fact immediately provide two examples of
Definitions of technicians

such difficulties. It refers to occupations which, in contrast to craftsmen's work, are 'professional (or technologist)'. The word 'professional' is one which, in any discussion involving international comparisons, it is wise to avoid. It is frequently translated into French as 'professionnel' and into Spanish as 'profesional'. Now, while the British (and some others) use the term, e.g. 'professional engineer' as a name for what has been called so far in this publication 'university-level engineer' (or scientist), the French word 'professionnel' and the Spanish 'profesional' are commonly applied in connection with work at a lower level in the technical scale; thus 'formation professionnelle' and 'educacion profesional' normally relate to education and training for skilled workers. The second point that might be made concerning the conference report has already been noted. In the extract quoted above the word 'technologist' is used, as it commonly is in the United Kingdom, to denote a university level qualified person in a technical area. In the United States, Canada and a few other countries, it identifies a person at the 'higher-technician' level.

The conference 'definition' attempts to locate technician work within the occupational spectrum—to do in words what Figure 1 does in visual terms. Another attempt at defining technicians in terms of occupational level is to be found in the Haslegrave Report. It reads.

Technicians and other supporting staff occupy a position between that of the qualified scientist, engineer or technologist on the one hand and the skilled foreman or craftsman or operative on the other. Their education and specialised skills enable them to exercise technical judgement. By this is meant an understanding, by reference to general principles, of the reasons for and the purposes of their work, rather than a reliance solely on established practices or accumulated skills.

This definition, equally with the other, uses United Kingdom nomenclature—not unreasonably, since the report of which it forms a part is concerned solely with technicians in that country. But compared with the other definition, it exhibits some interesting points. It states that technicians shall be able to exercise technical judgement, based on education and specialized skills; that is, through education and training directed towards this objective. Also, clearly, the last sentence could equally well be included in a corresponding definition of a 'university-level engineer'. Thus it shows that the technician has responsibilities of a different order from those of skilled workers. The other noteworthy point is that it specifically excludes the foreman from the ranks of the technicians.

Definition by function

These definitions should be compared with an important set provided by an authority on the situation in Eastern European countries, Dr P. G. Kochetkov. In dealing with the functions of technicians, he first sets out three main factors, and then expands them. He considers that the main functions of technicians are:

(a) they are the principal organizers and technical leaders in the primary stages of production; (b) they can provide immediate servicing of automated and other main machinery; and (c) they are assistant engineers.

In his elaboration of these statements, he makes much, under (a), of the supervisory responsibilities of technicians, as team leaders, in workshops, laboratories, etc. Under (b) he explains the maintenance function of the technician, making the point that the complexity of modern production equipment calls for a broader technical background and a wider spread of equipment knowledge than was previously necessary in a technician. In so doing he effectively makes the case for the development of training for 'advanced technicians', as has recently been introduced in the Soviet Union and Hungary, and is being planned in Poland. He stresses that the inevitable continued development of automated production processes will require a higher proportion of these technicians in the work force. As for point (c), the function of the technician as an assistant engineer, as outlined by Dr Kochetkov, is probably broadly in line with the concept in most other countries. It relates mainly to the sort of work one expects to see technicians undertake at the higher levels: that is, towards the right-hand limit of the technician area in Figure 1. He includes such functions as research assistant, scientific investigator, design draughtsman, production planner, etc. Indeed, Dr Kochetkov's picture of the technician function in Eastern European countries inclines one to the view that he foresees an increasing function for them in the 'senior' rather than the 'junior' area of the part of the spectrum allocated to the broad 'technician group' in Figure 1. However, he does stress the need for the acquisition of 'manual worker' skills for the technician.

It is important to note that, whereas the first two definitions quoted were 'occupational-level' definitions, Dr Kochetkov's is a functional one. The three main objectives postulated are outline functions and these are developed in fuller detail in his text. He also says:

The problem that remains... is to define the role of technicians and other specialists with secondary specialised education in each branch of the national economy, and to employ them with the greatest effectiveness.

He makes it clear that he regards it as essential to produce 'clear definitions of functions of specialists' and to take account, as necessary, of such changes in these definitions as developments may require.

Where should one look for 'definitions of the functions of technicians'? The obvious answer is 'within industry'; and most highly industrialized countries have built up, to a greater or lesser degree, liaison between the users of technicians (i.e. industrial enterprises, public services, etc.) on the one hand, and those responsible for their 'formation' (schools, colleges, training centres, educational planners and administrators, ministries of education, of employment, of industry, etc.) on the other. That such liaison is important cannot be doubted. A perusal of Part Two will reveal, to some extent, how this liaison varies between countries. In most, it amounts to meetings between the interested parties, resulting in planned curricula which should allow, ideally, the requirements of industry in each technician area to be met within a sound educational framework.

Is it possible to attack the problem of definition in a more scientific manner? Among those who would reply in the affirmative is another authority on technician education and training, Dr L. S. Chandrakant. He has given much attention to curriculum development for technician courses, based on activity analysis undertaken, in India, at three major occupational levels, including the technician range. The job analyses, conducted within industry, led to what he called a 'broad spectrum of activities for a technician', with five headings, which may be summarized as follows:

Managerial: a technician, given an overall plan of action material and personnel, must be able to organize and co-ordinate the labour used, and ensure that the work is carried out satisfactorily.

Technical: a technician, under the direction of an engineer, must be able to undertake investigations in connection with projects; to make and to interpret drawings and to understand both the whole project and its component parts; if required, to carry out production planning and to ensure that arrangements are made for it to operate satisfactorily.

26 Engineering technicians. Some problems of nomenclature and classification

Commercial: a technician should be able to understand terms and contracts concerning material and equipment supplies, and the factors (including market trends) determining prices of jobs and products.

Accounting: a technician should be able to do rate analysis, keep accounts of relevant expenditure and income and keep day-to-day records of progress.

Security: a technician should accept responsibility for life and health safety precautions and other security matters within his area of work.

These are, of course, functional definitions. It is felt that, while many technician occupations may well embody most of them, few, except perhaps at the senior end of the spectrum, will require them all. It is, however, interesting to note the good agreement between the first two of Dr Chandrakant's occupational criteria, and the general outline of the technician function given by Dr Kochetkov (except perhaps for the surprising omission of any mention of maintenance in Dr Chandrakant's summary).

Another interesting aspect of Dr Chandrakant's analysis is his indication of the need for technicians to possess, to different degrees, four skill attributes, namely, (a) specialization skills; (b) system and technique skills; (c) human relation skills; and (d) conceptual skills (perspective, analysis, problem-solving and decision-making). He indicates in a matrix diagram how the 'mix' of these components changes as one advances through the technician hierarchy (i.e. from left to right in Figure 1). Dr Chandrakant's matrix diagram, modified to align it more closely to Figure 1, and also in one or two other respects, is approximately reproduced in Figure 2. (One alteration concerns the representation of human relation skills, which Dr Chandrakant shows as diminishing as one ascends the hierarchy. This is contrary to the writer's experience.)

The matrix strongly underlines the need, mentioned earlier, to distinguish between the 'lower' and the 'upper' levels of technician. It effectively stresses (as does Dr Kochetkov) the need for supervisory and decision-making (i.e. managerial) skills, problem-solving abilities and others which are akin to those required of 'university-level engineers'. Indeed, the very different requirements in the 'mix' for, say, technicians at the lower and higher levels suggests education and training for these two stages, might need to be different in kind, as well as level. This question will be considered later.

It may well be felt that Dr Chandrakant's 'broad spectrum of activities' or a technician, interesting though it is, falls short
Definitions of technicians

Specialization skills

Technicians

Higher level

Lower level

Conceptual skills

Systems and technique skills

Human relations skills

FIG. 2.

of immediate practical use. What is needed is a detailed specification of subactivities, enabling us to see what is required of an electronic technician, of a design draughtsman, of a process planning technician, etc. Dr Chandrakant's paper goes on to consider this problem; and in an appendix he provides a very detailed activity analysis for one technician occupation.

Technician job specifications have been produced in many countries. In this publication it would be out of the question to reproduce them, although some examples do follow. To be of any real use, such specifications must be provided either by, or in cooperation with, industry. There are, of course, even in the engineering industry alone, large numbers of technician occupations. One of the points which much concerns us in this investigation is the extent to which they are common to the countries which have been considered in Part Two; and also, the extent to which, when they are common, they have common titles.
Occupational classifications and titles

There are many countries, including virtually all those in which engineering employment constitutes a major and well-developed part of the national economy, which have produced 'official' lists of technician (and other) job titles. These have often been devised by the appropriate government departments—for example, the Ministry of Labour or the Department of Employment, or whatever the name may be in the particular country. The extent to which a country's list accords with the titles used in industry depends a great deal upon the degree of liaison which exists between its industrial firms and the government department involved. Where industries have been nationalized, one often finds, naturally enough, that agreement is close. This is, for example, broadly the case in the East European countries. In many countries, too, each job title in the list has an accompanying job specification. A few examples are given later.

Clearly, it is worth considering whether there is any possibility of producing both job title lists and job specifications on an international, rather than a national, basis. Attempts have been made to do this, one of the most important being the International Standard Classification of Occupations (ISCO), compiled by the International Labour Office (ILO). As an example of the kind of categorization which ISCO provides, some entries from 'Electrical and Electronics Engineering Technicians' (0-34) and 'Mechanical Engineering Technician' (0-35) are reproduced below. (Major Group 0—Professional, Technical and Related Workers; Minor Group 3—Architects, Engineers and Related Technicians; the 'unit' number 4 isolates 'Electrical and Electronics Engineering Technicians', and the 'unit' 5, 'Mechanical Engineering Technicians'.) These may be followed by two figures giving the 'occupational category', e.g. 0-34.20 'Electrical Engineering Technician (High Voltage)'.

ELECTRICAL AND ELECTRONICS ENGINEERING TECHNICIANS, 0.34

Workers in this unit group perform technical tasks, normally under the direction and supervision of electrical or electronics engineers, contributory to the design, development, construction, installation, maintenance and repair of electrical and electronic systems and equipment.

Their functions include: assisting in research and development work concerning electrical and electronic systems and equipment; preparing

Definitions of technicians

detailed estimates of quantities and costs of materials and labour required for manufacture and installation; assisting with technical supervision of manufacture, installation and utilization, maintenance and repair of electrical and electronic systems and equipment; applying knowledge of electrical and electronics engineering theory and practices to recognize and solve problems arising in the course of their work.

Electrical engineering technician (general) 0.34.05

Performs technical tasks, normally under direction and supervision of electrical engineer, contributory to design, development, construction, installation, maintenance and repair of electrical systems and equipment: sets up and carries out experiments, makes tests, takes readings, performs calculations, adjusts instruments, records observations and otherwise assists in research and development work concerning electric-power generation and distribution equipment, industrial, domestic and other electrical equipment; prepares detailed estimates of quantities and costs of materials and labour required for manufacture and installation of electrical equipment and prepares work schedules; exercises technical supervision and control and gives technical guidance to workers engaged in manufacture, installation, repair and maintenance of electrical equipment; inspects and tests completed work to ensure compliance with specifications and safety standards; inspects and regulates functioning of installed electrical plant employed for power generation, manufacturing process, or other purposes; applies knowledge of electrical engineering theory and practices to recognize and solve problems arising.

Electronics engineering technician (general) 0.34.10

Performs technical tasks, normally under direction and supervision of electronics engineer, contributory to design, development, construction, installation, maintenance and repair of electronic devices and equipment: performs tasks similar to those of electrical engineering technician (general) (0.34.05) but specializes in electronic devices and equipment such as radio, television and radar equipment, telecommunications installations and automatic control and guidance systems.

Electrical engineering technician (high-voltage) 0.34.20

Performs technical tasks, normally under direction and supervision of electrical engineer, contributory to design, development, construction, utilization, maintenance and repair of high-voltage electrical systems and equipment: performs tasks similar to those of electrical engineering technician (general) (0.34.05), but specializes in high-voltage electrical systems and equipment such as that used in the generation and distribution of electricity.
MECHANICAL ENGINEERING TECHNICIANS 0.35

Workers in this unit group perform technical tasks, normally under the direction and supervision of mechanical engineers, contributory to the design, development, manufacture, construction, installation, maintenance, and repair of mechanically functioning plants and equipment. Their functions include: assisting in research and development work concerning machine tools, engines, vehicles, aeroplanes, heating, ventilating and refrigerating installations and other mechanically functioning plant and equipment; preparing detailed estimates of quantities and cost of materials and labour required for manufacture and installation; assisting with technical supervision of manufacture, installation, maintenance and repair of mechanical plant and equipment; applying knowledge of mechanical engineering theory and practices to recognize and solve problems arising in the course of their work.

Mechanical engineering technician (general) 0.35.10

Performs technical tasks, normally under direction and supervision of mechanical engineer, contributory to design, development, manufacture, construction, installation, efficient operation, maintenance and repair of mechanically functioning plant and equipment: sets up and carries out experiments, makes tests, takes readings, performs calculations, adjusts instruments, records observations and otherwise assists in research and development work concerning machine tools, engines, vehicles, heating, ventilating and refrigerating plant, plant and equipment for the release, control and utilization of nuclear energy, and other mechanically functioning plant and equipment; prepares detailed estimates of quantities and costs of materials and labour required for manufacture and installation, and prepares work schedules; exercises technical supervision and control and gives technical guidance to workers engaged in manumechanically functioning plant and equipment; inspects and tests completed work to ensure compliance with specifications and safety standards; inspects and regulates functioning of installed mechanical plant and equipment employed for manufacturing processes and other purposes; applies knowledge of mechanical engineering theory and practices to recognize and solve problems arising.

Mechanical engineering technician (motors and engines) 0.35.20

Performs technical tasks, normally under direction and supervision of mechanical engineer, contributory to design, development, manufacture, installation, maintenance and repair of steam, internal combustion and non-electric motors and engines: performs tasks similar to those of mechanical engineering technician (general) (0.35.10) but specializes in non-electric motors and engines as used for propulsion of vehicles or driving industrial and other machinery.
Definitions of technicians

May specialize in a particular type of engine such as diesel or petrol engines, or a particular type of application, as in aircraft, automobiles or ships. Technicians specializing in electric motors are classified in 0.34.90.

Heating, ventilation and refrigeration engineering technician 0.35.50

Performs technical tasks, normally under direction and supervision of heating, ventilation and refrigeration engineer, contributory to design, development, manufacture, installation, maintenance and repair of systems and equipment for heating, ventilation and refrigeration: performs tasks similar to those of mechanical engineering technician (general) (0.35.10) but specializes in systems and equipment for heating and air-conditioning industrial, commercial, residential and public buildings, making ice and cooling storage rooms.

Draughtsmen are considered under a separate group head. The job specifications are, it may be felt, good and clear—but perhaps too wide. This is appreciated, and the numbering permits any country which decides to use the ISCO system to add its own ‘sub-sub-groups’ if it wishes. Those responsible for compiling ISCO realized that there is a limit beyond which it would be unwise for any international classification list to attempt to go. In its preface, it states:

It is however recognized that, owing to differences in national practices in the organization of work and in the extent of economic development and accompanying specialization of work, the scope of an occupation as defined internationally may be broader or narrower than the group of duties making up a given national occupation.

Another important international classification of occupations is COTA, a Latin American index developed for the 1970 Census of the Americas by the Inter-American Statistical Institute (IASI). COTA and ISCO have many similarities.

In practice it is readily seen that national lists, while they may hold broadly to ‘groups’ and ‘minor groups’ along the same lines as ISCO, proceed to break down the unit groups into much more particularized job titles, thus producing a list very much larger than the number of ISCO occupational categories. As an example, there follow two lists taken from the Classification of Occupations and Directory of Occupational Titles (CODOT). Vol. I, issued by the Department of Employment, United Kingdom. The Department of

Employment claims that its lists and titles have been produced from a study of industry—'a list of key occupations (compiled) for statistical purposes'. It includes technicians as subheads of Group 25 'Professional and Related Occupations in Science, Engineering, Technology and Similar Fields not Elsewhere Classified'. Group 25 includes 'Draughtsmen' (subhead 253); and since these constitute some 30 per cent of the total United Kingdom technician force, the list is given below. It will be seen that there are no fewer than thirty occupational titles.

253 Draughtsmen
253.02 Chief draughtsman
253.04 Design draughtsman (general)
253.06 Design draughtsman (general mechanical engineering)
253.08 Design draughtsman (prime movers)
253.10 Design draughtsman (aircraft and missile structures)
253.12 Design draughtsman (vehicle chassis and bodies)
253.14 Design draughtsman (ship's structures)
253.16 Design draughtsman (mechanical plant, machinery and equipment)
253.18 Design draughtsman (electrical engineering)
253.20 Design draughtsman (electronic engineering)
253.22 Design draughtsman (heating, ventilating, refrigeration systems)
253.24 Draughtsman (instruments)
253.26 Draughtsman (plant layout)
253.28 Draughtsman (jig and tool)
253.30 Draughtsman (civil, structural engineering)
253.32 Draughtsman (architectural)
253.34 Draughtsman (maps, charts, etc.)
253.36 Detail draughtsman (general)
253.38 Detail draughtsman (mechanical engineering)
253.40 Detail draughtsman (ship's structures)
253.42 Detail draughtsman (electrical engineering)
253.44 Detail draughtsman (electronic engineering)
253.46 Detail draughtsman (heating, ventilating, refrigeration systems)
253.48 Detail draughtsman (pipework)
253.50 Drawing checker (technical drawings)
253.52 Map checker
253.54 Stressman
253.56 Technical illustrator
253.98 Trainee
253.99 Other draughtsmen

This list is followed by 254, 'Laboratory Technicians' (fifteen occupational titles, of which perhaps three are appropriate to engineering). Subgroup 255, 'Architectural and Construction Technicians' (seven occupational titles) and is followed by 256, 'Engineering Technical Supporting Occupations not Elsewhere Classified' (the 'elsewhere' classified people are largely draughtsman). List 256 is given below.
256 Engineering (excluding architectural, constructional and related) technical supporting occupations not elsewhere classified.

256.11 General technical assistant (mechanical engineering)
256.12 General technical assistant (electrical engineering)
256.13 General technical assistant (electronic engineering)
256.14 General technical assistant (chemical engineering)
256.19 General technical assistant (other engineering)
256.21 Technical controller (installation) (mechanical engineering)
256.22 Technical controller (installation) (electrical engineering)
256.23 Technical controller (installation) (electronic engineering)
256.24 Technical controller (installation) (chemical engineering)
256.29 Technical controller (installation) (other engineering)
256.31 Test engineer (mechanical engineering)
256.32 Test engineer (electrical engineering)
256.33 Test engineer (electronic engineering)
256.34 Test engineer (chemical engineering)
256.39 Test engineer (other engineering)
256.41 Maintenance technician (mechanical engineering)
256.42 Maintenance technician (electrical engineering)
256.43 Maintenance technician (electronic engineering)
256.44 Maintenance technician (chemical engineering)
256.49 Maintenance technician (other engineering)
256.51 Technical service adviser (mechanical engineering)
256.52 Technical service adviser (electrical engineering)
256.53 Technical service adviser (electronic engineering)
256.54 Technical service adviser (chemical engineering)
256.59 Technical service adviser (other engineering)
256.98 Trainee
256.99 Other engineering (excluding architectural, constructional and related) technical supporting occupations not elsewhere classified.

It will at once be seen that this listing of twenty-seven titles does not align itself with ISCO. In the ISCO list there were separate major heads for (a) electrical and electronic; (b) mechanical; and (c) chemical; and if one compares the twenty-seven titles under 256 of CODOT, they correspond to fifteen of the subgroups in ISCO. This does not seem too great an extension to cover, as CODOT purports to do, the actual titles in use in industry. But any person acquainted with British industry would be almost certain to question whether twenty-seven titles do indeed cover normal industrial usage in the United Kingdom.

Fortunately, the question can quite easily be assessed. In 1969/70, a careful investigation into the functions actually performed by technicians within the engineering industry in the United Kingdom was undertaken by the Engineering Industry Training Board (EITB), referred to above. It involved 338 establishments, employing a total of 285,000 people, of whom 20,500 were technicians. (The total of engineering technicians employed in the United Kingdom at the time...
of the survey was just short of a quarter of a million.) Those in the sample were divided by employers into 'technician-engineers' (i.e. higher or superior technicians) and 'technicians', according to the functional definition of 'technician-engineer' provided by the EITB.

This division was defined as follows:

*Technician-engineers* are that group whose education and training enables them to operate immediately in support of professional engineers, sometimes supplying detailed information on which professional decisions are made and later becoming responsible for implementing them; and sometimes working independently. Six main abilities appear to be demonstrated to a greater or lesser degree by all technician engineers in whatever branch of the engineering industry they may be working.

These are:

(a) The ability to use and communicate information.
(b) The ability to measure or make use of measurements which involve a variety of tools and/or instruments.
(c) The ability to choose materials and components and to understand the processing of materials.
(d) The ability to understand manufacturing activities and the general commercial organisation and practice of their companies.
(e) Diagnostic ability.
(f) The ability to organize (but not necessarily to supervise) and give direction to the work of others.

It will no doubt be noticed that this definition lays less emphasis on the managerial and supervisory responsibilities of superior technicians than do those of, for example, Dr Kochetkov and Dr Chandrakant, and is therefore, perhaps, more in line with the ISCO concepts.

The EITB definition goes on to include reference to education and training levels, but for this particular exercise the employers were requested to identify their technicians solely in terms of the levels of work in which they were engaged.

'Lower-level' technicians were not specifically defined. They were identified simply as those employees carrying out technician functions, but at a level lower than that of the technician-engineer as defined above. This does not mean that the EITB does not give a definition of a technician. It does, the definition being as follows:

*Technicians* [are]... that group whose education, training and practical experience enables them to apply in a responsible manner proven techniques and procedures and to carry a measure of technical responsibility, under the guidance of technician engineers or professional engineers.

The employers taking part in the exercise were asked to provide the job titles which they used for their technician staff. These were
Definitions of technicians

grouped under four main functional headings, namely: (a) 'commerce' (i.e. technician work directed outwards, to the supplier and/or the customer); (b) 'research, design and development'; (c) 'production'; and (d) 'services'.

Almost 100 technician job titles were identified. They are shown below, listed under the four functional headings, each heading having 'technician-engineer' and 'technician' jobs shown separately.

### COMMERCE

<table>
<thead>
<tr>
<th>Technician-engineers</th>
<th>Technicians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chief estimator</td>
<td>Technical sales engineer</td>
</tr>
<tr>
<td>Technical sales engineer</td>
<td>Headquarters service engineer</td>
</tr>
<tr>
<td>Home sales manager</td>
<td>Trainee estimator</td>
</tr>
<tr>
<td>Estimator</td>
<td>Senior service engineer</td>
</tr>
<tr>
<td>Customer service engineer</td>
<td>Demonstration fitter</td>
</tr>
<tr>
<td>Applications engineer</td>
<td>Wrapping technician</td>
</tr>
<tr>
<td></td>
<td>Service engineer</td>
</tr>
<tr>
<td></td>
<td>Contracts engineer</td>
</tr>
<tr>
<td></td>
<td>Buyer</td>
</tr>
</tbody>
</table>

### RESEARCH, DESIGN AND DEVELOPMENT

<table>
<thead>
<tr>
<th>Technician-engineers</th>
<th>Technicians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designer</td>
<td>Design draughtsman</td>
</tr>
<tr>
<td>Design draughtsman</td>
<td>Electrical draughtsman</td>
</tr>
<tr>
<td>Electrical draughtsman</td>
<td>Development draughtsman</td>
</tr>
<tr>
<td>Development draughtsman</td>
<td>Mechanical engineering draughtsman</td>
</tr>
<tr>
<td>Chief draughtsman</td>
<td></td>
</tr>
<tr>
<td>Checker draughtsman</td>
<td>Power transformer draughtsman</td>
</tr>
<tr>
<td>Section leader</td>
<td>Detail and design draughtsman</td>
</tr>
<tr>
<td>Design engineer</td>
<td>Draughtsman</td>
</tr>
<tr>
<td>Consultant design engineer</td>
<td>Junior draughtsman</td>
</tr>
<tr>
<td>Electrical designer</td>
<td>Product designer</td>
</tr>
<tr>
<td>Development engineer</td>
<td>Development engineer</td>
</tr>
<tr>
<td>Product development engineer</td>
<td>Assistant development engineer</td>
</tr>
<tr>
<td>Numerical control applications engineer</td>
<td></td>
</tr>
<tr>
<td>Senior R&amp;D engineer</td>
<td>Trials engineer</td>
</tr>
<tr>
<td>Assistant research engineer</td>
<td></td>
</tr>
<tr>
<td>Trainee stress engineer</td>
<td></td>
</tr>
</tbody>
</table>

### PRODUCTION

<table>
<thead>
<tr>
<th>Technician-engineers</th>
<th>Technicians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural designer</td>
<td>Senior design draughtsman</td>
</tr>
<tr>
<td>Assistant designer</td>
<td>Design draughtsman</td>
</tr>
<tr>
<td>Senior design draughtsman</td>
<td>Jig and tool designer</td>
</tr>
</tbody>
</table>
Jig and tool draughtsman
Production engineer
Chief planning engineer
Projects engineer
Manufacturing engineer
Chief test engineer
Senior methods engineer
Machine shop methods engineer
Maintenance engineer
Sub-contracts engineer
Work measurement engineer
Senior metallurgist
Works technician
Chief inspector
Performance Department supervisor
Production controller
Design draughtsman

Engineering draughtsman
Project draughtsman
Senior draughtsman
Detail draughtsman
Trainee designer
Production designer
Senior planning engineer
Planning engineer
Test engineer
Site test and service engineer
Inspector
Electrical test engineer
Methods engineer
Work measurement engineer
Production estimator
Electrical technician
Test technician
Programmer
Material controller
Quality control assistant

SERVICES

Technician-engineers

Technicians

Work study engineer
Senior work study engineer
Technical writer
Section leader: technical publications
Technical liaison engineer
Section leader: technical illustrations

Deputy chief service engineer
Data processing manager

While this list illustrates the wide variety of technician and technician-engineer titles used in industrial firms in the United Kingdom, it is not a comprehensive one. It was compiled as a result of about an 8 per cent sample and so has very many omissions. Some of these are surprising, since they are common, e.g. instrumentation technician; installation technician. In two other important EITB publications, namely Booklet No. 14, *The Training of Technicians*, and Booklet No. 9, *The Training of Technician Engineers,* a number of examples of detailed job specifications for certain technician occupations are given. There are ten of these examples in the booklet on technician training and twenty-four in the technician-engineer training pamphlet. In the former, no less than

nine of the examples provided have titles not included in the list given above, namely: mechanical laboratory technician; technical assistant; tool draughtsman; quality assurance technician—process surveillance; instrument technician; junior contracts engineer; scheduler and development technician. In the technician-engineer Booklet twenty-three out of the twenty-four jobs listed have names not included in the main list, although the number would have been ten less had the word 'technician' been inserted before 'engineer' in some of the titles. Technician-engineer titles not on the main list, but included in Booklet No. 9 are design draughtsman (electrical), automobile body design draughtsman, process planning technician-engineer, maintenance technician-engineer (N.C. systems), lamp development technician-engineer, wind tunnel technician-engineer, instrument development technician-engineer, tribology technician-engineer, commissioning technician-engineer, etc. As all these examples relate, like those in the main list, to actual jobs in firms and carry the titles which those firms use, it is readily seen that a complete list of engineering technician job titles as used by firms in the United Kingdom would be very large indeed; and certainly well in excess of the number given in CODOT.

It is obvious from the EITB lists that such a proliferation of job titles can lead to much confusion. There are examples of titles which are used by some firms for technicians and by others for technician-engineers; for example, technical service engineer, development engineer, design draughtsman, production engineer, jig and tool draughtsman, work study engineer. Also, there are cases where titles given to technicians appear to be superior to those for technician-engineers—for example, customer service engineer (technician-engineer) and senior service engineer (technician); assistant design engineer (technician-engineer) and product designer (technician); design draughtsman (technician-engineer) and senior design draughtsman (technician); planning engineer (technician-engineer) and senior planning engineer (technician); technical writer (technician-engineer) and section leader—technical publications (technician). Also some of the titles, while they are no doubt meaningful within the firms that use them, are too imprecise to convey much information to the outsider, e.g. section leader, works technician, area supervisor, etc.

In contrast to this lack of precision, some firms are concerned to indicate exactly the specialized nature of particular posts. To take an example from the list, the power transformer draughtsman was no doubt trained as a draughtsman, perhaps as an electrical draughtsman. It is the firm which has narrowed his work to the specialization indicated. The author has come across a man trained as an electronic technician who now bears the awesome title of
'radar presentation unit research technician', which can no doubt be justified as a description of what he does but is, perhaps, taking detailed nomenclature a little too far.

For historical reasons deriving partly from an earlier lack of correlation between educational course content and the needs of industry at the technician level, the United Kingdom presents, perhaps, a rather extreme case of complex nomenclature. Developments now in process will perhaps bring some improvement to the current situation. But without doubt, employers will continue to apply to specific jobs such titles as they consider appropriate, and all that can be hoped for is that some notice will be taken of the advice on this matter given by the EITB in the research report already extensively quoted, *The Technician in Engineering*.

Wherever possible the terms 'technician-engineer' or 'technician', if appropriate to the level of the job, should be included in the title: e.g. customer service technician-engineer/customer service technician; or technician-engineer (numerical control applications)/technician (machine shop methods).

Where the inclusion of the words 'technician' or 'technician-engineer' would create too unwieldy a title, the use of prefixes is advocated, namely 'senior' when the post is 'university-engineer' level, 'assistant' when it is at technician, no prefix being appended at the 'technician-engineer' level. Thus, metallurgists in an engineering works might be entitled 'senior metallurgist' if the 'university-level engineer' type; 'metallurgist' if at technician-engineer level; and 'assistant metallurgist' if at technician level.

Draughtsmen provide a special nomenclature problem. The engineer who designs an aeroplane, or a bridge, will be called a 'designer', the term being thus applied to a 'university-level engineer'. The man who produces, from sketches provided, the working drawings from which a craftsman will make individual parts is most frequently called a 'detail draughtsman'. Between these two come the 'technician-engineer level draughtsman', who may well have to apply theoretical and practical knowledge to realize on paper particular components or subassemblies; that is, he has to possess some of the attributes of the 'designer'. The terms 'designer-draughtsman' or 'design draughtsman' have been used for him; but, as a glance at the list will show, there are inconsistencies. The EITB recommends 'design-draughtsman' at the technician-engineer level and 'detail draughtsman' at the technician level. There is in these cases no need to include 'technician' or 'technician-engineer' in the title since it is generally recognized that draughtsmen are within the technician categories. With such short titles there is no problem in adding,
if desired, the nature of the work, e.g. 'design draughtsman (jig and tool)' or 'detail draughtsman (development)', etc. But the essential thing about this proposal is to restrict the word 'design', as a prefix for 'draughtsman', to the technician engineer level; and the term 'designer' used by itself, to the level above; that is to the 'university-level engineer' grade.

Another highly desirable thing is to avoid completely the use of the word 'engineer' at the lower (i.e. 'technician') level. In many countries this may well prove difficult, for in them the word may already be in widespread and indiscriminate use. In the United Kingdom, for example, the term 'engineer' has no legal protection. Any person, even if he is manually incompetent, and technically illiterate and innumerate, can call himself an engineer if he so wishes. So many workers, not only at technician level, but also below it, call themselves 'engineers'. Only specific titles, e.g. chartered engineer, technician-engineer (C.E.I.) and technician (C.E.I.) are protected, through the Engineers Registration Board, which is considered further below.

British experience would incline one to the view that a developing country considering an appropriate nomenclature for its engineering personnel would do well to:

Protect legally the title 'engineer' and restrict its use, as a separate title, to 'university-level engineer' personnel.

Specify two levels of technician-type personnel, in terms of function. (The justification for this recommendation has already been given, in terms of the country summaries. Over 75 per cent of those considered have already seen the need for two levels, and have incorporated them into their industrial structures.)

Call the lower-level personnel 'technicians', in the appropriate language. (Almost 80 per cent of the countries considered in Part Two already do this, using such titles as 'technicien', 'Techniker', 'tecnico', etc.) To these general titles short additions may indicate the broad categories, e.g. 'mechanical technician', 'Funktechniker', etc.

Call the higher-level technician personnel 'technician-engineers'. The justification for this title is, quite simply, that these workers have responsibilities which involve some of the attributes of the 'engineer'. As a person who straddles the grades of 'technician' and 'engineer', the name 'technician-engineer' seems wholly appropriate. It does not seem important in which order the two names are joined—'ingénieur technicien' is clearly equally acceptable. However, it must be said that, while 'technician' and its equivalents are widely adopted throughout the world 'technician-engineer' has, as yet, limited usage. Indeed, it is clear from initial reactions to a draft of this paper that the term is likely to prove unacceptable to a number
of countries. Unfortunately, the objections reveal two opposite viewpoints. Some countries (for example, Australia, France and the United States) consider it so important to restrict the title 'engineer' (or 'ingénieur') to 'university-level' engineers, that they feel the word should not be used (whatever others may be attached to it) in any description of an occupation at a lower level. Thus, Australia has adopted 'engineering associate'—but would not sanction 'associate engineer'.

The United States makes a clear-cut distinction by using the term 'engineering technologist', reserving engineer exclusively for the higher level. In France, the 'technician-engineer' level is firmly entitled 'technicien supérieur'. Indeed, since this is a clear-cut description of where the job ranks relative to the lower level of 'technicien', there is much to be said for it. Thus 'technicien supérieur', 'higher technician', 'técnico superior', etc. might well appear to have certain advantages over 'technician-engineer' as titles. Certainly no logical objection to their use can be advanced and on a purely personal basis, the writer would be happy to settle for 'higher technician' or 'technician-engineer' (and their equivalents in other languages) as alternative designations.

However, there are some countries which have adopted quite a contrary view to that outlined above. Although in most cases they agree that there are three levels above that of skilled worker, they divide them into two levels of engineer, with a single level of technician below. Thus, while countries such as Australia, the United States, etc., have been at pains to exclude the word 'engineer' from the title of the 'intermediate' grade, these other countries have been equally determined to remove the word 'technician'. Some of them tend to claim that their 'lower-engineer' grades are in fact 'true' engineers; and there is evidence to suggest that in certain cases, the standard of the 'higher-technician/lower-engineer' grade may be raised to justify the claim. (This may, of course, simply be a manifestation of the 'educational inflation' of occupations. This is the phenomenon that, as the supply of educated people grows, the educational requirements for particular occupations tends to rise.)

Also, it is undeniable that the prestige which attaches to the title 'engineer' tends to cause people to try to acquire it without any attendant technician appellation. Note, for example, in the country surveys, how in Belgium the title of 'ingénieur technicien' has given place to 'ingénieur industriel' with an accompanying rise in standard; and in Switzerland the 'ingénieur-technicien' title has been replaced by 'ingénieur ETS'.

The problem is also complicated by a few countries which have four levels above that of craftsman, making comparisons with those having three levels very difficult. However, it must be recognized
that countries which have developed over the years systems which they find suitable are unlikely to change their terminology simply to conform with practices which happen to be more common, unless they see strong reasons for doing so.

As noted, the large majority recognize three levels, but it will be obvious from the foregoing that a very real nomenclature problem exists. While, as stated earlier, the title 'technician-engineer' is a logical name for a grade which combines some attributes of both technicians and engineers, it suits neither those countries that wish to exclude the term 'engineer' altogether at this level, nor those who wish to dissociate it from the word 'technician'. Since these latter constitute a minority, it is felt as stated earlier, that either 'higher technician' (to satisfy the former) or 'technician-engineer' might usefully be adopted. The latter name, which the writer prefers, will be used throughout this book.

If one takes the major occupational groupings in the official lists available in some industrialized countries, it will be found that they commonly include all the main ISCO groups and subgroups, although the arrangements and numbering will usually be different. ISCO has suggested that its groups and subgroups should be used as a basis for national systems. As has been pointed out, if the main and subgroup heads were accepted, this would still enable the 'sub-subgroups' to reflect particular occupational needs which might well differ from one country to another. The particular names for these could be determined by agreement between industry and the responsible government department. Such agreements would desirably take into consideration the nomenclature employed for comparable jobs in other major countries with well-developed classification systems.

An interesting example is provided by the Federal Republic of Germany. It lists an enormous and comprehensive range of occupations in a book entitled Klassifizierung der Berufe (Classification of Occupations). While it does not precisely follow the ISCO groups and subgroups, it includes them, and also provides a list cross-referencing some 350 ISCO classifications with its own. The system is sophisticated but simple enough to follow, and can be used with material provided by the Bundesanstalt für Arbeit to closely associate the individual technician occupations with the educational qualifications appropriate to them, and with the institutions at which such qualifications may be obtained.

To take an example from the Klassifizierung der Berufe, Group 62 covers 'Techniker' (technician) with subgroups which

---

include 621 'Maschinenbautechniker' (mechanical technician) and 622 'Techniker des Elektrofaches' (electrical technicians). Group 63 is 'Technische Sonderfachkräfte' (technical specialists) and includes 635 'Technische Zeichner' (draughtsmen). Subgroup 621, the main 'mechanical technician' list, has seven subheads and embodies 65 occupations; subgroup 622, the electrical technicians, eight subheads and 52 occupations; and the draughtsmen (635), seven subheads and 24 occupations (but these include cartographers, architectural draughtsmen, etc. as well as engineering draughtsmen).

To provide a specific example, the electrical list is given below:

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6220</td>
<td>Techniker des Elektrofaches, allgemein</td>
</tr>
<tr>
<td>6221</td>
<td>Mess- und Regeltechniker</td>
</tr>
<tr>
<td>6223</td>
<td>Elektro-Projekttechniker</td>
</tr>
<tr>
<td>6224</td>
<td>Elektro-Konstruktionstechniker</td>
</tr>
<tr>
<td>6225</td>
<td>Fertigungs-Montagetechniker des Elektrofaches</td>
</tr>
<tr>
<td>6226</td>
<td>Betriebs-Wartungstechniker des Elektrofaches</td>
</tr>
<tr>
<td>6229</td>
<td>andere Techniker des Elektrofaches</td>
</tr>
<tr>
<td>6220</td>
<td>Bauführer (Fernmeldetechniker) Betriebstechniker für Elektronik</td>
</tr>
<tr>
<td>6220</td>
<td>Computertechniker Elektrizitätswerktechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Elektrokonstruktionstechniker Elektroniker (nicht Ingenieur)</td>
</tr>
<tr>
<td>6220</td>
<td>Elektroniktechniker Elektrotechniker (nicht Elektroinstallateur)</td>
</tr>
<tr>
<td>6220</td>
<td>Elektrotechnischer Assistent Energieotechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Fernmeldesekretär Fernmeldetechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Fernmeldetechniker (nicht Fernschmecaniker) Fernsprechtechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Fernsprechtechniker Fernsteuerungstechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Betriebstechniker für Elektronik Elektrotechniker (nicht Elektroinstallateur)</td>
</tr>
<tr>
<td>6220</td>
<td>Funk-Fernmessgerätetechniker Funktechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Gestaltungstechniker Hochfrequenztechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Installationstechniker Kabeltechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Leitungsrevisor (Techniker) Lichttechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Magnetophonstechniker Messtechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Mess- und Prüftechniker Mess- und Regeltechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Nachrichtentechniker Netztechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Prüffeldmesstechniker Radartechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Radartechniker Radiotechniker (nicht Radiomechaniker)</td>
</tr>
<tr>
<td>6220</td>
<td>Regelungs- und Steuerungstechniker Röntgentechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Rundfunktechniker (nicht Rundfunkmechaniker) Schalttechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Schwachstromtechniker Starkstromtechniker</td>
</tr>
<tr>
<td>6220</td>
<td>Systemtester Techniker für Bordelektronik</td>
</tr>
</tbody>
</table>
Definitions of technicians

Techniker (Rundfunk)  
Technischer Assistent—Fachrichtung Elektrotechnik
Telegraphenmeister  
Telegraphenbauführer  
Telegraphentechniker  
Tonmesstechniker

This list, and the others that go with it, are claimed to represent the actual titles used in industry. As with the British lists, there are virtual duplications—for example, 'Rundfunktechniker' and 'Techniker' (Rundfunk). Also, in both cases, it may perhaps be felt that if, instead of providing the entire range of titles, a somewhat shorter list were compiled, it would still be possible to include all the technician functions within it.

It is of interest to note, in view of the EITB recommendations quoted earlier, that forty-five out of the fifty-two electrical technician occupations listed actually contain the word 'Techniker' and of the seven which do not, three include the word 'Assistent'. Thus it would appear that the German lists are already well on the way towards meeting the nomenclature objectives which the British EITB consider desirable.

However, in one very important respect there is a major point of difference, which certainly constitutes a problem. It will be seen from the German technician lists that not only has great care been taken to ensure that the technician level is not confused with the one below (e.g. 'Radiotechniker, nicht Radiomechaniker'), but also that technicians shall be distinguished from 'engineer' grades of similar specialization (e.g. 'Elektroniker, nicht Ingenieur'). This ensures that technician occupations are clearly and separately listed. But no similar distinction is made in the list between 'engineers' and 'technician-engineers'.

'Ingenieure' are listed under Group 60, 'Ingenieure des Maschinen- und Fahrzeugbaues' (mechanical and vehicle engineers), under subgroup 601 (eight subheads, sixty-four occupations) and 'Electro ingenieure' (electrical engineers), subgroup 602 (eight subheads, forty-one occupations). If the numbers of occupations seem large, it should perhaps be noted that the mechanical/vehicle list includes all kinds of transport engineers (road, air and sea), as well as heating, refrigeration, instrument and measurement engineers, etc.; and the electrical list covers power, electronics, control, computer engineers, etc. Out of the 105 occupations listed, 81 contain the word 'Ingenieur' and some of the remainder are, clearly, senior engineer posts (some are obviously designers). But a number of the jobs listed are, by their own nature, technician-engineer posts (e.g. maintenance and servicing personnel). However, the list makes
no attempt to effect a separation. One finds, nevertheless, that in the courses listed in official booklets some of the occupations shown require the 'Ingenieur graduiert' qualification, and others the 'Diplomingenieur'. Thus, in the Federal Republic of Germany, while a distinction is made by qualification between three levels of skilled personnel above the 'skilled worker', one is technician (Techniker), while the other two are different grades of engineer. This is an important example of a nomenclature difficulty to which reference has already been made.

It is, however, understood that within industry, in the Federal Republic of Germany, as in many other countries, employers tend to decide for themselves what particular qualification levels and experience are needed for particular posts, and are reluctant to be bound by rigid structuring—except, perhaps, in relation to requirements at initial grades, where particular qualifications are often specified.

It will be clear from the ISCO lists, and from the two national systems from which examples have been taken, that the absence of an agreed uniform classification system makes it difficult for national lists to be fully comparable. Yet an examination of job specifications for technician posts in a number of the countries listed in Part Two reveals that, to a large extent, the actual jobs being done are comparable. They may differ in detail, and in emphasis. But the job specifications are more remarkable for their common material than for their differences. Thus, however differently they may be grouped, large numbers of job titles may be roughly equated between one national list and another. Thus it would seem that it ought to be possible to compile an international list of technician occupations—or, rather two lists, corresponding to the levels of 'technician' and 'technician-engineer'. Perhaps the vehicle for achieving this could be the Unesco Qualifications and Training Nomenclature (NQF) method.

The NQF method of analysis is primarily conceived as a manpower planning tool. It seeks to reply to two questions concerning any occupational area under review, namely 'Who does what?' and 'How many do what?'. In the particular exercise with which we are concerned, the second question is not under consideration; but clearly, if the NQF system is to be developed for international use, then one would hope that the answers to the first question would embody, at the technician and technician-engineer level, a mechanism leading to a nomenclature which will secure worldwide acceptance. Since 1973 Unesco has been carrying out

experimental action with the following three objectives: (a) to define, starting from real situations, the most appropriate methodology for the analysis of the different functions at the levels under consideration, i.e. engineers, technician-engineers, technicians; (b) on the basis of such analysis, to elucidate better the qualitative and quantitative needs that are to be met by programmes of education and training; and (c) to promote the internal exchange of information relating to these levels of education and training. Comparable action is being undertaken in France by the Centre for Study and Research on Qualification (CEREQ), by the Canadian Engineering Council and by the International Labour Office (ILO). With mutual exchange of information, there is indeed good reason to hope that there will emerge an international classification system which will be a great improvement on any currently existing.

A basis of the NQF system is an eight-level job classification, the lines of demarcation being drawn in terms of the educational standards required for the jobs. The eight educational levels do not exactly align themselves with those given in the International Standard Classification of Education (ISCED) (Unesco). But level 6, defined in NQF as 'complete higher education, i.e. 16 years or more' corresponds with ISCED’s level 6 'education at the third level, first stage, of the type that leads to a first university degree or equivalent'. Thus the 'university-level engineer' would come in this category.

Level 5 in NQF is 'complete secondary education plus two or three years of higher training, i.e. a total of 14 or 15 years'. This compares with level 5 in ISCED, defined as 'education at the third level, first stage of the type that leads to an award not equivalent to a first university degree'. This accommodates, in most countries, the technician-engineer.

It is, unfortunately, at the technician level that it becomes difficult to reconcile NQF and ISCED. The former defines level 4 as 'complete secondary education, usually including a technical or vocational training component; or middle level education, plus three or four years of training, i.e. a total of 11 to 13 years'. This definition could include, at any rate in the cases of courses having the longer duration, the education and training of technicians. ISCED does not list a level 4. But its level 3 includes the completion of secondary education, and lists programmes of a technician nature. No doubt it will prove possible to reconcile these differences, which are clearly marginal.

It is intended, for each occupation, to produce a 'fiche', or card, on which the job is analysed in terms of (a) skills and attributes, including degree of theoretical knowledge required; (b) degree of independence and personal initiative required; and (c) nature and
extent of responsibility. It would be interesting to continue with further details of the NQF system; but, for the purpose of this exercise, what matters is the 'fiche'. It is to be hoped that it will provide a basis for international outlines and job titles at technician and technician-engineer levels.

**Definition by qualification**

As we have seen, the NQF method is based on eight divisions, determined by the educational standards required by the job or rather, the 'formation' standards, since both educational and practical training criteria are mentioned. In fact, the successful attainment of these standards results in the award of a qualification. Thus the NQF system is virtually a 'definition by qualification' system. There are many countries in which 'definition by qualification' is used. (France is a good example.)

Obviously, if such a system is to be acceptable to industry, the qualification, along with the associated education and training, must meet the ultimate functional requirements of the job. The starting-point, therefore, is a job specification and, whatever the mechanism for producing it may be, the specification should be provided by industry. An education and training programme, in which the needs of industry are incorporated within a sound educational framework, may be derived from this basis. The question of the acquisition of necessary practical skills has to be dealt with whether, e.g. these are best acquired as part of an 'institutionalized' integrated course of education and training, or as 'off-the-job' training within industry, or as part of planned industrial experience.

These considerations may well lead to very different solutions according to whether one is concerned with the technician or the technician-engineer level. Technician jobs vary considerably in respect of the amount of craftsman-type expertise which they require. But a few countries—Switzerland and Indonesia, for example—require would-be technicians to follow a craft apprenticeship first. Some others operate courses in which the first phase of practical training is common for both craftsmen and technicians. For example, the Engineering Industry Training Board in the United Kingdom operates in this way, providing 'modules' of training in which the first basic workshop module is taken by all, irrespective of whether their courses are of the craft or technician type. In some other courses, practical training within industry is sandwiched between periods of instruction in teaching institutions; and in others, training is wholly conducted within such teaching institutions. A period of subsequent practical training may be required before a
Definitions of technicians

technician qualification is awarded. Examples of all these arrange-
ments may be found in the country summaries in Part Two.

An examination of such summaries will reveal that, although
there is much variation in the structure of courses leading to
qualification at 'technician' level, certain fairly common factors may
be noted. For example, in countries which have the 'two-tier'
structure, most technician courses, whether they are full time or part
time, begin at the age of about 16 and are of about two or three
years' duration, full time—longer, usually, if they are on a part-time
basis. So, referring again to the Unesco International Standard
Classification of Education (ISCE), such technician education and
training is carried out at second level, second stage; and, for
engineering technicians, would come under field 354. (There are in
some countries schools where a technically orientated programme,
leading on to 354, begins at the previous stage, i.e. second level, first
stage commencing at about the age of 12.)

It thus emerges that in a very large proportion of the countries
considered in Part Two, a 'first qualification' as a technician is
obtained at about the age of 19. However, it is important here to
distinguish between a 'school' or 'college' qualification—even if it is
awarded by the country's Ministry of Education—and the qualifica-
tion given by the country's official technicians organization, if it has
one. For example, it is possible for a 'first qualification' at technician
level to be obtained by a student in the United Kingdom at the age
of 19—even 18, in some cases. But the requirements of practical
training and of experience (a minimum of three years) have to be
met before the young technician can be accepted by one of the
technicians organizations. Thus, to be registered as a technician by
the Engineers Registration Board (see below, Chapter 3) with
entitlement to the designatory letters 'Tech. (CEI)' he must have a
minimum age of 21. In fact, few technicians qualify at this age.

However, to return to the actual courses, awards are commonly
made to successful students when they leave the schools or colleges
where they have studied, the awards implying the completion of a
programme of both theoretical and practical work (together with a
measure of general education). This will include whatever measure
of specialist education and training is appropriate to the nature and
level of the technician or technician-engineer occupation involved. It
is important that, both with respect to course content, and to
examination and testing procedures, there shall be close links
between education and industry. This point is referred to frequently
in Chapter 8, 'Country Summaries'. For the moment, it is perhaps

48  Engineering technicians. Some problems of nomenclature and classification

... enough to note that most educational establishments conducting technician courses test both theory and practical work. The exceptions are to be found in those countries where practical training is provided within industry. Tests of the necessary practical skills are usually, in those circumstances, conducted either by an Industry Training Board as in the United Kingdom, or by some form of 'technician apprenticeship' testing organization, perhaps associated with a technicians organization, such as are later described.

It is not easy to compare accurately the content of courses conducted in different countries, particularly with respect to practical work. There are different views concerning the practical skills particular technicians require. Indeed, in France, and some other countries where technician education is conducted similarly, there are two different three-year technician courses and examinations taken in the secondary school. One, the Brevet de Technicien (BT), is rather more specialized and contains less theory than the other, the Baccalauréat de Technicien (BTn). Also, until quite recently, there were two types of technician courses in the United Kingdom, the Ordinary National Certificate Courses and the City and Guilds of London Institute Technician Courses, the former being, year for year, of a higher theoretical standard. These have now been coalesced into a single system of programmes conducted by the Technician Education Council. These programmes consist of 'modules' or 'units' which may be grouped and taken, within certain prescribed educational limits, in groups, or singly, according to the needs and the abilities of the student, and to the time which he has available. Thus, the new system includes a degree of flexibility not hitherto available.

Just as a high proportion of the technician-level courses fall into one major category, so do many of the courses at technician-engineer level. The most common pattern is a starting-point which is the successful conclusion of a full secondary-school course at the age of 18 or 19. The course is usually of two years' duration, sometimes three, with a practical content which is either integrated with the theory, or provided in interleaved periods, or else subsequent to the institutional course. Thus, as we have noted already, the technician-engineer courses fall into ISCED level 5, 'education at the third level, first stage, of the type that leads to an award not equivalent to a first university degree'. Such engineering courses come under field 554, and produce technician engineers at about the age of 21.

It is interesting to note that the French (and some other francophone countries) have two qualifications at this level also, both obtained by two years of study after the baccalauréat. The first, the Brevet de Technicien Supérieur (BTS), is provided in the lycées techniques, or in technical streams of composite secondary schools.
The other qualification at the technician-engineer level is the Diplôme Universitaire de Technologie (DUT), a more recent development. The DUT is provided in university establishments, and the course requires a baccalauréat pass for entry. Here also, the difference is one of emphasis, the BTS being more technically specialized than the DUT, which has a broader mathematical and scientific basis. In the United Kingdom a somewhat similar situation has been obtained for some years. The higher National Diploma (two or three years' full-time or sandwich study, post-18 years of age) is roughly equivalent to the DUT, although offered in polytechnics and technical colleges, and not in universities. The Higher National Certificate, its part-time near-equivalent, has coexisted with the Advanced City and Guilds of London Institute technician courses, and has a lesser theoretical content. However, both of these courses are in the process of being replaced by the higher certificates and diplomas of the Technician Education Council.

It was suggested earlier that technician-engineer education and training might need to be different from that given to technicians, not only in level, but also in kind. No doubt it is this kind of thinking which has led to the establishment of such innovations as the French DUT, demanding as it does a standard of entry at a much higher level of general education than that required for the BT. However, many countries, like both France and the United Kingdom, are concerned to ensure that those who obtain technician qualifications, such as the BT, are not debarred from advancing to technician-engineer level by the high academic entry level to technician-engineer courses planned 'end-on' from a full secondary education. As the 'Country Summaries' show, there are many countries where this progression is achieved by having suitable courses for which the entry qualification is that which would be held by a technician. Thus in France, the holder of a BT might take the BTS; and in the United Kingdom, the holder of an Ordinary Technician Certificate or Diploma might proceed to the Higher Certificate or Diploma. In the Eastern European countries, it is a general feature that, although perhaps technician courses may be offered at one level only, they may be covered by a very flexible attendance arrangement. Thus syllabuses devised primarily on a full-time basis may be covered also by part-time study by day or evening; by 'block-release' periods from work; by correspondence courses; by in-plant courses, etc.; and students who may lack the necessary secondary-school entry qualifications for technician courses may acquire those by similar flexible study arrangements. As will be seen from Part Two, some of the Eastern European countries, which have until recently had only one level of technician qualification, are now introducing higher-level courses. Entry to them is also possible by a variety of paths, and study may be on either full-time or part-time arrangements.
Both Japan and the Republic of Korea do not fit readily into the
more common pattern which has been outlined. It will be seen from
Part Two that they have only one kind of technician course, a two-
year ('Junior College') one following (usually) a secondary technical-
school course aimed primarily at the production of skilled workers.
(In Japan, the five-year course also achieves the same objective.)
Technician-engineer work in the Republic of Korea is largely carried
out at 'Engineer 2' level. Such posts may be occupied by engineering
graduates from the universities, or by technicians promoted, after
suitable experience, on merit.

There is another complication which makes it difficult to fit some
countries into the predominant pattern. By this is meant technicians
after a two or three-year full-time course, from age 15-16 or
equivalent; and technician-engineers after a two- or three-year full-
time course, post-age 18-19, following the successful completion of a
full secondary-school course (or equivalent). It is that not all
countries achieve comparable levels of general and technical educa-
tion at the same ages. In certain developing countries, for example,
children have not had the opportunity to grow up in a technological
environment. It takes time to enable the students to acquire that
familiarity with simple mechanisms which comes so much more
easily to children in advanced countries, who have played with
mechanical toys, etc. Thus one finds that, in certain African
countries, some students at age 17-19 take the examinations which
their European counterparts might sit at 16. Thus a two-year
technician course upon leaving school at age 18 would bring these
students to technician level, not that of technician-engineer. This
explains why some of the post secondary courses shown in Part Two
are graded at technician rather than technician-engineer level.

There is now a tendency in a number of countries well
experienced in technician education and training to set out the
programme of work to be covered, not in the form of an old-style
syllabus, but as learning objectives. Correspondingly, the practical
training programmes are, commonly, set down as a series of training
objectives, or, sometimes, in terms of an activity analysis. The
essential thing, as mentioned earlier, is that those responsible both
for the formulation of the programmes, and for the teaching and
training involved, should be in close touch with industry. In a
number of countries, of which the United Kingdom was one, it could
be said in the past that training was left to industry and technical
education to the technical schools or colleges, with little co-operation
existing between the two. In the United Kingdom, the education
programmes of the Technician Education Council are determined by
advisory committees on which industry has strong representation;
and the courses are carried out with close co-operation with those
operating the training programmes set down by the engineering industry training boards; and in many other developed countries close association with industry is now being achieved. Thus the needs of industry are being met. There is, of course, often a problem in developing countries, where there may not as yet exist sufficient industrial activity for firms to do much, either in the provision of training facilities, or in taking a major part in developing curricula. Often, during the earlier years, much reliance has to be placed on the knowledge and experience of expatriates. Even so, it is essential to involve local industry as much as possible; for, ultimately, the education and training of a technician or a technician-engineer will be judged by the extent to which it has equipped him to do a practical job within the working environment of his community.
3. Associations of technicians and of technician-engineers

**General**

One method of ensuring that proper standards of technical competence are maintained is through the medium of associations of technicians and/or of technician-engineers. It is also a means whereby technicians and technician-engineers may be brought together and consider matters of mutual interest. These organizations may make an important contribution to the status of such personnel. Of the thirty-nine countries considered in Part Two, perhaps about half have such associations—and these are mainly the industrialized countries. Often, the associations are either part of, or are closely linked with, corresponding associations for engineers (i.e. 'university-level engineers', in the terminology of this book). Two examples will be taken.

**The Swiss register**

Perhaps the earliest European example is *Le registre suisse des ingénieurs, ingénieurs-techniciens et techniciens REG*, which was initiated in 1951 and, since 1966, has been the official national register for engineers, architect-engineers, architecture-technicians and technicians. At all three levels it was possible, until 1976, to secure registration solely on presentation of the appropriate diploma. In the case of the 'university-level engineer', the required diploma was the *diplôme d'ingénieur* of one of the Écoles Polytechniques or the universities. For technician engineer, the requirement was the diploma or certificate of *ingénieur-technicien* awarded by the Écoles Techniques Supérieures (FTS); and for technicians the technician certificate awarded by the Écoles Techniques (ET).

Since 1976 the acquisition of a suitable diploma or certificate has not been enough by itself to secure registration, for which a minimum period of at least three years' appropriate experience is now also required.
The Swiss postulated from the beginning that in deciding individual registrations the accent should be upon professional competence and responsibility, rather than upon academic qualification. Entry to the register was therefore made possible to others besides diploma holders. At ingénieur level candidates who had completed the full course without obtaining the diploma could be registered as ingénieurs if, after four years' experience, they could satisfy an examining commission as to their competence. Somewhat similar arrangements exist for those without the required diplomas or certificates at the other two levels (five years' experience for technician-engineers, seven for technicians). The regulations also permit self-taught persons to apply for registration, after longer periods of experience and provided a rigorous examination by the selection board was satisfied. (It will be noted from Part Two that new graduates of the ETS now carry the title ingénieur ETS and not ingénieur-technicien.)

Since in Switzerland all technicians must first serve an apprenticeship, it will be clear that the register offers routes, whether by formal study plus experience, or by informal study and work activity, so that sufficiently able craftsmen may, eventually, become registered ingénieurs.

It is of interest to note that the Swiss have a firm answer to a question often asked in connection with technical titles—namely, should they be accorded to people who are suitably qualified academically, or should they be given in terms of the job being done? The Swiss clearly believe that what qualifies one for the title is the ability to do the job; and that the acquisition of suitable diplomas is part-evidence, and justifies a lesser requirement in terms of experience than would be imposed upon those who cannot produce such evidence.

While many countries are fairly rigid about relevant academic qualifications, there are several (e.g. Belgium) which also have a ‘jury’ system which enables those who have not followed the normally prescribed courses to qualify otherwise—although the period of relevant experience acceptable may well be long, and the examination extremely exacting.

The Engineers Registration Board (United Kingdom)

The second example is the Engineers Registration Board (ERB) in the United Kingdom. It was established in 1964 under the Royal Charter granted to the Council of Engineering Institutions (CEI) to register suitably qualified persons as Chartered Engineers (C. Eng.) Technician Engineers (T. Eng. (CEI)) and Technician (Tech. (CEI)).
The British system of 'professional engineering institutions' is somewhat complex. The Chartered Engineer Section of the ERB consists of sixteen chartered institutions (e.g. the Institution of Civil Engineers, the Institution of Electrical Engineers, etc.) and two affiliate institutions. The Technician-Engineer Section comprises forty-five institutions (e.g. Association of Mining Electrical and Mechanical Engineers, Institution of Mechanical and General Technician-Engineers, Institution of Electrical and Electronics Technician-Engineers, etc). The Technician Section of the ERB involves thirty-three organizations (e.g. Institution of Plant Engineers, Institute of Quality Assurance, etc.). Each institution has its own conditions for membership. But these must be equal or superior to those laid down by the CEI for the institution to be acceptable for inclusion in the particular ERB section.

For registration with the ERB a candidate must be a member of an institution included in the list pertaining to the particular section. This will in general ensure that he will meet the educational, training and experience requirements laid down by the ERB. These are:

**Chartered Engineer Section (C. Eng.)**

Minimum age 25.
Academic standard—the CEI Part 2 examination or a recognized exempting degree in engineering or related subjects.
A period of training and professional responsibility, which will depend upon the requirements of the particular institution of which the candidate is a member, but will not be less than three years in aggregate (soon to be raised to four). (Some of the major institutions require two years of planned training plus three years of responsible experience.)
Corporate membership of one of the institutions listed in the Chartered Engineer Section of the ERB.

**Technician-Engineer Section (T. Eng. (CEI))**

Minimum age 23.
Academic standard exemplified by Higher National Certificate or City and Guilds Full Technological Certificate. (These are being replaced by the Higher Certificates and Diplomas of the Technician Education Council.)
Five years' engineering experience (including two years' approved practical training).
Membership of one of the societies listed in the Technician-Engineer Section of the ERB.
Technician Section (Tech. (CEI))

Minimum age 21.
Academic standard exemplified by Ordinary National Certificate or City and Guilds Part II Final Technicians Certificate (now being replaced by the Technicians Certificates and Diplomas of the Technician Education Council).
Three years' engineering experience (including two years approved practical training).
Membership of one of the societies listed in the Technician Section of the ERB.

There is a 'Mature Candidate' scheme which provides at all three stages a route to registration for a small proportion of exceptional candidates who, although they do not have formal academic qualifications at the appropriate level, are able to demonstrate that they have achieved a standard of technical competence comparable to that of their colleagues registered by fulfilling the requirements as listed above. The minimum age at which mature candidates may be admitted is 35. The criteria are stringent and not many candidates achieve registration in this way. Thus the British system is not unlike the Swiss; but its provision for the acceptance of mature students lacking the required educational qualifications is perhaps less generous.

The FEANI comparability investigation

One could go on by dealing with the Belgian, the Netherlands, the Indian, the Canadian and other national organizations which operate registration systems. A considerable amount of common policy would thus be demonstrated, and also differences, including some which are of importance. This leads naturally to the question of whether or not it would be possible to have an internationally recognized system, with criteria broadly common to all. Such a system would provide, as a minimal result, a means of comparing, perhaps only approximately, the relative worth of technician and technician-engineer qualifications obtained in the different countries of the world. At best, it could constitute a means of facilitating the free movement of qualified personnel between countries.

This is, of course, no new idea. It has been considered, in the context of the Treaty of Rome, by the countries of the European Economic Community. The Fédération Européenne d'Associations Nationales d'Ingénieurs (FEANI) has spent much time on the problem; and other international engineering organizations, such as the World Federation of Engineering Organizations (WFEO), the
Pan-American Federation of Engineering Societies (UPADI), the Federation of Arab Engineers (FAE), the Committee on Engineering Education in Middle Africa (CEEMA) and the Association for Engineering Education in South-East Asia (AEESEA). Others have given it consideration — although, in general, with more attention to the 'university-level engineers' than to the personnel below them.

Probably the most interesting attempt to publicize the problems of identifying criteria for engineering-qualification standards was that undertaken, at the request of Unesco, by FEANI, under the direction of Professor Victor Broida, its Secretary-General. The results of investigations involving eighteen countries were published by Unesco in 1975.1 FEANI divided the technical personnel above skilled-worker level into three categories, defined as follows:

Category C. 'Conception engineers', accustomed to think in abstract terms, to take a synthetic view of events which are not obviously linked together and to demonstrate a sufficient degree of creativity; to have a sufficient degree of practical knowledge; to be realistic and not limit themselves to speculation. This category corresponds to the personnel referred to so far in this book as 'university-level engineers', and has been included here because it effectively delineates the upper boundary of the 'technicians-engineer' band.

Category L. 'Liaison engineers or senior technicians', who provide the link between 'conception engineers' (whose predominant competence is theory) and 'execution technicians' (whose predominant competence is practice). The 'liaison engineers or senior technicians' are capable of understanding abstractions and of translating them into practical language, thus forming the essential bridge between the other two equally essential categories. This category corresponds to what has been called 'technician-engineers', the author of which believes that 'technician-engineer' is a better term, partly because of the reasons already given for adopting it, and also because the term 'liaison engineer' covers only a part of the functions which such personnel may perform.

Category E. 'Execution technicians', responsible for the execution of projects initially conceived by the 'conception engineers' and then adapted to the practical realities of industry by 'liaison or senior technicians'. This report will continue to refer to such personnel simply as 'technicians'.

The FEANI document then went on to list the education, training and experience requirements at the three levels thus defined, set down by the European Economic Community, in its Draft

Considering briefly Category C, the EEC Directive requires the possession of a diploma resulting from the completion of at least four years of relevant university study, plus a certificate of competent performance over a period of at least two years after the award of the diploma. FEANI simply requires that candidates, having passed an examination at university entry level, shall qualify as engineers 'in schools providing a complete scientific and technological education at university level'. No minimum time is stated, nor is there any requirement in terms of subsequent experience. The British ERB requires what is, in the vast majority of cases, an engineering degree (or its equivalent) normally obtained after a minimum of three years' full-time study (or its sandwich or part-time course equivalent). But this has to be enhanced by training and experience of at least three years (normally more, and to become four years) and at least two years of technical responsibility. Many schemes of practical training cover two years, making a four-year post-degree period a minimum, in practice. In many continental countries the longer university courses include comparable practical work. Hence, it may be said that the EEC and the British ERB requirements are not dissimilar. FEANI differs in requiring no period of experience after obtaining the academic qualification. However, since, in the context of this report, interest in the particular category relates solely to the establishment of an upper boundary for the technician-engineer grade, this point need not be pursued.

At the Category L, or technician-engineer level, the EEC Directive requires that no less than twelve years of education, including both studies and practical training, shall be followed by at least three years of study at a higher technical institution resulting in the award of a relevant diploma. This has to be followed by two years of attested competent experience. FEANI requires the attainment of university entrance standard, followed by three years of study at, and successful graduation from, 'schools that provide a less extensive but more practical scientific and technical education lasting at least three years'. Again, no job experience is required. But FEANI also provides for students who enter with a lower school attainment and follow a course at a 'higher technical school, of at least three years' duration and who have a minimum of three years' practical experience obtained before, during or after the course'. The British ERB, as has been indicated, sets its academic level in terms of examples of suitable (British) qualifications, rather than in terms of study time. In fact, these qualifications would require a minimum of two years of study beyond age 18, from roughly university entry
level. For many students, this would be part-time education, with concomitant training within industry (the first year being, perhaps, 'off-the-job' training). However, it would be even more common to find that students arriving at these qualifications would have left school at the minimum leaving age of 16 and (dependent upon their success in school examinations) would have taken either four or five years of part-time study to secure the sort of qualification required by the ERB. During this period they would receive, under the EITB technician training scheme, two years of planned training followed by some supervised experience. In all, a minimum of five years of 'training plus experience' is required by the ERB and the minimum age for registration is 23. Thus, the 18-year-old school-leaver can (just) get in the required five years by the age of 23. The 16-year-old school-leaver will have had seven years from his entry into industry as an industrial trainee before he can qualify.

Before considering which, if any, of these criteria should be accepted, it is advisable to look at the corresponding recommendations for the technician level—or Category E, as the FEANI document calls it. The EEC Draft Directive calls for at least thirteen years of education in a state-recognized technical school, including as a final stage a complete course of at least two years of full-time relevant technological education. It also requires at least two years of subsequent certificated relevant experience. FEANI did not, at the time the booklet was produced, offer any definition at this level. The British ERB, as has been explained, required qualifications which need two or three years of study, full time or part time, in a suitable course designed for technicians, beyond the minimum school-leaving age of 16; that is, following eleven years of general education. The ERB also requires at least three years' experience, of which two shall have been spent in practical training.

The experience requirement

Most of the associations also require, as well as a particular education-plus-training qualification, a period of relevant experience. The writer is strongly in agreement with such a requirement. He believes that, particularly in some areas of technician and technician-engineer work, a great many of the essential attributes can be acquired and developed on the job. It is therefore essential that any specification of education and training requirements for technician-engineers and for technicians shall be drawn up so as to permit qualification to be achieved either through full-time institutional integrated courses of education and training or by part-time education, accompanied by planned concomitant practical training within industry, and succeeded by job experience.
In trying to produce some form of general specification, it seems sensible to separate two components, namely formation (that is, education and training requirements) on the one hand, and experience on the other. The writer believes that official recognition, with the conferment of a title as technician-engineer or technician, should not occur until formation courses have been successfully passed, and the knowledge and skills thus acquired have been augmented by experience as a working technician-engineer or technician. How much experience should be demanded is not a question which can be (or should be) answered by a simple figure, for it should properly depend upon the extent to which the formation course contains practical work which can be sensibly regarded as 'equivalent experience'. It is for this reason that the British ERB asks, not for a specific period of experience after training, but for five years (technician-engineer) and three years (technician) of 'experience plus planned training', with a certain minimum of training contained within these periods. The general adoption of such an 'experience element' in the requirement for title would mean that each country would need to look at its 'formation' arrangements, and decide how much of them might fairly be regarded as practical training which might properly count towards the 'training-plus-experience' requirement. This would enable account to be taken of, and credit given for, the longer courses provided by some countries with, quite often, a larger practical ('equivalent experience') content than in the shorter courses to be found in others. One has to bear in mind that, in some developing countries, 'on-the-job' training is hard to come by. It is often a very good compromise to have a production unit, producing saleable material, and a maintenance workshop, actually accepting jobs, as part of the college facilities. This is getting as near as one can to the practical on-the-job situation, without being in actual employment. However, good though this is, it is felt that in no circumstances should the course training element be regarded as satisfying, by itself, the total 'training-plus-experience' requirement, no matter how long the course may be. The reason for this is the conviction that 'title' should be granted only to those who, having qualified through education and training, have also experienced working to deadlines, customer pressures, etc. (Testing, repairing and securing the precise and exact operation of a radar equipment in a college laboratory/workshop, without time constraints, is in some respects a different problem from doing the same job in the confines of a ship cabin, and under the compulsion of a departure time.) It is, however, suggested that the British ERB period of three years 'training plus experience' for a technician, and five years for a technician-engineer, should be considered for adoption as a guideline requirement, to be interpreted in each country in the light of the practical content of its courses.
4. International minimal requirements for education and training

Minimal educational requirements

The next consideration is whether any such general guideline can be given with regard to the ‘formation’ courses themselves, as the EEC, FEANI and the ERB (among others) have done. It is suggested that the most sensible attitude to adopt to this difficult question is to ask a subsidiary one: ‘what do countries with long experience of the “formation” and using of technicians and technician-engineers find the minimum effective course length to be?’ It can be assumed that if a country has found that a course of a given length and type produces trainees who, in the work situation, quickly become sound and effective technicians acceptable to industry as such, then it will see no reason for lengthening the course. On the other hand, if it were not successful, then one of the factors which would assuredly come under scrutiny would be the duration of the course.

Applying this kind of thinking to the technician-engineer situation, it is seen that the shortest courses are found in France and in the United Kingdom, namely, two years after a full primary and secondary education (thirteen years). However, instead of using the sort of terminology favoured by the EEC and FEANI, stating a length for the technician-engineer course ‘following thirteen years of school education’, to a specified level, it is suggested that it would be better to put the requirement as: ‘at least fifteen years of education, of which not less than the last two should be a specially constituted technician-engineer course, entry to which should require that an appropriate educational standard be reached. The final assessment of the technician-engineer course would need to satisfy the country’s official attesting authority’. Such a definition would have several advantages. It would, for example, include satisfactorily a country
which preferred a three-year technician-engineer's course following twelve years of school education. Also, it would enable the inclusion of students who had, perhaps, eleven years of general education, followed by a two-year technician course which, after a period of experience, could be succeeded by a two-year technician-engineer course.

It must be stressed that what is proposed is the minimum acceptable. The provision of a three-year, technician-engineer course is, in the writer's view, a better proposition.

An analysis of technician-engineer courses, of different lengths, in several countries, reveals that the general effect of lengthening the course is to enhance the practical content to a greater extent than the theoretical. Put another way, one can get adequate theory into a two-year course, but the subsequent requirement of practical training is greater than when the course is three years long. Thus the proposal, already made, of a five-year period of 'training plus experience' as a requirement for title would enable suitable credit to be given for the greater practical content of the longer courses.

An interesting point which needs to be dealt with arises from the few technician-engineer courses which are of four years' duration from the end of full secondary education—and it is partly because of this point that the Category C requirements were included. It might perhaps be held that such courses (which would be one year longer than a British engineering degree programme) actually meet the requirements of Category C, and that, therefore, successful students should be granted the title 'engineer', rather than 'technician-engineer', once they had fulfilled the 'training-plus-experience' requirement. The answer to such a claim is that, while the length of the course is a criterion, so too is course content, and the way in which the subject-matter is presented. Thus a course properly designed for 'university-level engineers' should, ipso facto, be unsuitable for 'technician-engineers'—and vice versa. It is on this basis that, in Part Two, some long courses starting from university-entry level, and long enough to meet the Category C criteria, have nevertheless been 'graded' as technician-engineer courses.

Turning next to technician courses, and taking the shortest existing well-tried courses as a means of identifying the minimal acceptable criteria, the requirement would be: 'At least thirteen years of education, of which not less than the last two should be a specially constituted technician course, entry to which should require that an appropriate educational standard be reached. The final assessment of the technician course would need to satisfy the country's official attesting authority.'
A 'broad banding' proposal

Such courses, at both technician and technician-engineer levels, would normally result in awards made, perhaps, under the aegis of the country's Ministry of Education. It follows that, since the courses of different countries may involve very different periods of study, they often cannot be precisely equated. Furthermore, if course 'A' from one country and course 'B' from another country are both labelled 'TE' in Part Two below, implying they are both technician-engineer courses, this does not mean that they are equivalent. What it does mean is that, in both courses, when there has been added to their practical training content whatever is adjudged necessary to make up five years of 'training plus experience', then successful candidates of both are worthy of the official title 'technician-engineer'. Even when this is done, it does not follow that the total 'formation plus experience' is the same in both cases. It simply means that each satisfies, or exceeds, the minimum requirements for title.

Thus the proposal does not involve the intractable problem of equating qualifications. All that is being attempted is a 'broad banding' exercise, with the object of allocating all technician-style courses into either the 'technician' or the 'technician-engineer' categories. This having been done, it would be a most useful step to review all course names, and ultimate titles so that, as far as possible, all should contain the words 'technician' or 'technician-engineer', as appropriate. These words could be preceded (or followed, according to linguistic usage), by descriptive subtitles; e.g. 'electronic technician', 'ingénieur-technicien (mécanique)', 'Technik (Mechanik)', etc. Such action would reduce very materially the confusion which at present arises from the multifarious and sometimes apparently unrelated names given to technician-type occupations which are virtually identical.
5. Titles—legal protection

General

Finally, there is the question of whether the titles of 'technician' and 'technician-engineer' should be subject to legal protection; and whether the freedom to practice as such should be restricted to holders of the titles. There are several problems arising from this question.

The first is that in many countries—the large majority, in fact—such terms as 'technician', 'technicien', 'Techniker', engineer, 'ingénieur', etc., are applied, often very loosely, to any workers adjudged to be doing the sort of jobs that warrant calling them by such names. In the ordinary parlance in such countries, the name goes with the job, not with the qualification. Furthermore, in many countries, employers would be most unwilling to accept any regulation which forbade them to 'label' workers in accordance with the job they were doing, and linked such 'labels' solely to qualifications. They would defend, also, their right (as they would claim) to promote any individual on grounds of demonstrated ability, and would object to being prevented from so doing because of the person's lack of some specified qualification. There are exceptions. It is commonly agreed that persons who take ultimate responsibility for jobs involving the safety of the public must be seen to have suitable qualifications; and in most countries there are legal requirements to ensure this. But in many countries—certainly at technician level—freedom to practice the profession is seldom restricted by the need for specific qualifications.

However, in a number of countries where such freedom prevails, the associations (or institutions) of technicians, technician-engineers and engineers have campaigned to persuade employers, and the general public, of the desirability of using the services of only such people as have qualified for the 'titles' which they bestow; and
frequently, one finds that government departments specify their requirements for technical posts in terms of these ‘titles’ and thus debar those who do not have them. Often such titles have the protection of law. Thus, while anyone in the United Kingdom who wishes may call himself a technician-engineer, anyone who uses the title ‘Technician-Engineer (CEI)’ without being on the register (ERB) may be subject to legal proceedings.

The problem of title without experience

It will be recalled that to be registered in the British ERB, it is necessary to satisfy four requirements—namely, age, academic qualification, training and experience. Thus a young man aged, perhaps, 21 years who has just obtained a Higher National Diploma can call himself a technician-engineer if he wishes. But he cannot be registered as such with the CEI and thus cannot claim the title of ‘Technician-Engineer (CEI)’.

In France however, a 21-year-old who has just successfully completed a course leading to the Brevet de technicien supérieure thus qualifies for the title of ‘technicien supérieure breveté’. In France, as in many other countries, anyone may call himself ‘technicien’; but ‘Technicien breveté’ is a protected title.

These situations present a problem which needs to be resolved. In some countries titles are given on the successful completion of ‘formation’. In others, titles are withheld until ‘formation’ is augmented by experience. The writer has already indicated that he favours the latter criterion.

Categories of legal conditions of title

In some of the ‘Country Summaries’ which follow in Part Two, the legal position is briefly stated, where it has been clearly determined in respect of the country concerned. Where the legal position is not referred to in the summaries, it does not necessarily mean that the country in question does not have a legal policy. It may be that adequate information has not been available to the writer.

In general, the legal position may conform to one of four categories, described below:

Category 1: Total freedom to use the titles of technician, technician-engineer or engineer and to practise as such, without any legal protection to those with formal qualification.
Category 2: No legal limitation to the general use of the three names, and general freedom to practise. But legal protection of qualifications, and to any distinctive titles attached to them (e.g. Diplomingenieur).

Category 3: No limitation of freedom to practise, but voluntary registration in a national register to use specified titles.

Category 4: Compulsory registration to secure both right to title and right to practise.

In general, the limitations implied in Categories 2, 3 and 4 apply most often to 'engineers' and to a lesser degree, if at all, to technician-engineers and technicians.
6. Summary of recommendations and conclusions

If the considerations and conclusions outlined in the various parts of this report be now brought together, it will be seen that the following general points can be made:

There is a wide measure of general agreement concerning the overall scope of the work of technicians and technician-engineers, as bridging (and, indeed, overlapping) the gap between skilled workers at the lower end and 'university-level engineers' at the upper.

A large majority of the countries examined recognized the need for two levels of personnel who should jointly span that gap—namely, technicians at the lower end and technician-engineers at the other. These titles, and their equivalents in other languages, were thought to be the most appropriate of those in present use, and are recommended for general adoption (with the possibility of 'higher technician' as an alternative to 'technician-engineer').

An examination of job specifications and of education and training syllabuses revealed a reasonable measure of agreement concerning 'core content', with variations in detail more evident in specialized areas. It was felt justifiable to conclude from this that it would be possible to provide a 'Standard Classification', using perhaps the Unesco method of analysis 'Qualifications and Training Nomenclature (NQF)'. This would, in the light of its structure, automatically place in separate categories technician occupations and technician-engineer occupations. Under each could be listed main group heads; e.g. mechanical, electrical, electronic, automotive, production, etc., these terms to be internationally agreed upon and acceptable. Subgroups indicating specific job titles could be employed for further distinctions. These would be more difficult to agree upon and the list might well have to include some titles meeting special country requirements. But an examination of existing lists would appear
to indicate that the problem is not insoluble. It has, of course, been attempted already—but not with separate listing for technicians and technician-engineers. The provision of an agreed-upon list of technician and technician-engineer occupations would be a major step towards the removal of the confusion which at present exists.

It is recommended that all titles (except for draughtsmen) should embody the words 'technician' or 'technician-engineer' as appropriate, so that level is clearly indicated. The 'subtitle' should as far as possible be one in the recommended list, so that the present jumble of different job titles for equivalent occupations may be resolved.

As these recommendations necessarily imply an agreement on minimal course requirements for grading as technician or as technician-engineer, it is proposed that (a) 'technicians' must have had at least thirteen years of education of which not less than the last two should be a specially constituted technician course, entry to which should require that an appropriate educational level be reached (the final assessment of the technician course would need to satisfy the country's official attesting authority); and (b) 'technician-engineers' must have had at least fifteen years of education, of which not less than the last two should be a specially constituted technician-engineer course, entry to which should require that an appropriate educational level be reached. The final assessment of the technician-engineer course would need to satisfy the country's official attesting authority. The fact that many countries operate courses considerably longer than the minimal ones postulated above may be partly compensated for by the paragraph below.

It is proposed that accession to the official titles of 'technician' and 'technician-engineer' should be restricted to those who, as well as satisfying the requirements of the paragraph above, have also completed adequate periods of 'training plus experience', three years in the case of technicians and five years in the case of technician-engineers. Such training activities during the course as may properly be regarded as 'equivalent experience' might be allowed to count as part of the required three or five-year period. (It is appreciated that this recommendation would, if accepted, raise difficulties in those countries where titles are awarded at present solely upon the successful conclusion of courses of education and training.)

Arrangements should be made to permit technicians to upgrade to technician-engineers; and somewhat less commonly, technician-engineers to engineers. The essential point here is that, while education and training systems should be so contrived that able
students to move from any level to the one above, the courses should be planned to achieve their primary purpose, i.e. technician or technician-engineer standards.

Encouragement should be given to the development of associations or institutions of technicians and of technician-engineers. Governments should co-operate with such organizations in determining the precise conditions for the award of titles, or should delegate to them the responsibility for making such awards.

At all levels, and in connection with both theory and practice, industry should play an important part in the formation of technicians and technician-engineers, and in determining the conditions under which titles may be given.

Titles so awarded should be protected by law. But lack of them should not preclude an individual from practising his profession, except in such respects as governments may consider desirable (e.g. in work in which responsibility for public safety is involved).

Organizations controlling the award of titles should provide a mechanism for enabling membership to be obtained by those who, although not having followed the normal channels of education and training, can demonstrate satisfactorily that they have achieved the same levels of competence. The requirement in terms of experience should be considerable, and the examination, whatever its form, suitably stringent.

It is felt that the general implementation of these recommendations would secure a much greater degree of uniformity in nomenclature and thus remove the confusion which at present arises. Further, the recommendations concerning qualifications and titles would, if implemented, lead to a greater degree of uniformity in levels of ultimate certification, while still permitting a country the considerable and essential freedom to organize its technician and technician-engineering courses in conformity with its own established pattern of education and culture, and in accordance with its particular technical needs. Also the implementation of the recommendations could facilitate the movement of technicians and technician-engineers between countries.
Part Two

Education and training systems in selected countries
7. Introduction

Much of the material of Part Two arises from investigations into the way in which some fifty countries provide the education and training of their technicians and technician-engineers. The systems of thirty-nine of these countries are briefly indicated in the summaries which follow.

The countries have been selected to provide as representative a coverage as possible. Hence, they include highly industrialized countries, and also examples of some where industry is as yet relatively undeveloped. Geographically, they have been chosen to include nations from Western Europe, Eastern Europe, Africa, the Middle East, South-East Asia, the Far East, Australasia, North America and Latin America. The exclusion of some countries (particularly those in the fifty but not in the thirty-nine countries) has mostly been occasioned by lack of particular items of reliable information often because the countries are undergoing educational change. The omission of such an important country as China, for example, is due to this cause.

It may be felt that there is an undue preponderance of examples from Western Europe. This is excused on the grounds that a great deal of early development in the field of the education and training of technician-level personnel took place in Western European countries. Also, three distinct systems emerged there, the German, the French and the British, each of which has exerted influence in many parts of the world. However, it must be confessed, this was also the area from which information was most readily available. (It would have been easy to have added another six Western European countries!)

For each country, a small diagram has been provided. It is important to understand, not only what it sets out to achieve, but also what it does not attempt to do. For example, each country summary begins with a 'flow chart'. This does not purport to
represent the educational system of the country concerned. It merely outlines, in the simplest possible way, the main paths only from the beginning of compulsory education to the acquisition of technician and technician-engineer qualifications. To this is added the main routes only to 'university-level engineer' and to 'skilled worker' (craftsman) qualifications, so that the 'boundaries' between which the technician and technician-engineer paths lie may also be seen. Occasionally, where these are particularly important, bridges between the four main qualification lines are inserted. But no attempt has been made to show these in detail—indeed, they have often been omitted altogether.

On the left-hand edge of each diagram is a circle with a number in it. The number represents the normal age at which compulsory education commences. Each square stands for a phase of education and/or training, indicated by PRI (primary), SEC (secondary) or by letters explained below the diagram. The figure in the square indicates the number of years of study involved. Thus, starting at the circle and progressing along a line until a technician or technician-engineer qualification is reached and adding the numbers in the squares passed, gives the total length of education-plus-training; and adding the figure in the circle provides the minimum age at which the qualification may be acquired. A square drawn with double lines indicates a period of full-time practical training, or of experience in industry, required as part of the qualification. These particular squares do not represent the whole of the practical training in the course. Some training—often a great deal—is integral with the courses in the institutions. In general, figures in squares represent either full-time institutional education and training; or part-time education, with concomitant training either within industry, or, perhaps, in special 'off-the-job' training centres. In many cases part-time courses alternative to the full-time ones, but without planned concurrent training, constitute an important part of a country's provision. This has, in general, not been shown; but a comment to this effect may be included in the written summary.

At the end of a course leading to a technician or technician-engineer qualification, the title achieved is given in the language of the country concerned, where this has proved practicable. Sometimes, a literal translation is added. Very frequently, especially in nations where there are many languages, this has proved impossible. In certain countries, however, the problem has been simplified by the fact that the nation has retained the name associated with the European country from which it has derived its education system. Thus 'technician' or 'technicien' are names widely used in African countries, for example.
Introduction

Each qualification deemed to be at technician level has been labelled 'T', while those at technician engineer level have the letters 'TE' appended. It has already been stressed that because two courses are both labelled 'T', or both 'TE', this does not necessarily mean that they are equivalent—merely that they both meet the entirely arbitrary criteria suggested. It is most important to note that these are not definitive gradings. They have been made solely as a demonstration to show how, if the criteria suggested in Chapter 4 were adopted, the particular courses might be rated. The word 'might' is important; for any definitive grading would need much more detailed and careful accreditation of courses to be undertaken than has been possible in this simple exercise. The very crude yardstick of formation would need to be augmented by considerations such as hours of instruction per working year; the proportion and nature of practical work; any concomitant or 'sandwiched' industrial training or experience; etc. However, incomplete and approximate though it is, and though it would be necessary to consider carefully whether or not the criteria proposed could be adopted, the exercise shows clearly enough the feasibility of establishing an international classification and nomenclature for technicians and technician-engineers.
8. Country summaries

The succeeding pages provide a brief picture of the formation of technicians and technician-engineers in the following thirty-nine countries or territories: Argentina, Australia, Austria, Belgium, Brazil, Canada, Czechoslovakia, Denmark, Egypt, France, Federal Republic of Germany, Ghana, Greece, Hong Kong, Hungary, India, Indonesia, Iran, Iraq, Italy, Ivory Coast, Japan, Kenya, Republic of Korea, Malaysia, Mexico, Netherlands, New Zealand, Nigeria, Pakistan, Poland, Spain, Sweden, Switzerland, Thailand, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland, United States of America, Zambia.
The education system of Argentina is in the process of change. The diagram illustrates the new system, which is not yet in general operation. Technician students now follow a three- or four-year course (four years for most engineering specializations), after nine years of primary and intermediate education. They are usually entitled 'técnico' (or sometimes 'auxiliar de técnico'). Technician-engineers courses are offered mainly in technical institutes, and lead to diplomas conferring titles of 'técnico superior', ingeniero técnico or—in the case of a few courses conducted in universities—'técnico universitario'.

There are some major firms which operate training schemes in conjunction with the technical schools; but these are few. Generally, at both levels it is expected that the courses will provide their own relevant practical content, and that the technicians will emerge trained to do the job.

As is usual in Latin American countries, engineers are registered with colegios; and Argentina is unusual in having regional colegios, additional to the national one. The activities of the colegios do not, as yet, have much impact at technician and technician-engineer levels.
As the individual states have a large measure of autonomy in the field of education, it is not possible for a single diagram to achieve a representative picture of them all. But, at the levels of post-school education, there is a high degree of consistency across states.

Australia, in common with most industrialized countries, has evolved a four-tier structure for its engineering personnel. The terms used are as follows: professional level, 'professional engineer'; middle or para-professional level, 'engineering associate'; technician level, 'engineering technician'; trade level, 'engineering tradesman'.

It will be noted that the level which has been referred to throughout this report as 'technician-engineer' is designated in Australia as 'engineering associate'. It is understood that the term 'technician-engineer' was specifically rejected, it being agreed that...
the word ‘engineer’, whether qualified by an adjective or not, should be reserved for the ‘professional level’ of the engineering work force (described as ‘university-level engineer’ in this book).

The Institution of Engineers, Australia (I.E. Aust.) is the body concerned with accreditation of professional engineering education. A parallel body, the Australian Institute of Engineering Associates (AIEA), performs similar functions for engineering associates.

Engineers qualify educationally from four-year full-time courses leading to degree of B.E. at universities or B.Eng. at most CAEs. Corporate membership of I.E. Aust., giving the status of Chartered Engineer (Australia), may be attained after three years of structured experience following graduation. The same educational qualification may be reached in a minimum of six years of part-time study, and one-fifth of students attend in this mode. A few CAEs offer sandwich courses.

CAE courses providing the educational qualification for engineering associate are of two years full-time following twelve years of school. The alternative and predominant route to educational qualification as an engineering associate is by part-time education at a technical college, accompanied by concurrent work experience. Such education is of four or five years' duration following ten or eleven years of school. Two years of satisfactory practical experience is then required before attaining the status of corporate membership of AIEA. There are few post-experience courses available for engineering associates.

Courses for engineering technicians take two forms, and are not available in all states. Trade-related technician courses, four years part time after ten years of school, are taken with indentured apprenticeship. Office-related technician courses normally are three years' part-time after ten years of school.

Engineering tradesman serve indentured apprenticeships of four years and concurrently undertake part-time study for three years. Post-trade part-time courses of one to three years duration are available as post-experience education for tradesmen and such courses are well supported.

Involvement of industry in the development and regulation of courses for engineering associates and engineering technicians varies between states, but on the whole there is close co-operation between industry and education, and in some states there is a heavy involvement of industry representatives on course advisory and development committees. The normal approach to the work components of education and training is by supervised experience. Technical and further education (TAFE) authorities exist at federal and state levels to supervise and conduct education in technical colleges, and apprenticeship authorities supervise apprenticeship and associated education.
Austria

The Austrian educational system is characterized by several types of school, especially at the secondary level. It is emphasized that the diagram is concerned primarily with main routes to technician and technician-engineer qualifications, and the number of years spent in achieving them.

The title given to technician-engineers is 'Ingenieur'; and, with only thirteen years of education, it falls well short of the minimum period of education and training suggested. But HTL courses feature upwards of forty class periods per week, plus compulsory summer practical work; also the conferment of the title does not occur until after at least three years of relevant experience, which may be considered as a major augmentation to the theory and practice of the course followed. The technician title is 'Techniker'. Here too, while the total period of education and training falls short of the length suggested, this is to some extent offset by the number of hours of instruction per session.

The title of the 'university-level engineer', namely 'Diplomingenieur' is protected by law, as is also the 'Ingenieur' title. While there is general freedom to practise the profession there are certain activities which may be carried out only by registered engineers.

The Austrian Register of Engineers was established in 1973. To qualify, the candidate must be a 'Diplomingenieur' with at least five years of post-qualification experience. There is a similar body for 'Ingenieur'. The establishment of comparable organizations for Techniker has been discussed.

R, Reifezeugnis; DI, Diplomingenieur; HTL, Höhere Technische Lehranstalt; H, Hauptschule; BS, Berufsschule (part-time school for apprentices); TF, Technische Fachschule (technical trade school); TK, Technisches Kolleg.
The schools providing courses at technician and technician-engineer level are the responsibility of the Federal Ministry for Education and the Arts, which defines their curricula by decree. But curricular changes are examined by industry before they are introduced.

The payment and promotion of technical personnel tends to depend upon ability and service. But some jobs are frequently advertised as requiring specific qualifications and are denied to those without them. There is close involvement with industry in the planning of technical courses at post-school level.
Belgium

The Belgian system of technical education is one of the few that, effectively, offers four levels of qualifications above that of skilled worker. The first, that of 'technicien', is achieved on the successful conclusion of a three- or four-year course, following the lower secondary-school cycle of three years. Although some schools offer the three-year course, the four-year one is common and provides the thirteen-year total suggested as a norm for the full education and training of a technician.

The second qualification involves passing a two-year course following the full secondary education of six years. According to the nature of the course, those completing it successfully acquire the title of 'technicien supérieur', 'technicien gradué', 'conducteur technique' or 'assistant d'ingénieur'. While the course provides a good formation lasting fourteen years, as this falls a year short of the recommendation, the label given is TE.

The upper level of this course has perhaps been partly determined by the existence of an intercalary grade between it and the 'university level engineer'. Until recently (1977), these intermediate-level personnel followed a three- or four-year course at a higher technical school, from which they emerged with the title of 'ingénieur-technicien'. The course (even at three years) met the minimum proposed requirements for the technician-engineer grade, and, indeed, exceeded it comfortably in those courses which were of four years' duration. It was therefore claimed that, despite its title, it...
was above technician-engineer level, a contention upheld by FEANI, which gave it an 'Ab' rating (i.e. in the 'second division' rating of 'engineers'). Perhaps partly because of that rating the courses have now all been made four year, and in some the programmes have been in a measure revised. The institutions offering them have been renamed 'Institut Supérieur Industriel'; and the title conferred upon those who successfully complete the course is 'ingénieur industriel', and no longer 'ingénieur-technicien'. This provides an example—of which, mercifully, there are few—of how difficult it is to draw arbitrary lines across the face of what is, in fact, the continuous occupational spectrum illustrated in Figure 1. The old 'ingénieur-technicien' qualification differed from that of 'ingénieur civil' largely in the emphasis which it placed upon engineering applications, and upon practical work. Its specifications read very much like those which many authorities have suggested as an ideal for a technician-engineer. However, the new 'ingénieur industriel' qualification has now replaced it; and those who have it may only be assimilated to the new title either by taking additional courses, or by being adjudged worthy of it in the light of their post-qualification experience.

Belgium is also unusual in the extent to which it has developed societies for engineers, technician-engineers and technicians. The main engineering bodies are the Société Royale Belge des Ingénieurs et Industriels and the Koninklijke Vlaamse Ingenieurs vereniging, for the two linguistic communities. There is also the Fédération des Associations Belges d'Ingénieurs, which involves both 'ingénieurs' and 'ingénieurs industriels', and includes both French- and Dutch-speaking members.

For the 'ingénieur industriels' there exist the separate language-based Vereniging van Vlaamse Technische Ingenieur and the Fédération des Ingénieurs-Techniciens; and finally the conjoint Union Nationale des Ingénieurs Diplômés de l'Enseignement Supérieur Technique et de l'Enseignement Supérieur Agricole (UNIT-NUTI).

There are also many regional associations, e.g. Association des Ingénieurs Techniciens de Bruxelles, etc. All these bodies organize symposia and concern themselves with professional training. They do not, however, act as qualifying bodies.

The title of 'ingénieur civil' is protected by law, and its holder may use the prefix 'Ir' to his name. Ingénieurs industriels may use the prefix 'Ing.'.

1. This organization embodies (a) ingénieurs titulaires d'un diplôme de grade scientifique (1884-1934); (b) ingénieurs techniciens (1934-84); (c) ingénieurs industriels (1977).
The titles of 'ingénieur technicien' and of 'technicien' are also protected; but not the titles at 'technicien supérieur' level. Apart from certain posts which are reserved for those with special qualifications there is freedom to practise the profession, and many 'ingénieurs-techniciens' have risen to the highest levels. Despite this mobility, it may be said that qualifications command both respect and, in general, a measure of financial reward.

As mentioned in Part One, Belgium has a jury system which enables educated persons with relevant experience to be awarded, at all levels, the appropriate certificates or diplomas, without attending formal courses, provided they satisfy a central examining body of their worth.
The Brazilian school system is still in the process of reorganization. One of the effects is to change the nature of secondary education (secundo grau), which was previously highly stratified, with the academic schools (escola secundaria) and the technical schools (escola técnica) separate in all respects, including curricula content. Now all secondary-level schools must provide a 'common experience' together with a 'habilitação', or qualification in a professional area. The reorganization provides for over fifty kinds of courses at technician level, and about eighty at assistant level. Requirements are specified in terms of hours, rather than years of study. This partly accounts for the % figures indicating the length of the secondary course. The engineering-technician courses may take four years. Also, the entrance examination to the universities, the 'vestibular', with a roughly 40 per cent success rate, frequently requires the student to study beyond the three-year period (often at 'cursinhos', 'cram' schools especially devised for this purpose). It is because of this reorganization that secondary schools have not been shown as establishments specializing in particular educational areas, although many still do, and the choice of 'professional options' may, in some, be very limited.

Technician-engineers follow two- or three-year courses at certain universities and at federal colleges of technology (stipulated length, 2,425 class hours).
At technician-engineer level, the title is either 'técnico superior' or 'técnólogo'. (These replace an earlier title which is still much used, namely, 'engenheiro de operação'—not to be confused with the 'university-level engineer' title of 'engenheiro', which is often formally used as a term of address.) Although the total 'education-plus-training' period could be fourteen rather than the fifteen years suggested, this is from the age of 7; so it is felt that the qualification reaches the proposed level. Certainly, it is highly regarded, and has been planned to provide personnel at the level of responsibility defined in Part One as appropriate to technician-engineers.

The technician is known as a 'técnico' usually with an addition to indicate his specialist area, 'técnico elétrico'. He qualifies as such after a course of about 2,700 hours of which about 1,000 will consist of specialized study. Not less than 10 per cent of the course will be spent in 'on-the-job' training. As the school course will usually be of four years' duration, the total 'education-plus-training' period will be twelve years short of the suggested minimum period. However, taking some account of the fact that education starts at the age of 7, and that the courses have been designed as technician courses, with a good content of practical work, they have been rated 'T'.

The secondary schools also provide a course, shorter by one year than the 'técnico' one, and with a higher proportion of practical work. It has a minimum duration of 2,200 hours, with some 300 spent in specialist studies. No 'on-the-job' training is required. Successful students qualify as 'auxiliar de técnico' (assistant technicians).

The schools also provide craft training producing, usually after further apprenticeship or learnership training, skilled and semi-skilled workmen. These are also trained through apprenticeship under the auspices of SENAI, an organization run conjointly by government and employers. SENAI (as well as the major firms on their own) also operate short-term training for adult students who did not complete the first eight years' schooling period. The system in this way (and otherwise) provides for a measure of qualification improvement, whereby skilled workmen can become 'técnico'; 'técnicos' may advance to 'técnicos superiores', and from there to 'engenheiros'. These 'progression' facilities are not without their problems. The earlier shortage of engineers has been to some extent made good. The major shortfalls are now at technician-engineer and technician levels. Despite these shortages, a very large proportion of those who qualify as técnicos (estimated at above three-quarters) go on to higher education. Thus the ratio of 'technician/engineers plus technicians' to university-level engineers is only about 1.5 to 1. This results in some engineers being employed in technician-level posts.
As in most Latin American countries engineers in Brazil are registered through membership of a board called a colegio—although Brazil is unusual in that it has regional colegios also. Associations of técnico, each concerned with particular occupations, and which register technicians, have developed in recent years.

While ability and experience are the main requirements for appointment and promotion, the growth in technical education and training is resulting in a greater demand for specific qualification.

The major industrial companies play a good part in determining that technical education relates to the needs of industry. They provide work experience at several levels of training; they run their own specialist and updating courses; and they co-operate with national organizations such as SENAI, SENAC, etc.
Canada

The major responsibility for education in Canada is at provincial level. In consequence there are differences between the systems operated in the various provinces. In particular, the system of the Province of Quebec is sufficiently unlike that of the rest of Canada as to warrant a separate diagram (b).
In the other provinces of Canada, the primary and secondary cycles commonly cover twelve years of education; but in some their high schools provide a thirteenth grade. Where this is optional one may find that good results at thirteenth-grade level are required for university entrance, while an adequate performance in the twelfth grade may suffice for entry to technician-engineer level courses. These are offered (as are also technician courses) at post-school establishments variously entitled, in the different provinces, junior colleges, community colleges and colleges of applied arts and technology. It will be seen that 'technologist' (technician-engineer) courses may be of two or three years' duration. Most are three-year courses; and where the colleges offer only two-year courses they involve much longer working years than is otherwise the case. The title acquired by students following the two-year technician course is 'technician', while those who succeed in passing the two- or three-year technician-engineer level courses are called 'technologist' (often preceded with the word 'engineering').

Another difference between provinces is the extent to which vocational education, including practical training, is provided in the high schools. There are some where this is small. Others effectively provide virtually full-scale skilled-worker training; and certain schools offer technical courses which may count for one-year credit in subsequent technologist courses (that is, direct entry into the second year of a three-year course).

In the Province of Quebec the high schools, in general, end at the eleventh grade and the students move to collèges d'enseignement général et professionnel, where in two-year courses they may either go into industry as 'technicien' or progress through two further years of study to the qualification of 'technicien supérieur' or 'technologue'.

Although many colleges provide evening-study courses for those already in the work force, the majority of trained technicians and technologists have taken the full-time courses indicated in the diagrams. These are planned to include a sufficient degree of practical work and 'equivalent work experience' to make the technician or technologist immediately employable as such on graduation. However, a number of firms provide additional training, partly general, partly 'product training' to newly qualified personnel. (Some firms provide their own complete technician training schemes.) Initial remuneration commonly reflects the level of qualification; and two major firms which indicated their pay scales both showed a technician scale where the top end overlapped that of the lower end of the technologist scale; and this, in turn overlapped, at its top end (and to a large extent) the scale for engineers. In both firms, high-level posts were said to be open to able men irrespective of qualification.
Canada has a number of associations of professional engineers. Partly through their efforts and in collaboration with industry, it has also developed corresponding organizations at technologist and technician level—for example, the Ontario Association of Certified Engineering Technicians and Technologists (OACETT). Membership of these associations normally requires the passing of their own examinations, or the acquisition of the appropriate corresponding diploma from the college. Experience, usually a minimum of two years, is also required. Successful candidates are registered as certified engineering technologists (or technicians). But, as there is general freedom to practise the profession, registration does not confer any particular rights.
Czechoslovakia

Technical education is the responsibility of the two ministries of education (one for Slovakia, the other for the Czech countries). Curricula are approved by the ministries of education, to whom the requirements of industry are made known through the other appropriate ministries.

Czechoslovakia is one of the few countries which has only one level of technician, 'stredni technik', perhaps best translated as 'middle-level technician' (although there are no others!). The four-year course contains a good proportion of practical work and any skills subsequently needed are, in general, acquired in the work situation. But full-scale training of technicians is not carried out in firms, which rely upon the school system to produce them. As in other East European countries, the possibility of self-improvement and of upward mobility in technical employment is enhanced by a wide provision of evening-class facilities. Broadly speaking, evening classes, with a smaller practical content than the full-time ones (because students are in industry) take one year longer than the full-time courses.

The professional interests of engineers and technicians are the concern of a national organization, Ceskoslovenska Vedecko-Technicka Spolecnost.
The school system in Denmark has recently been reorganized into a nine-ten-year comprehensive system. Entry into university-level establishments is then normally achieved by success in the studentereksamen following a three-year course in the gymnasium. The DTH and AUC courses lead to the qualification of 'civilingeniør', and the DIA (and AUC) to the lesser one of 'akademiingeniør'. It is not immediately clear whether the latter qualification should be regarded as a 'university-level engineer' one, or whether it should be rated at technician-engineer level. Bearing in mind that the commencing school age is 7 and that the DIA course is three years (plus at least six months' practical training) beyond university entry level, it would seem reasonable to regard it as above technician-engineer level (as in fact, does FEANI).

The qualification of 'teknikumingeniør' may be achieved by several routes, all involving a three-year course at a teknikum. The diagram shows the three main paths. In the past, the most favoured route has been through four years of vocational training, followed by a one-year preparatory course at an engineering college; however, the present tendency is for an increasing proportion to qualify by direct entry to the three-year course after three years of study at the
gymnasium. It will be seen that it is also possible to qualify by way of two-year course of vocational education (leading to a 'tekniker' qualification), followed by a preliminary year before entering the three-year teknikumingeniør course. There is also another path, not shown on the diagram, enabling the nine-ten-year course of basic education to be followed by supplementary theoretical courses (at studenterexamen level) and at least two years of vocational work, before the three-year course is entered.

It will be seen that the shortest of these routes enables the teknikumingeniør qualification to be obtained after fifteen years of study (but from the age of 7). On the criteria suggested this would put it into the 'technician-engineer' grouping, and therefore it has been so shown. However, it must be said that in the Danish Education Nomenclature (DUM), akademiingeniør and teknikum-ingeniør are placed at the same level within the system of further education. Thus this country provides one of a number of examples where divisions exist at the engineer level.

The qualification of 'tekniker' may be obtained either by 'short technician education' (a two-year course following the nine-ten-years of basic education) or by 'long technician education', which embodies 18 months to three and a half years following vocational education and training. Thus, at a minimum, the qualification can be obtained after eleven years of study. But as this is from the age of 7, it has been shown as 'T' in the diagram.

There are two professional associations of engineers in Denmark, but comparable organizations specifically at technician engineer and technician level do not yet exist. But the three titles of 'civilingeniør', 'akademiingeniør' and 'teknikumingeniør' may only be used by those so qualified. However, this does not restrict the right of anyone to practise the engineering profession.

There is a requirement that all engineering level qualifications must be preceded by practical training and/or industrial experience (usually both).
The two ways to technician qualification are shown in the diagram. The five-year course is recent, and produced its first output in 1975. The two-year course is at present the main source of technicians (about 3,000 a year). The title is 'amel fanni' (technician). The GCE examination, taken after twelve years of education, sorts out those who are selected for a five-year engineering-degree course at the universities. Those who pass the examination but fail to gain university engineering places may apply for admission to a higher technical institute and follow a degree course with an industrial bias. It is probably fair to regard this as equivalent to the American 'engineering-technologist' degree, which is considered to be at the upper end of the 'technician-engineer' spectrum. These graduates are called 'mohandess' (engineer).

It is probably true to say that, in the past, to some extent, still, lack of adequate practical training has been a weakness in Egyptian technical education. Recent years have seen a massive development in industrial training courses and in apprenticeship centres. There is an instructor training course at the industrial training institute.
Engineering technicians. Some problems of nomenclature and classification

providing a yearly injection of well over 200 'trained trainers' into industry and into craft and technician-producing establishments. Some sandwich courses are being developed.

Shortages of industrial personnel enable anyone able to do a technical job to obtain employment. But Egypt is 'qualification conscious' and technicians and higher technicians with the recognized certificates can secure good positions.
France

Titles used are 'technicien' and 'technicien supérieur'. However, there are other titles used in industry, such as 'agent de maitrise', who is commonly the man in charge of a group or groups of skilled workers. When the group is small the man in charge may be called a 'contremaitre'. Such men may or may not have a brevet de technicien or similar qualification. Another 'workshop rank' which may or may not be held by a 'technicien breveté' is 'agent technique', who may be a production planner, production controller, work-study technician or quality-control assistant.

Engineering diplomas from schools, such as the ENI, the grandes écoles and the universities recognized by the Commission des Titres d'Ingénieur are protected by law. Thus the title 'ingénieur diplômé' is legally protected, although the word 'ingénieur' by itself is not. It has become established practice to adopt the same attitude with
regard to 'technicien' and 'technicien supérieur' qualifications. This means in practice that, while anyone may call himself a 'technicien' or a 'technicien supérieur', he may not, unless properly qualified, claim to be a 'technicien breveté', 'technicien breveté supérieur' or a 'diplômé universitaire de technologie', since these titles relate to qualifications awarded by the state and protected by law.

No specific indication is given in the diagram of any requirements for practical training. In general, such training is an integral part of the technician and technician-engineer courses. Some categories of BTS and DUT courses, however, involve a period of compulsory practical training; and some schools have arrangements for short attachments to local industry. A relatively small amount of technician training is done in écoles privées, schools within works, usually operated by large firms. (Such schools are mainly concerned with skilled-worker training.)

France has a well-developed system of 'continuing education' which allows educational shortcomings to be made good, and permits the acquisition of higher qualifications, i.e. skilled worker to technician, technician to technician-engineer. In particular, facilities exist whereby selected holders of the DUT may enter the second year of courses at certain engineering schools. Access to the title of 'ingénieur diplômé' may also be available to DUT holders after three years of experience and the passing of certain courses. There also exists the uncommon system whereby employers pay a tax of 1 per cent of their pay roll as a contribution to training costs. They can recoup this by providing satisfactory training in their own establishments. There is in France an individual right of access to training. Every wage-earner has the right to training leave of one year in every twelve.

Compared with some other European countries, France has been relatively slow in developing professional engineering institutions.

The organization Ingénieurs Professionnels de France offers a certificat de qualification professionnelle; and France Intec (Société Nationale des ENP-BTS-DUT) provides a form of registration at the technician-engineer level to suitably qualified personnel who desire it. Neither institution has official (governmental) standing.
Federal Republic of Germany

Education in the Federal Republic of Germany is the responsibility of the Länder (states). Also education is undergoing important reorganization, at both school and post-school levels, which has progressed in different respects, and to different extents, in the eleven Länder. It is therefore not possible to give a picture in a simple diagram which truly represents the situation in all Länder.

The main modifications in the school fields are: (a) an increase in the period of compulsory education from nine to ten years; and (b) the introduction of eight-year Gesamtschulen which may eventually replace the Gymnasien and the Realschulen. Thus the two main school lines to higher education which now exist, a thirteen-year programme and a twelve-year programme, may coalesce into one common twelve-year line.

In higher education, the main change now in train is the development of Gesamthochschulen, which combine the four- (to five-) year engineering courses hitherto offered by the technical universities with the three- (to four-) year courses available...
originally at the Ingenieurschulen, now Fachhochschulen. (The '4+' and '3+' figures in the diagram indicate that the stated length of the courses is extended by periods of required practical training and project work amounting to about a year. There is also a requirement of about six months' training at or before the course begins.)

The effect of reducing the pre-university school period from thirteen years to twelve will tend to bring the 'Diplomingenieur' and the 'Ingenieur (Grad)' qualifications closer together, as will the planned arrangement (already effective in some institutions) of making the courses partly common. This will increase the pressure exerted in some quarters to make the standing of the Ingenieur (Grad) qualification the same as that of the Diplomingenieur.

Despite this, the ingenieur (graduiert) title has been tentatively equated to technician-engineer. In total study time, it exceeds the minimum suggested for technician-engineer only by the additional practical component appended to the three-year course. Also, the two-year period at the Fachoberschule contains a large practical element, indeed, attendance at the school may be part time. Thus the total preparation would appear to be an excellent 'formation' for a technician-engineer. The other title, 'Techniker', acquired after a course of about three and a half years following vocational education and training in a Berufsschule and in industry (or, sometimes, full-time training in a Berufsfachschule).

Each of the eleven Länder has promulgated a law protecting the right to use the qualifications of 'Ingenieur' both at 'Diplomingenieur' and 'Ingenieur (Grad)' levels (and including the technician-engineers who, before the introduction of Fachhochschulen, qualified as 'Ingenieur' at 'Ingenieurschulen'. There is a national register, the Verein Deutscher Ingenieure. Technician associations, such as the Verband Deutscher Elektrotechniker, have also recently been set up.

Relations with industry tend to be close. The Federal Commission of Engineering Education provides a direct link between industry and the education industries of the Länder. There are federal and Länder vocational training committees with strong industrial representation.

While renumeration and promotion depend largely upon personal record, there are some industrial firms which also have pay systems in which level of qualification is taken into account.
Ghana provides a notable example of complex nomenclature of technician-type jobs. While there are no countrywide agreed-upon names, the government has adopted the following names for technician posts within the civil service, at seven levels: (a) technical apprentice; (b) technical assistant (grade III - grade I); (c) assistant technician; (d) technician/technologist; (e) senior technician/technologist; (f) assistant chief technician/technologist; (g) chief technician/technologist. In other organizations, while these names may be used, so too may technical officer, supervisor, senior supervisor, engineering technician, technician engineer, senior technician engineer, etc. The diagram indicates what are perhaps the commonest names at the two levels.

The courses shown are the common full-time institutional ones, with the involvement of industry in the one-year training periods. In a few suitable areas part-time courses for City and Guilds qualification are also available.
Greece

The lower-level qualification is 'technitikos voitos' or 'technical assistant'. While it is intended to be a technician qualification, it is achieved after only twelve years of education—hence the 'T' label. The higher-level qualification is the result of a three-year course at a higher technical education centre. KATEE are of recent origin and have been formed from what were previously 'scholai ypomichanikai' or schools for 'assistant engineers' (i.e. technician engineers). It has been claimed that the three-year course at a KATEE leads to a qualification of 'professional-engineer' level, in the British sense, and that the previous title of 'ypomichanikos', or assistant engineer, is no longer applicable—that the title should, in fact, be michanikos. Whatever title may be adopted, it would appear that the application of the criteria suggested leads to 'technician-engineer' rather than 'engineer' status. So a TE rating has been appended.

The courses are institutional—links with industry, and the provision of industrial training, have yet to be well developed.

The titles of engineer and of sub-engineer are protected by law, and no engineer may practise as such in Greece unless he is registered with the Technical Chamber of Greece. Technicians are permitted to practise freely and no registration arrangements exist.
Hong Kong

The technical education system in Hong Kong resembles the British system from which it stems. Study for the ordinary technician diploma commences from the end of the five-year secondary education cycle. The course is of two years' duration and contains a good practical element. Those who succeed in it qualify as technicians. A further two-year full-time course leads to the higher technician diploma and a higher technician title (the name technician-engineer is also used, but not yet widely). The polytechnic, which has strong links with the professional institutions and the Council of Engineering institutions in London, also offers a CEI Part 2 course to selected students successful in the higher technician diploma. This has been shown dotted, as the route is an exceptional one.

Although of small size, Hong Kong is highly developed industrially, and has a strong Federation of Industries, and a Hong Kong Training Council. There are ten industry training boards. While much of the co-operation between the educational training establishments and industry is at the craftsman level, arrangements have been made for technician trainees also. There are well-established day-release, block-release and evening courses, at the technical institute and the polytechnic.
Engineering technicians. Some problems of nomenclature and classification

Hungary

The simplified diagram above omits, for reasons of clarity, the facilities available by part-time and correspondence studies. These provide, especially for those who have not passed the erettség (school-leaving certificate of the gymnasium), a means of access to technician and higher-technician courses. Those who obtain the diploma at the end of the technician course are, after two years of practical work, entitled 'technikus' (technician); and those who succeed in passing the course at the higher technical colleges qualify as 'uzemmérnök' (or in some cases 'technologus').

It will be seen that, while the technician-engineer level course meets the suggested guideline of fifteen years of education, the course in the technikum ends one year short of the proposed thirteen-year period. However, the total hours required for the four-year course are much the same as those for five-year courses in Western European countries. (The technikum course year is one month longer than that worked in the gymnasium). Also as mentioned, a two-year experience period is required.

The skilled-worker courses take place not only in schools but in factories. The specialized secondary-school courses involve about 30 per cent of practical work, and also summer training in production or other industrial work. Short periods of attachment to factories constitute parts of some courses. Thus good industrial training arrangements exist, in conjunction with the educational establishments. Technical qualifications are highly regarded and, in general, correspondingly rewarded.
India

Holders of the technician diploma, awarded on the successful completion of the three-year full-time or three-and-a-half-year sandwich course, are known by the title 'technician'. (There are a few two-year courses which claim to be for technicians but, judging by their curricula, they are closer to higher level craft courses.) The diagram shows a one-and-a-half-year post-diploma course leading to

Education is primarily the responsibility of state governments. There is in consequence some variation in the structure—but mainly at school level. State governments usually organize their technical education through directorates of technical education which function as the secretariat, and state boards of technical education, which control the polytechnics, where technicians are trained. National policy is influenced by two powerful advisory bodies, the Central Advisory Board of Education (CABE) and the All-India Council for Technical Education (AICTE). This latter body has a subsidiary, the All-India Board of Technician Education (AIBTE).

HSE, higher secondary examination; PUE, pre-university examination (also other titles); TD, technicians diploma; STD, senior technicians diploma; EC, engineering college; P, polytechnic; ITI, industrial training institute; AT, apprenticeship training. (The diagram represents the predominant pattern in 1978. It has been decided to replace it with what is known as the 10 + 2 + 3 pattern—ten years of general education, two years of higher secondary education with a bias towards vocational requirements, and three years to the first degree. No doubt, as now, most universities will require a longer period for an engineering degree. The changes seem unlikely to have much effect on the technician courses.)
a 'senior technician' award and title. To avoid giving a misleading picture, it must be stressed that these courses are of recent origin and, as yet, are few in number. Thus, in practical terms, India is a country with only one level of technician personnel, although, in time, the senior-technician courses may change this situation. Much work at senior-technician level is at present carried out by men with engineering degrees.

It has been said that many technician courses are too theoretical, and that they do not satisfactorily meet the needs of industry. The 'country paper' submitted by the Ministry of Education and Social Welfare to the International Conference on Education and Training of Engineers and Technicians, organized by Unesco in New Delhi in April 1976, described the three-year technician courses as 'wholly institution-based and generally academic and theoretical in content and method'. Some might well regard this as a good description of a bad technician course! However, an examination of curricula reveals that, for some establishments, it is inaccurate. Also, the criticism of an inadequate practical content has been to some extent met by the recent development of a four-year sandwich version of the three-year full-time course. This is but one example of the closer involvement of industry. Another is its co-operation in the revision of technician programmes, some of which were virtual copies of United Kingdom courses, without the necessary modifications required to meet India's needs.

Also, technician courses are under continuous revision because of the curriculum development and other work undertaken in this regard through the four specially established technician teachers training institutes which are training serving teachers in the technical institutions to make up their deficiencies in various areas such as pedagogic practice, industrial exposure and subject content. These institutes also conduct, as do other agencies such as the Indian Society for Technical Education, special programmes for updating and upgrading the technician teachers. A third and important development is the fairly recent regulation which has brought technician training within the purview of the 1961 Apprentice Act. Four regional boards of apprenticeship training arrange for placements of newly qualified technicians from the three-year courses, involving a one-year training programme, during which they are paid a stipend.

Degrees and diplomas, and the right to use any designatory letters associated with them, are conferred by universities and other higher education institutions. For polytechnies and industrial training institutes, the conferring authorities are the state boards. There is a Board of Assessment for Educational Qualifications which advises the government on standards of qualifications.
The major professional institution in the field of engineering is the Institution of Engineers (India). It includes all the major engineering disciplines. It conducts its own examinations and accords 'professional engineer' status to those who pass them at the appropriate level. Technicians may, by studying for associate membership, thus qualify at engineer level. In recent years a number of other professional bodies have entered the examination and qualification field, including some for technicians. Neither at engineer or technician level has registration become a requirement. There is freedom to practise, save only in certain posts where safety is important, and for which licences are required, e.g. mining, electrical power supply.

India provides a major example of a linguistic problem in connection with technical courses. Candidates will, in general, have undergone primary and secondary education in their indigenous tongue with English being taught as a foreign language. Their technician courses will, in most cases, be conducted totally in English. That this constitutes a difficulty for many students is quite certain. What one does not know is to what extent it contributes to the fact that nearly 40 per cent of the candidates fail to get through the three-year courses in the stipulated time.
Indonesia

The education system of Indonesia has been recast, and the old system is being progressively phased out as transitional arrangements are ended. Only the new system has been illustrated. It makes specific provision (as the earlier system did not) for courses for higher technicians and for trade technicians. The former have a total education period of fifteen years and thus meets the suggested requirement for TE. But the trade technician course, with twelve years, falls a little short. Even taking account of the fact that education is not begun until the age of 7, it is felt not unreasonable to suggest a 'T-' classification.

At all levels of instruction (except in some subjects in certain universities) the language used is Indonesian. At technician levels, this leads to problems over textbooks and other teaching materials. While some books have been translated, and others are being produced in Indonesian, the problem is a real one, and adds another dimension of difficulty to the learning process.

Indonesia is at a fairly early stage of building up the technician force needed to support the economy. Until recently most of the necessary skilled labour force were either expatriates or Indonesians who were given ad hoc on-the-job training by expatriate enterprises.
Iran

The provision for the education and training of Iranian technical personnel is at present under review. As the simplified diagram above shows, there are two main routes through the upper secondary school. The 'academic' line leads to the universities and the technical one, while it may provide entry to an engineering-degree course, also leads to a technician qualification called, commonly, by the English word 'technician'.

While there is no other level of technician, those who leave the upper secondary technical school having completed the longer course, are better equipped technically than those who have followed 'skilled worker' courses, either in the schools or in the training centres which have been recently developed. They are sometimes employed in what may be considered 'junior technician' capacities.

Although in the oil and petro-chemical industries a great deal of training is being done (and more is planned), there is not as yet much active liaison between industry and education in other fields.
Iraq

Since the political changes of 1968, many developments have taken place throughout the Iraqi educational system, particularly in the field of vocational education.

Primary education (six years from age 7) is now compulsory. It is followed by three years of intermediate studies, after which progression may be made to either general or vocational secondary schools. The former provide the major path to university education; but graduates from either type of school may proceed to two-year courses in technical institutes.

These technical institutes provide courses for middle-level personnel over a very wide range of vocational work, including all areas of engineering and related studies. The number of applicants vastly exceeds the places available and selection is determined by (a) the branch of specialization studied at secondary school; (b) the secondary-school examination results (Baccalaureat); (c) the numbers required in each specialization; and (d) student choice.

Government planning aims at a specialist/technician/skilled worker ratio of 1:4:40. There is at present a large shortfall in technicians, many of whom are still expatriates. The achievement of the numbers of technicians required—and, particularly, the ‘formation’ of Iraqis at this level—is the responsibility of the Foundation of Technical Institutes (FTI). This establishment, founded in 1972, is attached to the Ministry of Higher Education and Scientific Research. It controls curricula, course structure and standards in the technical institutes, and evaluates all technician...
diplomas granted by the institutes. It is also producing suitable textbooks in Arabic.

The government intends, by 1985, that the technical institutes within the foundation shall provide virtually all the technician education and training the country needs, and a massive expansion programme is in train. However, the present shortfall in technicians and in the facilities needed for their training has led to the use of some university faculties for the middle-level courses. Further, training centres attached to various ministries, and which are primarily concerned with the training and upgrading of skilled workers, are also having to be used for specialized technician training. Finally, as the diagram indicates, facilities ('parallel technical education') have recently been developed whereby skilled workers who have graduated from secondary schools may upgrade to technician level by following a course, partly on the work-site and partly in the technical institute.

All technician courses are of two years' duration, and involve a practice-to-theory ratio of about 70:30. Attachments to relevant works, etc. amounting in all to twelve weeks are made. It will be seen that the total period of education and training is fourteen years and is from age 7; so a 'T+' grading has been given. It is worthy of note that, as yet, Iraq has apparently seen no need for two levels of technician.

The clear-cut development plan for technician education and training in Iraq, together with the extent of its implementation so far, constitutes a very interesting example of manpower planning at this level.
Italy

The secondary-school system now permits entry to university courses to all who pass the matrìt(a) examination, irrespective of the 'line' they follow after the first eight years of compulsory education.

The diagram shows the normal (but no longer the only) route to the qualification and title of perito industriale at technician level. Until a few years ago there was no qualification between this and the 'university-level engineer' (ingegnero). But now a small number of colleges of technology offer two-year courses, end-on to the perito courses, leading to the qualification of 'perito superiore', or 'superperito', as it is commonly called. This is at technician-engineer level.

There is a Consiglio Nazionale Ingegneri, and each province has its Ordina degli Ingegneri. Registration is compulsory for Italian engineers who wish to practise as such, and persons not so registered cannot do so. As yet, there are no corresponding regulations for 'periti' or 'superperiti'.

Relations with industry are close at skilled-worker level. (The diagram does not attempt to show the many in-plant and conjoint arrangements for such training.) But at higher levels the view has been expressed that there still remains much to be done.
Ivory Coast

The education system is very akin to the French one from which it springs. The titles are much the same, namely 'technicien supérieur' at technician-engineer level, and 'technicien' at technician level. However, the title 'agent de maîtrise' is widely used also for technicians.

While the country does not have a national association, it is an active member of the Association des Ingénieurs et Techniciens Africains (AITA). This body is represented on the Commission Nationale Mixte, which is concerned with the problems of development of industry in the Ivory Coast, including the manpower planning aspects; also the training and upgrading of technical personnel.
Japan

Japan is unusual in that it has a single level of technician—although there are two separate routes to the qualification. These are by (a) the five-year technical-college course end-on to lower secondary school; and (b) the two-year course at a junior college, following, usually, a three-year upper secondary technical course, although students taking the 'liberal' secondary route may also be accepted. In 1976, special technological universities were established which accepted into the first year selected students from the upper secondary school (technical bias); but also, directly into the third year of the four-year engineering-degree course, suitable graduates from the five-year technician course. There are also ab-initio masters degree courses of six years' duration (post upper-secondary school) which selected students from the technical colleges may enter with two years of credit.

It will be seen that the technician qualification is earned after fourteen years of education. Thus it does not match the fifteen-year period suggested for technician-engineering rating. This is probably what is intended to be, so it has been labelled 'TE-' rather than 'T+'. Those who succeed in either course are called 'technician' (the system is, of course, similar to that of the Republic of Korea, which derived from it. But, in the Republic of Korea the five-year courses have been phased out).
While practical training forms a part of the technical courses, specific skill training is provided in a variety of vocational training institutes and special schools. The dotted line in the diagram shows entry to them from lower secondary schools, and also from the various types of upper secondary schools. But in fact the very flexible arrangements provide for special training courses for those at all levels, including university graduates and those from the technician-producing establishments. Training also occurs within industry, the major firms particularly having well-developed training schemes, for initial training, retraining and updating. The vocational training laws of 1958 and 1969 provided for a measure of government control of training within enterprises, with official approval given to those meeting prescribed standards.

Graduates in engineering from the universities may become legally registered engineers. Technical-college graduates may, on an individual basis, be similarly registered as ‘engineers’; but a much longer post-experience period is required than is the case with ‘university engineers’ and the same registration examinations must be passed.
Kenya

The Kenya system of education greatly resembles the British one from which it originated. But at technician and higher technician levels there is a difference, in that most of the courses are full-time integrated courses of education and practical training. Part-time courses for those in employment are available at the polytechnics; but the full-time courses constitute the major source. A few technician courses, mainly those associated with a single employer are operated on a sandwich basis. But the provision of practical on-the-job training is not general. The title of 'technician' is fairly widely used and understood; that of 'higher technician' less so. Attempts to introduce the term 'technician engineer' have apparently met with little success so far.

Kenya has had an Engineers Registration Board since 1969. Again, modelled somewhat on British lines it requires not only a degree level engineering qualification but also at least three years' experience, of which not less than two must be post-qualification. There are current discussions concerning the extension of the register to other levels.

EACE, East African certificate of education; EAACE, East African certificate of advanced education; HSC, higher schools certificate; OTD, ordinary technician diploma; HTD, higher technician diploma; GS, grammar school; STS, secondary technical school; P, polytechnic; TC, trade centre.
Republic of Korea

E, selection examinations; GHS, general high school; VHS, vocational high school; JS, junior college; ---, minority routes.

The Republic of Korea is unusual in that it has a three-tier structure of engineering personnel, based on the basically simple education system indicated above. The bulk of the country's qualified engineering workers are produced by the vocational high schools, through three-year courses with about a 40 per cent practical skill content (vocational training institutes, run by the Ministry of Labour, also produce skilled workers on a narrower base). But officials will often refer to the output from the vocational high schools as 'technicians'. They do indeed eventually handle, according to their individual abilities, ranges of work which, in the case of senior craftsmen, might be considered in many countries to be technician level. (Trainees emerge from the vocational high school as 'Craftsmen 2', reach 'Craftsmen 1' level after a minimum of three years, and 'senior craftsmen' no less than seven years later, tests having to be passed at both levels.)

However, the 'intermediate personnel' are largely provided by the junior colleges, which offer excellent technician programmes in often very well-equipped establishments. Not only the total period of education (fourteen years) but also the content and general standard of the courses, warrants placing them mid-way between the 'technician' and the 'technician-engineer' positions as judged, say, in
a West European context. They are perhaps marginally nearer to technician-engineer. The 'rank' of a newly qualified junior college graduate was translated by the Ministry of Education as 'field engineer', ranking on the official scale as 'Engineer 2'. After a minimum of two years' experience as such, and the successful passing of a test, he may advance to 'Engineer 1'; and, seven or more years later, to 'senior engineer'. The university-trained graduate starts at 'Engineer 1'. Thus the system, which is relatively new, ought to secure two important results. The first is mobility and promotion, depending upon both experience and ability; and the second is reward for qualification achieved. Despite this plan, the promotion possibilities at the moment greatly favour the university graduate. The country is, however, rather hampered by its traditions, which favour non-technical education. Thus parents tend to prefer the general secondary school-university route, rather than the alternative one for their children.

Practical training within enterprises is largely of a specialist nature, designed to add to the skills of newly trained craftsmen and 'second grade engineers', the particular skills needed by the firm.

There is a major involvement, by engineering teachers within the republic, in the association for Engineering Education in South-East Asia. But there is as yet no professional organization at either engineer or technician-engineer level.
Malaysia

Malaysia, having inherited a British system, has adapted it to the country's needs. It conducts courses for technician-engineers in an institute of technology, within, and under the control of, a university of technology. Those who succeed in obtaining the Technician Diploma are known as 'higher technicians'. (The titles have simply been 'adopted' into Bahasa Malaysia. There are no alternative indigenous words.) It will be seen that this qualification is obtained after only fourteen years of education. It has therefore been labelled 'TE-'. On the other hand, 'lower technicians' have a total of thirteen and a half years, the half-year being practical training. (This is an indication of the links between technical education and industry, the development of which has government support.)

Higher technician trainees who do well at the Institute of Technology may be transferred to that university's five-year engineering course, with two years of credit.

The courses have been developed in English and have hitherto been taught in that language. In accordance with government policy on education, a transfer to Bahasa Malaysia as the language of instruction is planned.
Engineering technicians. Some problems of nomenclature and classification

Mexico

The scheme is a 'stepped' one, as the diagram illustrates. The first technician-type qualification is obtained after twelve years of education, six of it with a degree of technical bias. The course at the CECT is followed by a six to nine months' practical period. But the terminology is confused, the qualification being 'auxiliar de técnico'. A further three years of study, at an ITR, results in a technician-engineer level qualification called, 'técnico'. (An additional three years of study, also at an ITR, can lead to the ingeniero qualification). To add to the confusion, some universities also run subdegree courses, usually of three years' duration and also leading to técnico qualifications (técnico de producción, etc.). But at least one gives a certificado de ingeniería for such a course.

Industrial training is not as yet well developed in Mexico, except in certain major organizations. This, and the extreme shortage of technicians, gave rise to the setting up of the Government Regional Centre for Industrial Training, with the aid of the United Nations Development Programme (UNDP) and Unesco. This centre trains all the main types of engineering technicians, with a considerable emphasis on practical work.

There is a Mexican Board of Engineers, with which the ingeniero registers. It is difficult to secure high-level posts unless one is on the register. There is much prestige attached to the ingeniero qualification. So although the country needs about five times as many technicians as qualified engineers, the present ratio is almost exactly the other way. The status of the technician is not high, and organizations for technicians have not been developed.
The education system in the Netherlands is in a state of change and is much more complex than the simplified diagram indicates. In particular, there are more 'bridges' between the four main 'lines' than have been shown. Secondary education has to some extent moved towards a comprehensive system, so that two or more of the four 'lines' may be found in the same establishment, which means the 'bridges' are more readily available to be crossed.

The four-year HTS courses (for technician-engineers) and the four-year MTS courses (for technicians) are both in 'thick sandwich' form, the third year being spent in industry.

The graduates of the HTS meet the suggested requirements for technician-engineer. They are known (like the graduates of the university-level establishments) as 'ingenieur'. But whereas the 'university-level ingenieur' has the right to use the prefix 'Ir' in front of his name, and to belong to the Koninklijk Instituut van Ingenieurs (KIVI), the ingenieurs from the HTS do not. The
Nederlandse Ingenieursvereniging (NIRIA) will enrol the 'HTS engineers' as 'register engineers' after five years' experience, and the submission of a thesis. Such engineers may use the designation 'Ing' after their names. As to the technician level, the title is 'technikus' or 'technisch assistent'. It is not protected, and no official definition of technician exists in the Netherlands. Nevertheless, their role is well understood in industry, and, as is evident, specific provision within both the education system and within firms has been made for their 'formation'.

However, it must be said that the Netherlands system is difficult to assess in the terms of this report, because of overlapping at the various levels. The Netherlanders themselves regard the products of the HTS as engineers—hence their title. By the criteria suggested in this report, they would come in the 'technician-engineer' category—which is also where they are placed in the Unesco-FFANI study, *Standards for Engineering Qualifications*. It is also claimed that the products of the MTS are technician-engineer in standard. As will be seen, in terms of total duration (fourteen years), the courses exceed the suggested norm for technicians, but fall short of that for technician-engineers.

The Netherlands thus provides a good example of a case where, if a reliable evaluation were required, something more detailed than a mere counting of years might be needed.

Promotion and remuneration depend largely upon the abilities of the individual, although the starting-point level may be influenced by qualification. It is interesting that an investigation some years ago revealed that 30 per cent of technician-engineer posts were occupied by *ingenieurs* (i.e., 'university-level' engineers), while about 20 per cent of 'university-level' engineer posts were held by graduates of the HTS, to whom, clearly, even the highest level posts are open.
New Zealand

The secondary education system is a comprehensive one and contains technical subjects as part of general education. In consequence, although technician courses are, in general, five years in length, exemption from Stages I and II may be given for suitable achievement at the end of the full five-year secondary course. An essential requirement in technician courses in New Zealand is that at least the last two stages (IV and V) must involve concurrent work of an appropriate kind. Thus one finds that some students may cover the course wholly by part-time study at the technical institute, whilst in relevant employment. Others may have one, two or three years of full-time study, completing the five years by concurrent work and part-time classes. These classes may be covered by day release, evening courses, block release (up to twelve weeks), correspondence or a combination of these (within certain limits). Thus flexibility is a major characteristic of the New Zealand system.

Although the courses in the different subject areas do not reach the same standard, all those who succeed are given certificates as technicians. There are no official upper or lower levels. With sixteen years of education, and the sort of content which some courses have, there is no doubt that they are at technician-engineer level. Others are not. Thus there seems no alternative to label the qualification 'T' and 'TE'.

The qualifications are awarded by a governemental body called the Technicians Certification Authority (TCA). The TCA prescribes and examines for New Zealand Technician Certificates in some forty subject areas, of which engineering constitutes a major part. Both at the national level of the TCA itself, and at the local level (i.e., in respect of the technical institutes themselves) there is close liaison with industry.

There is a comparable body, the Trades Certification Board, which is concerned with courses and training at the craft apprenticeship level.
Nigeria

While higher education is a federal responsibility, primary and secondary education (including that for technicians) is the concern of the nineteen states. There are in consequence some variations as between states, and these are augmented by a move to reorganize secondary education into two sections, each of three years, the sixth form being phased out. One object of this is to make technical and vocational education a more general component in school courses. It is not yet clear whether this will mean an extra year before students embark upon the technician diploma studies.

It will be seen that only one technician-level qualification is shown, and it is a higher technician diploma. Further, although the course for this diploma is of four years' duration it has been shown as in two parts of two years each.

The reason for this is that Nigeria is now changing from the original British-based system to one of its own. The British-based arrangement provided for a technician diploma after two years of study, and a higher technician diploma after two further years. This has been changed to a four-year course for the Nigerian National Diploma. It includes one year of practical on-the-job training, to be taken in one or more instalments at times arranged by each institution. There is some pressure to call the graduates of these four-year courses ‘technologists’.
It is interesting that Nigeria provides the only instance known to the writer of a country changing from a two-year level technician system to a single-level one. The general trend is the other way.

It has not been easy to secure on-the-job training for technician students, and major reliance has had to be placed upon the practical content of the courses. However, there is now an Industrial Training Fund which requires firms either to provide suitable training or provide subvention for young employees undergoing it. But, so far, this development has aided mainly craft-level trainees.
Pakistan

In Pakistan, as in India, the technician is trained mainly by means of a three-year full-time course of technical education and practical work in a polytechnic. Also as in India, recent pressure for a higher qualification has resulted in arrangements for upgrading technicians. After at least a year in industry, the qualified technician can return to the polytechnic and, after a one-year course, qualify for a Bachelor of Technology degree, at ‘pass’ level. The degree itself confers no title, but it is understood that its possessors wish to call themselves ‘technologists’. They can, after a further year in industry, and one more year of study in the polytechnic, convert their B.Tech. pass degree to an honours one, which will be equated to the university degree in engineering, and warrant the title of ‘engineer’. It appears likely that this new development has arisen, not from any expressed need of industry, but from pressure from qualified technicians who wish to become engineers.

There is as yet (with the exception of a few larger organizations) little planned industrial training within industry, in conjunction with colleges.
Poland

There is only one recognized level of technician in Poland, although the qualification can be obtained by various routes, as shown. While the study period necessary is shown in years of full-time attendance the flexible system makes all qualifications attainable by other methods of study also. The title of the technician is 'technik', to which is normally added the 'main line' of specialization, e.g. 'technik mechanik',—mechanical engineering technician. It will be seen that the total number of years of 'formation' (from a starting-point of age 7) either equal or exceed the minimum period proposed. It has been suggested that not all these routes result in the same end-point standard, and this may be so. But there can be little doubt, on the evidence of the curricula examined, that a good technician standard is likely to be achieved and in some cases well exceeded. Hence a rough rating of 'T+' has been assigned.

Poland is unusual in having no specific provision for technician engineers, although some technicians certainly carry out duties at this level in industry. In some cases, persons with the 'inzynier' qualification are being used (as in many other countries). Current discussions (1979) are considering the creation of this level of personnel, with the support of the Federation of Engineering Societies (NOT).

Practical work within industry is an essential part of all technical courses. In general, technicians may aspire to engineer qualification, although they may be required to work within industry for a specified period and pass the necessary entrance examination in order to do so.
Spain

The titles are 'ingeniero técnico' (usually with a descriptive addition such as 'eléctrico') and 'técnico' (or alternatively 'perito', the old name). The total educational period before the attainment of the qualification of ingeniero técnico can be a year short of the suggested minimum, hence the rating of 'TE-'. The técnico qualification is clearly a technician one, the total educational period being the thirteen years suggested.

In Spain all engineers, except civil servants, must join the colegio, or college of engineers attached to the appropriate technical ministry. As yet there are no associations specifically for technicians.

Each university has its patronato to ensure suitable public relations. For technical institutes this includes the establishment of close relations with industry.
Sweden

The recent reorganization of secondary education in Sweden has resulted in 'integrated secondary schools' which provide 22 'lines' and 450 specialized courses, which include provision for the basic and practical education of skilled workers and of technicians—as well as courses leading to entry to the engineering degree programmes at the 'technical universities'.

It should be noted that, in Sweden, compulsory education starts at the age of 7, one year later than in most other European countries. Despite this, the standard required for university entrance, after only twelve years of education, is not considered any lower than that generally expected elsewhere in Western Europe. However, even if this is accepted, it is seen that the longer of the two technician-type courses is still only one year beyond university-entrance standards. Thus the title of 'gymnasieingenjör' appears to fail to meet the technician-engineer specification suggested. It has therefore been labelled 'TE-'. Similarly, the title of 'institutingenjör', which is given to those who successfully complete the two-year upper-secondary course, falls short in time of the suggested requirement. It has therefore been labelled 'T-'. (Another title, carried by some who have passed the two-year course, before the secondary reorganization, is 'jackskoleingenjör'.) There are two professional organizations to which 'civilingenjörs' may belong, namely Sveriges Civilingenjörsförbund and Svenska Teknologforeningen; but there are as yet no corresponding technicians organizations. In general,
there is complete freedom to practise, except that certain theoretical and practical qualifications are required of persons responsible for work involving safety risks. There is no legal protection to titles; but persons who use an established qualification which is not theirs by right are liable to prosecution.

Within Swedish industry there are, roughly 2.4 institutingenjör and 2.3 gymnasieingenjör for each civilingenjör. Much specialized training of technicians goes on within industry, but there are no industrial schools for technicians, as such. While remuneration and promotion depend largely on ability and experience, it is interesting to note that, as the gymnasieingenjör joins the work force two years later than an institutingenjör of the same age, he does not equate to his salary until the age of about 27-28. At the age of 30, the gymnasieingenjör earns 84 per cent of the salary of a civilingenjör of the same age; and the institutingenjör, 82 per cent.
Switzerland

Because of differences in educational structure between the cantons of Switzerland, the diagram cannot be accurate in respect of them all. It represents a good general picture. Nomenclature is given in the two main languages of the country, French and German.

The course durations shown in the diagram relate to full-time studies. The fifteen specializations for technician-engineers may be studied either in full-time ETS, of which there are fifteen, or part-time (evening) in eight, the course lasting about four to five years. Part-time courses for the technician certificate also exist and take three to four years.

Those who pass the final examinations at the ET and ETS are authorized to call themselves, respectively, 'technicien ET' and 'ingénieur ETS'. However, the titles used on the register (see below) are (at the time of writing) 'technicien' ('Techniker') and 'ingénieur-technicien' ('Ingenieur-Techniker').

As already explained (see Part One) the Swiss have 'Le Registre suisse des ingénieurs, ingénieurs-techniciens et techniciens REG'. Registration is voluntary and there is freedom to practise without it. An important aspect of the register is the facility which its
regulations provide for workers who have not had the normal 'formation', but have acquired suitable knowledge through experience and/or self-education, to be registered at whatever level is appropriate. Thus, subject to a stringent examination, skilled workers can advance to technician level; technicians to technician-engineers; and technician-engineers to engineers.

In Switzerland it is strongly held that ability to do the job should be the criterion both for remuneration and promotion. Nevertheless, there is said to be good correlation between remuneration and level of qualification.

As in Switzerland, technician education and training follows an apprenticeship, it may be said that the needs of industry are built in from the beginning. The curricula for ETS are the responsibility of the cantons in which they exist. The cantonal authorities draw up the programmes in agreement with the Office fédéral de l'industrie, des arts et métiers et du travail (OFIAMT), the federal Department of Vocational Education. Also, industry is represented on all commissions, supervisory councils, etc. It participates actively in continuing education, in updating programmes, etc.
Thailand

The school system offers, after the first seven years of general education, two secondary paths—namely, the 'general secondary' course of five years and the vocational secondary course of six years. The latter has two three-year sections, after the first of which students may leave to become skilled workers. Those who stay on and successfully complete the three-year upper-secondary course emerge as 'industrial technicians'. However, if they succeed in passing the entrance examination, they may enter for a four-year course leading to a bachelor of technology degree. This course is also divided into two halves. Those who pass the first (two-year) section may leave with the title of 'engineering technician', which appears to be at the level of 'technician-engineer'. Entry to the second half of the B.Tech course requires the passing of the entrance examination. Success in the course has been shown as giving the title of engineer, which the B.Tech holders often use in exercising the profession. This they are allowed to do; but some doubt has been expressed concerning the validity of this. The matter is outside the purview of this report—except, perhaps, that if the graduates are not regarded as engineers, then they presumably must be in the technician-engineer category. The technician programmes are integrated courses.
Engineering technicians. Some problems of nomenclature and classification

involving both theoretical and practical work. While some technician training is provided in the work situation, there is as yet little organized practical training for technicians, outside the institutions in which they take their courses.
As the system of education in the USSR is characterized by extreme flexibility, with facilities for leaving and re-entering it at almost any level, and with tuition available by full-time, block release, evening and correspondence courses, the diagram is necessarily over-simplified. But it shows clearly the main technician routes, namely, the two courses in the specialized secondary schools—three to four years following the incomplete secondary school (eight years of education), and one to two-and-a-half years, after complete secondary school (ten years of education). All the times shown relate to full-time courses. Evening and correspondence courses take longer. It will be seen that the total education period to technician qualification falls short—in some courses, well short—of the minimum period of thirteen years suggested. However, there are other factors to be considered. First, education begins at age 7, so those leaving the ‘complete’ secondary schools are 17 and 18 years of age. Indeed, many students enter after work experience, the upper age limit being 30. Another major factor is the work load. Soviet students, in general, have a longer weekly programme and a longer annual
session than their counterparts in Western Europe and North America. Thus, to quote an American writer, '... the intensive program involved in the ten years is said to be the equivalent of the 12-year pre-university programme in the United States'. Students at the specialized secondary schools also engage in relevant industrial work during summer vacations. Their courses tend to be somewhat more specialized than those in many other countries, but the content of those examined was impressive. The successful students are entitled to be called 'technik' and are 'state-certified technicians'.

Until very recently—and indeed, in practice, it is still virtually true—only one level of technician was produced in the USSR, although, since courses in different specialities vary in length, not all technicians are trained to the same standards. But the Soviet Union, like a number of other countries, has identified the need for technician personnel with a higher level of attainment than that achieved in the specialized secondary schools (adequate though that is for its general purpose). In 1974, therefore, on an experimental basis, several polytechnics (higher-education institutes) commenced three-and-half-year courses for technicians, with a more advanced theoretical content. The first output has only recently been achieved and the writer does not know whether any special title is attached to the successful completion of this course. Although it falls somewhat short of the suggested fifteen years of study time, for the same reasons as have been given in respect of the technician course, it is considered as likely to be of technician-engineer standard.

A country in which all industry is under governmental control is well situat ed to secure a high degree of co-ordination between technical education and industrial training. Both practical work within the courses, and industrial attachments, are features of the technician programmes; and all those who succeed are guaranteed jobs in their specialist field. Thus there is a close relationship between pay and prospects on the one hand and qualification on the other.

Certified technicians may enrol (after passing the entry requirements—or, in the case of the top 5 per cent, receiving exemption from them) for the university-level courses (about five years) leading to the qualification of 'candidate of engineering science'. But a period in industry, normally two to three years, is required before entry to the course.

The professional interests of engineers and their supporting staff as a whole are the concern of the All-Union Council of Scientific and Engineering Societies; and the individual constituent societies have regard to sectional interests.

United Kingdom

O, general certificate of education, ordinary level; A, general certificate of education, advanced level; OTD/C, ordinary technicians diploma / certificate, awarded by the technician education council; HTD/C, higher technicians diploma / certificate, awarded by the technician education council; HND, higher national diploma (two years full time, three years sandwich); degree, awarded either by universities or by the Council of National Academic Awards after three years (full time) or four years (sandwich); CFE, college of further education; T and E, training plus experience—the figures indicate the number of years required as post qualification for entry by the engineers registration board.

The diagram shows the system existing in England and Wales. The patterns for Scotland and for Northern Ireland are slightly different. With the exception of the 'higher national diploma' the future of which is uncertain, no mention is made of national certificates and diplomas, and of the technician certificates of the City and Guilds of London Institute, since they are all in process of being replaced by the certificates and diplomas of the Technician Education Council. These are obtained by aggregating 'units', in specified groups appropriate to the particular type of technician study. This may be done (within certain limits) by any convenient mode of study. The asterisks on the chart are intended to indicate that any mode of study (full-time, sandwich, block release, part time day or evening) is possible. Thus the number of years needed for a qualification may vary. Also a diploma requires more 'units' than a certificate. Particularly at the 'ordinary-diploma' level, these additional requirements may add breadth to the course. Commonly, diploma courses are planned for full-time or sandwich students, and certificate courses for part-time attenders. But it does not have to be so.
Titles used are 'technician' and 'technician-engineer'. They are not protected by law, nor is the possession of any particular qualification a condition of employment, unless individual employers decide to require it. The latter title is still not widely used in industry, but is becoming more so.

The periods of training-plus-experience are those required by the relevant institutions of engineers, technician-engineers or technicians; and candidates for registration with the Engineers Registration Board must meet these requirements, as well as the others outlined above. Those who do so are entitled to be (voluntarily) registered as 'chartered engineers' (C. Eng.), 'technician-engineers' (T. Eng. C.E.I.) or 'technicians' (Tech. C.E.I.). These titles do have a measure of legal protection.

The possession of the designatory titles does not confer any remuneration rights upon those who have them. But many employers, in advertising for staff, either require the appropriate qualification, or state that its possession would be an advantage. Some firms (a minority) give actual financial awards to those who obtain qualifications, the object being to encourage young trainees to persevere with their studies. Employers are generally emphatic that both remuneration and promotion must depend upon demonstrated ability, and must not be tied to qualification. Nevertheless, median salaries are higher for those with qualification than for those without, or with lesser ones.

There is strong industrial representation on the many committees of the Technician Education Council responsible for curricula and for examinations. Industry is also well represented on the Council of Engineering Institutions and its constituent bodies, at all three levels; and upon the governing bodies of colleges and polytechnics.

In January 1980, Engineering our Future, a report of the Committee of Enquiry into the Engineering Profession ('The Fenniston Report') was published. Among its many recommendations were some advocating changes in education, training and nomenclature. These do not affect technicians, and the education and training of technician-engineers would not be materially changed, but it is proposed to change their name to 'associate engineers' and to register them with the designatory letters 'R.Eng. (Assoc.)' (registered engineer). At the higher level a four-year course is proposed, leading to a M.Eng. degree. It would have a first year common with a less arduous three-year degree course with a B.Eng. award. Suitable practical training and experience would lead to registration as R.Eng. (Dip.) (registered engineer diplomat) for those with M.Eng., and R.Eng. for those with B.Eng. These two designations would replace the present C.Eng.
At present, the report has the status of a proposal document only. It remains to be seen whether the government will accept its recommendations either in whole or in part. Any changes which are accepted will need time to bring into effect. Thus, the above plan is likely to represent the United Kingdom situation for at least the next few years.

While this report is not primarily concerned with courses for chartered engineers, a recent development in them needs to be noted, as it will have an important effect at the technician-engineer level.

It has come to be realized that, while considerable numbers of 'university-level' engineers are produced annually in the United Kingdom, there is nevertheless a shortage of well-trained engineers with real innovative and design ability. It is therefore proposed that special university-level courses, one year longer than normal ones, should be developed, for especially selected personnel. These four-year full-time (or five-year sandwich) courses will, it is hoped, produce a higher level of chartered engineer than many of those who now achieve this status. The question which thus arises is, should chartered engineer status be reserved for (and only for) these new higher-grade engineers? The answer is that, while it would be unwise to restrict chartered-engineer status in this way, there is a need to raise it. Thus one professional engineering institution has given notice that, by 1982, its corporate membership educational requirement will be either an 'enhanced' degree, as described above, or a present-day-type degree at first or second-class honours level. Other engineering professional institutions are likely to take a similar line.

The question which then arises is, what sort of professional qualification will be available for graduates who qualify, but below these standards? The answer is 'technician-engineer'. But it has already been pointed out that courses for 'university-level' engineers and for technician-engineers have different objectives and should therefore be different in their structure and content. Thus this development may well result in three-year full-time degree courses in university-level institutions, some being designed for chartered engineers, and some for technician-engineers. So, then, there will be three-year full-time courses leading to degrees, and two-year full-time (and part-time equivalent) courses leading to higher technician diplomas (or certificates); and successful students from both types of courses will be enabled to qualify as 'technician-engineers'.
United States of America

Education in the United States is primarily the responsibility of the individual states. Although in most of them compulsory education ends at 16, a very high proportion of the students complete high-school programmes. At the age of 18 or so, about half enter employment, the other half going on to some form of higher education. It will be noted that the diagram, unlike almost all of the others, does not show examinations. This is because, although examinations are used, continuous assessment plays a major role in education in the United States. Both at high school and college level 'grades' and 'credit hours' play a large part, both in determining what courses may be followed, and in assessing the degree of success achieved. This system contributes to the educational and vocational mobility which is characteristic of the United States. Partly because of this system, it is generally possible to enter courses for higher qualifications with credit given for any previous relevant studies.

It will be seen that both engineer and technician-engineer courses are of four years' duration, the former leading to an engineer qualification, and the latter to that of 'engineering technologist', after sixteen years of total education. The two-year courses train technicians, entitled officially 'engineering technicians'. The four-year vocational high school (VHS) courses have as their primary objective the production of skilled workers. Some of these pro-
grammes, followed by training and experience within industry (plus, perhaps, additional part-time education) enable a minority of VHS graduates to achieve technician posts; for in the United States, while particular qualifications may be demanded for direct entry to a particular grade of post, progression to it from a lower one is frequently achieved by performance, rather than by qualification. Even so, salary reviews show that, overall, formal qualifications are financially rewarded.

In the United States there is widespread existence of training and orientation programmes outside the formal educational system. Most large companies provide, for technicians and technologists, as for others, on-the-job training, specialist and updating courses, etc.; and many firms have direct links with universities or colleges, often resulting in the provision of conjoint courses.

The engineering profession in the United States is well organized, at both engineer and technologist level (but less so at technician level), with independent, autonomous societies representing specific engineering disciplines. They exact appropriate requirements as to qualification and experience for the registration of their members.

The Engineer's Council for Professional Development (ECPD) has been given major responsibility for accrediting the educational programmes for engineers and for engineering technologists throughout the United States. While considerable flexibility exists with regard to the content of programmes, the accreditation procedure is rigorous, and is carried out with the co-operation of the relevant professional engineering societies referred to above. In a country as large as the United States, with so many autonomous universities and colleges, this system does much to ensure that, at these two important levels of engineering personnel, variations in the standards of education are confined within reasonable limits.
Zambia

After twelve years of education, the GCE examination is used as a sorting device. Those with good results, especially in maths and physics, may proceed to the five-year engineering course at the university. Those entering technician-type courses usually have a common first year after which they are allocated to 'technician' courses, or to longer and more demanding 'technologist' courses. The former (apart from certain special two-year courses, mainly in one college) last for ten terms, of which two are devoted to industrial training. (The major technician-training colleges have four terms to a year.) The technologist courses last thirteen terms of which three are spent in industrial training.

The major colleges have well-established links with industry, especially in connection with mining in the copper-belt area. A well-planned structure exists for technician and technologist training, although it is still in the development stage, under the direction of the Department of Technical Education and Vocational Training. Evening courses are available in the major centres.

GCE, general certificate of education (O level); CT, certificate of technology; DT, diploma of technology; TC/IT, technical college or institute of technology; TTI, technical training institute.
Bibliography


FEANI. Classification and Registration of Engineers and Technicians in Europe and in the World. Brussels, FEANI, 1975.


IRAN COLLEGE OF SCIENCE AND TECHNOLOGY. Conference on the Education and Training of Engineers and Technicians in Iran. Tehran, Iran College of Science and Technology.


—. *The Training of Technicians*. Watford, EITB. (Booklet No. 14.)

—. *The Training of Technician Engineers*. Watford, EITB. (Booklet No. 9.)

