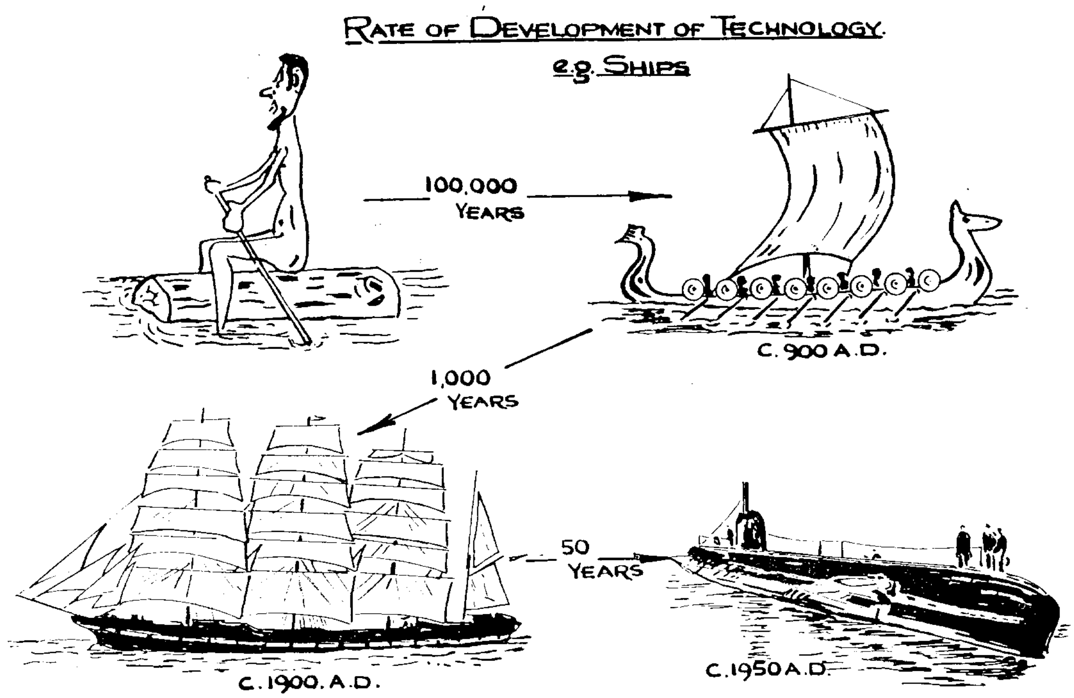

FIG. 1

DEVELOPMENTS IN TECHNICAL EDUCATION AND TRAINING

BY

COMMANDER C. M. ROBINSON, R.N., A.M.I.MECH.E. AND
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Developments in technical education and training are proceeding at a faster rate now than ever before; this is a world-wide phenomenon associated within developments in modern technologies. The following article is a lightly-edited transcript of a lecture first given in H.M.S. Fisgard *in June, 1966, which aims to explain present developments and put them into perspective with what has gone before.*

Introduction—by Commander Robinson

We are at present in this country in the middle of one of the biggest periods of change in training and education, particularly in the technical field, which has ever taken place, but which possibly has not yet got to the stage where it is generally known and appreciated. A lot of what follows depends directly on an understanding of the evolution of technical training and education, so that quite half of this will necessarily be history.

The development of technology has not proceeded at a steady rate, and in technical magazines you will find that it is now being referred to as the 'acceleration of technology'. FIG. 1 shows an example which is fairly near to home and illustrates this in a very basic way—the rate of development of technology, ships and shipbuilding.

As you can see, it took hundreds of thousands of years to develop from the simplest seagoing vessel to the primitive sailing ship; about a thousand years to develop from that to the peak of development of the sailing ship, and only 50 years to develop from there, through the age of steam, to the nuclear-powered submarine. These figures, 100,000 years, 1,000 years, 50 years, bring home the point about acceleration. Now in this particular example, consider the shipbuilder of 1900: if he was still building in wood his trade was little different from that of the man who built the Viking ships, in fact it was virtually unaltered. But now just ask yourself whether the shipbuilder of the 1960s is doing the same sort of work, and quite obviously, building a nuclear submarine has practically nothing in common with building wooden sailing ships. Again, in other forms of technical society, the same thing applies. The masons who built the cathedrals in the middle ages for instance were doing the same as those who built the pyramids, and it is only recently that we have got away from the concept of carving a lump of stone into the right shape and piling it on top of another one, and replaced that by other forms of construction such as reinforced concrete, so here is another fundamental technological change.

If you now accept, as I think you must, that technical training—the type of training which is given, and the method of giving it—must depend on the end product, then you will see that the training which held good in all the years of building wooden ships blown along by the wind will in all probability no longer be suitable for things which are changing as rapidly as they are today.

Now the traditional pattern of technical training has been apprenticeship, and this goes back into the very dawn of history. The origins of apprenticeship are known to be tied up with primitive societies, initiation rights, taking young men through their adolescence into manhood and training them as hunters, farmers, or warriors, and it is known that this type of training was going on in ancient civilizations—the Babylonian and Egyptian civilizations, for instance—and that fundamentally it hasn't changed until today. In other words a young man, probably in his teens, is taken into some particular order of society, and is given a training at the end of which he is formally accepted into that particular bit of society.

Apprenticeship was more or less standardized at the time of William the Conqueror (in fact the word apprentice comes from the French—*appendre*, to learn, *apprentice*, one who learns) and it was firmly established in the middle ages—Chaucer's *Canterbury Tales* talk about the apprentice, and the Guild system was set up about that time. The Guild system, of course, was merely a forerunner of the Trade Unions, in that it protected the interests of particular crafts or trades who each set up their own Guilds, and restricted the people who were allowed to ply the trade to those who had received the form of training recognized by the Guilds themselves. I use the word restricted so you can see this is essentially a restrictive organization. The first time that this system broke down was round about Queen Elizabeth's time, at which time there was a 'First Industrial Revolution' when all the original old trades which had their own Guild began to be joined by a number of others. The wool trade, the textile trade, cutlery, etc., had begun to develop in the 15th and 16th Century, and the members of the Guilds were worried about this and sought to protect their interests. So in 1563 an Act of Parliament was passed called the Statute of Artificers (Artificer being the word in common use at the time); this was an Act which laid down that there should be a 7-year apprenticeship, that there should be a ratio of journeymen to apprentices, and which made it illegal for anyone who had not been apprenticed to exercise his trade; but they made a mistake, because they laid down 61 trades to which it applied. Well this was fine in 1563 and for a few years afterwards, but a century or so later the Industrial Revolution was in full swing; the first Elizabethans had never conceived of many of the trades which were commonplace towards the end of the 18th Century, so the Statute of Artificers, with its limited number of trades had broken down completely, and in 1814 was formally repealed in Parliament. In keeping with the spirit of the times, apprenticeship and training arrived at a system of complete *laissez faire*—come what may, anyone can ply any trade, no need for training, if you can make it pay, get on with it.

By about the middle of the 19th Century a number of forces began to take effect. One was the Trade Unions beginning to get a grip, another was the rise of education and general humanitarian principles, but probably the overriding one was the growth of technology, rapidly outstripping the ability of *ad hoc* methods of acquiring technical knowledge to cope with its complications. These combined to produce a move back to the traditional apprenticeship system which, having broken down for a hundred years or so, then became re-established in the middle of the last century. And this time the interests of the tradesman were protected, not by Act of Parliament, but by the Unions taking the law into their hands to restrict the trades to those who had qualified—another restrictive organization, and the basis of many industrial problems today. Then after the middle of the last century, we began to move from traditional apprenticeships, where a boy was bound to a master, to formal 'off the job' apprentice training; this began in the dockyards, the naval and other Service training schemes, and the big firms. Development over the next century was largely the history of the rise of technical education—an apprentice still served the same length of time at his craft, but starting from the beginning in 1840 or thereabouts, when the more enlightened employers started to teach them to read and write, until the middle of this century, the educational content of apprenticeship increased enormously, though there was little change in the pattern of apprenticeship as such.

Developments in Technical Education—by Captain Waller

As you see, the growth of technology, and hence technical education, has been greatly accelerated over the last century. There is not time to give a full history of technical education since the beginning of the 19th Century but let us pick out a few important milestones in its development, not only in the country as a whole, but in the Royal Navy, and it is most important to stress straight away that the Royal Navy has always been in the forefront of technical training and technical education.

In the old days an apprentice learned his trade from his employer or from a journeyman. Any additional education he wanted he had to pick up for himself in his own spare time. Compulsory education was unheard of. One of the first examples of an employer providing special educational facilities for apprentices was the institution in 1843 of the Dockyard Schools in the Royal Dockyards to give 'book-learning', as opposed to practical instruction, to Shipwright apprentices. This was a hundred years before the famous 1944 Education Act, and it is interesting to note that the syllabuses of the Dockyard Schools covered a broad, general education. Not only were mathematics, mechanics and basic engineering science taught, but reading, writing and religious instruction were given, the Dockyard Chaplain attending every Saturday for the latter.

Very quickly the demand for technical education grew and this was initially provided by voluntary, local initiative which led to the setting up of various forms of evening institutes. It says much for the spirit of the times that students were prepared to attend evening classes, which they had to pay for, after a long, hard day's work. It obviously demanded considerable will-power and diligence on the part of those who attended year after year. Foundations such as the City and Guilds of London Institute set up in 1878, have played a profound role in the development of technical education in this country.

In 1889, the first official effort on a national scale was made by the Board of Education which decided to institute technical schools throughout the country as part of the growing demand for secondary education. The school-leaving age had just been raised to 14. This move was unfortunately a bit of a flop, largely because of lack of money and drive on the part of Local Education Authorities. Some technical schools were founded at this time, however, and it is significant that soon after (in 1903) the R.N. Artificer Apprentice scheme was started. Many artificer apprentices came from technical schools or from schools with a special technical bias.

After the 1914-18 War we had the years of depression when the demand for skilled men was limited. Money was scarce and technical training was, in general, carried out by voluntary attendance at evening school. There was a slow advance in organization, however, notably in the growth of the influence of such bodies as the C. & G., the U.L.C.I. (Union of Lancashire & Cheshire Institutes), the A.E.I. (Association of Educational Institutes) and the Professional Engineering Institutions who organized examinations and syllabuses of training on a regional or national level. The Board of Education, too, instituted in 1927 the National Certificate scheme in conjunction with the Professional Institutions.

The old National Certificate scheme involved a five-year course: three years to an Ordinary National Certificate and a further two years to the Higher National Certificate. The O.N.C. course was essentially a basic theoretical course covering mathematics, physics and drawing, while the specialized technical work was done in the H.N.C. course. The courses were designed for part-time study in evening schools and, although a great advance, came at a time when demand was limited.

The 1939-45 War saw the tremendous increase in demand for engineers and craftsmen and produced the very important 1944 Education Act. This did not deal with technical education especially, but with secondary education in general. Its aims were to raise the school-leaving age to 15, introduce selection at 11-plus for the three main types of secondary school: grammar, technical and modern, and to improve secondary education in general. It is lucky that money was available to carry the project through otherwise it might have foundered, like the former technical school scheme.

One of the most important effects of the 1944 Act was that a far greater number of brighter boys stayed on at school until they were over 16. This meant that the better boys were not now entering industry as craft apprentices, and the tradition of recruiting higher technical staff from the ranks of the craft apprentices who had improved their education by their own hard efforts was now being undermined. Industry was expanding but the supply of well-trained technical staff was declining, so much thought had to be given to improving methods of recruiting and training for particular specialist jobs. As a result, one of the great developments over the last 20 years has been the emergence of, and increasing demand for, the man known as the Technician, and many of the changes in technical education have been designed to recruit and train Technicians both in industry and the Services.

The Royal Navy, as always, was in the forefront in tackling the problem. In 1947, Artificer Apprentice training was remodelled and the Series Training scheme introduced. Later, our courses were recognized for the award of Ordinary National Certificates. In the Royal Dockyards, the Dockyard Apprentices training was reviewed and in 1953 it was decided to recruit and train two categories: Craft apprentices and Student apprentices—the latter being the new Technician. There is no doubt that the improvements made by the Royal Navy anticipated in a remarkable way the changes made much later in the country as a whole.

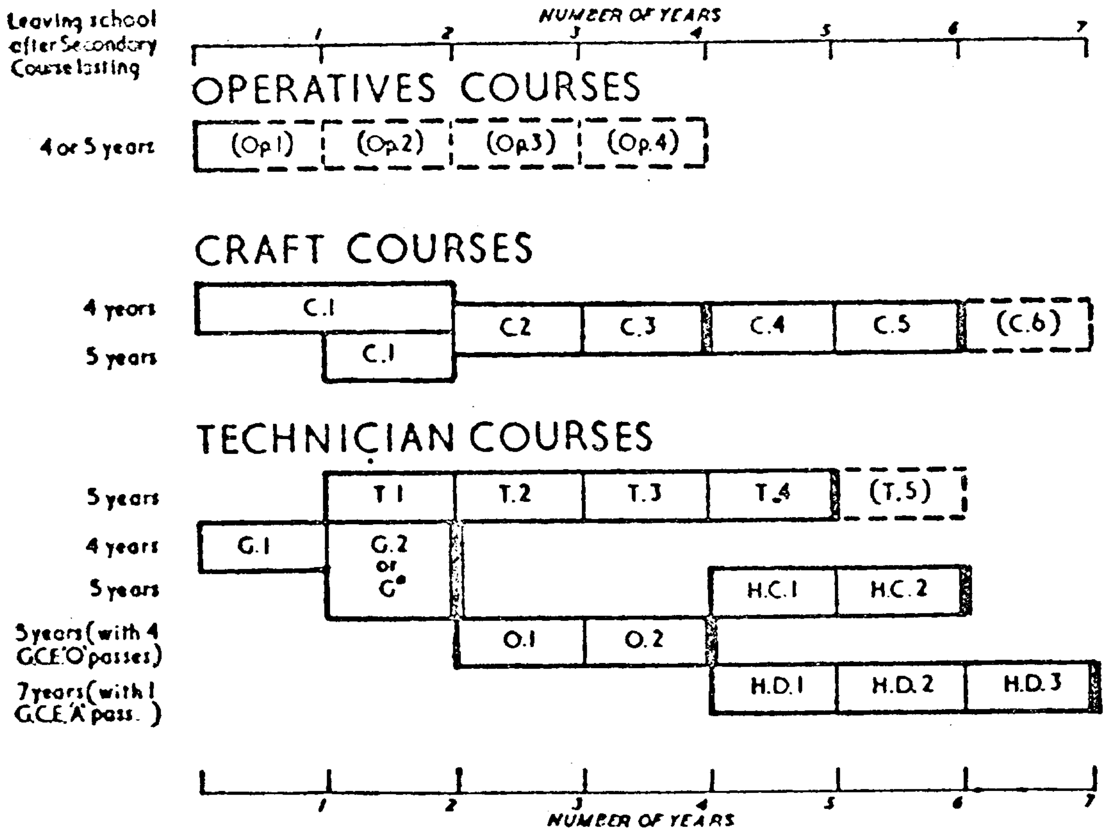

FIG. 2—OUTLINE OF THE NEW PATTERN OF COURSES
(*Better Opportunities in Technical Education* (*Cmnd, 1254, January, 1961*)

Notes: 1. Courses for Degrees, Diplomas in Technology or other qualifications leading direct to technologist status are not shown. Students gaining Higher National Diplomas or Certificates may also reach technologist status by further study; such further courses are not shown.

2. This outline does not show all the possible routes open to the individual. For example there will be opportunities for some students to transfer from a course of one level to an appropriate point in a higher course.

Op.—Operatives Course. (These courses vary greatly in length.)
C —Craft Course
T —Technician Course
G —General Course
O —Ordinary National Certificate or Diploma Course. (The Certificate Courses are part-time; the Diploma Courses full-time or sandwich.)
H.C.—Higher National Certificate Course (part-time)
H.D.—Higher National Diploma Course (full-time or sandwich)
||| —Denotes an intermediate or final stage associated with an examination
* —Students leaving secondary school after a five-year course will not normally take a one-year General Course.

It was not until 1961 that the Ministry of Education brought out the Government White Paper 'Better Opportunities in Technical Education'. This gave a new look to technical colleges, with more emphasis on full time, day-release and sandwich courses, and less on evening classes. Courses were designed to fit in better with the new school-leaving pattern and with the requirements of industry. There was less emphasis on the old type National Certificate courses which until now had been the only courses for technicians but had produced far too many failures.

It is typically British that in this upheaval of technical education the Ministry of Education relied enormously on private enterprise in the form of the Professional Institutions and the City and Guilds to help provide the pattern of the new system.

It will be seen from FIG. 2 that courses are provided at all levels of technical requirement. At the lowest level even the operative is expected to be given some basic training in certain industries.

The next level is for the Craftsman. Craft courses are designed for the type of worker who works mainly with his hands and who will spend most of his working life on the shop floor, although he may well have supervisory duties in due course. But his course is aimed at teaching him the simple, essential calculations and scientific principles demanded by his trade.

To concentrate on the new courses for Technicians, we should first define what we understand by a Technician. The Government White Paper simply places him between the pure Craftsman and the Technologist by saying, 'The term "Technician" is applied to a wide range of responsible jobs involving a higher level of scientific and technical knowledge than that needed by a craftsman but below that needed by a technologist'.

It is important to note here that a 'Technologist' is a professional engineer, probably a graduate, whose function is to engage in research, design or management at the highest level.

A more detailed description of the Technician is as follows: 'Between the levels of professional responsibility and craft skill there lies a wide range of work which calls for technical knowledge or manual skill in varying degrees. Those working in this way are broadly defined as technicians. Draughtsmen, technical writers, certain trained assistants in laboratories, in production planning, estimating, and material purchasing departments, some workers in inspection and testing departments, many of the senior workers in development workshops and many servicing engineers, may be classed as Technicians, as are also many of those in junior posts in management on the shop floor'.

The important point about this definition is that the Technician must be able to communicate with the Technologist on one hand and yet be in touch with, and possibly supervise the Craftsman or Operative on the other. He must have a high standard of technical knowledge but must also have a degree of knowledge of, even if not skill in, craft work. He must also have a certain amount of ability for management. If we compare these requirements with those of our own naval artificer you will see that we expect an artificer to be a technician. He has a fair level of craft skill, he must have a pretty high mental capacity to complete his technical education, and he is a junior manager, a leader—a Chief Petty Officer at an early age. This shows why we are so interested here in the new Technician courses as we have been training technicians for years in *Fisgard* and the Part II establishments.

There are two main streams of courses for the Technician: the O.N.C. stream, and the City and Guilds Technician courses. The O.N.C. course demands a higher academic ability and the syllabuses are fuller and more theoretically biassed than the more practically biassed Technicians' courses. Students are sorted into the two streams by their performance in a preliminary General Engineering Course, either a two-year (G1 and G2) course if the student starts at 15, or a one-year (G*) course if he starts at 16. To enter an O.N.C. course the student must gain over 55 per cent in mathematics and 55 per cent in science in the General Engineering examination which is set by the City and Guilds. Four 'O' levels, including maths and science also qualify a student for an O.N.C. course.

The Technicians' courses are rapidly gaining in popularity and it has been suggested that they may entirely replace the O.N.C. courses, but so far the latter still perform a very important function of pushing the brightest students up the ladder towards Technologist qualifications.

One trend which is beginning to show, however, is a move away from the National Certificates towards National Diplomas—basically similar courses but for full-time rather than part-time students, and with the workshop or technical content provided by the college rather than the employer. As far as can be seen at present, therefore, the National Certificates and Diplomas will remain as good qualifications in their own right, and as an important part of the overall pattern of technical education.

In the Royal Navy, the Artificer Apprentices courses were recognized for the award of O.N.C. The *Fisgard* course equates to the City and Guilds G* course and depending on his passing out marks at *Fisgard* an apprentice enters the equivalent of O.N.C. or Technicians stream at his Part II establishment. The Navy Department Part II examination now carries exemption from the Technician's Part I examination. There are many advantages of aligning naval courses with the national system both from a recruiting angle and from a resettlement point of view.

Finally, I should like to point out that it is an interesting fact that the national system of technical education—particularly in Technician training—has been modelled very closely on the system which we have developed in the Royal Navy. It is important to note that the national system has at last caught up with the naval system of training. This does not necessarily mean that we have fallen behind, but it does mean that the old attraction of a naval training, as being the best training available, has been weakened.

Developments in Technical Training—by Commander Robinson

It is appropriate at this stage to start by quoting from a publication called *European Apprenticeship*, produced by the International Labour Office in Geneva. It says: 'Many of the principles of modern apprenticeship were already applied in the period between the two World Wars. What is new is that they have gained universal acceptance . . . The standards and patterns of training which were established before and immediately after the Second World War have in many cases proved unsuitable in the present period of accelerated technical and economic change. Basic legislation and the structural organization of training has, as a consequence, been changed in Czechoslovakia, Denmark, and Switzerland. Demands for reform have been a subject of sometimes heated political discussion in Austria and Germany. A new Industrial Training Act, which goes far beyond the limits of traditional apprenticeship, has been adopted in the United Kingdom'.

The Industrial Training Act became law in 1964, and was another measure that arose out of the state of affairs just described, whereby between 1945 and 1955 it was plain that young people were not coming forward in the increasing numbers required for training in technical life today. After the War the Government set up a committee known as the Carr Committee which looked at the whole field of industrial and technical education and training, and which reported in 1958. One of their statements may seem obvious now, but nevertheless was important at that time of some doubt and confusion: they reaffirmed that in technical education and technical training, the education part should be the responsibility of the State, and the training side should be the responsibility of industry. From this resulted the 1961 White Paper on Technical Education already mentioned, and in 1962 the other aspect was covered when the Government published a White Paper on their proposals on industrial training, which became law in 1964 as the Industrial Training Act. The Industrial Training Act has already begun to have profound effects, and again to quote, this time from the *Chartered Mechanical Engineer* for April, 1966: 'It is clear that an explosion in training will begin this year which will perhaps reach a peak of activity in the coming 2 or 3 years and trainees will ride as on surf boards, the wave in front of the explosion, gathering speed as they go. The Industrial Training Act came on the Statute Book in March 1964 and can be regarded as one of the most important pieces of legislation in our time, a fact now being recognized by industry. For the first time an Act of Parliament makes provision for: ensuring a good supply of properly-trained men and women in industry; improving the quality and efficiency of industrial training and re-training; and sharing the cost of training more fairly between firms'. Under the Act there were set up a number of Industrial Training Boards, and the article goes on: 'The Boards are appointed by the Minister of Labour and the proposals they make for the exercise of their powers require the Minister's approval. He has set up a Central Training Council to advise him but the implementation of the Act remains the responsibility of the individual Boards. Shortly after the passing of the Act the first Boards were formed, of which the Engineering Industry Training Board was one. The Act, however, covers every industry in the country, and other Boards either have been, or will be, set up. Engineering enters very substantially into almost all industries and therefore the Engineering Industry Training Board has very wide interests and responsibilities. It covers all electrical, electronic and mechanical engineering, and generally anything made wholly or in large part from metal. It includes the Aircraft and Motor Industries as well as the Optical and Communications Industries, but engineering is the basis of operation also of many other industries, such as chemical, transport, ceramics and textiles. Engineering training is, therefore, of fundamental importance'.

The Engineering Industry Training Board started in 1964, and already has taken the bull by the horns and revolutionized many ideas in engineering training. One of the first things they did was set up a Training Committee, to look into the requirement for engineering training in its broad sense (bearing in mind that this includes electronics, telecommunications, shipbuilding, etc.) and this Training Committee having investigated the requirement then disbanded and set up a number of Training Policy Committees for the various categories of training to be dealt with. The first of these sat on First Year Training for Engineering Craftsmen and Technicians; others were set up to report on Craft Training, Technician Training, and a number of others that are not quite so obvious—Commercial Training, Technologists Training, Supervisor Training and Management Training. Committees are or have been sitting on all these.

One of the first requirements was to spread the cost of training more evenly across the industry. Throughout this century the bulk of training had been under the 'big firm pattern', whereby the great majority of small firms (and hence a large part of the industry) drew on the output of the few big ones who tended to over-train for their own requirements. Today you have only to look at the members of Council of the Institutions of Mechanical and Electrical engineers for instance, to see what firms were training 30 or 40 years ago—Metro Vickers, English Electric, Dockyards, etc., while others lived on the fat which they had been feeding. What the Engineering Industry Training Board had to do, therefore, was to spread the cost of this training over the whole of the engineering industry. They therefore listed all the firms in the industry (and again remember that engineering covers electronics, communications, etc.) with over five technically qualified employees, or with a total payroll of over £5,000 a year—so this is going well down the scale—and it is now law that all of these firms shall pay a levy to the Engineering Industry Training Board, of a percentage of their annual wage bill. This was set at 2½ per cent and it runs to nearly £100m. a year. Having done this they then decided on the share-out, to be made to firms training in accordance with the approved policy of the Board. There are, of course, a number of conditions attached to this, such as compulsory day release or block release for going through a recognized City and Guilds or National Certificate Course, but the sums involved are well worth while. The big bit of bait is that if you have a first year craft or technician trainee, and you train in accordance with the Board's requirements, you get £500 back, and while conventional apprenticeships are still going on you will get £150 a year for an apprentice so long as he is indentured to your firm, So, whether you train or not you are paying out $2\frac{1}{2}$ per cent of your payroll; if you do train you can get some back, and you may even be able to win on this, so here is the best of all possible reasons why everybody should think very seriously about training, which is just what they are doing. Whether or not a firm should set up its own training scheme, enter a group training scheme, or decide not to train at all will differ in every case, of course, with many factors affecting the decision, but the fact is that already the boom in training has begun.

One of the first major decisions to be made was whether engineering training should be broad or narrow. It was decided quite firmly, for a variety of reasons, that First Year training, at any rate, must be on a broad base. In other words, you take somebody who is going to be a technician or craftsman, and must give him the widest general background with a technical bias that can be got into one year; this means physics, heat and electricity, a little bit of chemistry, maths, engineering drawing, and engineering materials and processes. The alternative is, of course, to take someone and train him purely in what he is going to do. In other words, if you are wanting a Turner for instance, you eliminate everything except what directly applies, train him on very narrow lines right from the start, and at the end he will be trained in Turning to great depth and detail, but will know absolutely nothing else. The Engineering Industry Training Board have rejected that approach, as incidentally have most other authorities, in proof of which I quote again from the I.L.O. publication: 'In the 1930s, and in some countries during the period immediately following the Second World War, there was a general trend towards the creation of many new specializations and towards classification of trades along relatively narrow lines. More recent trends, obviously influenced not only by technical considerations but also by a desire to broaden the field of recruitment, have emphasised broad and basic qualifications rather than narrow specialization. The establishment of broad and basic trades has been in the joint interests of the Educational Authorities, the Unions and the Employers. It facilitated the organization of training in the schools. It increased the worker mobility sought after by the Unions. The Employers saw in it a measure which would widen their field of recruitment'. In a word, it's flexible.

So, therefore, when after their levy and re-allocation scheme the Engineering Industry Training Board came out with their statement on first-year training, it emphasised this broad basic training. It took the form of a book, which cost us 37*s.* 6*d.* because we are not contributors to the Board, but every firm in the country who contributes to the Board gets one of these free which tells them how to run their first-year training. It tells them that first-year training must be 'off-the-job' in a special training workshop; lays down exactly what has to be done with integrating it into the technical college course; gives them a specimen syllabus, with all the jobs they need to make, and gives a complete specimen of how to keep trainee's records. All these are the sort of things that we have been doing for years, and people have come and asked for guidance about, but now it is given to them on a plate, so this in itself is a big change.

The next thing which the Board have said is that they aim to do away with the traditional form of apprenticeship, and propose instead a system of training based on what they call 'modules'; you can see this best by referring to FIG. 4 published by the Engineering Industry Training Board, representing their ideas for training Craftsmen and Technicians. Everybody does a common first-year (which in effect is what we give artificer apprentices at H.M.S. *Fisgard*); the intention then is to classify all the skills—maybe a hundred or two hundred, it depends how many it works out at—and for each of these will be laid down the length of time necessary in formal training in that particular skill; they will also lay down the length of time necessary to acquire experience of that skill, and these periods may differ in every case. Thereafter, any trainee, provided he has a

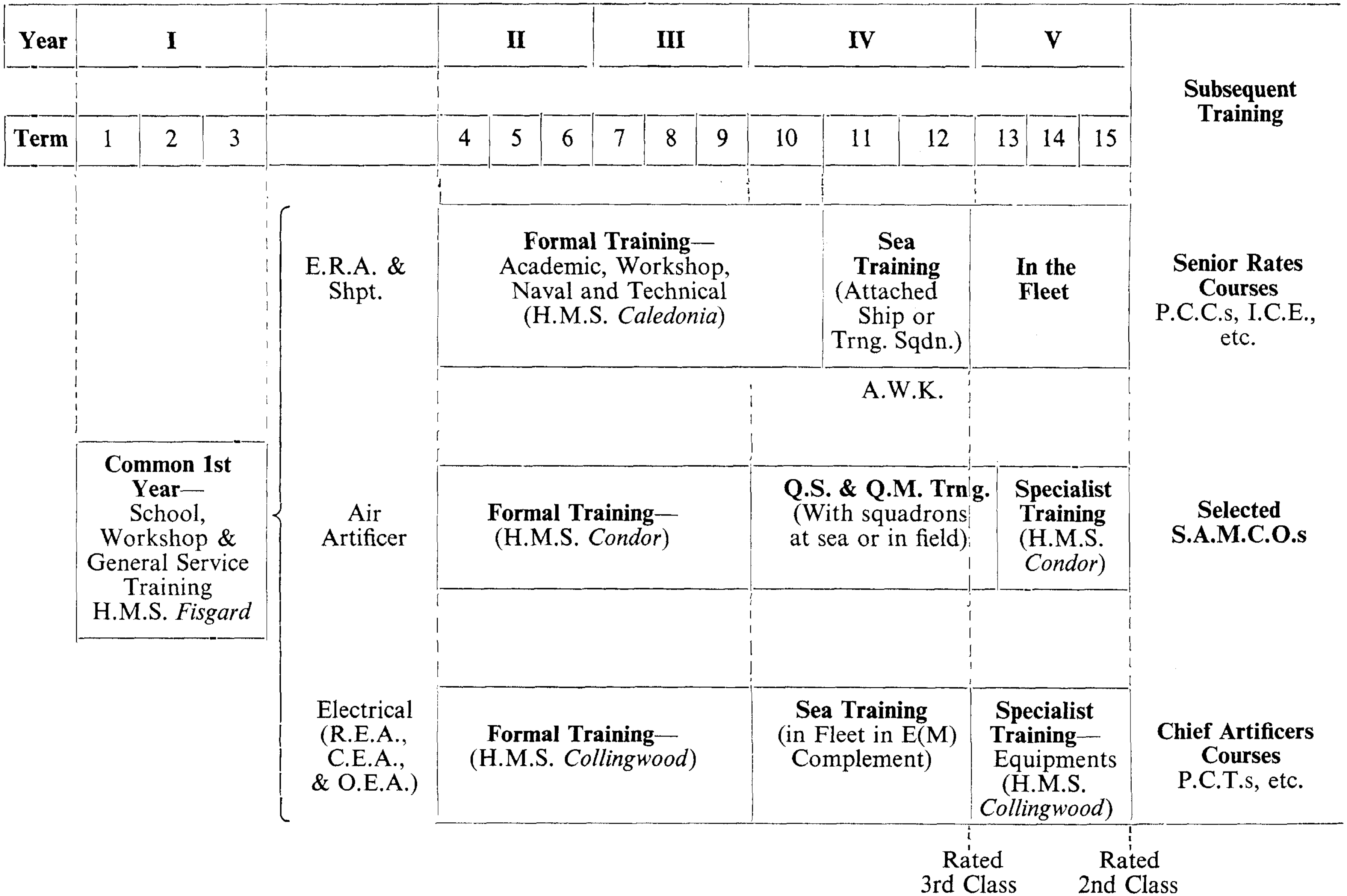

FIG. 3—EXAMPLES OF NAVAL ARTIFICER TRAINING, 1967

Showing the common first year; the block training of Engine Room Artificers and Shipwrights; the near-sandwich course of Aircraft and Electrical Artificers; and the trend towards shorter initial training plus subsequent training or re-training.

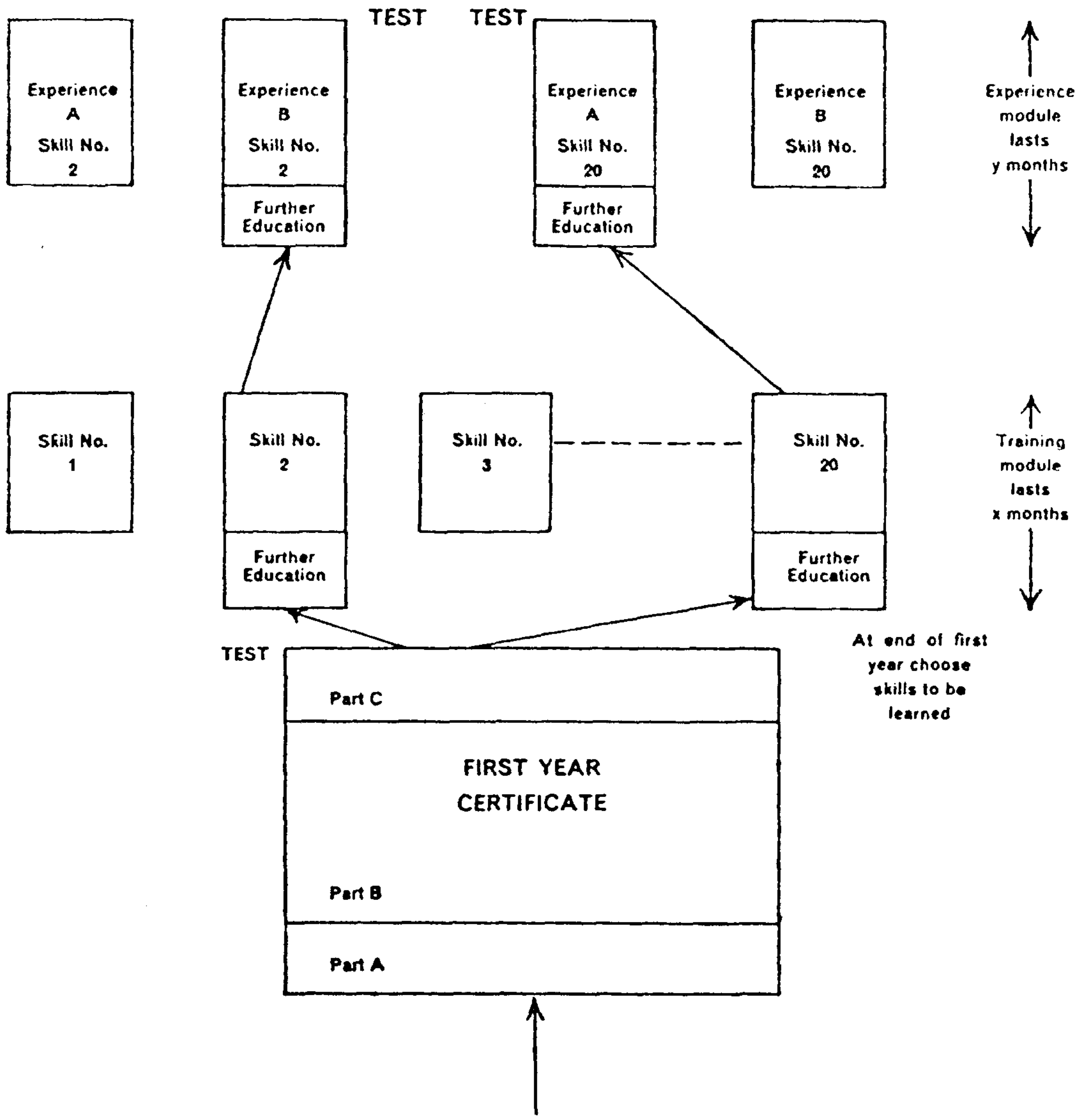

FIG. 4—TRAINING AND EXPERIENCE MODULES
(*Engineering Industry Training Board's Paper No. 6, May, 1966*)

recognized first-year training, can (*a*) acquire any necessary or desired combination of skills, or (*b*) pick up any new skill. Now this makes for complete flexibility; you can see that for a maintenance fitter in a small works for instance, they might require a man who is a bit of a turner and a bit of a fitter, so in this case they can recruit a trainee, give him his first year, and then can put him through training in those skills in a block, add his experience period on top of it, and at the end he has qualified in those. It may be, however, that the particular works concerned only wants one skill, or maybe a combination of 4 or 5. Either case is easily satisfied; all that is necessary is that for each skill the appropriate training module must be completed, followed by the experience module. Skills may be acquired either in series or in parallel, and at the end a man's certificate will be completed; the first year will already have been completed, so now is added the skill and experience numbers in which he has qualified. This must at all times be co-ordinated and integrated with further education as approved by the Engineering Industry Training Board—otherwise no money!

So here is a scheme which cuts right across the roots of traditional apprenticeship. Discussions are going on between the Boards, the Ministry of Labour, the Unions, and Employers; the outline of the scheme has been published, and a working party is already at work on classifying and tabulating the skills.

At the same time as the above developments have been going on there has been another revolution becoming apparent in training and education. This is the emergence of a complete new technology about the subject. It shows itself in all aspects and is running in parallel with, and closely allied to, modern techniques of work study, systematic management, modern developments in industrial and educational psychology, and the development of up to date training devices and computers. This new approach will really make a science of education and training. The end product required of the training will be the subject of detailed job specification and job analysis; the training and education given can be precisely tailored to meet the end requirements; the methods of training will be far removed from the traditional blackboard and work bench; qualifying tests and examinations may be precisely related to the job to be done; and the performance of the trained man on the job will be the subject of data feed-back and analysis just as is done these days with equipment. Training and education in fact, will become a 'closed loop' system.

There is no doubt that the Services are well ahead in this field, and co-operation between them is growing. We have already seen how the Navy's Artificer Training Scheme anticipated by nearly a quarter of a century much of the pattern of technical training today. Much pioneer work is being done in the Services and by their psychologists on teaching and education, and a Training Research Unit has been set up. In the fields of programmed instruction, teaching machines, and various combinations of these, a great deal is being achieved.

The pattern of apprenticeship in the Navy has also been the subject of evolution over the past few years. In general the block of apprenticeship at the beginning has been getting shorter and in some cases has evolved into what is virtually a 'sandwich'. In other cases the principle has begun to be recognized of a shorter initial block of training, with specialist or changed qualifications added as convenient later in a man's career. Courses on electronic equipments, aircraft types, or ship machinery, for example are all aspects of this trend and the training of artificers and mechanicians has been drawing significantly closer. This pattern is obviously a precursor of the type of training which is likely to be evolved from the developments in the country as a whole today.

Conclusion

That then is the national picture at the moment, emerging along the lines of the 1944 Education Act, the 1961 White Paper 'Better Opportunities in Technical Education', and the 1964 Industrial Training Act; these combined form the lines along which the whole future of industrial and technical training and education must run for the next few years.

What are the implications of this? How does it affect us for a start? Obviously competition is going to grow enormously for the sort of people for whom we have had a good market in the past—the Artificer Apprentice. No longer will it be simply the big firms, the Dockyards, and the Royal Navy offering first-class apprenticeships, but now there's no reason why any small firm in the country shouldn't give just as good a training—there is every inducement for them to do so, and you have seen how the first year training scheme which the Engineering Industry Training Board have set out is extremely close to what we do in the Navy, while the module system is obviously very close to a lot of our developments. As far as the country is concerned, we must expect an enormous increase in trained technical manpower in the country over the next few years—one wonders whether eventually the Services will be able to give up the basic education and training of their skilled ratings and be able to obtain sufficient numbers of 'direct-entry' recruits of sufficient ability. The second implication, touched on with that diagram of the module type of training, is that the complete flexibility of the new system should remove the rigidity of the old apprenticeship, and hence the temptation to a restrictive type of protection system, and demarcation disputes. What will be the effect on the Trade Unions for instance? What will be the effect on the social structure in the country? What will be the effect on the politics of the country, the productivity and the place in the world of the country? I don't know, but there will be profound effects, without doubt.

We have tried, then, to put across a balanced view of the history of technical training and education, and what is going on today and why. You will see that there have been three upheavals, each associated with a time of technological change: there was the upheaval leading to the Statute of Artificers in 1563, there was another upheaval towards the 19th Century, and there is another one now, and in each case it was because the training and protection system had become too rigid for the advance of technology. It may be that the work being done today will overcome the failures of the previous solutions, which lasted for a relatively short while only.

As far as we in the Navy are concerned, it is clear that we must continue to develop our training as we have in the past. We are doing the right thing, are still up in the lead in the country and the world, and so long as we don't rest on the laurels of our predecessors, but proceed on these lines, and keep our selves fully alive to the requirements of the future, then all should be well.