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TRANSACTIONS (TM)

Presidential Address

ENGINEERING AND EDUCATION — A MARINE ENGINEER'S VIEWPOINT

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Read at 1730 on Monday 14 October 1985

ISSN 0309-3948
Trans I Mar E (TM)
Vol. 98, Paper 3a (1985)

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Engineering and Education — A Marine Engineer's Viewpoint

SYNOPSIS

Today, both the role and status of the engineer in society are under continual debate and far reaching developments are taking place in the United Kingdom involving registration standards and examinations. In marine engineering, the arrangements for the certification of seagoing engineers are being radically changed. The paper reviews primary, secondary and technological education over the last 150 years and shows how the wealth of this country was produced by the Victorian engineers and their predecessors who did not have the benefit of a university education. In those days education was not compulsory; engineering was not recognized as a profession and the great artisan inventors 'were grimed in soot'. Their success gave rise to the impression that education was unnecessary for engineers and that engineering was a task for the uneducated lower social classes. Some of the attitudes then formed have persisted. Throughout the period covered by the paper, many warnings were given on the shortage of well qualified engineers and the poor facilities for technological education, but progress was, and still is, slow. The history of marine engineering is also traced over the same period including the formation of the Marine Division, Board of Trade in 1850, the introduction of compulsory examinations for seagoing engineers in 1862 and the inception of the Cadet Training Scheme in 1952. The role of the professional institutions, registration and licensing are also discussed. It is hoped that the lessons learned from the past may assist in determining policies for the future.

INTRODUCTION

Critical reviews are currently being conducted into the UK national registration standards and examinations for engineers of all levels; radical changes are being made in the arrangements for the certification of seagoing marine engineers; and the role and status of the engineer in society is under continual examination. It therefore seemed appropriate to me to look back over the years and present a contemporary history of events and attitudes relevant to engineering in general terms and marine engineers in particular. The background may indicate lessons to be learned in determining future policies and provide some explanation of the present position and attitudes.

The statutory 'Board of Trade' Certificates of Competency for seagoing marine engineers quite naturally provide a central theme for several reasons. They were introduced in 1862, 37 years before the Board of Education was formed and 59 years before the National Certificate Scheme (1921) was started. They are, in fact, licences to practice and it has been held that licensing is one means of increasing the status of engineers in general (although my experience as one of the Department's Chief Examiners does not lead me to that conclusion). These Certificates have an enduring role since, following the entry into force in 1984 of the Convention on the Standards of Training, Certification and Watchkeeping, 1978, they are an international requirement.

However, the objectives of this review will not be met unless a much broader view of education and training is taken. Consequently, in compiling the chronological list of events (see Appendix), provided for a ready appreciation of the social attitudes prevailing during the last 150 years, some events outside the field of engineering have been recorded.

THE AGE OF THE GREAT INVENTOR

The Victorian engineer

The Great Exhibition of 1851 in the Crystal Palace coincided with the high point of Great Britain's brief period as the 'workshop of the world'. Craftsmanship and industrial manufactures from many countries were on view at a time of worldwide technological revolution. Britain's national resources of coal and iron, skilled work force and, above all, the ingenuity of her engineers had given her a worldwide lead in industrial production of heavy machinery, iron goods and textiles. Yet these engineers and even applied scientists (eg Humphrey Davey, John Dalton and Michael Faraday) did not go to university. The Victorian engineer and his predecessors were trained in the old craft apprenticeship system (eg Stephenson, Bramah, Maudsley, Nasmyth, Brunel, Bessemer, Whitworth, Newcomen, Brindley and Hargreaves). Nineteenth century literature describes 'the great inventor' as 'one who has walked forth upon the industrial world, not from universities, but from hovels; not as clad in silks or decked with honours, but as clad in fustian and grimed with soot and oil'.[1] Attitudes towards engineers had already been formed!

A census carried out ten years earlier (1841) had not even listed engineering as a profession (it was not until the census of 1861 that civil engineering became the first engineering discipline to be recognized). The literature[1] quotes, for example, the case of one Joseph Clement born in 1779 who could 'read little and write with difficulty' and whose inventions and improvements included 'a self-acting lathe, fluted taps and dies, a calculating machine and a series of steam whistles'. The very success of Britain's inventive craftsmen gave rise to the persistent impressions that education was unnecessary for engineers, and conversely that engineering was a task for the uneducated lower orders of society.

During the previous 50 years, the average real income per head had doubled and, in the prevailing complacency coupled with the insidious philosophy[2] of 'self-help' (eg that 'schools and colleges gave but the merest beginnings of culture compared with daily experience') exemplified by Samuel Smiles, there was little pressure on an unwilling government to introduce any form of technical education. Yet, noting the increasing challenge from abroad and, no doubt, the system of education[2] established in Germany following the defeats by Napoleon early in the century (1809–1810) and the system of polytechnics Germany had developed the preceding 20 years, *The Times* leading article (13 October, 1851) at the closing of the Great Exhibition was significant, especially for a newspaper as conservative in outlook. This leader included the statement 'Some think that we must effect a radical change in our educational system . . . that we must substitute a living science for dead literature, and distribute the honours and rewards of life in channels where they may fructify to the use of the Commonwealth instead of being limited to the learned professions, the military and naval services, and the residents of our universities'. But a pre-requisite to a technical education is basic literacy, and the education of the great mass of the population was in the hands of voluntary societies.

EDUCATION BEFORE THE SECOND WORLD WAR

Victorian education

The state's first grants (£20000 in all) to the voluntary societies for education were made in 1833, and although by 1851 the annual grant for education had been increased to £164000, the population in general was not literate.

There were four English universities. Oxford and Cambridge had not yet been reformed and non-Anglicans were not admitted as students and were excluded from the teaching staff. The University of London included King's College (Anglican) and University College. University College was referred to as 'the Godless institution' since it was open to all, regardless of religious beliefs. It had a chair of engineering since 1841. The University of Durham was the fourth English university and although mainly devoted to the training of Anglican priests, it had held classes in engineering since receiving its charter in 1837. The first chair of engineering in the UK was filled in Glasgow University in 1840 when the prevailing attitude to engineering was clearly demonstrated. The unfortunate professor, Lewis Gordon,[3] was denied the use of lecture rooms by his colleagues who disapproved of the development. Only the intervention of the Lord Advocate allowed him to take up his duties. A report of 1868 lists Queen's College, Dublin as being 'efficient in the teaching of technical education'. The ancient universities, Oxford and Cambridge, did not establish chairs of engineering until 1908 and 1875, respectively. The brilliant Professor of Engineering, Hele-Shaw, was appointed at Liverpool University even though he did not hold a degree, as did not the next five engineers appointed to the post.[4]

By 1900 there were still fewer than 20 engineers in England who were entitled to be addressed as 'professor', and the total strength of the academic staff of all engineering departments did not exceed 100. It is therefore not surprising that, in 1900, the number[4] of scientists and technologists produced by German universities and technical high schools was some five times as great as the number produced by English universities and university colleges.

The public and grammar schools were devoted to providing a classical education and prevalent opinion was that[5] 'a classical education is necessary for everybody because everybody has agreed to think it so' or more snobbishly 'the advantages of a classical education are two-fold – it enables us to look down with contempt on those who have not shared its advantages, and also fits us for the places of emolument not only in this world but in that which is to come'.

In concluding this brief summary of the position in the mid-nineteenth century it must be emphasized that technology was already being thought to be for the lower classes. There was no formal technical education, there was almost a complete absence of elementary education and it was only in 1880 that compulsory elementary education for children between 5 and 10 years was introduced. It is remarkable that England relied on voluntary enterprise in the educational field for so long. Our continental competitors had also at one time looked upon education as the concern of the church but had turned from this belief over a century earlier, as had Scotland which, in 1696, ensured the provision in every parish of a schoolmaster whose services were available to all regardless of social distinction, and the Scottish system of elementary schools was held up as a model to the entire United Kingdom.[5] A similar comparison was applied to the universities in 1867 by John Stuart Mill who wrote 'Youths come to the Scottish universities ignorant, and are there taught. The majority of those who come to the English universities come still more ignorant and ignorant they go away'.

Attitudes to education

In 1862 the 'Revised Code' was introduced. This Code set standards in reading, writing and arithmetic and led to learning by rote because the Code included a system of Government grants to elementary schools based on 'payment by results' (see Appendix). Robert Lowe, Vice President of the Committee of the Privy Council on Education, based the system of grants on the results of examinations conducted by HM Inspectors and expressed his view that 'if the new system will not be cheap, it will be efficient, and if it will not be efficient it will be cheap'. In the event, cheapness won and the quality of teaching was reduced whilst the state grant fell from £930000 in 1859 to £656000 in 1865. Lowe expressed the prevailing philosophy when he stated 'I hold it as a duty not to spend public money to do that which people can do for themselves'. There was a genuine fear that state intervention would lead to state control.

A similar attitude applied to technical education and whilst the Great Exhibition had provided some stimulus it was woefully inadequate because of the combined effect of the employers' reluctance to have technical processes taught to potential competitors and the state's reluctance to spend money on pure technical instruction. In 1867, the Taunton Commission (which was enquiring into the unsatisfactory state of the grammar schools) received a letter from Sir Lionel Playfair stating that 'the Industrial Exhibition at Paris in 1867 furnished evidence of a decline in the superiority of certain branches of English manufacture over those of other nations', and that, in his opinion, 'this decline was partly due to a want of technical education in England'. The Commission approached other competent observers and found that this opinion was general and concluded 'The cause of this inferiority upon which there was most unanimity is that France, Prussia, Austria, Belgium and Switzerland possess good systems of industrial education for the masters and managers of factories and workshops and that England possesses none'.

During the latter quarter of the nineteenth century the need for government intervention was being expressed in various sections of the community. Some members of the ruling classes felt that it could be justified on political, economic and broad moral principles. Businessmen referred to ideal workers as those 'who never drink, never strike, always go to church on Sundays and always express themselves in respectful language'. The Royal Commission on Depression[6] included an opinion relating to commitment when it stated 'We think that careful and thorough training in the habits of punctuality and order, of alacrity and diligence, and of close attention and prompt and implicit obedience to instructions ought to occupy more of the time and thought in elementary schools'. Education[6] was seen as a way of ensuring a more temperate work force and would discourage 'walking off in the middle of a foundry melt'.

Economists 'saw education of the masses as the means through which the growth of population could be controlled;

as a guarantor of social order; as an instrument of national economic development; and, not least, as an indispensable agent to the promotion of political democracy'.

It was thus not solely increased competition from Germany and the USA which focussed attention on state intervention in the field of education. There is no doubt, however, that for a variety of reasons that situation improved. The Education Act of 1870 had required the voluntary schools to establish a minimum standard and, in areas not adequately covered by them, School Boards were elected to build and maintain new elementary schools by means of rates, Government grants and fees. By the turn of the century a Board of Education had been established (1899), the system of payment by results was finally phased-out (1897), and an aid grant of 5 shillings per head per annum was available to needier voluntary schools. The extension of basic education produced young people able to appreciate a technical or trade training. The City and Guilds trade and technical examinations' standards were increased and the 1889 Technical Instruction Act had permitted the first grants to universities and colleges by enabling the new County and County Borough Councils to support technical education out of the rates, although many would not do so. Evening classes were given a great stimulus by the recognition of students over 21 years of age for grant purposes.

Parliamentary reports

As a result of Playfair's observations and other disquiet a Parliamentary Select Committee on Scientific Instruction was set up in 1868 under the Chairmanship of Bernhard Samuelson. As many similar enquiries (predictably set up in times of depression or war) were to report, the Committee found that the main problem was the inadequacy of primary and secondary education and the shortage of science teachers. A witness before the 1868 Committee said 'I do not know a single manager of iron works in Yorkshire who understands the simple elements of chemistry'. For sometime after this there was a movement to found a real technological university, but it led to nothing.

Further disquiet led to a 'Royal Commission on Scientific Instruction and the Advancement of Science' which sat under the Chairmanship of the Duke of Devonshire between 1870 to 1875. It made eight reports which included recommendations that science should be taught at elementary schools and in colleges, that grants for their buildings and equipment should be increased, that science should be included in the curricula of the old and new universities but without undue specialization, and finally that there should be a Ministry of Science and Education created as a matter of primary importance (90 years later a Secretary of State for Education and Science was appointed on 1 April 1964).

The Clarendon Report into the principal public schools (1864) and the report of the Schools Inquiry (Taunton Commission 1868) had both advocated increased emphasis on science on which the latter reported 'We cannot consider any scheme of education complete which omits a subject of such high importance. We think it established that a study of natural science develops better than any other studies the observing faculties, disciplines the intellect by teaching induction as well as deduction, supplies a useful balance to the studies of language and mathematics, and provides much instruction of great value for the occupations of after-life'.

These views were in line with the conclusions of the Devonshire and Samuelson Reports. These influences had led the Department of Science and Art to provide the highest grants to those institutions which taught science and its allied subjects at secondary level. By 1900, 183 institutions had received official designation as schools of science; each offered systematic instruction in science 'though not . . . to the exclusion of those literary subjects which were essential for a good general education'. The Board of Education continued this practice and in 1901–1902 the maximum grants were earned by schools which offered 13 hours of mathematics, science and art each week. This emphasis was in marked contrast to the endowed schools examined by the Bryce Commission who found that, on average, 1.83 hours per week was spent on science compared with 3.67 hours per week on Latin. It seemed that science had reached its rightful place, but not for long!

The Polytechnics

In 1882 Quintin Hogg founded the Regent Street Polytechnic to provide classes and leisure facilities for the poorer sections of the community. This venture was used as a model for other London Polytechnics including the People's Palace and East London Technical College (now Queen Mary College, University of London) and the Northern, Borough, Battersea and Chelsea Polytechnics.

These Polytechnics were designed to 'promote the industrial skill, general knowledge, health and well being of young men and women belonging to the poorer classes of London'. They were initially funded from the substantial resources of the City of London parochial charities following an Act of Parliament which required that these resources be devoted to 'objects within the Metropolis' of which technical education might be one.

The Civic University Colleges

Also during the latter part of the nineteenth century, public awareness of increased competition to local industries from foreign countries resulted in new colleges in, for example, Liverpool and Sheffield. University colleges were founded at Newcastle upon Tyne (1871 as the University of Durham College of Physical Science), Leeds (1874 as the Yorkshire College of Science), Bristol (1876), Sheffield (1879), Birmingham (1880), Nottingham and Liverpool (1881) and Reading (1892). These colleges were founded on the basis of the generosity of the provincial cities. Most initially taught for University of London external degrees until they eventually achieved independence. There were a wide variety of problems, emphases and difficulties. The greatest financial difficulties were felt in those colleges where scientific and modern studies were stressed. They were, said Sir Bernhard Samuelson, 'Inadequately provided with funds and not very numerously frequented'.

The financial problems led to the appointment of a Committee to advise the Government on the distribution of grants to the new colleges (the forerunner of the University Grants Committee). Government grants were initially small by comparison with local support. For example, Liverpool University College was founded[2] as a result of £80000 donated by local citizens but when Government grants were introduced in 1889, Liverpool's share was a mere £1500. In 1901, its annual income was £25000, of which the Government paid 12% and the local authority 8%. By comparison, in Germany the average university income ranged from £50000 to £150000, of which the State contributed almost 80%.

These provincial universities did not enjoy the social status of Oxford and Cambridge. They were rather looked upon as working class cousins responding to a pressing national need for scientists and engineers.

The 1902 Education Act

The Cockerton Judgement had ruled in 1900 that it was unlawful for advanced teaching to be given in State Schools under the Education Act of 1870 as the Act authorized only 'elementary' education. The Education Act of 1902 abolished School Boards, and County Councils and County Borough Councils became the local education authorities (LEAs) responsible for the provision of both State elementary and secondary education. Regulations made in 1904 and applied to grant-aided secondary schools specified a curriculum which included science, mathematics and modern languages. By 1906, these schools had to offer a minimum of 25% free places to elementary school children.

The authorization to provide secondary education could have boosted technical education but unfortunately in 1902 the Board of Education's Report shows a reaction against the emphasis on science resulting from the grant system. The report deplored the fact that 'Greek had disappeared from the curriculum of the grammer schools and that in many schools Latin was disappearing'. The Report warned 'It must be remembered that those who are educated in these schools are those in whose hands will rest a greater part of the local Government of this country. From them will come the greater number of the teachers and the writers for the Press. They are allowed to leave school without any adequate training in some of the most important parts of mental activity . . . This must have a most harmful influence on the intellect and character of the nation'. As a result of this reaction, emphasis was shifted towards the humanities and minimum hours of instruction for each subject were allocated. Science was allocated 3 hours compared with 4.5 hours for geography and history and 3.5 hours for the (compulsory) foreign language and 6 hours where 2 are taken. The Board had to be satisfied that the omission of Latin was to the advantage of the school. It undoubtedly looked upon higher education as being exemplified by a humanities curriculum and consequently science and technical education were relegated to a more humble role.

Thus whilst the Education Act of 1902 had given an impulse to higher education generally, its effect on technical education was, in practice, largely counteracted by the greater allocation of funds to the secondary schools and to the training of teachers. The Board's Report for 1909–1910 stated that 20% of the 750000 students in evening schools failed to complete enough attendances for the local education authorities concerned to earn grants for them; and the total amount of advanced instruction in technical institutions remained 'disappointingly small'. There was a general apathy towards technical education from both employers and employees and the effectiveness of evening technical schools was very low.

Full-time students in engineering and technology

In 1912–1913 there were only 1487 full-time students of engineering and technology in universities and colleges in England and Wales, together with 1199 advanced full-time students in technical instruction, ie a total of 2686. In Germany the comparable figure was 11000. In its report of 1918 the Thomson Committee commented on the wilfully small number of graduates in mathematics, science and technology and recommended that a large amount of public money be spent to develop university science. This report and the effect of the War resulted in an immediate post-War increase in university students in science and technology but the number of technological students fell off due to a depression in trade and industry and because of the comparatively high cost of courses. This high cost was one of the reasons why the Royal Commission investigating the universities of Oxford and Cambridge when they applied for Government grants in 1922 reported that the facilities at Oxford were inadequate for science students. Benefactions for scientific training to Cambridge had been more generous and the University served as a unique training ground for British scientists.

Between 1922 and the Second World War the percentage of students reading science and technology declined, although one might have expected, in view of the potential for industrial and technological developments, that there should have been a considerable increase. Even during the depression of the 1930s Government aid to the universities was running at about £1½ million per year coupled with a swing towards the arts subjects. Out of 71 new chairs created, only 22 were in science and technology (15 science and mathematics, 4 technology, 3 agriculture and forestry); 39 were in arts and the other 10 in medicine and miscellaneous subjects. At the commencement of the Second World War, there were only 10278 students of science and technology at English Universities compared with 9852 in 1922.

Table I: National Certificate and Diploma Awards from 1923 to 1964

	1923	1931	1944	1964
Ordinary	663	2043	4070	24744
Higher	168	749	1405	14340

National Certificates and Diplomas

The most significant development in technical education between the First and Second World Wars was the introduction of the National Certificates and Diploma schemes in 1921, which were intended to meet the need for nationally recognized qualifications in technology and which combined both practical and theoretical competence. They were awarded jointly by the Board of Education and the professional institutions. They were of two grades: ordinary and higher, ie ONC, HNC and OND, HND. The examinations were set and marked by the schools and colleges and assessed and moderated by external examiners appointed by the Joint Committees. The number of these awards grew steadily, as shown in Table I.

This growth was not the result of a definite policy of either industry or the Board of Education, which had attempted to distance itself from technical examination in the years following the Education Act of 1902. It became involved only because of the absence of initiatives outside. Indeed in 1948 the Ministry of Education gave the aim[2] of these examinations as 'to enable the best of young workers in industry to qualify themselves for promotion'. In 1961, the Minister of Education stated that 'they have provided qualifications in their own right suitable for different grades of technician' and 'they have provided a route to professional qualifications'.

Commenting on the part-time courses for ONC and HNC, the Crowther Report (1959) stated that the shortage of time made it difficult for the courses to serve any broader educational purposes beyond the immediate vocational object in view. There was a heavy failure rate amongst those who had to take a preliminary course before entering the technical course proper at age 16. Crowther reported that of all students entering a National Certificate course without exemptions, 26% eventually obtained an ONC and 10% an HNC. The figures for students who were exempt from the first year were 51% and 26%, respectively. Many of the successful students took extra time on the course. For example, only 11% of students entering engineering courses without exemptions obtained an ONC in the standard time of three years, and only 3.3% obtained an HNC in the standard time of five years.

This high and unacceptable failure rate was recognized when the Minister of Education presented to Parliament the paper 'Better Opportunities in Technical Education' in January 1961. The paper recognized that students should not have to rely wholly on evening classes for their vocational education and that this should be avoided by the extended grant of day release. In accordance with the report's recommendations, the first year of the ONC was abolished and entry to the course was confined to students who possessed four appropriate passes at GCE ordinary level or had equivalent potential to complete the course successfully. The HNC became a technician qualification rather than a route to membership of one of the professional institutions.

The diploma courses (OND and HND) were intended as a route for technologists. The hours of study on the courses were increased in accordance with the raised standards.

The National Certificate schemes were eventually phased out and replaced by the qualifications of the Technician Education Council (TEC) and the Business Education Council (BEC). These two Councils were eventually merged (see later).

Further education

The arrangements for further education were subjected to much criticism during the inter-war period and a Board of Education pamphlet in 1926 severely criticized existing college buildings which were 'distasteful to teachers who have known the amenities of study in a university, and cannot but repel those students, at least, who have had recent experience of a moden secondary school'. The Malcolm Committee on Education and Industry (1926–1928) found that the part-time evening system was particularly hard on the perseverance of young people in full-time employment. Only a small minority of employers permitted their employees to attend day-release classes.

Lord Eustace Percy in his book *Education at the Crossroads* referred to the tendency to regard the technical colleges as a lower grade of education and proposed that a large proportion of evening classes should be converted to day classes. He advocated that technical colleges should be local centres for education, leadership and higher learning, and the exploitation of their facilities would need originality and imaginative leadership.

Technical education was not expanded sufficiently to play a full part in the economy of the country as there was no pressure from industry for its expansion and management apparently considered that manpower demands were being adequately met by the existing provisions during the period of slump and depression. The Balfour Committee on Industry and Trade (1927) argued that 'until industry discovered and made known its industrial requirements, little progress could be made'. Industrial management was unimaginative, there was a reluctance to employ scientists and technologists at the top level and the value of research and development was not appreciated.

PRIMARY AND SECONDARY EDUCATION[7]

1944 Education Act

The Spens Report (Secondary Education) of 1938 had recommended the creation of technical high schools to supplement the Grammar and Modern Schools, thus advocating a tripartite system of education. The Norwood Report (Curriculum and Examinations in Secondary Schools) asserted that children could be divided into three categories: those interested in learning for its own sake, those whose interests and abilities lie markedly in the field of applied science or applied art, and those who deal more easily with concrete things than ideas (see Appendix, 1943). On the basis of this unjustifiable assumption that children of 12 years could be so identified, Norwood apportioned them to Grammar, Technical and Secondary schools according to their abilities. Thus Technical schools by the Norwood definitions would cater for those for whom 'the subtleties of language were too delicate' whilst Secondary schools would be attempting to educate those who 'deal more easily with concrete things'.

The Norwood Report is yet another example of the educational establishment's tendency to regard the application of science as an inferior pursuit to pure science and classical studies.

It is unfortunate that the idealist Education Act of 1944 (which made no such assumptions) should have been interpreted in the 'Norwood' tripartite manner by Governments of both political parties. The good intentions of the 1944 Act included compulsory further education (on day release from employment as necessary) for young people under 18 at 'County Colleges'. This section has never been implemented but its other provisions and its philosophy of equality of educational opportunity (see Appendix) place it as one of the three great educational acts (1870, 1902 and 1944). The Act helped to ensure that entrants to further education came with an improved background knowledge and experience. Furthermore, it required LEAs to submit detailed plans to the Ministry of Education covering their provisions for further education for those who wished to take advantage of it. However, it left a large proportion of the educational talent of the country in the private sector. Today, private schools teach 5% of the pupils and provide 20% of the A-level passes.

HIGHER TECHNICAL AND SCIENTIFIC EDUCATION[4,7,8]

The Percy Report, 1945

The Percy Report (Special Committee on Higher Technological Education) had a major influence on post-war policy for universities and technical colleges. It repeated the inevitable warning of every similar report since 1851, that Britain's position as a leading industrial nation was being endangered by a failure to secure the fullest possible application of science to industry; this failure being partly due to deficiencies in education. The report criticized the lack of liaison between universities and technical colleges and pointed out that 'the industrialist cannot easily find his way amongst institutions so many and so various, and is uncertain how to make his requirements known to them'.

It recommended that a number of technical colleges should develop courses of university standard, and also offer postgraduate courses in special technologies and new developments. The Committee 'urged the need for a national campaign to increase the prestige of the technical professions and to counteract the impression that the road to responsible executive posts in industry does not lie through these professions. Such a campaign should be specially directed towards public boarding schools, whose bias is often overwhelmingly against the technical professions, and for most of which the universities of the industrial Midlands and North hardly exist as possible places of education for their scholars'.

Scientific Manpower Report, 1946

An analogous enquiry into the purely scientific field was conducted by Sir Alan Barlow and its recommendations were published by HMSO, under the title 'Scientific Manpower', in 1946. This report advocated the doubling of the 1946 output of 2500 science graduates per year and pointed out that only one in five of the possible university entrants actually got into a university. It supported the conclusions of the Percy Report and stated that university-type institutes of technology were to be encouraged.

Regional Advisory Council and National Advisory Council on Education for Industry and Commerce

By 1947, the Regional Advisory Councils as advocated by Percy had been established, and in 1948 the Central Coordinating and Advisory Body was formed as the National Advisory Council on Education for Industry and Commerce (NACEIC). Its function was to advise the Minister on all aspects of national policy. Its first report dealt with technological education at first degree or professional institute membership standard. It recommended improvements in accommodation, equipment and financing of colleges. In addition it recommended the establishment of a 'Royal College of Technologists', which would validate courses, set standards and make awards. The principal award would not be a degree 'which would not receive the support of the universities'. But, as the London County Council Education Officer explained, whilst Government might increase grants and LEAs might try to establish advanced courses, 'we shall never attract students into these courses until we are in a position to award academic qualifications . . . at least comparable to a degree'.

National Council for Technological Awards

The proposal of the National Advisory Committee for a National Council for Awards in Technology at Technical Colleges was implemented. This Council was merely to create awards and to administer them.

Lord Hives of Rolls Royce accepted the chairmanship of the Council, whose name was shortened to the National Council for Technological Awards. The establishment of this forerunner to the CNAA in 1955 was a victory for those Ministry officials who felt that higher education should not be confined to the universities. The Hives Council provided details of the requirements for the recognition of its Diploma in Technology courses and set up subject panels for each technology in 1956. By July 1957, 49 courses had been accepted.

Robbins Committee and Technological Universities

In the event, the Robbins Committee recommended that the Colleges of Advanced Technology (CATs) should become technological universities, presumably on the grounds that they were already achieving standards equivalent to those of some universities and they would be less attractive to students and staff if they were unable to award their own degrees or be styled as universities. This Robbins recommendation was accepted by the Government and responsibility for them was given to the University Grants Committee. Most of them became universities by the end of 1967.

Robbins also recommended that the Hives Council be replaced by a National Council for Academic Awards covering the whole of Great Britain which would award honours and pass degrees to students in regional and area colleges. The Robbins' principle that all qualified entrants would secure a place in higher education was met by the formation of the CNAA. The public sector colleges were intended to meet an ever increasing need for vocational, professional and industrially based courses by offering degree level courses for appropriately qualified entrants, full-time and sandwich courses of a less rigorous standard and part-time advanced courses.

A White Paper entitled 'Plan for Polytechnics and Other Colleges' was issued in 1966 and outlined plans for concentrating resources by reducing substantially the number of colleges engaged in higher education. Only colleges designated as polytechnics would be permitted to introduce new courses in higher education. A list of 29 such colleges was published in 1967. The criteria for designation as a polytechnic included the requirement that the Secretary of State must approve the Instruments and Articles of Government. It could thus be ensured that the institution was serving national as well as local needs and that the governing body should have a wide autonomy consistent with the responsibilities of the local authorities.

THE FORMATION OF THE MARINE DEPARTMENT OF THE BOARD OF TRADE[9,10]

In 1830 the British Merchant Marine was the biggest in the world. It was also the worst. Its ships were unseaworthy, its officers and seamen irresponsible and its owners negligent. Each year during the 1830s, 2000 persons were drowned and over 500 ships were lost. Table II compares the increase in losses during the early part of the century and the rapid growth of steamships on foreign service over the period from 1818 to 1835.

There was much public agitation and by 1836 the pressure on Parliament was sufficient to force the House of Commons to select a committee 'to enquire into the causes of the increased number of shipwrecks, with a view to ascertain whether such improvements might not be made in the construction, equipment and navigation of merchant vessels, as would greatly diminish the annual loss of life and property at sea'.

The General Shipowners Society were strongly opposed to the Committee's recommendation that a Mercantile Marine Board be set up in London with powers to draw up a complete maritime code and, inter alia, to examine officers for competence. As in the case of a similar proposal (130 years later) by the Lord Rochdale Committee of Inquiry, no action was taken on this recommendation.

After more select committees, further public concern and the intervention of the Foreign Office (who were concerned about the fair name of Britain being sullied), the reluctant Government established, in 1850, the Marine Department of the Board of Trade to 'undertake the general superintendence of matters relating to the British Merchant Marine'. This superintendence included the introduction of statutory examinations for Masters and Mates.

Early examinations for marine engineers

During the early part of the nineteenth century, steamships were almost exclusively used in and around harbours for towing and other purposes, and a large and increasing number were so employed. The relatively small number of foreign-going steamships increased steadily during the century. In 1817 there were 14 foreign-going steamships. In 1836 there were 554, in 1843 there were 855, but it was not until about 1870 when the number of steamships surpassed the number of sailing ships.

These steamships were unsafe 'as the use of steam entailed a disadvantage of particular concern to those aboard the steamship. The steam, which was raised to high pressure, did not always reach the piston; sometimes it blew up the boiler first. More and more men were killed each year. By 1817 the reaction to this idiosyncrasy became so pronounced, that it could no longer be ignored'. A Select Committee of the House of Commons was appointed 'to consider of the means of preventing the mischief of explosion from happening aboard Steam Boats, to the danger or destruction of His Majesty's Subjects on board such Boats'.

There was general opposition to any legislative measure on the grounds that 'the science and ingenuity of our artists might appear to be fettered or discouraged'. Nothing was done and accidents continued, and during the 1830s 92 steamships were lost with 634 lives. Despite the strong opposition of the shipowners, the Act of 1846 gave the Board of Trade the responsibility to appoint inspectors to survey all steam vessels. In 1841 a report said 'Engineers are a new class and must be protected, for steam vessels cannot be worked if they are taken away', and the report shows that 1226 were protected from impressment in time of war.

Resistance to essential legislation was diminishing during the late 1850s and examinations for marine engineers were introduced in 1862, but without a Chief Examiner as the Department was still facing a continual struggle for resources during the economy drive following the expensive Crimean war. The marine engineer examinations were set centrally in London and administered directly by the Board of Trade from their inception rather than through Local Marine Boards as were those for masters and mates until 1914 when the Board of Trade took direct control.

Table II: Ship losses from 1816 to 1835

	1816	1817	1818	1833	1834	1835
Losses	353	402	439	601	497	554
Ships in foreign trade			24448			28243
Steamships in foreign trade			0			538

In 1873 the Marine Survey Service was reorganized and a consultative organization was set up in London (the professionals did not get administrative responsibilities until a century later). Mr J MacFarlane Gray, a founder member of the Institute of Marine Engineers, was appointed as the first Chief Examiner of engineers. He dispensed with the examinations papers then in use and the publication entitled 'Examiners Answers to Questions put to Engineers (Form EXN 13)'. In their place he substituted a list of 188 engineering knowledge questions which served as the subject's syllabus. By the turn of the century this list had been increased to over 300 questions, primarily because of the greater coverage of electrical machinery and equipment.

The background covering the standard of technical education in the United Kingdom given earlier in this paper indicates that the first engineers sitting the Department's examinations most probably received their initial education at either the Anglican or Non-Conformist Voluntary Schools (both groups were resisting state interference in education), possibly supplemented by evening attendances at the several mechanics institutes or at one of the so-called 'Schools of Design'. These latter schools were administered by the Board of Trade (independently of the Marine Department). They were mainly devoted to elementary adult education rather than to technical instruction.

Although the initial standards of the Department's examinations were low by comparison with those of today, an indication of the contemporary literacy may be gained from Table III relating to recruitment to English and Scottish regiments supplied to Parliament during the debate on the 1870 Elementary Education Act.

A study of contemporary arrangements for training and reference to the Department's Regulations show that the first marine engineers were trained as craftsmen. Due to the absence of basic technical education ashore during their apprenticeships, the Department's examinations had to be set at the minimum level necessary for safety purposes.

The basic nature of the ship's machinery and its unreliability had a major influence on the form of the examinations. They were essentially practical in nature and were conducted by the Department's marine surveyors. A major emphasis was placed on the ability to repair the ship's machinery, as may be judged from the following summaries of the syllabuses of the examinations.

Second Class Certificate of Competency

Candidates for a Certificate of Competency had, inter alia, to be 21 years of age and have served for at least 3 years as an apprentice to an engineer employed in the making and repairing of engines. After serving at least one year at sea in the engine room he had to be capable of giving a description of the construction of boilers together with the use and management of the items in the machinery space. He had to 'understand how to correct defects from accident, decay and means of repairing such defects, be able to describe how a temporary or permanent repair could be affected in the case of a derangement of a part of the machinery or a total breakdown; be able to pass a creditable examination as to the various constructions of paddle and screw engines in general use; and, be able to write with legible hand and understand the first five rules of arithmetic and decimals'.

Table III: Reading ability in the UK in 1870[a]

		Total men	Well	Imperfectly	Not at all
Reading ability	English	7506	33%	36%	31%
	Scottish	4970	37%	44%	19%
Writing ability	English	8563	19%	39%	42%
	Scottish	4970	23%	48%	29%

[a]Hansard 3rd Series, Vol 198, Cols 168–9

First Class Certificate of Competency

A First Class Engineer had additionally to serve for not less than one year in the engine room whilst in possession of a Second Class Certificate of Competency and in the capacity of a Second Engineer. He had 'to be able to make rough working drawings of the different parts of the engines or boilers; take off and calculate indicator diagrams; calculate safety valve pressures and the strength of the boiler; state the general proportions borne by the principal parts of the machinery to each other; explain the method of testing and altering the setting of the slide valves and of testing the fairness of the paddle and screw shafts and adjusting them; be conversant with surface condensation, super-heating and the working of steam expansively'. An essential part of both First and Second Class Statutory Examinations was an oral examination of about one hour's duration.

In addition to the statutory examinations, the Department introduced an Extra First Class Certificate of Competency as Marine Engineer. It was voluntary and 'intended for such persons as wished to prove their superior qualifications, and are desirous of having Certificates for the highest grade granted by the Board of Trade'. Initially, a pre-requisite for entry to the examination was that the candidate had to have served at sea for two years in possession of a First Class Certificate of Competency, but this requirement was withdrawn in 1885. It might be mentioned that the form of this examination and its conduct was varied from time to time. At one stage, it was conducted as an 'open book' examination over 100 years before the principle became briefly fashionable in other spheres.

The Board of Trade system of examination and licensing was unique in that, throughout the nineteenth century, it provided evidence of competence not available elsewhere. Certificate of Competency holders could show evidence of practical training, operation of boilers and machinery, a basic minimum standard of education, practical knowledge and sobriety, an uncommon attribute at that time. Extra First Class Certificate holders could qualify as Marine Surveyors in the Board of Trade and it was natural that the marine survey service was given the function of investigating the failure of boilers and pressure vessels both on land and at sea when the Boiler Explosions Acts were introduced in 1880 and 1882. The Board of Trade continued to exercise this function until 1976.

The Department's Certificate of Competency Examinations, twentieth century changes

Towards the turn of the century the Board of Trade initiated consultations and proposed changes in the engineer examinations regulations. The initial proposals included an increase from three to five years workshop service for Second Class Certificates of Competency. The Institute of Marine Engineers commented favourably on this proposal but expressed disapproval on the proposed time allowance to candidates attending technical school, ie three years technical school to two years in the workshop. It said that three years of technical school training should count as equivalent to one year of workshop service and that no allowance should be granted for time in excess of three years spent in a technical school. In the event, in 1901, the workshop service was raised

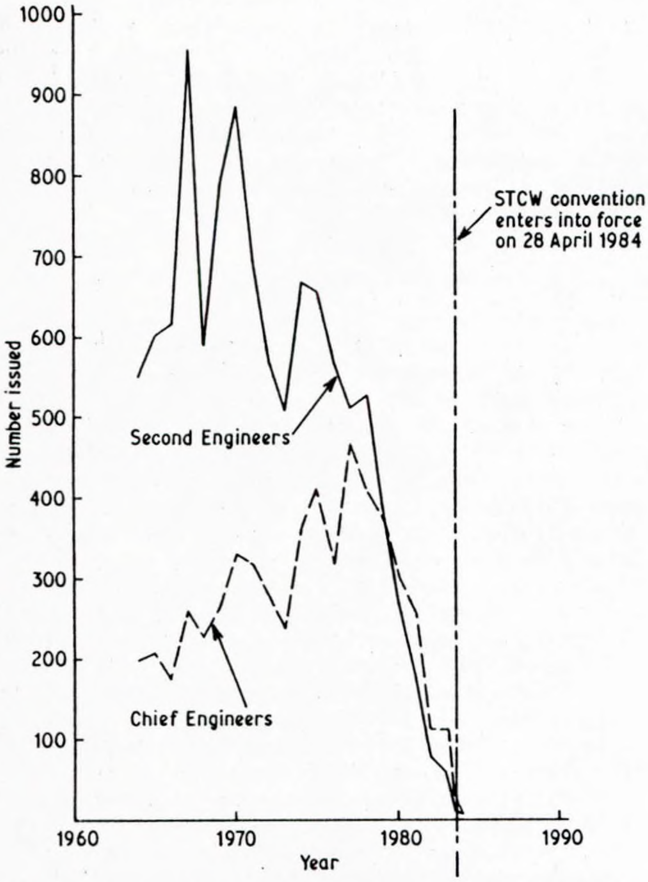

FIG. 1: Dispensations issued to Chief Engineer and Second Engineer Officers from 1964 to 1984

to four years but time spent at an approved technical school having an engineering laboratory was allowed to count in the ratio of three years of technical school to two years in the workshop despite the Institute's disapproval. The Department's approved list contained the names of several renowned university colleges and polytechnics.

In 1911, the Department announced that for examinations commencing after 1 January 1915, the period of sea service for both First and Second Class Certificates of Competency would be increased from 12 months to 18 months. However, the Department simultaneously announced that a candidate for either a Second Class or a First Class Certificate who, within two years from the date of application to be examined, had attended an approved course comprising general mathematical and scientific instruction at a recognized technical school would be allowed to count the time so spent as equivalent to sea service in the ratio of three months at the technical school to two months at sea subject to a maximum of one-sixth of the total sea service. This allowance did not meet with the Institute's approval. The Department later (1916) allowed attendance at College whilst studying for the Department's Certificates of Competency to be used to compensate for deficiencies in sea service, college time being counted at one and a half times sea-service time. Note that whilst the Department clearly put greater emphasis on workshop service ashore than either sea service or college time, it was trying to encourage attendance at technical colleges.

The Department's recognition of technical colleges for the above purposes did not reduce its own 'educational role'. For example, a circular giving 'hints to boiler attendants on board fishing and other vessels' included a list of 91 questions and answers and was first issued in 1891. This type of publication was additional to the Department's notices giving precautions against fire and explosion.

The 1922 Revision

In 1922 the examinations were extensively revised to meet the greater breadth of knowledge necessary for more highly developed ships' machinery and construction. The arithmetic examination was replaced by two papers at both First and Second Class level entitled 'Practical Mathematics', but in reality they were a collection of numerical questions on naval architecture, hydraulics, mechanics, heat engines and strength of materials. Engineering drawing was introduced at both Second and First Class levels with the intention of the candidate demonstrating 'that he is capable of making a dimensioned drawing of a part of the machinery such that, if the drawing were sent home from a foreign port, the part in question could, if necessary, be accurately reproduced and a new article fitted in place on board the ship on her return, without alteration'. Only a few principal dimensions were provided so that the exercise was also a test of engineering knowledge.

The Engineering Knowledge papers for both First and Second Class consisted of twelve questions, all of which had to be answered. The questions were divided into First and Second papers but there was no differentiation between the types of questions. The papers included questions on engines, boilers, practical naval architecture and electricity.

To meet the need for better communicative skills, the first question in both papers was always a report addressed to a shipowner or superintendent describing defects to engines and boilers etc. A note was attached to this question requiring that 'attention should be paid to composition, spelling and punctuation, as it is important that a Second or Chief Engineer should be able to write technical reports in good English'.

Provision was also made for 'Motor Endorsements' of Steam Certificates which would permit the holder to sail in the statutory positions on motor ships. Also, in 1922, the Department ceased to publish the list of 301 engineering knowledge questions about which candidates were expected to be knowledgeable and in their place introduced the publication of specimen examination papers. Candidates were requested, when answering the examination questions, to list the titles of the text books they had studied.

It is difficult to judge the relative standards of the Department's examinations and the national certificates and diplomas introduced in 1921. It would, however, appear that during the inter-war years the academic standard of the Department's examinations did not keep their earlier lead over shore-based qualifications.

Report of the Departmental Committee on Examinations of Engineers in the Mercantile Marine

During the unprecedented slump in the late 1920s and the early 1930s, the shipowners found difficulty in engaging and retaining engine-room staff. The status of seagoing marine engineers declined and between the years 1929 and 1936 there was a reduction of 50% in the number of certificates of competency issued to marine engineers. Shipowners became concerned and a Committee of Inquiry was set up 'to consider the present system under which candidates for certificates as engineers in merchants ships are examined by the Board of Trade . . . and make recommendations'.

The committee recommended that there should be regular changes in the surveyors employed on examination work at the ports in order that they might keep abreast of the latest developments in marine engineering and that all surveyors who undertake examination work should receive a period of three months training in that duty. Significantly the committee concluded that 'the overall standard of the examinations should be maintained'.

The committee recommended that the Board of Trade should approve courses of technical instruction and recognize the certificates gained for the purpose of exemptions. They reasoned that doing so would 'result in a much larger number of prospective marine engineers attending part-time day or evening classes regularly during their apprenticeship'.

However, the committee reasoned that the part B subjects of the examinations 'have, on the other hand, a very definite marine bias and we do not think that any courses included in the curricula of technical schools or even of schools specializing in marine engineering would warrant any exemption from these subjects. In any case we consider that the Board of Trade should retain direct control of the examination requirements in part B of the examinations'.

All the committee's recommendations were accepted by the Department and incorporated into the Regulations.

Alternative Training Scheme, 1952

After the 1939–1945 war, large numbers of marine engineers left the sea and there were insufficient certificated marine engineers to man the expanding fleet. In the early 1950s discussions took place between the Chief Examiner of Engineers and, initially, representatives of Shell Tankers and the Blue Funnel Line on an 'Alternative Training Scheme for Training Engineering Officers'. This was initially a course of four and a half years durations, which consisted of first a two year Ordinary National Diploma course in mechanical engineering at an approved technical college, with additional practical training during vacations, secondly a period of 18 months service as an apprentice engineer at sea, and finally a period of 12 months special training in a shipyard or marine engine builders or other suitable engineering works. Candidates satisfactorily completing this course were, on a subject for subject basis, given exemption from the fundamental knowledge subjects of both First and Second Class examinations and from the fundamental knowledge parts of the subjects Electrotechnology and Naval Architecture. No exemptions were granted from the practical knowledge subjects, ie Engineering Knowledge.

Initially limited numbers of these cadets were recruited and the shipowners could be very selective. At the time of introduction of the Alternative Training Scheme (later the Cadet Training Scheme), almost 900 traditionally trained engineer officers passed the Second Class Certificate examination but it was obvious that these numbers were declining. By 1973 the cadet schemes were producing 256 of the 573 Second Class Certificates issued. However these cadets were then coming from 3 separate schemes as the number of cadets qualified to enter the National Diploma courses had decreased because of the wider opportunities for higher education following the expansion of the universities and the introduction of CNAA degrees mentioned elsewhere in this paper.

A major problem for the shipowners was that the brighter cadets in the Ordinary National Diploma based cadet course were qualified to enter degree courses at the new technological universities and many did so. This was one of many reasons why shipowners had insufficient certificated engineers to man their ships. During this period (1950 to the mid-1970s) extensive use was made of the provision of Section 78 of the 1906 Merchant Shipping Act. Under this Section ships could be exempted from any part of the Merchant Shipping Act of 1894, and in order to keep ships sailing engineers without certificates of competency were, on the recommendation of the company concerned, given an oral examination and, if considered acceptable for the particular ship and type of voyage, were accepted in lieu of certificated engineer officers. These 'Dispensations' ran at very high levels (Fig. 1).

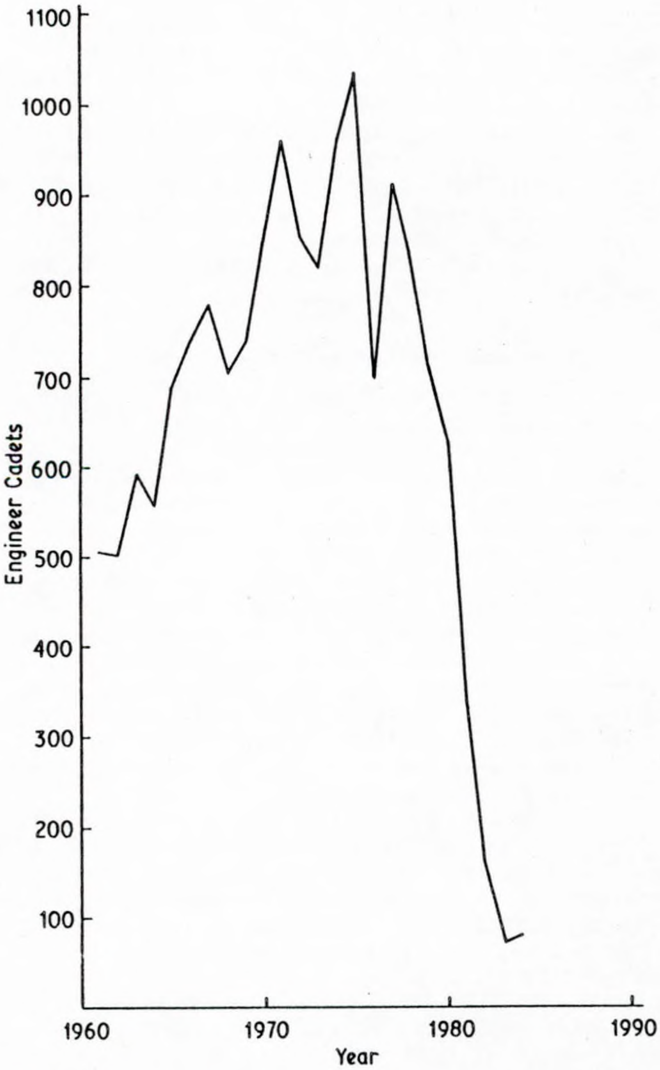

FIG. 2: Annual Engineer Cadet Recruitment from 1961 to 1984

International Standards of Training, Certification and Watchkeeping Convention, 1978

The entry into force of the International Standards of Training, Certification and Watchkeeping Convention of the International Maritime Organization on 28 April 1984 severely restricted an administration's ability to issue dispensations from the Convention's requirements. Any dispensations issued must be reported to the Organization. This development has led the Department to introduce additional certificates at lower levels than the First and Second Class Certificates of Competency (incidentally renamed Class 1 and Class 2) according to the horsepower and trading area of ships. A Watchkeeping Certificate (Class 4) has also been introduced as, under the Convention, all engineer officers in charge of a watch must be certificated.

It must be mentioned here that since 1973 the size of the UK fleet has fallen even more dramatically than it rose before that date. In response to absence of profitability and falling freight rates, shipowners have cut the recruitment of engineer cadets from its peak of over 1000 in 1975 to less than 100 in 1983 and 1984 (see Fig. 2). Figures 3 and 4 show the variations in the number of Class 2 and Class 1 Certificates of Competency, respectively. Inevitably the fall in cadet recruitment will be reflected first in the numbers of Class 2 Certificates issued followed two or three years later by a corresponding fall in the number of Class 1 Certificates issued. The number of Extra First Class Certificates of Competency is holding up well (Fig. 5), presumably because a greater proportion of the statutorily qualified engineer officers with good academic backgrounds are attempting the examination in order to obtain advancement in their careers and/or qualify for registration as a Chartered Engineer. Further comments on these aspects are dealt with later.

PROFESSIONAL INSTITUTIONS AND SOCIETIES PRIOR TO 1965

The Institution of Civil Engineers was the first formed (1818) of the present Chartered Engineering Institutions. It had been preceded by the 'Society for the Improvement of Naval Architecture', which was established in 1791 but like so many similar Societies it came to an end (in 1798). It was followed in 1847 by the Institution of Mechanical Engineers and by the turn of the century most of the current Chartered Institutions had been established.

The Institutions and Societies then, as, today, were concerned about status. In 1868 the Council of the Institution of Civil Engineers was pointing out that in England the profession of engineering was entirely unconnected with the Government and that there was no public provision for engineering education and so 'every candidate for the profession must get his technical, like his general education, as best he can; and this necessity has led to conditions of education peculiarly and essentially practical'.

Status appears to have played a significant part in the activities of the Liverpool Engineering Society which was formed in 1875. It is significant[4] that the first presidential address, given by Mr Graham Smith, was entitled 'The Status and Prospects of Engineers'. Referring to engineers, Mr Smith said 'their progress has been gradual. At the present time the leaders of the engineering profession are totally unrecognized by the British Government. On state occasions the merest subaltern takes precedence over engineers whose energy, ability and perseverance have been instrumental in placing Great Britain on the high pinnacle on which she now rests'.

In 1891 the President, Professor Hele-Shaw, reviewed the ways in which some of the leading engineers had entered the profession. He mentioned that Sir William Fairburn had been apprenticed at Percy Main Collieries and Sir Joseph Whitworth had joined Messrs Creighton's works at Manchester. Henry Bessemer had come to London at 18 years of age and got work as a designer. On the other hand, the only two on his list who had a university education were foreigners. He pointed out that times had changed, and said 'At one time an engineer was a many sided man who could do everything but now they were becoming increasingly specialized. It was becoming common practice for artisans to be kept in one branch or one detail of a branch of engineering. He was therefore at a disadvantage for the introduction of new machinery superseded his acquired skill and there were few opportunities for an artisan to go further'. As an ex Whitworth Scholar himself he mentioned that although the scholarships were really open to working men, they could not take advantage of them and not one of the Whitworth Scholars was then an artisan.

The Institute of Marine Engineers

The question of status appears to have been a primary factor in the formation[11] of the Institute of Marine Engineers. The increase in standards of the Board of Trade examinations over and above that which was seldom, if ever, obtainable by the typical young engineer before going to sea led to certified seagoing engineers demanding a status equal to that of the deck officers and a corresponding improvement in their conditions of service and salaries. It appears that the deck officers tended to maintain an unwarranted bias of superiority derived when engines were first fitted into sailing ships which were maintained by craftsmen with little or no technical education or social qualifications.

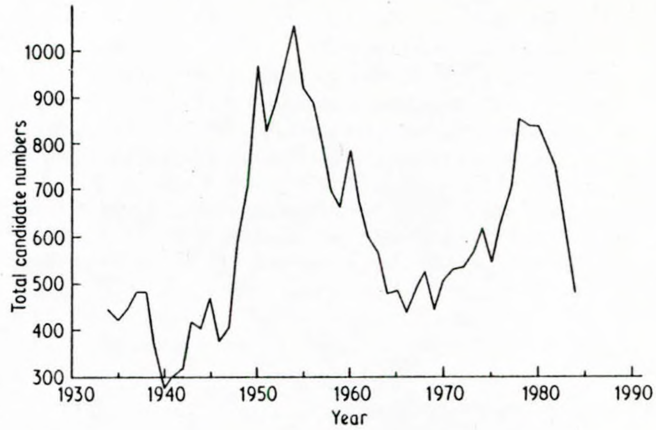

FIG. 3: Annual total issue of Second Class/Class 2 Certificates from 1934 to 1984

As an outcome of meetings amongst seagoing chief engineers of the leading mercantile shipping companies an association entirely separate from the element of trade unionism was formed. The organizing committee distributed a printed circular explaining the objectives of the Institute which included 'the social elevation of the members generally' and 'the maintaining and improving of the status of the profession of marine engineers, by creating greater facilities for self-culture, by social intercourse and the exercise of those faculties which tend to elevate and enoble'. Perhaps surprisingly, one of the first, and successful, battles the Institute fought was in respect of improving the status of marine engineers in the Royal Navy.

During the inter-war period, the Institute grew stronger in both membership and status and it was granted its Royal Charter in 1933. Its ten thousandth member was elected on 25 July 1956. The membership of other Institutions also grew during the twentieth century but, until 1965, each Institution chose its own entry standards of education, training and experience.

The status of marine engineers in the Royal Navy[11,12]

During the nineteenth century, the low status of engineers affected recruitment of engineer officers into the Royal Navy where the general view was apparently shared by the Admiralty Board. Engineer Officers were classed as a civil branch of the Navy. They had no executive control in their own Departments and had no power to award even minor punishments. They were not permitted to sit on a court martial when an officer or man of the engine-room department was being tried for departmental offences. In the 1890s there was an unsatisfactory age for age relationship in rank between engineer officers and executive branch officers and the engineering branch did not have a representative on the Admiralty Board, although it had a personnel of around 25000, ie about one-third of the total personnel of the Royal Navy. The first engineer officer was not appointed to the Admiralty Board until the late 1960s.

Note that in 1858 there were 971 commissioned officers in the engineering branch out of a total personnel of 3851. Forty years later in 1898 the corresponding figures were 845 commissioned officers and 22289 personnel. This was notwithstanding the fact that between those years the number of steamships rose from 3 (still chiefly dependent upon sail for propulsion) to over 500.

There were no educational or training reasons why engineer officers should have been considered lower in status than executive officers. Comparisons of the scientific and mathematical papers, submitted both at Keyham and Greenwich, showed that the naval engineer officers were, as a body, at least as highly educated as the officers of the executive branch.

The shortage of engineer officers was illustrated in a paper presented at the Institute of Marine Engineers in 1900 where comparisons of warship manning and merchant ship manning levels were made. For similar horsepowers, RN ships were shown to carry one fleet engineer, one engineer, five assistant engineers and one artificer engineer, a total of 7 commissioned and 1 warrant engineer officer. The merchant ship was shown to carry 22 engineer officers, of whom 10 held First Class and 3 Second Class Certificates of Competency. It is interesting to note that in addition the merchant ship (Cunard's *RMS Lucania*) additionally carried 2 electricians, 1 boilermaker, 24 greasers, 78 firemen, 60 trimmers, 2 storekeepers and 2 donkeymen. The paper explained that 'the civilian rank of the engineer officer and his consequent inferiority to every officer of military rank places him in many anomalous and humiliating positions, and completely undermines his authority over the men in his Department'. The paper quotes a debate on the navy estimates in which a member of Parliament stated 'It (rank) was a matter of extreme importance to the well being of the ships and ought to be dealt with in a broad and comprehensive manner. If the engineers were to have equal pay with the other branches of the service, but inferior rank, that branch would not attract equally able and good men. We had to think of the safety of our ships, and to consider whether the authority of the engineer was so great and so well defined as it ought to be'.

During 1900 and 1901 there was continual discussion at the Institute of Marine Engineers and the North East Coast Institution of Engineers and Shipbuilders on the unsatisfactory conditions prevailing in the engineer branch of the Royal Navy. A Joint Memorandum was presented to the First

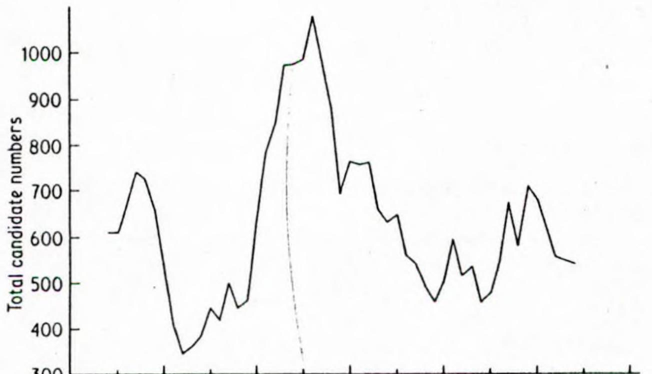

FIG. 4: Annual total issue of First Class/Class 1 Certificates from 1934 to 1984

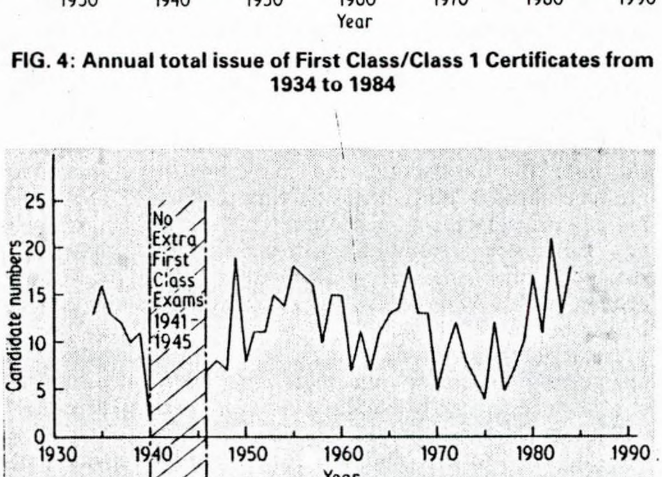

FIG. 5: Annual issue of Extra First Class Certificates from 1934 to 1984

Lord of the Admiralty, Lord Selborne, who on 16 July 1901 received a deputation consisting of 30 members of the House of Commons and 7 representatives of the two Institutions. These representations resulted in the Admiralty putting forward a new scheme (the Selborne Scheme) under which all officers for the engineer branches of the Royal Navy obtained their commissions through a common system of supply, entry and training. The outcome was thus most satisfactory although engineer officers in the Royal Navy were not granted military rank until December 1914. This was withdrawn in 1925, and with it went the opportunity for engineering officers to command ships and operational units.

STATUTORY REGISTRATION AND LICENSING

It seems appropriate at this juncture to say something about statutory registration and licensing. As these terms have not been explicitly defined and occasionally lead to confusion, for the purposes of this paper statutory registration means that the standards of qualification and rules of professional conduct of engineers would be set and administered by a publicly accountable body which would maintain a register of qualified persons who would have a distinctive title reserved to them by law. Licensing would mean that certain persons on the register would have certain functions reserved for them. It will be noted that the composite register of Chartered Engineers, Technician Engineers and Engineering Technicians operated by the Council of Engineering Institutions/Engineers Registration Board (CEI/ERB) was essentially a voluntary register which was not even formally recognized by the Government.

Some engineers believe that the status of the profession would be increased if there were a statutory register which would restrict the right to practise engineering only to those on the register. Others would prefer that a system of licensing should be introduced so as to restrict functions to certain individuals specifically qualified to perform them whilst others would wish both statutory registration and licensing to be introduced.

In its full page spread entitled 'The Way Ahead for the Engineering Profession and for Britain' published in *The Times* on 25 October 1978, the Institution of Electrical Engineers (IEE) expressed the view that statutory regulation of the profession would be in the public interest. The Institution made the point that 'the transfer from the present voluntary system of registration to a statutory system without any form of licensing would not be worth the effort it would entail'. It believed that statutory registration without licensing would contribute little, if anything, to improving the protection of the public, and the authority of the registering body would depend upon the effect of its ultimate sanction, namely the withholding of registration. This would be minimal unless it restricted in some way an engineer's opportunities for employment. That Institution believed that the registering body should be publically accountable and created by an Act of Parliament. It was envisaged that the controlling body should be a council composed mainly of members of the profession, so that the profession continued to be essentially self-regulating. The engineering members of the registering council would act in a personal capacity, ie they would be independent of the institutions. The IEE saw the role of the institutions in the qualifying process as being advisory, the executive responsibility residing in the registering council.

The opponents of compulsory registration ask who would be competent to assess the qualifications of about one-third of a million persons in the engineering profession. What would happen to those engineers who were not admitted to the register? If all existing practising engineers were admitted to the register, what difference would statutory registration make? If licensing were necessary, who would issue the licenses? Possible organizations include the relevant professional institutions, the body representing all engineering institutions (ie like CEI), a statutory authority, a Government department, or a non-statutory body.

Regarding status, the author can see no reason to suppose that statutory registration or licensing to practise would, of themselves, help to raise standards. Licensing could even lead to a depression of standards to the lowest common denominator. Industry would certainly oppose a proposal for licensing if it meant a restriction on the number of people available for employment. Most firms would argue that they were the best judges of the competence of people they wished to employ.

Whilst licensing has been considered appropriate in both the cases of licensed firms (eg the aircraft industry) and licensed individuals (eg ships' engineer officers and posts within the mining industry), in the author's opinion there is no firm evidence that it has raised the status of engineers within those industries above the status of engineers in other industries. Whether statutory registration of the whole profession, if this were to be accepted by the Government of the day, would eventually lead to increased status for engineers is a matter of individual judgement. However, there seems to be insurmountable problems to its establishment.

REGISTRATION OF ENGINEERS IN THE UK

The Council of Engineering Institutions (CEI) and Engineers Registration Board (ERB)

Following the formation of the European Common Market and the UK's (initially unsuccessful) application for membership, there was a feeling that, unless our professional engineer's qualifications were seen to match those of our continental neighbours in academic content, our engineers would not be permitted to practise in other countries. Moves were made to establish a uniform higher standard of academic qualification. These events culminated in the formation of the Engineering Institutions Joint Council (EIJC), and the Institute made its first crucial decision which was to participate in this venture. The EIJC was succeeded by the Council of Engineering Institutions (CEI).

CEI obtained its Royal Charter in 1965 and the author's memory was refreshed by the discovery of his programme for a Reception to mark the occasion in the presence of Her Majesty The Queen and HRH The Duke of Edinburgh. Apart from representatives of the thirteen founder institutions, the reception was attended by some 140 official guests of the highest rank. With the approval of every appropriate organization and personage from Her Majesty downwards, the Chartered Institutions had taken upon themselves the right to govern themselves. That right was acknowledged by the granting of a Royal Charter. Little did anyone guess that Chartered Engineers would voluntarily abandon that right in less than twenty years' time!

Although the 18 years of CEI were plagued by discontent, much was achieved. By October 1967 Part 1 of the qualifying examination for Chartered Engineers had been set. Part 2 of the exemplifying examination was first held in April 1968. However, the full qualifications were not instituted immediately and there was a period of concession which lasted until 1971. A register of Chartered Engineers was established and included about 70% of those engineers qualified to be so registered. In 1971 the Engineers Registration Board (ERB) and the composite register were established so as to include the registration of Technician Engineers and Engineering Technicians. Section Boards for the latter were formed in 1971 and a Chartered Engineer Section Board in 1978. A comprehensive system of vetting education, training and experience for registrants on each of the three stages of the register worked smoothly. The organization was also very effective in operating the CEI examination for prospective Chartered Engineers. The Department's Extra First Class Certificate of Competency examination was assessed by various university professors on behalf of CEI and successful candidates were eligible to be registered as Chartered Engineers. The statutory First and Second Class Certificates of Competency holders were eligible for registration as Technician Engineer and Engineering Technician, respectively.

Despite these accomplishments, CEI never achieved the prominent coherent voice in the nation's affairs that its founders had hoped for. It could not halt the erosion of the status of engineers, improve their pay or make an impact on public opinion. Probably too much was asked of it. Engineering produces some 40% of the country's total output and about 50% of its export of manufactured goods. If the economy was failing then responsibility had to be placed somewhere, and much of it was being placed on engineers. The fact that engineering had a tarnished image meant that it was being starved of the best brains in the country.

FINNISTON INQUIRY INTO THE ENGINEERING PROFESSION

After much speculation and press interest in the disagreements in CEI, on 5 July 1977 Eric Varley, the Labour Government's Industry Secretary, announced an 'Inquiry into the Engineering Profession' with the following terms of reference: 'To review for manufacturing industry, and in the light of national economic needs

1. The requirements of British industry for professional and technician engineers, the extent to which these needs are being met, and the use made of engineers by industry;
2. The role of the engineering institutions in relation to the education and qualification of engineers at professional and technician level;
3. The advantages and disadvantages of statutory registration and licensing of engineers in the UK;
4. The arrangements in other major industrial countries, particularly in the EEC, and to make recommendations.'

Finniston Report

A Conservative administration came into power in May 1979 and the report of the Committee of Inquiry into the Engineering Profession was presented to its Secretary of State for Industry, Sir Keith Joseph, on 16 November 1979. In its report the committee referred specifically to the particular emphasis they had laid on the requirement that they conducted their review 'for manufacturing industry and in the light of national economic needs'. Their paramount consideration and test of their conclusions was 'will this benefit manufacturing industry and further national economic needs?'

These emphases led them to relate the particular issues before them to the general concept of the 'Engineering Dimension', which they defined as 'the effectiveness of manufacturing organizations in translating engineering expertise into the production and marketing of competitive products through efficient production processes'. The committee's principal recommendation was the establishment of a new Engineering Authority with a remit to promote and strengthen the 'Engineering Dimension' within the British economy. This Authority was to be a statutory body, funded by the Government, with 15–20 members appointed by the Secretary of State to reflect the balance of interests within the engineering dimension; members, the majority of whom should be engineers, would serve in an independent capacity.

Although the committee favoured a statutory register, they were opposed to any generalized reservation of engineering work to registered engineers except in areas of activity where public health and safety considerations arose. Where licensing was justified (and the committee felt that the present areas should be widened), the persons holding licenses were to be both suitably qualified and registered engineers. The Committee also believed that the Government should introduce legislation for the licensing of engineering consultants.

The Parliamentary Debate on the Finniston Recommendations

When the report was debated on Friday 13 June 1980 in the House of Commons only junior Ministers were present. Fourteen MPs spoke and at one stage it was pointed out that only 12 members were present.

The junior Minister acknowledged that Finniston had done a great service in illustrating the importance of the 'Engineering Dimension' to industrial enterprise but emphasized that it was only one of the many facets that are required for success in world markets. The direction of the Government's thinking was evident when he said that it would be wrong to suppose that the acceptance or implementation of the report rested solely, or evenly primarily, on whether the Government decided to establish a new authority.

As might be expected, the debate followed traditional party lines. The Labour opposition members were in favour of a statutory authority whilst a Conservative MP said that the intention behind the Finniston Committee report was to raise the status of engineering and to make it a more attractive profession. He felt it would be a retrograde step to put it under Government control. That would put engineers in an even worse position than they were today. Labour members felt that the report had not gone far enough as it had not recommended licensing as such. They believed it would be necessary to introduce licensing in the case of large industrial plants in which explosions can occur, in the case of nuclear power stations, chemical plants, oil rigs etc. The opposition members stated that if the Government did not establish an engineering authority a future Labour administration would do so.

ENGINEERING COUNCIL

On 7 August 1980, the Secretary of State for Industry announced the intention to set up an Engineering Council. Almost a year later (30 July 1981) in a written Parliamentary Answer, the Parliamentary Under Secretary of State for Industry told Parliament that Sir Keith Joseph had recommended that the Privy Council advise that a Royal Charter should be granted to establish the Engineering Council and that Sir Kenneth Corfield had agreed to become its chairman designate. The draft charter provided that the objects of the Council would be to advance education in, and to promote the science and practice of, engineering for the public benefit and thereby to promote industry and commerce in the United Kingdom.

The Council's task would, therefore, be to advance what the Finniston report called the 'Engineering Dimension' to help to harness the country's engineering expertise into the production and marketing of internationally competitive products and into wealth creation. Under the Charter, the Council would establish a national register open to all who met its standards and criteria. The Council would control the accreditation of academic courses, industrial training programmes and arrangements for experience satisfying its standards and criteria. However, the Council was expected to use as its agents, to the maximum extent possible, the engineering institutions and other bodies which it nominated for those purposes. The position of all engineers registered by the ERB would be safeguarded and it was envisaged that the title of 'Chartered Engineer' would become available to the Engineering Council. It was recognized that this transfer of title would have to be approved by the membership of CEI followed by a petition to Her Majesty The Queen.

The members of the Council would be appointed by the Secretary of State for the first three years of operation. The members would be appointed as individuals and not as representatives of any particular interested group.

After the initial three years, the Chairman and other members (between 15 and 24 in number) would be selected by the Council in accordance with its by-laws. At least half of the membership would have to have experience as employers or managers of practising engineers and engineering technicians and the Chairman and at least two-thirds of the other members would have to be Chartered Engineers, selected from a list of names put forward by employers organizations, educational institutions or nominated chartered engineering institutions.

The Government would help to finance the Engineering Council's initial running costs, but the firm intention was that the Council should become financially independent as soon as possible. On 5 November 1981, the Secretary of State for Industry announced that Her Majesty The Queen had indicated her intention to grant a Royal Charter to establish the Engineering Council. The CEI Board had, however, already publicly confirmed its willingness to seek the agreement of the membership of CEI to any transfer of its functions to the Engineering Council when it was satisfied that their interests would be fully protected.

To relinquish its charter, the CEI Board had to obtain a two-thirds majority of its members. The author well remembers chairing an Extraordinary Meeting of the Council of the Institute of Marine Engineers on the morning of 11 November 1982 immediately prior to the CEI Board meeting. There was an excellent debate and a lively discussion of all the issues. It was a serious matter, for to vote for the transfer of CEI's functions meant relinquishing the right of self-regulation by the Institutions. In the event, the Institute's Council members voted unanimously to support the transfer of the CEI Charter to the Engineering Council.

At the CEI Board meeting later that day, the six points on which the CEI wanted assurances were discussed. In the subsequent vote on whether to relinquish the Charter, none of the Institute's nominated members voted against surrendering the Charter. Incidentally, the necessary majority would have been obtained even if the Institute had voted against surrender of the Charter. This decision was confirmed by a poll of all Chartered Engineers conducted between 15 November 1982 and 7 February 1983. In view of the decision of the CEI Board and the recommendation by all Chartered Institutions to their members to vote for the transfer, it was only to be expected that the Chartered Engineers would vote for a transfer of powers. However, it was not so clear that the result would be so decisively in favour of the transference of powers. Of the 41% of the Chartered Engineers who recorded their votes, 93% were in favour of a transfer of powers and only 7% were against. On 29 March 1983, the CEI Board passed, by the necessary two-thirds majority, a special resolution to wind up the affairs of the Council completely and to surrender the Royal Charter.

The Engineering Council (EC) differs from the CEI in that it is independent of the Institutions whereas CEI was a federal organization composed of representatives of its member institutions each of which had a single vote regardless of its size. Representatives of the Institutions serve on the EC's Board for Engineers Registration (BER) and the EC's executive group committees. Institution representation and voting power within the EC is in proportion to the numerical strength of the Institutions.

In my view, the most fundamental difference between the CEI/ERB organization and the EC relate to their respective objectives. In brief, CEI intended to establish, uphold and advance the standards of qualification, competence and conduct of professional engineers and to advance the aims and objectives of its members and to promote and maintain the unity, integrity and quality of the engineering profession.

On the other hand, the Engineering Council was established against the background of the country's reliance on the performance of its engineering industry and in response to the recommendations in the report of the Finniston Committee of Inquiry. The principal aim of the Council is to advance education in, and to promote the science and practice of, engineering for the nation's benefit, and is much wider than CEI's and takes into consideration efficiency and competitiveness of industry and the nation's future industrial, economic and social prosperity.

The EC's future success will depend largely on whether it gets greater support from Industry and the Government than did CEI. There are hopeful signs. It has recognition in that it was set up by the Government who appointed its initial members and helped to finance its initial running costs. Both the Government and Industry will need to contribute increasingly to the training and educational programmes proposed by the EC. The Institutions will undoubtedly continue to provide strong support for the EC within their areas of competence.

THE PRESENT SITUATION

Secondary education

The twentieth century has seen the introduction and cessation of issue of School Certificates, which for their attainment required a breadth of knowledge over a combination of subjects. These were replaced by General Certificates of Education at both Ordinary and Advanced level, which could be obtained as single subjects, although combinations were normally required for entry to courses of higher education or by prospective employers. Later, in response to continual pressure from parents, a reluctant Education Department was forced to introduce Certificates of Secondary Educatic ı (CSEs) for pupils of lower academic ability. At present[13] some 20% of young people now obtain at least one General Certificate of Education A-level pass, about 75% leave school with at least 5 graded (ie GCE O-level grades A to E, or CSE grades 1 to 5) results and about 10% leave school without any graded results at all.

The present GCE O-level and CSE examinations are being reformed. Currently, there are 20 separate examination boards each awarding its own certificates, many hundreds of subject titles, and nearly 19000 syllabuses. The O-level and CSE grades overlap and it is difficult to form a clear understanding of the relationship between a CSE grade 1 Certificate and the corresponding O-level grades.

In June 1984, the decision to introduce The General Certificate of Secondary Education (GCSE) with a 7 point scale of grades A to G, to replace O levels, CSE and the joint 16 plus examinations, was taken. The first GCSE examinations will be held in 1988. The main feature of the GCSE will be a single system with differentiated assessment, which is intended to permit candidates at each level of ability to show what they know, understand and can do on the basis of suitably differentiated papers, or differentiated questions within papers, in all subjects. This system will be administered by 5 groups of boards instead of the present 20 independent boards.

These proposals have, however, been severely criticized by both the Centre for Policy Studies (CPS) and a GCE examining boards' joint report. Fears have been expressed on the new GCSE examinations' emphasis on monitoring standards by classroom performance and project assessment by the candidates' own teachers. Also criticizing the variations in the national criteria published for each subject, the CPS say that standards are bound to vary widely from subject to subject.

The GCE boards' report criticizes scathingly the Secretary of State's 'simplistic' view that the new examinations will, unlike existing ones, assess what candidates know rather than what they do not know.

No radical changes are proposed in respect of GCE A-level examinations (including Special papers). A levels set standards of excellence, they have an educational value in their own right and they play an important role in selection for higher education. However, there is concern about the nature of the grading system, including the definition of grade boundaries, and about the content of A-level examinations. A working party of the Secondary Examination Council is studying the A-level grading system. The grades are not an absolute level of achievement and vary according to performance of the students sitting the examination. In addition, the A-level syllabuses are being considered by the GCE Boards and the Standing Conference on University Entrance.

The present arrangements for examinations at 18 plus and for admission to higher education encourage students to pursue good grades in a limited range of A-level subjects. To promote greater breadth for A-level students, Advanced Supplementary (AS) subjects, following the introduction of new examination courses, are being introduced. These AS subjects will require about half the amount of teaching time of an A-level course. It is expected that the first AS-level examination will be introduced in 1989.

As a general point, the success of all the above developments will depend upon the whole-hearted support of enthusiastic teachers, and in the present state of unrest and disagreement with the Government over levels of remuneration it is difficult to see how maximum benefit can be obtained from the proposed changes.

Higher education

The Government is advised on higher educational policy for the Universities by the University Grants Committee (UGC) and for public sector higher education by: for England, the National Advisory Body (NAB); for Wales, the Wales Advisory Body (WAB); and for Scotland, the Scottish Tertiary Education Advisory Council (STEAC). In brief, in the UK there are 46 publicly funded universities (including the Open University); there are also 30 polytechnics and (in Scotland) 16 central institutions and some 364 colleges providing higher education. In spite of these facilities, the economic performance of the UK since 1945 has been disappointing and there are shortages in several branches of engineering. Other competing countries are producing more qualified scientists, engineers, technologists and technicians than the United Kingdom.

The effects of the cuts in financial support for higher education has meant that, since their introduction in 1981, university intakes have been reduced by about 10% and the University Grants Committee has indicated a 2% cut in real terms for the next three years. The network of Industrial Training Boards (ITBs) established under the 1964 Industrial Training Act included, at its maximum, 27 ITBs with a total levy income of £200 million, representing 2.5% of the wage bill of each Establishment. In 1981, the number of ITBs was reduced to 7 and the levy/grant system was replaced by a levy across the board on employers in the relevant industrial sectors, currently between 1 and 1.1% of the wage bill of each workplace. The consequence of this has been to place a greater emphasis on industry's voluntary efforts to provide and co-ordinate training. Will industry respond? This history gives little cause for optimism.

The Government[14] is attempting to change the subject balance in higher education by maintaining a distinct emphasis on technological and vocational courses and has established an Information Technology Skills Shortages Committee. It is concerned that industry is handicapped by an inadequate supply of high-quality, skilled graduates in the fields of electronic engineering and computer science and related disciplines. In March this year, influenced by the Engineering Council, it announced a decision to allocate £43 million over

Table IV: Changes in employment in electronics industry in Scotland

	1978	*1984*	*Change*
Total employees	36800	36650	None
Scientists and technologists	1879	3636	+94%
Technicians	4384	5425	+26%
Operators	18700	15300	−18%

the next three academic years for the provision of extra places to increase the number of graduates and post-graduates in engineering (particularly electronic engineering), applied physics, material science and computer science. When this programme is fully implemented it is estimated that some 4000 additional places will be provided.

It is trying to influence the proportions of undergraduates in science and technology at the expense of places in higher education in the arts and social science subjects. It is also attempting to introduce performance measurement in higher education by assessing the value for money expended by an analysis of benefits and their related costs in different activities in order that its economic value may be identified. These attempts have been criticized by Enoch Powell, who had asked the Secretary of State 'to recognize that it is barbarism to attempt to evaluate the contents of higher education in terms of economic performance or to set a value on the consequences of higher education in terms of a monetary cost benefit analysis'.

However, an even more significant shift towards the manufacturing industries than has so far been ensured is essential because, for the first time since the end of the eighteenth century, during the past 2 years the United Kingdom has had a negative balance of payments in manufactured goods. In 1981 we had a positive balance of £5 billion, but in 1984 we had a negative balance of £4 billion. A major crisis has only been avoided by the export of surplus North Sea oil, the output of which will begin to decline next year. But it is difficult, even for the Secretary of State, to compel students to take particular courses. The UK educational system is not organized to be susceptible to external direction and despite statements that higher education must be used to improve the economy, it is hard to see how compulsion can be introduced. Certainly the majority of those concerned with education, and even training, would be opposed to compulsion. Even if additional places could be provided in science and technology, this would not necessarily solve the country's problems unless the brightest students could be persuaded to take them. Producing increased numbers of mediocre graduates would certainly not increase the status of engineers and applied scientists.

Current trends indicate that future needs of industry will be greatest in the graduate and more highly qualified technician areas of the working population. John Cassels, Director General of the National Economic Development Office, quotes the EITB manpower figures for the electronics industry in Scotland (Table IV). During the same period, craftsmen's jobs fell by 9%, administration occupations fell by 14% and management posts rose by 22%.

In assessing the future needs for highly qualified personnel, account must be taken of the potential student population.

Statutory Certificates of Competency for marine engineers

At the time of writing the Department is consulting with the Industry, colleges and national examining bodies on new arrangements for Certificates of Competency which will be based on the B/TEC and SCOTVEC examinations. It is envisaged that the Department's involvement will be limited to maintenance of standards and final assessment of a candidate's competency.

These developments follow the reduction in the size of the UK fleet. The recent and anticipated falls in the number of canidates and the policy of full cost recovery of services performed by Civil Servants means examination fees will be prohibitively high under the present system. The changes are an extension of the system of exemption pursued on the engineering side since the Viscount Runciman review of 1938. The policies of B/TEC and SCOTVEC in their use of 'units' of study have made it feasible to extend the Department's exemption practices to candidates who have not qualified for entry to the examinations through the Cadet Training Schemes. It is, however, too soon to speculate on the responses to the Department's proposals. If a satisfactory relationship can be mantained between the statutory examinations and national qualifications, it must be in the long-term interests of marine engineers and the profession in general.

Brief mention must also be made of the effects of the National Advisory Body's review of the marine colleges in England. The net result has been a reduction to only four Colleges offering courses for the Department's Class 1 and Class 2 Deck and Engineer examinations. Colleges in other parts of the UK are also under review.

The Engineering Council (EC) and the Professional Institutions

The Council's proposals for Standards and Routes to Registration (SARTOR) are still being responded to by the institutions, but the major decisions have been made. The qualifying standard for Stage 1 registration will be, for courses commencing in 1987, an Honours (BEng) degree in engineering. This will necessitate changes in the EC's own examination and a reconsideration of the Extra First Class Certificate examination, which currently attracts exemption from Stage 1 (Academic) and covers the Stage 2 (Training) and Stage 3 (Experience) requirements for registration as a Chartered Engineer. A working group of the Institute's Professional Affairs and Education Committee is working on the development of an 'Enhanced' Extra First Class Course and examination intended to satisfy the new EC academic standard for registration. This group will take into account the eventual outcome of the proposed arrangements for the statutory examinations.

The other alternative to qualifying by a BEng degree is through the EC's own examination, and, recognizing the particular difficulties for marine engineers qualifying through the statutory certificate route, the Institute made a submission to the EC. The basis of the proposals was that registered Technician Engineers be permitted to enter Part II of the EC examination subject to the Institute's 'sponsorship', ie the Institute would be obliged to ensure that such candidates had been so educated and prepared as to have a reasonable chance of success.

Other changes will involve Professional Interviews for both Chartered Engineers and Technician Engineers and a Professional Review for Chartered Engineers.

SUMMARY AND CONCLUSIONS

The pessimist will conclude that, in the period under review, nothing has changed. In justification, it will be pointed out that the same pleas and messages are being made today as were made in 1841 and at every economic crisis and wartime emergency during the period. Only the style changes. In 1841, *The Times*' leading article was saying 'we must distribute the honours and rewards of life in channels where they may fructify to the use of the Commonwealth', whilst the 1985 Green Paper[14] speaks of the need 'to convince pupils and students that scientific and technological qualifications will increase their chances of a rewarding career'. The evidence is that young people are not entirely convinced as the recent tendency for them to choose science and mathematics A levels has been checked and the increased numbers of science and technology places in public sector colleges planned by the National Advisory Body for the 1984/85 academic year were not fully taken up.[14] There would be no point in continuing to provide more places in science and technology in higher education unless enough students of suitable quality were coming forward to fill them. This has been a recurring theme throughout the period of the review, eg in 1915 it was stated that the Board of Trade wished to raise the standard of its statutory examinations but 'were prevented by the total failure of the educational bodies to raise their educational standards'.[4] In view of its national importance, why is it that technology is not commensurately attractive? Why is the educational system not directed in a positive manner to engineering and technology? There is no single or uncomplicated answer but, in the opinion of the author, two reasons are paramount: the British characteristic respect for individualism and the class-conscious attitude to engineering and industry. Only in times of national emergency is there a movement towards national objectives and effort and a begrudging acceptance of the value of engineers and applied scientists.

Until late in the century, Victorian governments believed the country's prosperity was, and would continue to be based, on national characteristics of individualism and ingenuity. The mass of the people may have been illiterate but if they wished to learn they could teach themselves. The public schools were providing the leaders: the statesmen, diplomats, administrators for the Empire; the Admirals and Generals; the Officers and gentlemen. Britain's industrial prosperity was due to its engineers' 'hereditary instinct for engineering'.

These engineers had succeeded without formal, much less higher, education and their achievements gave rise to the myth that engineering was a factory process for the uneducated. Their success and the social attitudes of the times gave them the opportunity to send their sons to public schools and universities where the emphasis was on classics (Table V) and engineering and manufacturing were held in low esteem. The entrepreneural initiative was lost. Furthermore, since engineering was for the less educated, and the working classes were the least educated, engineering was looked upon as a working-class occupation.

The need for higher education remained unrecognized and, with some notable exceptions, British industry continued to use rule-of-thumb methods rather than applying the principles of operation or design before commencing construction. Other countries, notably Germany, developed science-based industries. As science and technology advanced the need for higher technical education became more essential. The steam engine was developed indepedently of an academic understanding of the laws of thermodynamics, but Dr Diesel developed his engine after writing a thesis on its principles of operation. Sir Frank Whittle's understanding of the potential for exploitation of the thermodynamic cycle was a major factor in his development of the gas turbine. British inventions were exploited by foreign teams more highly qualified by scientific training. Osborne Reynolds' pumps, Parson's steam turbine and Dugeld Clark's two-stroke gas engine (as well as the application of the two-stroke cycle to Diesel engines) are but a few examples.

The nineteenth century image of an engineer as a 'practical man' has died hard in the UK. It is still reflected in the lower proportion of graduate engineers in UK industry than in competing countries (one in fourteen compared with one in five in the USA) and in the annual output of engineering graduates (15000 compared with 60000 to 70000 in Japan).

Consequently there has never been a national plan for technical education at any level, indeed there has never been any cohesive system of education! In the nineteenth century the spirit of self-help pervaded and the state was reluctant to provide education, even at elementary level, when our competitors were developing educational systems in the interests of the community as a whole. Whilst Germany trained all workers through specialized courses, British training has been organized so that individuals may secure what they think best for themselves.

These factors have meant that academically able sixth-form students clearly preferred to apply for university courses in classics, law and the pure sciences rather than engineering and technology. They believed that less 'good' careers are offered in engineering, technology and production than in the medical professions and the pure sciences. This is in sharp contrast to other countries, eg Germany, France, the USA and Japan where 85% of the members of the Boards of large companies in industry (as well as a high proportion of top administrators) have taken degrees in physics or engineering. 'To the ordinary Japanese, successful businessmen are as well known as pop stars are to the ordinary young Englishman'. It is recognized that they work for the national good and when Mr S. Honda was criticized for his apparent recklessness in pushing ahead with the expansion of his business he replied 'even if my business were to go bankrupt because I expand my plant too fast, the plant itself will remain to be of use for the development of Japanese industry'.

This single-minded recognition of the needs of the country is not generally evident in Britain where we have obvious difficulty in accepting the necessity for change. For example, that remarkable gentleman, Harold Macmillan, 1st Earl of Stockton, educated at Eton and Balliol College, Oxford, has in the House of Lords debates recently been expressing his strong and sincerely held views on the evils of unemployment. Yet, when he returned to Oxford, he voiced his regret at the presence of 'those no doubt essential but somehow discordant temples dedicated to science and technology' and he reminisced of 'the days when there were happily no industries to mar the city's charms'.

The proven success of the 'science parks' around American universities has fortunately led to similar developments here and, for example, the number of high technology firms in the Cambridge area has grown from 100 to 300 in the last ten years whilst 25 years ago there were only 30. Collaboration between industry and higher education establishments will be further facilitated by the government's decision to allow public sector colleges to undertake commercial activities in

Table V: Fellowships at Oxford and Cambridge in 1870

	Classics	*Mathematics*	*Law and modern history*	*Natural science*
Oxford	145	28	25	4
Cambridge	67	102	2	3

Table VI: Average A-level grade score[a] of home entrants to first degree courses from 1980 to 1983

	Universities (GB)		*Public sector higher education*	
	1980	1983	1980	1983
Education	7.6	8.8	5.0	5.2
Medicine and health	11.5	12.3	6.3	6.7
Engineering and technology	9.7	10.8	5.1	5.3
Agricultural and veterinary science	9.6	10.7	6.4	6.3
Science	9.7	11.1	4.6	5.1
Social and business studies	9.6	10.8	5.0	5.6
Professional and vocational studies	9.3	10.3	5.2	5.4
Languages	10.3	11.3	5.2	5.9
Arts other than languages	9.5	10.4	4.7	5.4
Music, drama and visual arts			4.7	4.9
All subjects	9.9	11.0	4.9	5.4

[a]A-level grade points: A=5, B=4, C=3, D=2, E=1.

connection with their educational and research work.

The 'national needs and resources' were intended to form the basis of the Robbins' Committee's review of the pattern of higher full-time education in Great Britain and its establishment of the principles on which its long-term development should be based. But (rightly or wrongly) the Committee established the principle that 'courses of higher education should be available for all those who are qualified by ability and attainment to pursue them and who wish to do so'. In practical terms, this means that the number of places in the various subjects of study are determined by the demands of the potential students. Given individual choice, the brightest students will choose subjects which lead to, in their opinion, the most satisfying and socially accepted careers. The future needs of the economy were thus neglected by the Robbins' Committee. Instead of a structured programme for producing graduates according to the needs of the country, the result was a relatively small increase in student numbers. By comparison with other countries of similar size, eg France, Italy and Japan, the UK fell further behind because of the expansion programmes of those countries.

Students' freedom of choice led during the late 1960s to a strong swing away from science at A level and 'between 1961 and 1967 the number of students specializing in arts subjects increased by 114% compared with an increase of only 52% in science'. This movement towards arts subjects has however been checked and reversed in recent years.

It is no longer the case that students entering engineering facilities have lower than average A-level scores (Table VI) and, whilst it is sad that it takes a crisis before British Governments pay attention to engineering and technology, their importance is being recognized. There are some grounds for optimism. Apart from the attempts to swing the balance further from the Arts to applied science and the more liberal attitude[14] to mature students in higher education, the extracts from the debates given earlier show that both Houses of Parliament are more frequently discussing engineering and technology. This greater interest contrasts strongly with the almost indifference that the Finniston Report was accorded during the debate in the House. Hansard reports reveal that the Engineering Council is making its presence felt in Parliament. It is increasingly referred to and its opinions are quoted in a manner befitting an authoritative organization. This is something which the Council of Engineering Institutions (CEI) never achieved.

It is too early to say whether the Engineering Council will achieve for British engineers the status the engineering profession enjoys in the societies of our competitors. The Institutions did not succeed either individually or collectively within CEI. But HRH Prince Charles was certainly correct when he said that 'until engineers are afforded the same respect and given the same status as they are in Germany, the United States and Japan, we will be fighting an appalling up-hill struggle and we will be left floundering and further behind'. HRH Prince Philip has also spoken out forcibly on similar lines. He is an active participant in the work of the Fellowship of Engineering in his position of Senior Fellow. He is also deeply involved with the current Industry Year project on which the Engineering Council represents the engineering industry. Let us hope that the combination of royal involvement and the Council's resources gets the message across before it is too late.

This review began at the time when Britain's engineers had earned her the enviable title of 'workshop of the world'. Yet in spite of (and paradoxically because of) their immense contribution to her prosperity, engineering as a profession never attained a commensurate status. Readers of this paper may have other views, but this study has led me to conclude that our industrial lead was lost because of two main reasons: lack of recognition and our concern for individualism, particularly in education. It is unreasonable to expect that Britain could continue to lead industrially in an advancing technological world whilst a classical education was still held to be superior to all others. Natural science was considered to be more prestigious than applied science and engineering and technology were not regarded as scholarship.

The British educational system has been based on individual choice and love of learning for its own sake and, as a consequence, Oxford and Cambridge have won more Nobel prizes than all the European Universities put together. Japan has won only two but has out-performed us industrially, yet few would claim that Japanese engineers are inherently more ingenious or inventive than their British counterparts. Could the difference in performance lie in the different national attitudes to engineers and engineering? If it does, can we change our sense of values before the oil runs out?

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APPENDIX

Chronological list of events

1802 Health and Morals of Apprentices Act specifying religious teaching for apprentices in factories and instruction in reading, writing and arithmetic during the first four years of apprenticeship (this Act was never fully enforced).

1807 S. Whitbread's Parochial Schools Bill proposing two years' compulsory schooling between the ages of 7 and 14 and the establishment of parish schools supported by the rates and supervized by clergy. This Bill was thrown out by the House of Lords.

1830 Marriage Registers show that one-third of the men and two-thirds of the women sign the register with a mark.

1833 First State grants for education (£20000 in all) made to voluntary and charity schools. Only 76 MPs present when voting took place.
Factory Act: Factory children to have two hours' instruction daily.

1836 Select Committee of House of Commons appointed to enquire into the causes of the high number of shipwrecks each year. No action taken.

1837 First school of design founded (these schools were adminstered by the Board of Trade until 1857).

1839 Committee of Privy Council for Education established.

1840 First school inspectors appointed.
First Chair of Engineering (Civil Engineering and Mechanics) held by Lewis Gordon at Glasgow University.

1841 Engineering not included as a profession in the census.

1843 Another Select Committee on Shipwreck appointed. Further recommendations made but still no action.

1847 Board of Trade sets up a Commission to enquire into the state of the merchant service.

1849 Repeal of the Navigation Acts which sheltered British ships against foreign competition.

1850 Mercantile Marine Act establishes Marine Department of Board of Trade. It also introduces a compulsory system of examinations for masters and mates operated by local marine boards consisting of Mayor or Provost, stipendiary magistrate, two to four members nominated by BOT and two to six members nominated by local shipowners.

1851 School of Mines founded (later to become part of Imperial College). It had annual average of 14 full-time and 51 part-time students.
Queen Victoria opens the Great Exhibition in the Crystal Palace which displayed craftsmanship and industrial manufactures from many countries.

1861 Civil Engineering listed as a profession in census.

1862 Merchant Shipping Act introduces compulsory system of examinations for marine engineers and requires foreign-going ships to carry First and Second Class Certificated Engineers. Examination centres set up at Bristol, Glasgow, Greenock, Hull, Liverpool, London, Newcastle, North Shields, Southampton and Sunderland.
The Revised Code introduced. This measure followed the report of the Newcastle Commission on Popular Education in England. It discontinued the current system of central Government grants and replaced it by a yearly payment to each school based on attendance and individual examination in reading, writing and arithmetic. The grant payments were by results. Children aged between 6 and 12 were to be examined by the school inspectors under six standards. One-third of the grant per child of 8 shillings per annum was to be forfeited for examination failure in each of the following subjects: reading, writing and arithmetic.

1864 Examination centre set up in Plymouth.
Report of the Clarendon Commission (on the principal Public Schools).

1868 Report of the Taunton Commission (on 'Grammar' Schools).

1870 Education Act assumed that the voluntary societies had insufficient resources to provide an adequate network of elementary schools. Therefore Government machinery was created by which state schools (controlled by School Boards) could be founded in areas where there was a need 'to fill up gaps'. School boards expenditure was to be recovered from the rates. The education department was empowered to Initiate School Boards which were to be elected by rate payers. The education department could declare a School Board to be in default. Board Schools were to give only undenominational religious teaching. The Board Schools became eligible for grants in 1871.

1873 The marine survey service was reorganized and a consultative organization set up in London. Mr MacFarlane Grey was appointed as Chief Examiner of Engineers.

1875 The Devonshire Report (Royal Commission on Scientific Instruction and the Advancement of Science) reported on higher education and science teaching. The Commissioners felt 'compelled to record our opinion that the present state of scientific instruction in our schools is extremely unsatisfactory' and concluded that the 'almost total exclusion of science from the training of the upper and middle classes amounted to little less than a national misfortune'.

1876 Education Act (Lord Sandon): made parents responsible for ensuring that their children received efficient education and made it illegal for children under 10 to undertake paid employment. Children over 10 could not leave school before the age of 14 unless they had exhibited proficiency in reading, writing and arithmetic or had certificates confirming a minimum number of attendances.

1880 Education Act provided for compulsory elementary education between the ages of 5 and 10 years.
City and Guilds of London Institute founded by City of London Livery Companies who wished to promote, inter alia, the education of young artisans and others in the scientific and artistic branches of their trades. The Institute took over and expanded the system of technical examinations begun by the Society of Arts.
Boiler Explosions Act (and 1882).

1881 The City and Guilds Institute founded the first English technical college at Finsbury.

1883 First Chair in Naval Architecture held by John Elder at Glasgow University.
Additional Board of Trade examination centres opened at Aberdeen, Belfast, Cork, Dundee and Leith.

1884 City and Guilds Central Institution founded (later becoming part of Imperial College).
Report of the Royal Commission on Technical Instruction (Samuelson Report): this report recommended that drawing, with metalwork and woodwork, should be encouraged in elementary schools; that science and art classes should be established and maintained by School Boards and local authorities; that science in teacher training colleges should be increased and made more efficient; that scientific and technical instruction should be greatly increased in the endowed secondary schools of the country.

1888 The Cross Report on Elementary Education: the majority report recommended that 'rate aid should be available to denominational schools as well as to Board Schools; salaries of teachers ought to be fixed and should not fluctuate with the grant; the present system of "payment by results" is carried too far and is too rigorously applied'.
Local Government Act: County and County Borough Councils created.

1889 Institute of Marine Engineers founded.
Technical Instruction Act by which local authorities were enabled to raise a penny rate in support of technical instruction.

1890 The Local Taxation (Customs and Excise) Act permitted certain sums of money (so called 'whisky' money) out of customs and excise duties to be allocated to local authorities to subsidize technical education.

1891 Elementary Education Act instituted free elementary education.

1893 IMarE resolution to BOT recommending 5 years' workshop service for seagoing marine engineers and the introduction of a Third Class Certificate of Competency.

1894 The Merchant Shipping Act consolidated all previous merchant shipping legislation.

1895 The Bryce Report (on secondary education) recommended: a Government department presided over by a Minister responsible to Parliament should be appointed to supervise the secondary education of the country; there should be created a local education authority (LEA) for secondary education in every county and in every county borough; the local authority should be responsible for securing a due provision of secondary instruction and the administration of such sums, either arising from the rates levied within its area, or paid over from the national Exchequer, as may be

at its disposal for the promotion of education.
1897 Education Act: aid grant of 5 shillings per head to be paid to necessitous voluntary schools through the association of voluntary schools; payment by results finally phased out.
1899 Board of Education Act: Board of Education established to superintend education.
1901 IMarE Memorandum on the status of Naval Engineers sent to House of Commons. First Lord of Admiralty receives deputation from IMarE, NECIES and MPs.
1902 Education Act: this Act abolished School Boards; county and county borough councils became the local education authorities; these new LEAs were made responsible for the provision of state elementary and secondary education; voluntary schools were given rate aid.
Admiralty introduces Selborne Scheme for training RN officers as a result of deputation (see 1901).
1904 Regulations for secondary schools: grant-aided secondary schools to provide a four year course for pupils aged 12 to 16 years; curriculum to be non-vocational (English, geography, history, science, mathematics, modern languages, Latin).
1905 Trade Schools established (known as Junior Technical Colleges after 1913) with an intake at 13+ years.
1906 Merchant Shipping Act gives powers of dispensation from the requirement to carry certificated officers (between 1864 and 1884 various shipowner societies had petitioned the Board of Trade to both reduce the requirements to carry certificated engineers and to reduce the standards of the examinations).
1907 Imperial College of Science and Technology established.
25% Free Place Regulations: secondary schools in receipt of central Government grants to offer a minimum of 25% free places to elementary school children.
1911 The BOT Regulations introduced two types of certificates of competency. The first known as the Ordinary Certificate (First or Second Class) was in fact the existing certificate. The other known as the Oil Engine Certificate (Second Class only) entitled the holders to sail as Chief Engineers on home trade passenger ships propelled by oil engines (not on foreign-going ships or on home trade passenger steam ships).
1915 IMarE elects Lord Fisher as Honorary member in appreciation of his part in gaining military rank for RN Engineer Officers.
1916 Home Trade Oil Engine Certificates abolished. First and Second Class Motor Certificates introduced, together with endorsements to Ordinary or Motor Certificates. Notice given that, as of 1 January 1922, Ordinary Certificates will no longer fulfil the statutory requirements of ships propelled by internal combustion engines.
1916 Department of Scientific and Industrial Research set up following the Committee Report in 1915 which found that the main reason for the slow development of science was the lack of research facilities in the many small firms which existed and the fact that the annual output of 530 good honours graduates in mathematics, science, and technology was wilfully small for the national purpose.
1917 Secondary School Examination Council set up: institution of School Certificate Examinations.
1918 Education Act: this Act aimed to establish national system of education; LEAs were required to submit educational schemes; compulsory schooling between the ages of 5 and 14 years was introduced; 50% of approved LEA expenditure to be met by Government.
Thomson (National Science) Committee condemned the insistence on compulsory Greek in the entrance examination for Oxford and Cambridge; Oxbridge should provide more courses suitable for non-honours scientists; a large expenditure of public money would be necessary to develop university science; heads of technological departments should be allowed to carry on some private practice; a concerted effort by employers, teachers, LEAs and the State was needed to increase the supply of capable students for training as scientific workers.
1919 University Grants Committee set up.
Burnham Committee instituted to determine teachers' salaries.
Aliens Restriction Act prevents aliens from sailing as Chief Engineer of a UK registered ship and consequently from obtaining First Class Certificates of Competency.
1920 State scholarship introduced.
1921 National Certificate scheme introduced.
1923 Board of Trade Notice 52 announces the introduction of permits to enable engineers to complete the required 9 months qualifying sea service on motor ships to qualify for Motor Endorsement examination.
1926 Hadow Report: education up to the age of 11 years should be known as primary education and education after that age by the name of secondary education; schools of the secondary type which pursue in the main a predominantly literary or scientific curriculum to be known as Grammar Schools; schools of the existing selective central schools which give at least a four years' course from the age of 11 years to be known as Modern Schools; schools of the present non-selective central schools also to be known as Modern Schools; the curriculum of Modern Schools was to be more limited in scope than that of the Grammar Schools . . . and more time and attention will be devoted to handwork and similar pursuits; the 11-plus examination should consist of a written examination and wherever possible an oral examination.
1926 Victoria Alexandrina Drummond passed for Second Class Certificate of Competency on 27 September.
Malcolm Committee (Education and Industry) reports that what industry wanted from elementary school leavers was general intelligence and adaptability rather than a specialized vocational training; the part-time evening system was particularly hard on young people already doing a full job in industry; the number of full-time senior technical students might well be expanded from the figure of 6000 which then obtained; only a small minority of firms were showing a practical interest in the further training of their employees, and their action related mainly to part-time evening instruction and not to the more fruitful day-release system.
1928 Women over 21 years get the vote.
1930 Lord Eustace Percy in his book entitled *Education at the Crossroads* wrote of 'The appalling waste of the facilities of the Technical Colleges which was one of the worst examples . . . in all educational history. The main job of the colleges was to teach men to think, and they should not be a lower grade of education.' A large proportion of evening classes should be converted to day classes. He urged colleges to run courses in higher industrial management in competition with the training offered by the public schools and the universities. He advocated above all the training of men to take on responsibility.
1938 The Spens Report (Secondary Education) recommended a tripartite system of secondary education by advocating the creation of technical high schools to supplement the Grammar and Modern Schools; the Committee was convinced 'that it is of great importance to establish a new type of higher school of technical character quite distinct from the traditional academic Grammar School. Such schools would recruit their pupils at the age of 11+ and provide a five year course up to the age of 16+'; the Committee considered it was 'of great importance that everything possible should be done to secure parity of status for Grammar Schools, Technical High Schools, and Modern Schools'.
Board of Trade Departmental Committee on Examination of Engineers in Mercantile Marine; the comprehensive recommendations dealt with workshop service, qualifying sea service, the conduct of examinations, subjects and syllabuses of the examinations, replacement of endorsed certificates by combined certificates and the granting of exemptions from certain subjects of the examination by virtue of nationally recognized qualifications. These recommendations were accepted by the Board and were phased in gradually and fully implemented by the end of the Second World War.
1940 Government orders comulsory registration of all professional engineers.
1943 The Norwood Report (curriculum and examinations in Secondary Schools): this report defined three types of children for secondary schools by postulating three 'rough groupings' of children whose respective abilities would suit them to three different kinds of education. First, those pupils who are 'interested in learning for its own sake . . . who can grasp an argument or follow a piece of connected reasoning'. Secondly, those whose 'interests and abilities lie markedly in the field of applied science or applied art . . . he

often has an uncanny insight into the intricacies of mechanism whereas the subtleties of language construction are too delicate for him'. The third group were those who deal 'more easily with concrete things rather than with ideas'. He may have much ability, but it will be in the realm of facts. Having recognized these three categories the report advocates 'that there should be three types of education, which we think of as secondary Grammar, the secondary Technical, the secondary Modern'.

1944 Education Act:
1. Created the Ministry of Education under a Minister with wide powers to 'secure the effective execution by local authorities, under his control and direction, of the national policy' concerning education.
2. Two central advisory councils for education were created, one for England and one for Wales.
3. Public education to be organized 'in three progressive stages to be known as primary education, secondary education and further education'. No fees to be payable in maintained schools.
4. LEAs to have regard to parents' wishes in the provision of efficient instruction and training.
5. Schooling to be compulsory up to the age of 15 and to be raised to 16 when practicable.
6. Full-time and part-time education was to be provided by LEAs for persons over compulsory school age.
7. Leisure time occupation, in such organized training and recreative activities as are suited to their requirements, for any persons over compulsory school age who are able and willing to profit by the facilities provided for that purpose.

1945 Ministry of Education pamphlet entitled 'The Nations Schools' endorsed the tripartite organization of state secondary education.
The Percy Report (Special Committee On Higher Technological Education): a number of technical colleges should hold courses of university standard and issue Bachelor and Diploma of Technology awards; national campaign to increase the prestige of the technical professions.

1946 Scientific Manpower (Barlow) Report: number of science graduates (2500 in 1946) should be doubled.

1948 National Advisory Council on Education for Industry and Commerce formed. It advocated a 'Royal College of Technologists' to grant awards at degree level for the public sector colleges. Universities were opposed to degrees being issued.

1949 IMarE submits proposals to marine and education departments for an Engineer Cadet Training Scheme.

1951 The Association of Marine Engineering Schools formed (first AGM held in 1952).
General Certificates of Education introduced.

1952 Engineer Cadet Training Scheme (ECTS) introduced (known as Alternative Training Scheme) due to difficulty of obtaining sufficient numbers of traditionally trained engineers. Single (OND) Scheme only.

1955 National Council for Technological Awards (forerunner to CNAA): recommended that higher education should not be confined to universities; re-designation of public sector colleges which would include Colleges of Advanced Technology (CATS).

1956 Technical Education. Ministry of Education White Paper (Cmnd 9703) presented to Parliament; reviewed situation in universities and colleges and includes the statement 'There has never been any uniform pattern of education throughout the country'.

1959 Crowther Report (15–18): compulsory part-time education up to 18 years and provision of County Colleges (as per 1944 Act).
International Maritime Organization formed.

1960 Leith Scheme introduced (permitting ER ratings to become certificated engineers).
Beloe Report: new examination (CSE) for 40% of fifth year secondary school pupils of less than GCE ability level.

1962 ECTS split into three streams: Part A, ONC and OND.
Council of Engineering Institutions formed.

1963 Robbins Report: CATS should become universities (but not the regional colleges); Robbins' principle (all qualified students should obtain a place in higher education); Council for National Academic Awards (CNAA) should award honours and pass degrees to students in regional and area colleges.
Newson Report (Half Our Future) considered education of 13–16 year old pupils of less than average ability.

1964 Introduction of Certificate of Secondary Education (CSE).

1965 Council of Engineering Institutions (CEI) obtains Royal Charter. Thirteen Chartered Institutions. Exemplifying standard for Chartered Engineer to be Council's Part 2 examination first held 1968.

1966 A Plan for Polytechnics and Other Colleges (Cmnd 3006): White Paper reduced the number of colleges engaged in higher education. In future, only Polytechnics to introduce new higher education courses. Secretary of State to approve Articles of Government.

1967 Fourth Stream (HND) added to ECTS. Pearson Report recommends changes to certification system.
MSA extends area of application of 1894 Act regarding certification to ships leaving ports outside the UK.

1968 Extra First Class, First Class and Second Class Certificate holders accepted by CEI as Chartered Engineer, Technician Engineer and Engineering Technician, respectively.

1969 Haslegrave Report on Technician Courses and Examinations.

1970 Lord Rochdale Committee of Inquiry into Shipping Report recommends an Industrial Training Board for shipping and changes in the marine examination system (never implemented).
ECTS modified to three streams: METC, OND and HND.
MSA enacted with provision for repeal of all 1894 Act concerning certification (and much besides). Section 43 of the New Act empowers the Department to make Regulations concerning Manning and Certification.

1971 Engineers Regulation Board (ERB) set up under CEI Charter.

1972 Marine Engineer Examinations adopts metric (SI) system (believed to be first examinations to do so).
School leaving age raised to 16 years.

1973 Technician Education Council (TEC) set up to take over City and Guilds and Joint Committees (eg HNC, ONC etc.) Examinations.

1974 Frequency of examinations reduced from 22 First Class and 22 Second Class per year to 9 First Class and 9 Second Class per year.

1975 Direct grant schools to become either independent or comprehensive. State-aid withdrawn.
Candidates allowed to retain marine engineering examination question papers.

1977 Finniston Inquiry into the Engineering Profession 'To review for manufacturing industry, and in the light of national economic needs . . . matters relating to professional and technician engineers'.
Second Class Drawing examination overhauled and reduced to 4 hours.
Merchant Shipping (Certification of Marine Engineer Officers) Regulations 1977 laid before Parliament.

1978 Marine Engineer Officer Requirements made under the 1977 Regulations became effective from 1 September 1978. Single subject passes allowed in Part A. Electrotechnology and Naval Architecture split into separate subjects. Class 3 and 4 certificates introduced together with service endorsements. Calculus introduced into Second Class Mathematics Examination.

1979 Finniston Report, presented to Secretary of State on 16 November 1979, recommended a Statutory Body of 15–20 members appointed by the Secretary of State to promote and strengthen the 'Engineering Dimension' in the British Economy.

1980 Government Announcement on 7 August that an Engineering Council (EC) would be set up.

1981 Government Announcement on 30 July that a Royal Charter would be granted to the EC and that Sir Kenneth Corfield would be first Chairman. EC would establish a national register of engineers, control standards and award titles.

1982 IMarE Extraordinary Council Meeting decides unanimously to support transfer of CEI Charter to EC on morning of 11 November. At CEI Board meeting in afternoon all Chartered Institution representatives vote for transfer of Charter to the EC.

1983 Poll of all Chartered Engineers confirms transfer of CEI Charter to EC.
Business and Technician Education Council (BTEC)

formed from merger of Business Education Council (BEC) and Technician Education Council (TEC).
First EC Board for Engineers Registration Meeting 3 June.
EC Consultative document on Standards and Routes to Registration proposes an Honours BEng degree as academic standard for Chartered Engineer. This standard to apply to courses commencing in 1987.

1985 Rayner Review of Departments' Examinations Arrangements recommends that written papers be included in the National BTEC/SCOTVEC system.

Published for THE INSTITUTE OF MARINE ENGINEERS by Marine Management (Holdings) Ltd
(England Reg. No. 1100685) both of 76 Mark Lane London EC3R 7JN.
Photoset by Paston Press, Norwich. Printed in England