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VICE-ADMIRAL SIR GEORGE RAPER, K.C.B., C.Eng., M.I.Mar.E.

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Admiral Raper entered the Royal Navy as a Dartmouth cadet in May 1929. He trained in H.M.S. *Frobisher* and at the Royal Naval Engineering College, Keyham, and after service in H.M.S. *Newcastle*, qualified at the advanced M/E course at Greenwich.

Early in the last war he was Senior Engineer of H.M.S. *Edinburgh*, which was employed on Russian convoy duties and which, in May 1942, was sunk in action on returning from Murmansk. For his services in this action, Admiral Raper was mentioned in Despatches and awarded six months' seniority. In the same year, he joined the Engineer-in-Chief's Department where he was engaged mainly on new turbine designs. In 1948, on promotion to Commander, he returned to the Engineer-in-Chief's Department, where he was this time in charge of the Projects Section which was then mainly concerned with development of prototype machinery for the *Whitby* and *Blackpool* Class frigates and the Canadian *St. Laurent* Class destroyer escorts.

From 1952 to 1954 he was the Engineer Officer of H.M.S. *Birmingham* which took part in the Korean activities.

Admiral Raper was then sent on loan to the Royal Canadian Navy, where he established the Engineering Design Investigation Team for the development of propulsion machinery design. On his return to the U.K., he became Technical Assistant to the Engineer-in-Chief of the Fleet, Vice-Admiral Sir Frank Mason, K.C.B. He was promoted to Captain in June 1957 and, after qualifying at the Imperial Defence College, was, from 1959 to 1961, the Commanding Officer of H.M.S. *Caledonia*. This was followed by another appointment to the Ship Department as Deputy Director of Marine Engineering and from 1963 to 1965, he served as CSO(T) and Maintenance Captain on the staff of Flag Officer Sea Training, at Portland. He was promoted to Flag Rank in January 1966 and returned to Bath as Director of Marine Engineering, in which capacity he served until the first stage of the re-organization of the Ship Department was announced in September 1967, when he became the first Deputy Director General Ships.

He has held his present appointment of Director General Ships since 1968, in addition to which he holds the posts of Chief Naval Engineer Officer and Senior Naval Representative, Bath.

Admiral Raper was made K.C.B. in June, 1971. He joined the Institute as a Member in 1961.

PRESIDENTIAL ADDRESS

of

VICE-ADMIRAL SIR GEORGE RAPER, K.C.B., C.Eng., M.I.Mar.E.

The honour which the Institute has so generously paid me by my election as President for this year is one of which I am proud and for which I am very grateful: the more so because I take it as a compliment to the Engineering specialization of the Royal Navy: for this is the world in which I have been brought up and whose standards and ideals I understand.

As marine engineers we face problems and pressures which I venture to think are fairly common to widely differing fields of engineering. It is to these problems and the place of our Institute as an important influence in helping us to face them that I believe we should give some substantial thought. The fundamental object of the Institute is "to promote the scientific development of marine engineering in all its branches" and to this end it tries to provide the best possible means of communication between engineers of like interests. Exchanges of information and discussions allow engineers to be aware of what others are doing or have done, of the outcome of various efforts at innovation, of thoughts for the future and of developments in fields closely related to their own from which further development in marine engineering may derive.

Because the Institute tries to cover the interests of its membership, which will soon span the three Engineering Registrations of professional, technician engineers and technicians, the matters of interest also span a large variety of subjects and functions. It is perhaps worth remarking here that Marine Engineering consists of men as well as Engineering systems. The education, training, and the standards of these men are also one of the fundamental concerns of the Institute.

The Marine Engineering Branch of the Royal Navy has a hierarchy in which these gradations of engineer all have their place, their educational standards and training are clearly defined, and their functions are complementary to each other. They can only work properly as a team and, as in all teams, each one is dependent on the others doing their part. However, the responsibilities and interests of engineers at each level have changed quite substantially over the last 20 years and will continue changing. It is information about change and what is new and what its effects are that mostly interests people. Anyone involved in education must try to anticipate change because of the long time lag between re-shaping a syllabus and the arrival in ships of a new breed affected by the change. I believe the developments in naval engineering are probably representative of what is happening in much wider fields and it is worth giving a few examples of the changes at different levels to explain this theme.

In the operation and maintenance of naval machinery the emphasis is steadily shifting from the need for craftsmanship as the basis of training for those whose task is the care and operation of machinery, to the need for education as a technician. Several major developments have influenced this. The enormous progress in manufacturing processes and accuracy has taken the manufacture of replacement parts out of range of the capacity of a ship's workshop where such parts were often made by Artificers until the end of World War II and we are now dependent on spare parts being available for fitting, in the ship or at a base. The same developments have made it possible to make spares truly interchangeable and so the need for delicate fitting work to allow spares to be fitted in place is steadily disappearing.

The use of automatic and centralized remote controls on propulsion systems and ship services has necessitated the fitting of a multitude of sensors and the consequent opportunity for more instrumentation. So instead of the craftsman's judgement of the machine's health, formed by feeling with his fingers the heat of the bearing caps, by smelling and listening, and with a few pressure and temperature gauges to help, we now have the technician's appraisal of whether all is well or not, diagnosed from an array of monitoring instruments and automatic data logging, from which he can make a detailed survey of the performance of the plant. This has made it possible to provide warning lights when some variation from the normal occurs and has made diagnosis of incipient failure a far more deliberate process of analysing the significance of rows of figures, rather than waiting for a funny noise or worse still, a funny smell, or the feel of a funny vibration to tell the watchkeeper that something is surely going wrong.

The sequel to this used to be that the offending machine was dismantled to find what, if anything, had actually gone wrong. Now people are being urged to find other ways of establishing the health of machines so that they are only dismantled at intervals proved necessary or when it is known that they need to be. Some such ways under trial or investigation are vibration analysis and comparisons, spectroscopic analysis of fluids, various quasi-medical devices for viewing the insides of equipment without dismantling it, ultrasonic measurement of thicknesses, detection of cracks and so on. Such devices are rapidly proliferating and so the technician is faced with the need to think out the significance of what he sees or reads and to back his judgement of whether it indicates something wrong or not. This requires the exercise of some very different faculties and a somewhat different education to those of the man who takes the machine to bits to measure its condition and thereby judges whether it is fit to continue running or not.

So the operators' and maintainers' jobs change, as does the job of the man in charge of them. The scope of his responsibilities has clearly changed too. He is finding that his systems, propulsion, electric power generation, refrigeration, air conditioning and so on all have automatic controls of some sort, pneumatic, hydraulic, fluidic, electric, or electronic and instrumentation, each of which may require the study and attention of a semi-specialist. So the man in charge tends no longer to know more about each component than any one of his subordinates knows. Increasingly he finds himself dependent upon one of his subordinates for detailed knowledge of a particular part of his system. Consequently he will tend to become dependent upon them for diagnosis of what is wrong with any component, though he himself should be the quicker on where in the system there is something wrong. More and more he will tend to have the task of managing a mixed team of technicians each of whom is somewhat specialized, together covering an ever widening spectrum of engineering disciplines and techniques.

The operators of ships inevitably look for the maximum availability for operation and so a great deal of forward planning and good management of his department's activities is what is required of the engineer in charge of a warship's Engineering Department.

Here it is worth mentioning another responsibility. It is traditional in the Royal Navy and an obligation constantly emphasized to everyone who has any responsibility, from Leading Mechanics upwards, that he must train those subordinates for whom he is responsible; to train them not only to do their job in that ship, but also to be able to take more responsibility and thus prepare for advancement to the next rank or rating. The naval engineer is responsible for the welfare of his men in every sense and it is a responsibility from which he is never freed. If proper standards of management and of day to day engineering work are to be sustained this is an indispensable condition.

What of the job at the next level, the professional engineer the General List Engineer Officer? His career covers a variety of appointments after he has attained an engineering degree, either at the Royal Naval Engineering College. Manadon, or at a University. He goes to sea in each rank until, as a Commander, he is Chief Engineer of a large ship or Squadron Engineer Officer of a group of submarines, frigates or destroyers. He has probably already been the Chief Engineer—or as it is now called "the Marine Engineer Officer"—of a submarine or a frigate in a lower rank. It is at this point in his career, probably his second appointment in the Department, that he may well be given a substantial responsibility, in the Ship Department of the Ministry of Defence, for development and design of future warship systems and machinery, including those in nuclear submarines.

At this level the challenges have changed to an even greater extent. Here the need to be aware of what is going on elsewhere is of very great importance indeed. The development of marine engineering systems and machinery are often his main preoccupation. Twenty-five years ago his task was likely to be, to develop a steam plant for a frigate of say 22 370 kW (30 000 shp) on two shafts, within a stated total weight of fuel and machinery. Within that weight he had to develop a plant which, as well as producing the full shaft power, would give the ship a steaming range of several thousand miles at about half of its full speed and to design the whole installation to fit into machinery spaces of a specified length and shape. It was all done against a very tight time scale and the sums of money devoted to development ashore were very small by present day standards. On the day the ship worked, people were justifiably proud. The challenge was a real engineering challenge.

But there were then many things which we did not know when a new class of ships joined the Fleet. Now a cost conscious organization increasingly requires that these things should be known. For instance, the reliability of the various systems or the likelihood of breakdown within a period of six months or a year away from base; the total maintenance task between refits in terms of manhours and days in harbour; the cost of upkeep in terms of spare gear and replacement of machines for overhaul and the cost of overhaul itself. There is increasing emphasis on achieving a known standard of reliability and a reduction of manpower costs. These determine much of the life costs. This emphasis also makes necessary a substantial increase in the use of techniques developed comparatively recently to predict the behaviour and life costs of new systems as they are developed.

Twenty-five years ago a propulsion plant for a warship of 22 370 kW (30 000 shp) was inevitably steam. Now we have a choice of steam, Diesel, gas turbine or nuclear, and a variety of each of these possibilities or combinations of them. The introduction of automatic and remote control systems has brought electronics firmly into the engine room. Instrumentation for data logging brings further complexity. The chances of costs getting out of control during the design development are greatly increased. And so the engineer's tasks of management becomes a major part of his job, requiring knowledge of many of the project management techniques, covering costing and budget control as well as engineering.

Not so long ago an economic justification of technical decisions sufficed and often this was only concerned with the cost of procurement. There are new factors now which may make justification of such decisions more complicated. There is talk of further exploitation of the earth's resources of fossil fuels being overtaken by rising consumption at the end of this century. There are many regulations in the pipe-line to prevent ships from discharging any sort of waste in harbour and indeed far more control of such discharges at sea. The whole business of controlling noise, smoke, and dry or wet waste becomes increasingly serious as limits are set more tightly.

So already to such life costs as we can predict to justify what we do we can see being added the necessity to foresee these sorts of world wide trends.

Perhaps the day is coming when the engineer will be judged, not purely on the direct economics of his product, but on a basis of absolute virtue if he conserves resources and recovers waste products without polluting the environment and thus keeps his masters out of trouble for the 20 year life of the ship or however long his creation survives. Unfortunately he is likely to be retired or even buried before his foresight is recognized.

Maybe this is straying somewhat into the future, but there is another aspect which certainly we have with us here and now—the study of the jobs that the designer is creating for the men who will operate and maintain the ship he is producing. This is only just removed from a direct economic consideration. Unless one creates jobs which men will find rewarding, they will not stay in that occupation and nothing is more expensive than losing trained men and having to recruit and train more to replace them. This is therefore an aspect of the designer's task, which is clearly of widespread significance. It demands a very comprehensive knowledge of what people actually do in ships and preferably personal experience of this.

As machinery and systems become more sophisticated, the genius for improvisation by operators and maintainers, of which we were justly very proud in the past, has to be suppressed. The designer of a nuclear plant, for instance, has to specify exactly what can and what cannot be done by operators or maintenance staff in all sorts of eventualities. This tends to take away initiative and choice of how to tackle a breakdown, or indeed anything which causes the plant to be worked on. It emphasizes instead the needs for accurate diagnosis and the use of a pre-planned procedure for putting right any defect. It is again a change which runs through every level of engineering and requires a somewhat different upbringing at each level.

And yet the ability to improvise is one which all engineers value highly. It is only developed by practice and by much forethought on possibilities. We are moving this forethought away from the man in the ship and into the drawing office. In the Navy we contrive to exercise people in artificially created situations to stimulate their imagination, but this needs much planning and training time.

The process of involving the development and design engineer in a study of the wider implications of his creation is to be welcomed. To try to exchange the physical exertion of the men in ships by mental exertion of people in the design office and on the drawing board, is surely a right development. This and the study of resources and of waste recovery demonstrates the social responsibility which is now being increasingly demanded of the scientist and engineer. Already, purely as an engineer, he is conscious of the need to incorporate several disciplines in his system designs. Mechanical, electrical, electronic and an increasing variety of techniques as well as technologies are rapidly establishing their place in what were once primarily mechanical engineering systems. So already the engineer has a somewhat more complex personnel and engineering management problem on his hands. However, to get people of different disciplines and of different levels working together on a common problem is exceedingly rewarding and the interplay of different backgrounds undoubtedly adds to the creativity of such teams.

The adoption by the Institute of a membership structure which includes the different levels of engineers and technicians will, I am sure, enhance its ability to play a leading rôle in future developments. But I believe the time has come to consider the increasing clamour for an altogether wider frame of reference for the things we consider for the future. In Defence it is no longer possible to think in terms of strategy or tactics in one of Nature's elements singly. Thought for the future has to embrace consideration of things in the air, in space, on the water, above and under the water, and on land; a need to consider the industrial base for defence and so on—systems of enormous sophistication as far as the types and varieties of technologies are concerned. In an analogous way people now think in terms of transport systems incorporating road, rail, the ship, loading and unloading and the relationship to air transport, submarines, hovercraft and so on. Minds are turning increasingly to ocean engineering and the enormous potential developments in sea bed exploitation.

Such phrases tend to become a catalogue of the bright-eyed visionary exhortations to scientists and engineers. But what is treated as visionary to-day is converted into engineering enterprise in a very short time nowadays and the question seems to be not so much "How is it to be done?" as "Who is going to do it?"

The share which British Industry has taken of these new maritime equipment markets is at present patchy. Perhaps this is an area in which engineers need to be better informed to stimulate the enterprise necessary to take advantage of such new opportunities.

I have tried to give some indications of the ever widening responsibilities and fields of interest in which the modern engineer must be involved if he is to survive in the front rank of the world's engineering development. This is bound to raise the thought as to whether the traditional relationships between the engineering institutions in this country (with or without a capital "I") are the best which can be devised in the context of modern engineering developments. Could we perhaps devise relationships which would allow these much wider systems to be considered without the limitations imposed by the normal scope of any one organization.

Our Institute has become a world wide Institute. Its primary function is to promote the scientific development of marine engineering and to this end it has striven to provide the means for the discussion of such developments among marine engineers. But to be a marine engineer in the present world is to be a man with interests in a wide field of academic Disciplines, of different levels of Technology and of Management of people. I believe the future use of the potential provided by such a world wide and varied membership deserves some thought.

The changing pattern of demands on engineers at the professional, technician engineer and technician levels, the increasing need to define everything that has to be done in production, assembly, operation and maintenance; the consequent change in rôle which people fulfil at each level and the effect on the appropriate education and training needed to fit them for their jobs; our reaction to these may well have a great effect on the future of marine engineering in this country as well as elsewhere. The essentially practical and first hand experience, which our membership can bring to bear on such problems should make its contribution to future planning invaluable.

On the whole these are activities we are already well fitted to pursue.

But the modern world is increasingly pre-occupied with "Systems" on the grand scale. The development of these implies joint ventures across many frontiers of science and engineering, some of which have tended to become barriers rather than meeting points between people of different disciplines or environments. Marine engineers have an important place in the development of such maritime systems and it may be time for us to do some research into how best to promote such developments and how we can best contribute to them.