JOINT MEETING OF THE INSTITUTION OF NAVAL ARCHITECTS AND THE INSTITUTE OF MARINE ENGINEERS

Symposium on

THE EDUCATION AND TRAINING OF NAVAL ARCHITECTS AND MARINE ENGINEERS

Presented on Wednesday, 6th February, 1957, at 10 a.m. in the Weir Lecture Hall, The Institution of Naval Architects, 10, Upper Belgrave Street, London, S.W.1; VISCOUNT RUNCIMAN OF DOXFORD, O.B.E., A.F.C., D.C.L. (*President I.N.A.*) in the Chair, supported by Mr. T. W. LONGMUIR (*Chairman of Council, I.Mar.E.*)

A NEW DEAL FOR NAVAL ARCHITECTURE IN UNIVERSITY EDUCATION AND A FEW RELATED PROFESSIONAL QUESTIONS

By PROFESSOR E. V. TELFER, D.Sc., Ph.D. (*Vice-President, I.N.A.*)*

Extract from Objects of the Institution of Naval Architects;

"Thirdly . . . the investigation of those professional questions which often arise, and were left undecided before the establishment of this Institution. . . ."

Section 1

It is axiomatic that a professional institution should not only have one of its council committees keeping a watchful eye on professional education, but from time to time it should also test the feeling of its members on this vital subject. A convenient method of testing the membership is by writing and discussion of papers; and as twenty years have now elapsed since Mr. Lloyd Woollard wrote his then very timely 1936 paper, a similar opportunity for useful discussion might reasonably be regarded as now even more timely. Since Mr. Woollard's paper the incidental intervention of a world war, a world upheaval, a transformation of world outlook, factually, politically, and educationally, all endorse the understatement of timely, and add force to the present national and international emphasis on technological development. In this emphasis it is thus pertinent to inquire how naval architecture, or its more practical part shipbuilding, should respond to the call for more intensive technological education; and the present symposium should greatly assist to this end.

An immediate result of Mr. Woollard's paper was the setting up of a special committee of the Council to consider the issues raised; and in June 1939 the findings and recommendations were published as the "Report of the Committee on the Education, Training, and Employment of Youths and Apprentices for the Executive Grades of the Shipbuilding Industry."† For the sake of present completeness this report and its recommendations are given in Appendix I. With the advent of the war any effect the report might have had was obviously entirely lost; and on re-reading it in 1956 one realizes how far away those nostalgic pre-war days have now really become.

A study of the recommendations and particularly of those concerning training at university level strongly suggests that the age-old squabble between so-called highly theoretical training and managerial training had evidently seriously occupied the attention of the Committee. For example, in paragraph 5 of the report itself it is stated that:—

> "The three universities with faculties of Naval Architecture can amply supply the output required by the industry of graduates with a high degree of theoretical training. The Committee does not hold that graduation from a university is essential to qualify for the executive grades of the shipbuilding industry, but it is an experience which should prove a great asset. To carry full value graduates should complete a recognized apprenticeship in a shipbuilding establishment, and in addition should acquire by practical experience an adequate knowledge of the commercial side of the industry."

Again in paragraph 11 discussing post-graduate research scholarships the Committee felt that:

> "The industry as a whole is not deriving from the work of the research scholarship holders quite the benefits that may have been expected, and furthermore that such scholarships tend to direct the energies of their holders into channels which may not always be in their best interests or of any great benefit to the industry."

However true this latter observation could have been in individual cases it is surely an extraordinary comment for a Committee to make concerning the expenditure of funds which the industry neither directly nor indirectly provided. It may be as well to emphasize at the outset that no *research* scholarship in naval architecture has *ever* been directly financed by the British shipbuilding industry; and as this unfortunately continues to be still true to-day, the 1939 spirit probably still lingers on. One appears to sense in these particular findings of the Committee a slight antagonism to the higher university product. The Committee were clearly criticizing men who had enjoyed a high and certainly liberal standard of education; and who by a highly selective process had been deemed worthy of profiting from such an education. It is a pity therefore that the Committee reported without taking any evidence from the men whom they were criticizing. If their criticism had any justification at all it should have been directed against the universities and not against their products.

The three universities to which they refer all were liberal in that they catered for the arts, the church, medicine, the law, and the pure and applied sciences. That naval architecture was included in the liberal outlook of these universities is to their eternal credit. It is therefore difficult to see how a graduate naval architect could escape some liberalizing influence; and one is tempted to conclude that it was possibly the lack of this same influence which allowed the Committee to plead the non-essential value of a university education to future executives of the shipbuilding industry. Is the best possible education *ipso facto* too good for the shipyard? It would seem so since it is known to many that one illustrious member of the Committee laid it down categorically that two B.Sc.'s per annum—or was it four?—would more than meet the then foreseeable needs of the whole British shipbuilding industry. That he was utterly wrong even when he said it is beside the point. The distressing fact is that he could and did say it; and he was not one who could normally be accused of lack of vision. Such statements do not help recruitment of the best to the industry. Neither does a recent public statement of our own and worthy President—to the effect that specialists can readily be bought but men of wide outlook are almost unobtainable—either help the common cause or, with respect, square with the existing facts. If Lord Runciman is right, the advertising columns of our national dailies and learned weeklies are uncommonly wrong; and in making this direct reference to our President it will be appreciated that although I am deliberately baiting the lion in his den, I am also attempting to make certain of at least one useful contribution to the discussion of this, if not thought-provoking then at least wrath-provoking paper.

The paper is being written at a time when the Government

* Professor of Naval Architecture, Technical University of Norway.

† See TRANS. I.N.A., 1939, p. 352.

sees in increased technological education the life-line to greater national prosperity and security. There is no doubt that the shipbuilding industry is equally discerning. It has no need to be told, for example, that the sandwich system is not an attack on the luncheon habits of the worker. The industry has known longer than most, most of the value of technical education. A possible fault, as disclosed by the 1939 Committee's report, appears to be its curious inability to appreciate how essential a university—and hence the best—education is for those who are chosen to develop and control technically as well as commercially the future of British shipbuilding. The Committee may have had in mind, of course, only those entering the industry as outsiders via the universities or promoted from the apprentice ranks to the university. This distinction is essential when it is appreciated that by far the greater number of those in control of British shipyards to-day *are* actually graduates of liberal universities—and, in fact, of one in particular. Do I therefore preach to the converted? I wonder.

Section 2

Let us first consider our learned Committee's statement that the Institution research scholarships were not producing quite the results the industry wanted. This suggests that either the Committee were deliberately restricting their terms of reference or they were somewhat premature in their complaint, for let us see what has actually happened to the very research scholarship holders they must have had in mind. The industry would doubtless still welcome a managing director of a famous ship repair establishment, a director and general manager of an equally famous shipyard, a Ministry of Transport chief surveyor, a director of the Royal Aircraft Establishment, a director of Pametrada, three directors of Ship Experiment Tanks, several senior officials of experiment tanks, three professors—two of naval architecture who hold forth in this present symposium—and one of aircraft engineering. Others, less senior, are holding responsible positions in industry, research associations, or in consulting work. Again, so far as this Institution is concerned, at least six of its research scholars are at present on the Council, one as an Hon. Vice-President, one as a Vice-President, and the remainder, at the moment, as Members of Council. From whatever standpoint this record is judged it surely is not a record of failure. It is at least a tribute to the discernment and wisdom of our Scholarship and Publications Committee in the original selection of their research scholars.

It would be of interest to have the present views of those members of the 1939 Committee who are fortunately still with us, on some of the reasons for their findings. It is, of course, possible that the industry may have parochially imagined that research scholars should have proved their executive value within the shipyards themselves; and as it is somewhat obvious that few of them have stayed in the shipyards there is clearly a case for inquiry to establish why such undoubted talent either deserted the shipyards or found them professionally uncongenial compared with the many more attractive appointments in circles or institutions ancillary to shipbuilding. The fact that these more attractive appointments almost invariably offered complete security of employment as well as relatively excellent retirement pensions must of course have influenced the choice of some scholars, but I doubt whether this was either the sole or the motivating reasons for the choice. Since, moreover, the present prosperity of the shipbuilding industry is likely to continue and security of employment and retirement pensions are now the contemporary bait of most industries, at least one good reason governing graduate discrimination has been removed. If despite this the industry should still fail to attract graduates having the highest qualifications into the shipyards, clearly the reasons should be sought elsewhere. An industry whose elders themselves, rightly or wrongly but nevertheless deliberately, planned for a shrinking economy automatically thereby issued a warning to those whose natural ability and national heritage would have ordinarily attracted them to the shipyards and the shipbuilding industry. It is thus not hard to understand why shipbuilding has had difficulty in attracting the best brains to its service. At the time of writing we have lost—I trust only momentarily—our pride of place as the world's leading shipbuilders to Japan and Germany. Could this have been foreseen, was it inevitable, could it have been prevented? Alternatively, more simply and more generally, does history not teach that it is better, granted survival, to be beaten in battle; and then to have to alleviate the pangs of defeat by the gradual restoration of self-respect and national pride that comes only through hard productive work? The solutions of these deeper issues and indeed of many other political issues have a direct bearing on education, general and technological. They must necessarily form a backcloth to our present stage and colour the performance of the actors.

Section 3

Let us now postulate that the shipbuilding industry *is* worthy of the best brains in the country, despite the fact that other industries may deny our postulation. In attempting to attract these brains we must now examine why our previous methods could have been so prone to failure. This Institution during the last fifty years has undoubtedly done its best through scholarships to make it possible for any young man who is competitively awarded a scholarship to secure a university education in naval architecture. Most of these scholars were already in the shipyards and were therefore in an excellent position to profit fully from this training at the liberal Universities of Durham, Glasgow, and Liverpool at which the scholarships could then be held. Now despite the apparent excellence of these opportunities the extraordinary fact is that for many years past the competition for these scholarships has been distressingly poor, so poor in fact that it has been frequently a matter of some concern whether a scholarship should be awarded at all and thus perhaps wrongly have to encourage the doubtfully selected candidate. One explanation for this otherwise inexplicable state of affairs probably starts in the shipyard amongst drawing office apprentices themselves. They frankly doubt whether the hard work involved and the sacrifice of pleasure hours is financially worth while. They are in a privileged position to see the immediate reward for such sacrifices and they have not been greatly impressed. Justification for their views is evident from the identical sentiment of paragraph 5 of the Committee's Report previously quoted. These views so long held are not easily changed to-day in an atmosphere of incentive-killing taxation of the professional classes actual and potential. Another not impossible explanation of the decreasing competition for our own scholarships is the current near-profligacy of our County Councils. They appear to excel in automatically granting scholarships to students who pass their final school examinations high enough, provided their parents are poor (or clever) enough not to provide the funds which the County Council abstract from the pockets of other parents. These latter are generally judged by the County Council to be rich enough to prevent their own children enjoying "free" education in this cuckoo land of fair shares for all. The effect of this entirely unmoral system has been to allow many students to feel that they have the moral right to a university education at the expense of the community without having to undergo the further indignity of having their particular talent tested by peculiar scholarship examinations devised by Institutions such as our own. It is of interest to contemplate whether we should now, therefore, accept this state of affairs and realize that as our non-research scholarships cannot be awarded to the absolute best* they should be discontinued forthwith as a

* I feel compelled here to express my profound admiration for the current Norwegian method of meeting this situation. Every student

potential menace to the industry. Alternatively, should we retain these scholarships and in self-defence confine their award primarily or exclusively to the children of our own members?

The difficulty with County Council assistance is that it directs the student into the university before he has had time really to decide his future profession; and by the time he has graduated, even in pure science, he is inclined and generally decides to enter a profession which accepts the university degree as a sufficient qualification in itself without any further or previous training. He makes this decision rather than start at the bottom of some industrial ladder as a very junior junior endeavouring to forge ahead in an environment of less privileged and possibly somewhat resentful young men of greater works experience and of more immediate value to their respective employers.

The answer to this problem is surely, therefore, to get hold of the student just before he leaves his school, take him on as a trial apprentice during the first long vacation prior to university. He can then decide either to go direct to the university, returning to the shipyard during the subsequent long vacations, or to spend a further year in the yard and take the first year university examination externally ultimately proceeding to an honours degree. Either alternative will involve a three-year university career. This is, in fact, not unlike the Shipbuilding Employers' Federation's own scheme. It is only fair that students originally chosen to receive a grant from their local education committee, however, should, on deciding to enter the shipbuilding industry, have their grant now paid by the industry itself, particularly so as the industry now legally avoids any serious contribution to the local rates and thus to any local education charges, technical or otherwise. This escape from communal responsibility cannot be pleasant to the shipbuilder. It is surely better to pay local rates and so reduce one's own workers' local expenditure than to pay out allegedly swollen profits which merely arouse the envy of the worker and help to energize the inflationary spiral. This transgression may appear to be politics in the raw but clearly it also vitally affects education. Returning, however, to the student and his pre-graduation shipyard training, he is probably more willingly accepted by his non-university contemporaries if he changes shipyard at each long vacation. A still better plan would be to arrange these vacations to be spent in continental shipyards under an exchange scheme with continental students. The travelling expenses should be, of course, a charge on the original employer or his federation. This arrangement, although probably not acceptable to the federation at the moment, has many obvious psychologically sound advantages. Primarily it is designed to attract good brains, if not as yet the best brains, to the industry. It offers them a first-class liberal education, foreign travel, a technical education and, let us hope, a well-paid profession.

Section 4

Despite the fact that until very recently we have led the world in shipbuilding, the industry as such is somewhat down the scale of financial or labour importance in the general field of engineering in this country. This relative unimportance is in violent contrast with the standing of the industry in time of war; and the greatly increased labour force then directed to it plays havoc with its peace time balance and efficiency. Fortunately the contemporary world awakening appears to be producing an almost insatiable demand for shipping. This means that if the shipbuilding industry is now to grasp its opportunities before they recede, it must expand; and expand with its stability assured by the high quality of those serving it at all levels. There is an interesting guide to the general absence of this high quality at the moment. It is a sobering thought that in the early days of our Institution we had at one time some ten Fellows of the Royal Society on our Council. Several of these were naval architects or shipbuilders and Fellows in their own right. At the moment the Institution has only one shipbuilder so honoured; and whilst this may be a correct assessment of the relative importance of science in shipbuilding versus the rest of engineering it could suggest to young men of some scientific discernment that shipbuilding as a profession did not appear naturally to foster recognized leaders in applied science. Admittedly not all young men can be expected to be so discriminating, but in universities catering for all professions students do at times get some extraordinary ideas. For example, students could well ask themselves why naval architecture which was previously professed at three British universities is now only available at two? Is this the sign of a healthy industry or an expanding profession? Again, in Scandinavia, Belgium, and the Netherlands, the total amount of tonnage under construction at the end of September 1956 was just a little more than half that under construction in this country, yet the number of professors of naval architecture required by these other countries to ensure the supply of scientifically trained men is seven times that considered ample in this country. If the U.S.A., Spain, and Yugoslavia are brought in to produce broad equality with British tonnage, then something like thirteen times the number of professors are required. These figures could, of course, be used to show how wonderfully economical the British shipbuilding industry is in absurdly expensive university professors, but such a use would hardly deceive our intelligent student in search of a profession. He might be encouraged to examine the position in Japan and Western Germany, our present leaders in world shipbuilding, and find they each have some three to four times the number of professors that we have. His further thoughts would alert him that these differences referred to real and immediate onslaughts on the serenity of his contemplated profession. There would be no need to conjure up a gigantic foreign menace against which an army of technologists have at once to be trained by non-existent professors to restore intellectual and commercial supremacy to the country. If our intelligent student is therefore content to rest on his intelligence he will smile and pass us by. A newer world beckons him. On the other hand, if his intelligence causes him to halt and ponder his heritage he may decide that the challenge is exciting and worthy of all his intelligence; that science and shipbuilding do mix; but that one or two changes of heart and outlook on the part of the industry in regard to education and professional standing might go a long way to increase its attractiveness and ensure its own future. Let us pursue the issue.

qualified to enter and accepted by a University can *borrow* money from a special Government fund to keep himself at the University until he graduates. Some nine months after graduation the accrued loan becomes subject to interest (currently 3¾ per cent per annum). It is then expected to be repaid within fifteen years. When the student's parental income *tax* is reduced because of the student, the amount which can be *borrowed* is generally expected to be reduced by about the same amount. Default to date has been infinitesimal.

Section 5

The outstanding lesson of the previous section is that to secure even approximate equality with our principal competitors the number of university professorships in naval architecture should be increased some three or four times their present strength of two. This does not only mean that, say, a minimum of five new professors have to be found, but also that five new schools of naval architecture have to be established and staffed. These could well begin by the revival of the Liverpool school, the development of the Belfast School at Queen's, an entirely new school, say, at St. Andrews and Dundee (or Aberdeen or Edinburgh?), another new school at London University, and finally a new school at Cambridge University. These schools would not be intended merely to duplicate existing facilities. They should have extreme individuality and by such develop a co-operative rivalry stimulating the whole subject and profession. For example, not all would present the subject as now, chiefly from a producer stand-

point. It is conceivable that London and Liverpool, being primarily shipping centres, could well and should foster a user presentation of the subject, a difference broadly illustrated as that between the material in the *Transactions* of the Institute of Marine Engineers and in our own. Again, the East Scotland school could well establish its individuality by developing the small craft and fishing vessel demands on naval architecture. There is undoubtedly fine pioneer work to be done in this fascinating field. At the other end of the scale should be the Belfast School. Here we have the big ships and one would naturally look to this school for guidance in expanding naval architecture. I am sure that Glasgow would welcome the rivalry.

The Cambridge school would naturally differ from the rest. The University has neither a shipbuilding nor a shipping environment. It has, however, a very saturated university environment and it is undoubtedly one of the finest youth "dispersal-centres" in the world. A student who profits by his stay at Cambridge has partaken of one of England's best educational opportunities. He should have clashed with his fellows in and on many fields. He should have learned to appreciate and tolerate many different viewpoints; and knowing that a very high proportion of his friends will eventually become leaders in many different professions he should out of sheer *amour-propre* determine to go and do likewise. The Turkish proverb that "grapes get black by watching one another" appears to say the same thing rather more picturesquely. In any case a student's stay at Cambridge should have allowed him to mature into a vintage product endowed at least with the ability to mix, to express himself, and above all to think. There are many who feel that the precise subjects in and by which a man is taught to think are not important. So perverse can this outlook be at times that it is held that a man can be taught Latin and Greek plus the ability to forget both and automatically become a leader of men in the sublimation process. Indeed, judging by results and in shipbuilding, too, there must be something in it. It is equally true, however, that learning to think is usually quite successful in a naval architectural atmosphere; and were this *inter alia* provided at Cambridge in addition to the boat race the graduate would be ready for work without having to risk undue professional delay by attending another university or college having naval architectural facilities prior to ultimate employment in the shipyard. It is, moreover, true that one university life is sufficient and that two can produce conflict.

It is not suggested that the above remarks apply only to Cambridge. Most of them clearly and equally well apply to any of the other liberal universities. Nevertheless, as a compact conglomerate of educational units Cambridge does appear to be widely preferred as a character-forming, pre-industrial dispersal-centre. It is undoubtedly true that the best pre-industrial brains of the country do find their way there; and if only the best is to be good enough for shipbuilding in the future, it is clearly there at least that the shipbuilding industry should seek its executive recruits. A Cambridge school of naval architecture would still better serve to provide the recruits and prepare them more rapidly and economically for service and opportunity in the industry.

Section 6

It will be appreciated that we are confining attention here to the development of increased facilities for the highest technological education in naval architecture. We are not concerned with anything less; for it is felt that if the highest is put right the betterment of anything less automatically follows.

It may now be appropriate briefly to discuss developments in the actual teaching of the subjects normally understood as branches of naval architecture. Many of the subjects are old and, in fact, very old. This means that some of the oldest textbooks are still surprisingly good; so good in fact that very little improvement in the classic presentation of the subject can be claimed to have taken place in the last sixty years. As this field broadly covers the technical work usually required in the ordinary shipyard drawing office it is a matter of some difficulty to agree how this part of the subject should best be taught. On the one hand, it would appear to be too elementary to justify a professor lecturing on it; on the other, it is much too basically important to be treated too lightly. It could, of course, be taught by senior lecturers if these lecturers generally existed. If they do not. the Professor, who is presumably chosen for his ability and achievement in more complicated branches of the subject, has to get down to it and do the job himself. The situation is analogous to a shipyard manager being deprived of all drawing office staff and being expected to prepare every plan himself just because he is presumably capable of doing so. This particular difficulty is here being emphasized not only because it is very real but to show that an adequate school of naval architecture also requires an adequate staff. Staff shortage merely serves to draw attention to the major problem of how much a student at university level should be expected to teach himself under professorial or tutorial guidance; and how much he should be lectured and professorially dictated to from notes which were already old when the professor himself was young.

A difficult and generally unsatisfactory situation could here be greatly alleviated by professorial pedagogical collaboration; and it is now suggested that this Institution should sponsor and found an international conference of professors in naval architecture in order to examine all the pedagogical issues involved. From the work of such a conference, for example, an agreed standard presentation of first principles could well emerge. What is here in mind is a loose-leaf tutorial treatment of the subject specially drawn up to explain and hence to avoid difficulties which are known to arise in the general comprehension of successive generations of students as the subjects unfold. The pooled pedagogical experience of all professors, of their failure and success in the putting-over of their subject would be reasonably certain to produce an entirely new approach to naval architectural (or any) education. It is extremely doubtful whether any such collaboration or discussion has ever been previously attempted in naval architecture. A student's difficulties of comprehension are apt to be regarded as reflecting his low level of intelligence; and lecturers themselves rarely accept responsibility for such students' difficulties. In other words, if the student does not follow the inner workings of the professorial mind, so much the worse for the student. There is not the slightest doubt that this "putting-over-efficiency" is the major problem in university work to-day. The natural development of each subject and the inevitable increase in the number of subjects which are pressurized into a university curriculum makes the position intolerable to the student and distressing to the professor. Moreover, professors in applied science are not always natural teachers. In an industrial world where shorter hours with increased pay are the order of the day, the longer hours and harder work which the university student is expected to put in clearly exposes him to the first stages of industrial schizophrenia. Unless, therefore, means are developed for improving "putting-over-efficiency" at a quicker rate than that of subject-expansion, students will arrive in the shipyard not so well equipped for immediate duties as they possibly were in earlier years.

If our Institution can thus successfully convene and ultimately found the professorial pedagogical collaboration committee as above envisaged, naval architectural education could be greatly streamlined. In addition to agreeing on a pedagogically correct basic approach with standardized basic notes, diagrams, lantern-slides, etc., agreement could also eventually be reached on the more advanced presentations of the subject. Professors specializing in particular branches could undertake the prepara-

tion of a presentation of their subject, *considered primarily from the standpoint of the student being able most simply to assimilate it*. The presentation would, moreover, be expected to respect the common basic approaches previously accepted; and, of course, should be mutually agreed by the whole committee prior to final acceptance. This type of organization would be of enormous help to all professors and to all students. All would have the satisfaction of knowing that the notes on any subject were those prepared and vetted by the world's experts. Each professor, instead of trying without too much personal interest to give a general picture of the whole subject, could feel himself freer to develop his own branches and for the common good. The students now having first-class notes in printed loose-leaf form could interleave these as they wish, taking further notes as may arise from their own professor's actual presentation of the particular lecture. It is obvious that this presentation, complete with lantern-slides and epidiascope projection, can be put over much more rapidly than an ordinary blackboard lecture. It will leave much more time for high-lighting, additional explanation, and the answering of the students' professorially invited questions or discussion. Only by such an improved and streamlined approach can the modern intensive curricula be accommodated. The blackboard should no longer be the surface on which a professor rewrites his lectures year after year. The fact that he writes at about the same speed as his students copying the notes merely has physiological and not pedagogical significance. The blackboard is an excellent medium for spontaneous explanation and discussion, but is a grossly abused instrument of university education.

One of the further duties of such a collaboration committee would be to find the answer to probably the most serious problem in shipbuilding education, i.e. how are the future teachers and professors themselves to be trained? In the past those who have taught in shipbuilding have learnt by being themselves taught shipbuilding. Few have had any pedagogical training or have been trained how to teach. I do not propose here to solve the problem. It is sufficient to mention it and to realize that it must be faced and solved if shipbuilding education is to succeed.

In concluding this section a reference should be made to drawing office work from a university standpoint. The reference is made principally to show that it has not been forgotten. It is a subject upon which opinions differ widely. My own opinion is that ship drawing work as such should be learned and taught in the shipyard. It should be a productive effort rather than only an educational one; and in the university, drawing, owing to its time-consuming nature, should be reduced to a minimum. On the other hand, the principles of good draughtsmanship, good hand-printing, and general neatness should be taught as basic in the first year of any university course and the highest reasonable standard insisted upon even to the final year. This cannot be too highly stressed. It is vital to a student's entire professional outlook and self-respect. It can help him over many difficulties, whereas lack of neatness can frequently destroy whatever clear technical vision a student may have acquired. Students who enter a university from an apprenticeship in the shipyard have in this respect an enormous advantage over those who come without this experience. The advantage does not primarily lie in their knowledge of ships. It lies in their general neatness and their ability to work quickly, neatly, and accurately.

Section 7

It is hoped that the foregoing thoughts are sufficiently wrath-provoking to merit discussion. They would be incomplete, however, without some consideration being given to what the industry really does offer the student with brains and other commercially desirable assets. Perhaps it would be better to state at the outset just what it does *not* offer him within the foreseeable future in this country. It does not offer him the slightest protection of a professional nature. (Neither, of course, does this Institution!) He will have no powerful trade union behind him to operate a closed shop on his behalf. He will find that unlike the majority of his university colleagues (and his opposite numbers in the Royal Corps and in continental shipyards) he can belong to no officer class. The shipbuilding industry is a classless democracy. Its way to the top is just as open to those devoid of all *technical* qualifications as to those with the highest, but as this is also true of many other British industries it merely illustrates how the sacred principle of equality of opportunity can and does work out in practice. In other words, scientific training, however good, is not everything.

No student worth his salt, however, should enter the industry without a secret ambition to leave it better than he found it; and it is here that the industry offers the fullest opportunities. There is clearly so much to be done. There are many new problems to be solved. We are already in the supertanker age and are probably now facing a period of almost equally rapid growth in the bulk carrier. In a world of rising labour costs increased building or running economy can only be got from increased size of ship. The best solution of these and many other problems requires the development of the research outlook in the shipyard to the fullest possible extent. Fortunately, the pioneer work of the British Shipbuilding Research Association has already shown the way, but before a tendency becomes a habit, a discernible trend to take all research away from the shipyard and throw it on to the Association should be strangled at birth. It is, of course, natural that a shipbuilder, having covenanted with his colleagues to charge his shipowner client more for his ships in order to finance the research association, feels he has a duty to his client to keep these charges down to a minimum. Be this as it may, a central organization for research which has to function to the exclusion of research in the shipyard cannot be the ultimate organization. In my opinion, therefore, it is the duty of every shipyard to have its own research department; but however small such a department may originally be, it *must* be directly responsible to the board of directors *through a fully qualified research director who is himself a member of the board of directors*. Only when this change has taken place in every shipyard in the country will the intelligent student in search of a profession realize that the search is over. The research director will be concerned and only concerned with the solution of to-morrow's problems. He will lead a forward-thinking group. Each department in the shipyard having a to-morrow's problem, as distinct from to-day's—and which have not?—will clearly provide the intellectual fodder for the group. No to-morrow's problem should be excluded: education, planning, production, labour relations, costing methods, design methods, product analysis in its widest sense, all must come within the purview of the department. It might be objected that labour relations is the last subject which should be examined in a research department. Labour relations, however, as a to-morrow's problem should at least convince the worker that there is a tomorrow for him in the industry; and that the industry is devoting its best brains to the solution of his to-morrow's problems. Can this be wasted effort?

The existence of the research department is bound to have its repercussions throughout the whole shipyard organization. Science and scientific training cannot be appreciated and represented at the highest levels without their ultimately permeating the whole structure. What this means in increased opportunity for the intelligent student needs no further expansion or emphasis. He should still smile, but no longer pass us by.

Section 8

If the author of a paper forming one of a symposium can be euphemistically referred to as a sympositor then it is no part of a single sympositor's duty to attempt the whole story. He

must be content with the opportunity given him to state his point of view. In appreciation of this very necessary limitation of outlook my plea for a new deal now draws to its close. A new deal necessarily involves a reshuffling, both at cards and in ideas. The play is for money and the new deal has to be financed.

Who has to pay for the suggested new deal in naval architecture? That it must be a co-operative effort there can be no doubt. It is humbly suggested to the shipbuilders that an industry which earned the very sympathetic consideration of the community when times were distressingly bad should now express its gratitude to the community in very tangible form. Clearly, when it was de-rated, the industry had no wish to cause others to pay for the local education of the majority of its present staff and workers. Yet this is very largely what has happened and is still happening. Is it too much to suggest, therefore, that shipbuilders should now additionally covenant amongst themselves, and this time at their shareholders' and Government taxation expense, and so repay this debt? Scientific education is an essential ingredient of scientific research and if the pound for pound slogan profitably holds good for research it should similarly hold for scientific education. A decision of the shipbuilders to invest in increased scientific education should therefore rank as a research contribution and be met by a corresponding Government grant. If this is not the case then it clearly should be.

Similarly, as it has been suggested that the proposed London and Liverpool schools should incline to a user technologist presentation, one could equally humbly suggest that our shipowners and ship-repairers might join forces and explore how best to secure Government emulation in the provision of the necessary finance.

The Cambridge school probably calls for the fullest co-operation not only between shipbuilders, shipowners, ship-repairers, and the Government, but also with the shipbuilding trade unions. An invitation to our trade unions to invest in the true mechanism of their own members' prosperity is surely not ill-timed and could be the beginning of a new era in shipbuilding labour relations.

In the foregoing contemplation of our problem it has been tacitly assumed that the universities would welcome the necessary development to cater for our needs. University politics can, however, be curiously conservative and introspective at times. Their intellectual freedom and autonomy have nevertheless many desirable features; and in any proffered industrial collaboration these should not be forgotten. Nothing but good can come from such increased collaboration. I am not here suggesting, of course, that at Glasgow and Durham the collaboration needs to be increased, but rather that their type of collaboration should be more widespread. A marked increase in the number of university schools of naval architecture would automatically raise the peak standards of the whole profession. A fourfold increase in professorial posts and a still greater increase in the demand for adequately qualified lecturers and staff, all at sufficiently attractive salary level, must necessarily result in further all-round increase in the number who are prepared to uplift their scientific qualifications in readiness for such appointments. Prior to this their continued employment in industry must surely be for the benefit of the industry as a whole; and if the industry wish to retain their services they must compete not only in salary and general working conditions but also in offering the fullest opportunities for scientifically congenial employment. When one learns, however, from a very recent Government publication that there are only 69 qualified people actually employed in research and development in the entire shipbuilding industry in this country and that the increase envisaged by 1959 is still relatively small (this information is supplied by the industry itself), we realize how much an industrial change of heart is really overdue. The shipbuilding industry is expected to be energized anew by a scientific sprinkling of a mere 0·4 per cent of its working population. When it is realized that the corresponding figure in the electrical engineering industry is five times as high we see the profound difference of outlook in current industrial leadership. An outsider to the shipbuilding industry would naturally regard this difference as shocking. Those inside in the industry will hardly see it this way. They know that science is not ignored in shipbuilding. What they do not see and never have seen, of course, is that five times the amount of science would transform and do immense good to the industry. If the present symposium can bring this truth home to the industry it will not only have served its purpose, it will have accomplished an industrial miracle. Let us therefore show the youth of the industry that the age of miracles is not yet past, that they have opportunities ahead of them which were either denied us or which we were too weak to grasp or perhaps too indifferent to create. Theirs is the future, deluged in difficulty; and a challenge indeed.

APPENDIX I

Institution of Naval Architects

REPORT OF THE COMMITTEE ON THE EDUCATION, TRAINING, AND EMPLOYMENT OF YOUTHS AND APPRENTICES FOR THE EXECUTIVE GRADES OF THE SHIPBUILDING INDUSTRY

1939*

Members of the Committee:

Sir Eustace H. T. d'Eyncourt, Bt., K.C.B., D.Sc., F.R.S., LL.D. — Chairman.

	Appointed by:
Sir Stanley V. Goodall, K.C.B., O.B.E.	Admiralty
Mr. J. Montgomerie, D.Sc.	Lloyd's Register of Shipping
Mr. J. M. Ormston, M.B.E.	Shipbuilding Employers' Federation
Mr. E. W. Russell	
Eng. Vice-Admiral Sir George G. Goodwin, K.C.B., LL.D.	Institution of Naval Architects
Sir Westcott S. Abell, K.B.E., M.Eng.	
Sir Maurice E. Denny, Bt., C.B.E., S.B.	
Mr. A. T. Wall, O.B.E., A.R.C.S. ..	
Sir Amos Ayre, O.B.E.	
Mr. F. Bryant, C.B., O.B.E.	
Mr. G. V. Boys, M.A.	Secretary

Terms of Reference

"To consider and report on the education, training, and employment of youths and apprentices for the executive grades of the shipbuilding industry."

In considering this question the Committee has had regard to the following points:—

1. The expression "executive grades" in the terms of reference is held to include all grades appropriate to the higher posts of the shipbuilding industry.

2. The fact that the shipbuilding industry is subject to periods of severe depression is not considered to have a direct bearing on the issues before the Committee. Nevertheless, it has to be recognized that industries less subject to periodic depression have by that fact an advantage over the shipbuilding industry, which the latter must offset if it is to succeed in appealing to young men considering the choice of a career. The Committee is of the opinion, however, that there are opportunities presented by the industry to those aspiring to obtain the posts covered by the terms of reference which are commensurate with the effort required.

3. Although there is a wide variation in the character of the products of different yards, it is considered that the personnel under review can be divided into four broad categories, namely:—

(*a*) Those occupying the higher executive and technical posts;
(*b*) Outside managers, chief draughtsmen, and their principal assistants;

* Reprinted from TRANS. I.N.A., 1939, p. 352.

(*c*) Those occupying the higher commercial posts and their principal assistants;
(*d*) Overseers, surveyors, and consultants;

with the proviso that it is not possible to draw a hard-and-fast line between the categories, more especially between categories (*a*) and (*b*).

4. The education and training which the men in the four categories in paragraph 3 should possess may be defined in broad terms as:—

(*a*) and (*b*) Practical, scientific, and commercial, including labour relations;
(*c*) Commercial, with special reference to shipyard accountancy, contracts, timekeeping, wages and costing, together with the elements of naval architecture and shipbuilding;
(*d*) As at (*a*) and (*b*), depending on circumstances;

with the same proviso as that contained in paragraph 3.

5. The three universities with faculties of Naval Architecture can amply supply the output required by the industry of graduates with a high degree of theoretical training. The Committee does not hold that graduation from such a university is essential to qualify for the executive grades of the shipbuilding industry, but it is an experience which should be a great asset. To carry full value graduates should complete a recognized apprenticeship in a shipbuilding establishment, and in addition should acquire by practical experience an adequate knowledge of the commercial side of the industry.

6. The system of higher education, which led to the examinations in Naval Architecture, Stages I, II, and III and Honours, by the Science and Art Department, and later, until discontinued some twenty-five years ago, by the Board of Education, was in the opinion of the Committee suited to the requirements of the industry. That system secured a national standard both in the scope of the teaching and in the measure of the achievement. It was essentially a non-course or single-subject system, but it encouraged the study of additional subjects, such as mathematics, a knowledge of which is required for a better understanding of the main subject. That system led but did not force its students to the desired end.

7. With the discontinuance of the system referred to in paragraph 6, a grouped course system was introduced by the Board of Education which was local as well as national in character. This paved the way to the introduction of the National Certificate system in which, while the main subjects are common, the courses of study are adapted to local conditions, subject to approval, in the case of Certificates in Naval Architecture, by the Board of Education, the Worshipful Company of Shipwrights and the Institution of Naval Architects. The scrutiny of the final examinations by assessors by these bodies assures to these certificates a standard of national character.

8. The National Certificate scheme possesses, however, both the advantages and the disadvantages of the grouped course system. Its candidates must reach a certain standard of proficiency before they may take the course and they are required to take the complete course. This has the effect of preventing some and discouraging others from starting the course. It attracts few outside the category of the drawing-office apprentice and is beyond the powers of the average shipyard trade apprentice, who was able to profit by the so-called "practical shipbuilding" course given in the earlier stages of the old system, and who was thereby given an incentive to further effort.

9. The elementary school boy, who has not been selected at the age of eleven to continue his studies at a secondary school, will probably remain at the elementary school until the age of fourteen or fifteen, unless he passes on at the age of thirteen to a Junior Technical School. Shipyard and other apprentices, unable or unwilling to take the major grouped courses leading to the National Certificates, namely, three years of a senior course known as S_1, S_2, S_3 and two years of an advanced course known as A_1 and A_2, may take the two years of a Junior course known as J_1 and J_2. (These technical courses, which cover seven years, have hitherto been designated T_1 to T_7 inclusive.)

It is observed that the system of selection for the secondary school places at a disadvantage the boy who is slow in development and who may be a better stayer, in that he is picked or rejected at the early age of eleven.

10. Except for two research scholarships, it is noted that all the scholarships administered by the Institution of Naval Architects are for university study by apprentices-to-be, apprentices, or ex-apprentices. Assuming, therefore, that the university course is suitable, these scholarships give the right kind of encouragement to those seeking a comprehensive training and education, as referred to under (*a*) and (*b*) in paragraph 4 above.

11. Of the two post-graduate research scholarships, tenable each for two years, one is offered annually, so that in effect there may be three holders of such scholarships at any time. The number of candidates recommended for consideration for the award of these scholarships is small and it is not unusual for there to be no more than one holder of a research scholarship. It is felt by the Committee that the industry, as a whole, is not deriving from the work of research scholarship holders quite the benefit that may have been expected, and, furthermore, that such scholarships tend to direct the energies of their holders into channels which may not always be in their best interests or of any great benefit to the industry.

12. It is noted that few shipyard apprentices, if any at the present time, who possess a university degree, take advantage of the Industrial Bursaries offered by the Royal Commissioners of the 1851 Exhibition, of which forty-three were awarded in 1936 to graduates in other branches of engineering. It is considered that this scheme of Industrial Bursaries admirably fulfils its object of giving financial assistance to deserving men in their early twenties, and that it deserves wider notice. It is also considered that additional similar schemes are worthy of encouragement.

13. It is recognized that a man's fitness to serve in the highest executive positions cannot usually be judged until he is approaching or has attained the age of thirty. So long, therefore, as the industry is able to obtain and absorb a supply of younger men trained and educated to the desired standards so will it continue to be able to draw from this source the leaders it most needs to enable it to maintain its position in the ever-increasingly competitive world markets.

As a result of the above inquiry the Committee unanimously recommends:—

I. That the universities with faculties of Naval Architecture be invited—

(*a*) To broaden the scope of the courses of that faculty, more especially in the third and/or fourth year, so as to include, or to include more fully, subjects such as economics and commercial shipyard practice directly useful to the practical shipbuilder and to the prospective yard manager.
(*b*) To encourage only those students to read for a degree in Naval Architecture who have been, or are at the same time, apprenticed to a shipyard either by a "sandwich" system or otherwise.

II. That local education authorities be invited—

(*a*) In the selection of teachers in mathematics and other group subjects for those taking the senior and advanced evening courses leading to National Certificates in Naval Architecture, to give preference, other things being equal, to men (if available) who are themselves versed in Naval Architecture and therefore better able to interest their students in what may be thought a less attractive though essential subject.
(*b*) To allow shipyard apprentices, if they so desire, to take one or at the most two subjects taken from the J_1, J_2, and S_1 courses, and to provide for the formation of "practical shipbuilding" classes for these years devised to suit the requirements of shipyard apprentices of the various trades.

III. That shipbuilding firms be invited—

(*a*) To extend the practice adopted by many firms of encouraging their yard apprentices who satisfactorily complete approved courses of evening study, by granting bonuses or refunding fees.
(*b*) To offer facilities to promising shipyard apprentices who qualify under III(*a*) to enter the drawing office, and to provide opportunities for promising drawing-office apprentices to obtain some experience in the shipyard.
(*c*) To institute a "sandwich" system for those among their apprentices who wish to take a university course, and can satisfy some strict criterion to demonstrate their fitness and ability.
(*d*) To give so far as may be practicable special encouragement to employees, under the age of thirty, who, having served a full apprenticeship, have either satisfactorily followed a university course in Naval Architecture or have taken a Higher National Certificate in Naval Architecture, and otherwise show promise.

IV. That the Council of the Institution of Naval Architects be invited to take powers to allocate to Industrial Bursaries, similar to those awarded by the Royal Commissioners for the 1851 Exhibition, the funds now administered under the Sir William White Post-Graduate Scholarship.

June 1939.

APPENDIX II

In view of Fig. 1 of Professor Burrill's paper I have thought it of interest to include a similar diagram, Fig. A, giving the variation of the number of shipbuilding students at the Technical University of Norway. This University is at Trondheim and was founded in 1910, and thus is almost completely parallel with Durham University naval architecture department founded in 1907. The relative behaviour of the two sets of statistics is extremely interesting. It is quite clear that there is a definite interrelation present, the hollows of Durham being matched by the peaks of Trondheim. Durham has always had a very good quota of Norwegian students; and in all probability if a list of all the nationalities trained at Durham in naval architecture were prepared it would be fairly safe to assume that the second on the list would be Norwegian. In view of this it has been thought of interest to combine the two statistics; and it is evident from Fig. B that the total students of both universities up to 1945 remain much steadier and do not generally show the violent fluctuations that they each do singly. The cancellation of the minor fluctuations allows the steady growth from 1907 to 1943 to be better appreciated. This growth was from about twenty to

FIG. A

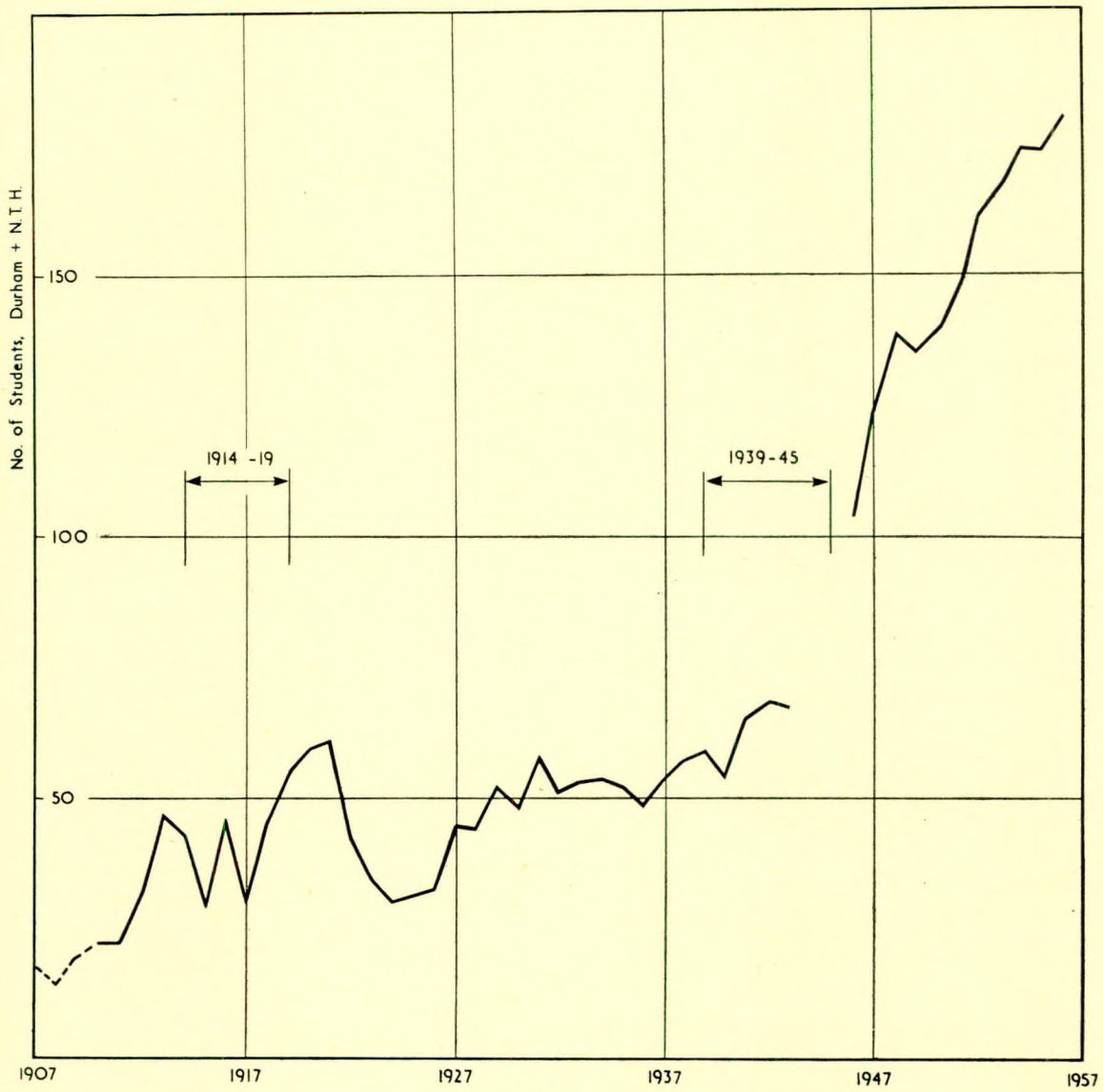

FIG. B

sixty. The brief post-war boom from 1919 to 1921 followed by the world slump to 1926 is clearly evident. Consider the separate statistics, however. The 1914–18 war meant to us that we did not recover our 1913 strength until 1921. In 1917 we passed through an all-time low. On the other hand, Norway was not a combatant in the 1914–18 war and had almost as rapid a rise over this period as we had a fall. Undoubtedly this partly meant that some of the Norwegian students who would normally have come to Durham were prevented from doing so by the war and therefore helped to boost the N.T.H.* figures. Both clearly suffered sharply from the post-war slumps, but whilst N.T.H. commenced a sharp recovery from 1924, our own continued to decline until 1926 and no certain sign of recovery took place until after 1934. Even in this pre-1939 period, i.e. the looking-back period of our 1939 Committee, N.T.H. had roughly three times the students that we had in Durham. This fact in itself is an interesting sidelight on our Committee's findings, but the extraordinary difference between the N.T.H. and Durham strengths is worthy of some further consideration. It is fairly certain that N.T.H. had over this period more shipbuilding and marine engineering students than had the whole of Great Britain.

* N.T.H. is the usual abbreviation for Norges tekniske högskole which is usually translated as above.

How could this be possible? The one fundamental difference between the two countries is that in Norway the universities are state educational centres and education as such is entirely free. In England the universities are not part of the state system and their fees are not small. In a period of depression these fees could be sufficient to deter many who might otherwise have profited by a university education. It is exactly the poor entry during this period which is now giving our industry so much concern by the absence of well-trained men of mature age who should now be controlling our shipyards. Conversely, the opposite Norwegian situation should be free from our own difficulty. The statistics, however, do not necessarily imply this; and one alternative explanation appears to be that some of the rapid growth from 1924 in Norway was caused by students training with the deliberate intention of emigrating to the U.S.A. This was a time of difficult employment in Norway and clearly such education was regarded as a real investment for life.

The upward movement which started in 1934 in England was delayed until 1937 in Norway, but whereas it collapsed in 1939 in England, it continued until 1943 in Norway. The English collapse is understandable. The Norwegian continued growth during the occupation is explained by the desire to avoid pro-

duction for the Germans and prepare for happier times. The break between 1943 and 1946 is due to the closing down of N.T.H. since attendance then required membership of the Nazi party. The post-war period of both countries is striking. In Norway the growth appears to be reasonably continuous with that starting from 1936, but in England there was a complete change shortly before 1945 which caused a three-fold expansion up to 1948, a slight setback in 1948, followed now by still further expansion. In Norway it is felt that apart from the expanding shipbuilding industry the government students loan fund introduced just after the war has been the principal reason for the expansion. In England the government grants to the universities in financing greater facilities and the County Council grants in encouraging more students have had practically the same effect. It is not known what percentage of the Durham students are English. At N.T.H. all the students are Norwegian.

Another point to remember is that at N.T.H. our students have equal shipbuilding and marine engineering qualifications. They are at once available to both the shipowning and the shipbuilding industries. The only real slumps in students at N.T.H. coincided with two shipping slumps. One gets the general impression that at Durham the intake of students in shipbuilding is extremely sensitive to the state of the industry. For example, the extraordinary decrease after 1948 (when vacant berths were available in British yards) is quite remarkable. The N.T.H. growth does not appear to have been affected at all over this period. At the moment further expansion of N.T.H. intake is limited by space facilities. More students could be accepted if extra space were available and many more would be forthcoming if admission standards were reduced. There is of course no intention of doing this.

A recent analysis of the present positions of N.T.H. graduates shows a number of interesting features. The analysis covers the period of 1914–1954 and includes 278 graduates. Of these 99 are in the shipbuilding industry, 47 are in shipping, 28 are in classification, 12 in consulting work, 14 in research, 46 in agency work or left the profession, 24 have found employment outside Norway, and 8 have died. Briefly, this can be summarized by saying that for every ten graduates, four go into shipbuilding, two go into shipping, one into classification, and the remaining three go into research, consulting and agency work. These figures appear to be quite rational and it would be extremely interesting to have the corresponding figures for the two British Universities.

So far as our own Institution research scholars are concerned one can expect a different segregation. For example, from the information given in Section 2 it would appear that for every ten research scholars, two subsequently go into industry, two go into education, one goes into classification (or survey work), and five go into research. Again there appears to be nothing unnatural about this segregation and it suggests that the scholars have rationally found the profession most helpful to the industry as a whole. If some of the ideas suggested in the present paper are adopted, particularly if each shipyard develops its own research department, some changes in the probable segregation of the research scholars can be expected. Ultimately one might expect out of every ten scholars three would go to industry, two to shipping, two to education, two to research, and one to classification.

I am indebted to my colleagues Siv.ing. Örvig and Siv.ing. Voll for their assistance in deriving the N.T.H. statistics detailed in this Appendix and related diagrams.

UNIVERSITY EDUCATION AND THE TRAINING OF NAVAL ARCHITECTS

By Professor A. M. Robb, D.Sc. (*Vice-President, I.N.A.*), and
Professor L. C. Burrill, M.Sc., Ph.D. (*Member of Council, I.N.A., Member, I.Mar.E.*)

Part I

By Professor A. M. Robb, D.Sc.*

Admission to a first graduating course in the University of Glasgow is restricted to holders of the Certificate of Fitness issued by the Scottish Universities Entrance Board. The Certificate is awarded on results obtained in the examinations for the Scottish Leaving Certificate or for the English General Certificate of Education, or in the Scottish Universities Preliminary Examination. In the Scottish examinations an applicant must obtain four passes on the higher standard, or three on the higher standard and two on the lower; English must be passed on the higher standard, and the other passes must include one in a language other than English. An applicant presenting the General Certificate of Education must show passes in six subjects, with two at advanced level, or in five subjects with three at advanced level; in both cases there must be a pass in a language other than English. Concessions may be given to applicants who have attained the age of 23. A supplementary condition of admission imposed by the Faculty of Engineering at Glasgow is that the Certificate of Fitness must show a pass in mathematics on the higher standard or at advanced level; there is no insistence on a qualification in either of the other basic sciences treated in the course.

The successful applicant for admission enters a four-year course, with the academic year covering two terms, each of 10 weeks, from October to March. There are no regular classes on Wednesday afternoons and on Saturdays, and the time available for formal tuition amounts to about 32 hours per week, or 640 hours per session. The allocation of the available time among the various subjects of study can best be indicated by dealing with each year in succession.

First Year

Mathematics	140 hours
Natural Philosophy	160 hours, including 60 hours in laboratory
Chemistry	150 hours, including 50 hours in laboratory
Engineering Drawing (Solid Geometry)	60 hours
	510 hours

Students who have attained an adequate standard in the work of the first year sit the First Examination at the end of the session, and have another opportunity of sitting the examination shortly before the beginning of the new session. The examination covers papers in mathematics, natural philosophy and chemistry, but not in engineering drawing. In order to obtain admission to the second-year classes a student must show at least two passes in the First Examination. Students who do not attain an adequate standard in the class work may be suspended from attendance for one year. The majority of the students who are so suspended do not continue the course. The wastage on this account has on occasion been more than 20 per cent for the whole Faculty of Engineering.

The ordinance prescribing the curriculum makes provision for exemption from one year of the course for students who have completed an equivalent course at an approved university or similar institution. In practice it has been found possible to grant exemption only from the first year, and the exemption is conditional on the applicant satisfying the examiners for the First Examination.

Second Year

Mathematics	100 hours
Applied Mechanics I	140 hours, including 40 hours in laboratory
Heat Engines I	90 hours, including 40 hours in laboratory
Electrical Engineering I	90 hours, including 40 hours in laboratory
Engineering Drawing	80 hours
Naval Architecture	20 hours
Ship Drawing	60 hours
	580 hours

The Second Examination is held at the end of the second year of the course, and again shortly before the beginning of the new session. It covers papers in applied mechanics, heat engines and electrical engineering grouped as one subject called General Engineering, in engineering drawing and in mathematics; there are actually two papers in engineering drawing, and naval architects take a special second paper.

In order to obtain admission to the compulsory classes of the third year a student must have passed in all three subjects of the Second Examination, but a student who is not thus fully qualified may attend certain optional classes of the third year. A suspension rule is operative also at the end of the second year, but the wastage on this account is much smaller than that at the end of the first year.

Third Year

Naval Architecture	100 hours
Ship Drawing	100 hours
Applied Mechanics II	140 hours, including 40 hours in laboratory
Heat Engines II	92 hours, including 40 hours in laboratory
Higher Natural Philosophy	80 hours
An Additional Subject	60 hours
	572 hours

* Professor of Naval Architecture, Glasgow University.

The class of Heat Engines II covers twelve special lectures in marine engineering given by a director of a Clydeside firm who was formerly on the staff of the engineering department.

For the Additional Subject the student has a wide range of choice. He may take metallurgy, fuels, engineering economics, engineering production, industrial psychology, or advanced mathematics; nuclear engineering was last year added to the list of approved courses. In fact, many students take two Additional Subjects; the inclusive fee chargeable for the whole course permits attendance on two such classes.

Papers on Heat Engines II, Higher Natural Philosophy, and Additional Subjects form part of the Final Examination, but they may be taken at the end of the third year. There are no degree examinations in Naval Architecture nor in Applied Mechanics II in the third year.

Students who have not attained an adequate standard in the work of the third year may be refused admission to the fourth-year classes, but there is no suspension rule in operation.

Fourth Year

Naval Architecture ..	100 hours
Ship Drawing	180 hours
Applied Mechanics III ..	104 hours, including 60 hours in laboratory
	384 hours

The class in Applied Mechanics III comprises two sections—technical dynamics and hydraulics—and students may take either section; some students take both sections.

In addition to the papers in Heat Engines II, Higher Natural Philosophy, and an Additional Subject the Final Examination includes a paper in Applied Mechanics II, a paper in Applied Mechanics III, and four papers in Naval Architecture. The six papers in naval architecture and applied mechanics constitute a group, and the total mark for the group determines the classification of the Degree—1st Class Honours, 2nd Class Honours, or Ordinary. In order to obtain Honours the candidate must pass in all six papers at the first sitting. Failure in one paper prevents a candidate from obtaining Honours. A candidate failing in one or two papers may take these papers again at the next session of examinations. A candidate failing in more than two papers must re-sit the whole group.

For the four years of the course, with 2,560 "nominal" hours available, the allocation of the total time is:

Naval Architecture ..	220 hours	
Ship Drawing	340 hours	
Applied Mechanics ..	524 hours	including time in laboratories and on engineering drawing
Heat Engines	182 hours	
Electrical Engineering ..	90 hours	
Mathematics	240 hours	
Natural Philosophy ..	240 hours	including time in laboratories
Chemistry	150 hours	
One Additional Subject	60 hours	
	2,046 hours	

Incidentally, the "nominal" hour is, in fact, commonly about 50 minutes, so far as lectures are concerned; it is necessary to allow about a ten-minute interval to enable students to get from one classroom to another.

A point of importance, indicated by the allocation of the time, is that the Degree is *in Engineering*. There are seven branches of engineering for which courses are provided, and apart from the introduction of naval architecture in the second term of the second year the first two years of the courses are the same for all. Moreover there is a considerable amount of common ground in the third and fourth years, although there is a different bias for each branch; it would not be quite true to say that there is specialization. Incidentally, freedom to change from one branch to another is operative until the beginning of the third year.

A further point is that the curriculum is based on what is now commonly known as the "sandwich system," with theoretical and practical training alternating in periods of approximately six months. The system was not, however, deliberately adopted. When formal instruction in engineering was instituted with the establishment of the Regius Chair of Civil Engineering and Mechanics in 1840 the university session covered only two terms. The two-term session actually survived into the present century, but when a third term was adopted for other classes the classes in engineering were still restricted to two terms. The deliberate institution of a sandwich system seems to be associated with the founding of the Royal School of Naval Architecture and Marine Engineering at South Kensington in 1864. In a paper to the Institution in 1867 John Scott Russell, who graduated M.A. at Glasgow University in 1825, outlined the scheme of training at the School, and in the course of it he used these words:

> "Thus, then, it was determined that the best education for the naval architect is divided thus:
>
> "During the inclement months of winter, when the days for work are short and liable to interruption, it is best that he should devote himself exclusively to those studies and occupations, which can best be conducted within the walls of a school, or in the halls of lecture; and that on the other hand, the long days and finer weather of summer can best be turned to account, by engaging in the active operations of the workshop, the dockyard and the manufactory . . . and so the council believe that they have made each half of the student's time during three years both the antidote and the supplement, the preliminary and the consummation of the other half. To the young naval architect, therefore, science and practice are not two, but one."

It is on record that Scott Russell, initially destined for the church, spent his summer vacations from the university in neighbouring workshops. It is possible that his own experience had some influence in the adoption of the alternating system at South Kensington.

Until the 'twenties of this century the training was not truly on the sandwich system, in so far as there was not the necessary co-operation of the shipbuilding industry. The young man who wanted to embark on a university course commonly did so after serving five years, or more, in a shipyard. Accordingly, in earlier days the majority of the students were familiar with the common run of drawing and designing office work, and the more elementary matters could be treated briefly. In later years, however, the attitude of the industry has changed, and the university course has become truly a part of a sandwich; the five-year apprenticeship covers both the time in the shipyard and the time at the university. The change of attitude on the part of the industry is reflected in a change in the character of the student. In present days the majority of the first-year students are junior apprentices, or young men fresh from school. There is no insistence that an applicant shall have worked in a shipyard before admission, although in the years when there was an unfulfilled demand for admission it was occasionally possible to direct an applicant to a shipyard, with an assurance of admission in the following year. The young man who does come straight from school can commonly be introduced to a shipyard, and an apprenticeship, at the end of the first Session; the Clyde Shipbuilders' Association has been very helpful in this respect.

An objection to the sandwich system with six-month periods is that the time available for university training is severely limited unless the course be extended to cover five years, like the usual apprenticeship. On the other hand, an objection to a

three-term university session is that the summer vacation may be too short for an adequate spell of shipyard training, especially when the need for a holiday is taken into account. These considerations may be related to the fact that there is a body of opinion in favour of a period of practical training as a prelude to technical training. In 1942, in a paper to the Institution of Electrical Engineers, Sir Arthur Fleming stated that

> "There is growing support for the arrangement whereby prospective engineering undergraduates spend a year in industry between school and university. So long as reasonable provision is made for the continuance of scientific and mathematical study, this arrangement is in every way advantageous. It would seem to offer the most effective means of self and guided selection, and the opportunity it affords for mental adjustment is of the greatest importance."

In the following year, in a pamphlet on the training of engineers published by the Institution of Mechanical Engineers, the case for practical training before university training was more fully developed:

> "The advantages of an organized pre-university practical training are that the boy has an opportunity of finding out what engineering is like; the experience assists in the general development of his character, and he enters the university in a more mature state; contact with engineering practice is of the greatest help in giving him an appreciation later of the significance of his theoretical studies; he is accepted by the craftsmen and helped in a way that would not be possible if he were an adult."

Finally, in the course of a discussion at the Institution of Mechanical Engineers during 1950 it was indicated that practical experience after a full-time university course might be inadequate and would be too late to illuminate the theoretical study. It was suggested that a university course should be preceded by three years of practical training and part-time technical tuition. Incidentally the majority of Clyde shipbuilders seem to desire their apprentices to have a year in the yard before embarking on a university course.

The suggestion that a university course should be preceded by a period of "sandwich training" seems to deserve consideration. It carries the implication of an "educational ladder," with the university as the ultimate stage in the formal training. It therefore carries also the implication that the university should have no concern with the elementary studies. On this basis the university would deal only with the best of the "sandwich" students. In effect, the university would take the pick of those who had been taught "how," in an endeavour to lead them to understand "why"; incidentally, a rough indication of the distinction between a technical college and a university might be that in one the emphasis is on "knowing how," whereas in the other it is on "understanding why." There would be a reduction in the number of university students, but that would be proper in view of the consideration that university education is probably more costly than other forms of education.

A question which arises from the suggestion of a sandwich training as a prelude to a university course is whether the practical training so obtained would alone be adequate, or could be made adequate. In this connection it may be permissible to quote again from the pamphlet published by the Institution of Mechanical Engineers:

> "For a long time the term 'apprenticeship' has ceased to represent the complete, intimate, and thorough training which it represented in the days of the guilds. The degree of responsibility shown by the employer towards the apprentice varies from almost zero to something which still falls below the highest standard set by the 'masters' in the days of the guilds."

It is perhaps not fully proper to institute a comparison between the relatively well-paid apprentice in modern industry and the ill-paid, or unpaid, apprentice of the old-time craftsman. Nevertheless there is an indication that industry may not fully recognize the responsibility for the training of potential managerial staff. Is it possible to intensify the practical training, and so to integrate it with the technical training that at the end of a not too long period the trainee is adequately equipped for development from the foundation provided?

In conclusion I must emphasize that any opinions indicated are personal and are not shared by all my colleagues in our Faculty of Engineering.

Part II

By Professor L. C. Burrill, M.Sc., Ph.D.*

Introduction

Before discussing the details of his education and training, I should like in the first place to define in very broad terms what the qualities of a naval architect should be, and also to say something about the kind of openings which exist to-day for a well-trained man, in the field of commercial shipbuilding.

It seems to me there are four major requirements for a good naval architect. The first of these is a clear understanding of the fundamental principles of applied science, and more particularly of those aspects of science which have a direct application to ships and shipbuilding. The student naval architect should therefore have a sound training in the basic subjects of mathematics, physics, and mechanics, together with some knowledge of chemistry, and, in particular, of hydrostatics and hydrodynamics, the nature and behaviour of materials, considerations of structural strength, the stability of floating bodies, resistance and propulsion, and the behaviour of fluids in motion. This understanding of basic principles is an essential part of his mental background, if he is of make logical and correct deductions from given facts and experiences.

In the second place, I would put a wide and detailed knowledge of existing practice in shipbuilding, of the historical development to the various types and sizes of ships, and also of the structural arrangements of the different parts of a ship.

In the third place, I would put actual personal experience in applying accepted methods to the design, construction or running of ships, and of the way in which the various practical and theoretical problems are tackled in the day to day work of a shipyard.

The fourth requirement, which is perhaps the most important, is an attitude of mind. It can perhaps best be described as an aptitude for tackling new technical problems, and of finding a satisfactory working solution in line with immediate requirements. I refer to the attitude of mind which not only accepts new problems willingly, but which continually seeks to find new and improved solutions to existing problems. It is perhaps the

* Professor of Naval Architecture and Director of the Naval Architecture Research Laboratories, King's College, Newcastle upon Tyne, University of Durham.

true "inventive" quality, and includes initiative, perseverance, sound judgment, the acceptance of responsibility and finally the ability to come to a decision. The ability, in fact, to finish the job and to issue clear instructions either in the form of a report, a specification or a drawing.

This quality is involved in such practical matters as the arrangement of accommodation or the provision of adequate means of access to and from working spaces, just as much as in the more complex technical problems of deciding the principal dimensions and form for a new ship, the amount of power needed to give a certain speed, or the achievement of satisfactory conditions of trim and stability.

These four requirements, which may be summarized briefly, as

(*a*) An understanding of basic scientific principles.
(*b*) A knowledge of facts and procedures relating to ships.
(*c*) Experience and practice in a shipyard.
(*d*) An aptitude for technical work

all represent qualities which are essential to make a good naval architect, but they still do not provide a complete specification, as there are many human qualities such as personal character and integrity, organizing ability, leadership and the ability to mix and work with others, which are equally important.

It will be seen that these requirements cover a very wide field; so that attendance at a university course in naval architecture cannot be expected to do more than initiate the young student into the fundamental principles of the subject, give him an enthusiasm for the kind of work involved, and thus set his feet on the right path. It is not sufficient merely to have followed a course of instruction in theoretical naval architecture, or to be cognisant of the accepted knowledge of facts and procedures relating to ships and shipbuilding to become an efficient naval architect, and sound practical experience, with the maximum possible degree of personal responsibility, is essential to give that confidence which is necessary to undertake the various tasks he will be called upon to execute in the course of his professional career. The type of man who is continually referring to text books, note books, and reference books in order to tackle his day-to-day problems is not in my opinion a fully-fledged naval architect. He must know from experience the results of his own work, and also be aware of the successes of others in the same field.

Practical work in a shipyard, in the design office, wood and outfit, steel and estimating departments, and later in the mould loft and outside on the building berths, is therefore a most important part of his training.

It is also very desirable that he should have some sea experience and an opportunity of visiting shipbuilding centres in other countries, if this is at all possible, as contact with ship's officers and engineers, a knowledge of port facilities and methods of loading and discharging cargo, together with an understanding of the behaviour of ships in heavy weather, are extremely important to the ship designer. A knowledge of the effects of general wear and tear, corrosion and damage, and of the requirements of classification societies, underwriters, surveyors, and others who are concerned with the running and maintenance of ships, is also extremely valuable.

Careers in Shipbuilding and Allied Industries

There are many different posts which are open to a well-trained naval architect, but the future of each student will be governed very largely by his natural aptitudes and abilities, and to some extent by the opportunities which present themselves during the course of his career. There is, however, a good deal of truth in the idea that each man "makes his own opportunities"; so that it is well for a student to have some idea of the line he wishes to follow and of the kind of position he hopes finally to achieve. There are, for example, openings on the design side and on the practical side of shipbuilding, in general management or in survey work, and finally in research. These are illustrated in the following table of appointments to which he may aspire:

Design and Technical	*Practical Shipbuilding*
Technical Manager	Shipyard General Manager
Naval Architect	Shipyard Manager
Chief Estimator	Ship Manager
Chief Designer	Dock Manager (repairs)
Technical Draughtsman	Chief Draughtsman (P.D.O.)
Research Appointments	*Surveying and Shipowning*
National Physical Laboratory	Lloyd's, M.O.T., or Underwriters Survey work
B.S.R.A. and A.D.A., etc.	Ship Superintendent
Lloyd's Register specialist appointments	Shipowners Naval Architect
Private Shipyard Tanks	Consultant Practice
University and Technical Colleges	Foreign Government Appointments
Royal Naval Scientific Service	

There are also other openings with the various makers of ship fittings and auxiliaries, and finally with the Royal Corps of Naval Constructors, to which a student may turn after graduation. Undoubtedly, these different branches of the profession will appeal to different types of student, and opportunity obviously plays a big part in determining each man's choice of career. It is also true that the training of one who eventually occupies a senior research or design post will at some point diverge from that of the man who turns to the managerial or practical side of shipbuilding, but there is a good deal of common ground which should be covered by both. After all, what the industry requires is, on the one hand, research and design men who have a practical outlook and a sound knowledge of current practice, and, on the other hand, shipyard managers and surveyors who have a full and proper appreciation of technical matters.

Theoretical Training

In our university courses at King's College we endeavour to introduce the student mainly to the fundamental and theoretical considerations which are necessary as a background to future development. At the same time, the drawing office periods, which are extensive, are intended to give him ample experience in the application of these first principles, the engineering laboratory work, in mechanical and electrical engineering and metallurgy, is introduced to give him an appreciation of engineering problems, while the other general subjects, which are studied in different departments of the university, are intended to make the course for the B.Sc. degree a broad education in applied science rather than a narrow specialist training.

In this connection, it should be remembered that the Department of Naval Architecture is part of the Faculty of Applied Science in the University of Durham, which includes civil, electrical, mechanical, marine, and four other branches of engineering, and that the overall pattern of the courses for first degrees in all branches is the same, namely, a broad and general training in applied science, plus a series of specialized lectures dealing with the professional subjects which are peculiar to each branch.

The basic course is a four-year course of studies leading to the honours degree or to the general degree in applied science, although students may also read for the ordinary degree in three years.

In the first year (or preliminary year as it is now called) the subjects of examination are mathematics, physics, and chemistry, although some lectures are given in elementary shipbuilding and two afternoons per week are spent in the naval architecture

drawing office, where instruction is given in mechanical drawing and ship drawing, respectively. In the years which follow, the student pays more and more attention to his professional subjects, and while studying such general subjects as mathematics, heat engines, hydraulics, strength of materials, electrical engineering and metallurgy, the course includes all branches of naval architecture.

Lectures are given on ship calculations, trim and stability, launching, flooding, watertight subdivisions, tonnage, freeboard, ship types, and the historical development of current designs, local and longitudinal strength, ship design, steering, waves and oscillations, resistance and propulsion, and ship vibration. The work carried out in the drawing office is closely allied to the lecturing programme and is intended to give the student an opportunity of applying the theoretical work covered by the lecture notes.

some subject connected with ships. The lecture courses which are followed by students in this Final Honours year, include more advanced work on ship design, transverse and longitudinal strength, hydrodynamics and aerodynamics, propeller design and propeller theory, together with a related subject, which is taken in another department and may be either marine installations, stress analysis, theory of structures, or some other approved course. The course in mathematics for honours must also be taken by those who have not already passed this subject in the third year of their studies.

As an alternative, a student may elect to study four years to take the General Degree. The course for this degree is broader than that for the Ordinary Degree and is neither so specialized nor advanced as that for the Honours Degree; the training offered is very suitable for those who have in mind the taking up of managerial posts in the Industry. Those who study for this degree

TABLE I

ANALYSIS OF SUBJECTS FOLLOWED IN EACH YEAR OF THE DEGREE COURSE

DEPARTMENT OF NAVAL ARCHITECTURE (KING'S COLLEGE, NEWCASTLE UPON TYNE)

Figures in brackets after each subject indicate the number of hours per academic year spent on that subject, assuming that lectures are given for 24 weeks each year.

First Year		Second Year		Third Year		Fourth Year (Honours Year)	
Shipbuilding	(24)	Naval Architecture I and II (Initial Stability Large Angle Stability Launching Tonnage and Freeboard Ship Types)	(72)	Naval Architecture III, IV, and V (Strength and Design of Ships Waves, Oscillations and Vibration Resistance and Propulsion)	(168)	Naval Architecture H1, H2, H3, H4 (Design Calculations and Investigations Structural Strength and Vibration Propeller Design and Theory)	(144)
Drawing Office	(144)	Drawing Office	(216)	Drawing Office	(216)	Drawing Office	(360)
Total Professional	(168)	Total Professional	(288)	Total Professional	(384)	Total Professional	(504)
Mathematics	(144)	Mathematics	(96)	Mathematics	(72)	Mathematics	(72)
Chemistry	(72)	Electrical Engineers	(24)	Marine Engineering	(74)	Marine Engineering	(24)
Physics	(72)	Mechanical Engineering	(72)	Mechanical Engineering	(48)	Hydrodynamics	(30)
Chemistry Laboratories	(72)	Economics	(24)	Metallurgy	(24)	Language	(24)
Physics Laboratories	(144)	Mechanical Engineering Laboratories	(72)	Mechanical Engineering Laboratories	(72)	Related Subject	(24)
		Electrical Engineering Laboratories	(72)	Metallurgy Laboratories	(36)		
Total non-Professional	(504)	Total non-Professional	(360)	Total non-Professional	(276)	Total non-Professional	(198)
Grand Total	(672)	Grand Total	(648)	Grand Total	(660)	Grand Total	(702)

Table 1 gives an analysis of the courses followed in each year up to the Honours Degree stage, and shows the number of hours spent on each subject. There are three terms in each Session, which lasts from the beginning of October to the end of June of the following year, with two vacations at Christmas and Easter, respectively.

The selection of candidates for the Honours School normally takes place at the end of the second year, but provision is also made for students who have completed the ordinary degree in three years to proceed to the honours degree after an additional year's study.

During this additional year, it is usual for the student either to prepare a complete design for a new ship in accordance with specified requirements, or to pursue a course of research work on

take additional courses in economics and management, statistics, fluid mechanics and metallurgy, together with some further studies in naval architecture. Students who have obtained the Ordinary Degree in naval architecture may also proceed to the General Degree by studying for at least one further year in another department, such as mechanical or marine engineering. This arrangement leads to a qualification which is very suitable for those who may wish to become ship surveyors. This new system whereby students may read for the Ordinary, General, or Honours Degrees was introduced in October, 1955, and it is hoped that the introduction of the new courses for the General Degree (on which Honours may be awarded, if the student shows sufficient merit in the Final Examinations) will lead to a greater flexibility in examination procedure and will serve the needs

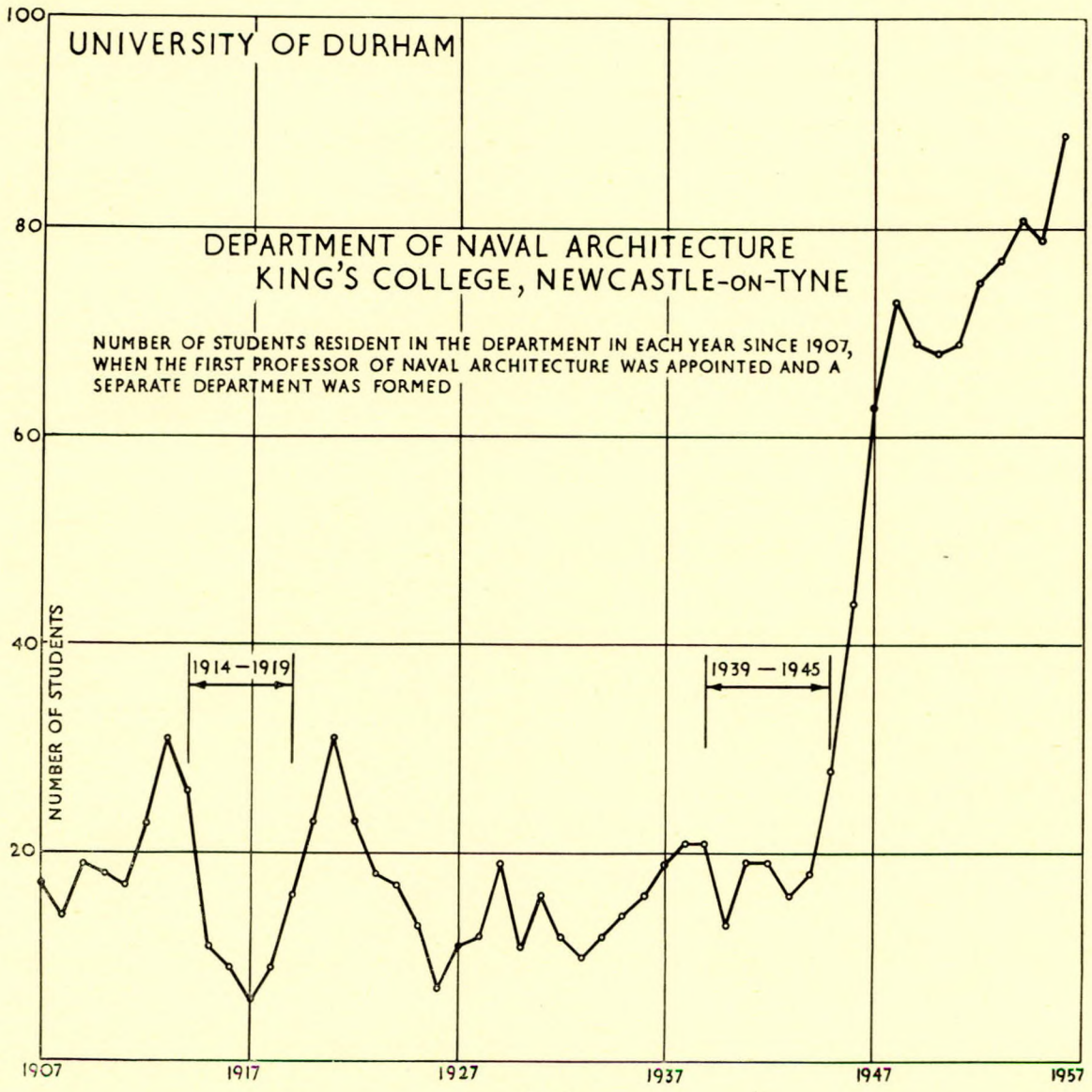

FIG. 1

of the different types of candidates more adequately than the previous courses of study, which were limited to two classes, namely, the Pass and Honours Degree candidates.

Exemptions from the preliminary year of all courses may be granted to those who have obtained three advanced level passes in the General Certificate of Education, or who have passed with good marks in the final examinations for the Higher National Certificate in Naval Architecture, or in the 4th Year Dockyard Technical College examinations.

Students are drawn mainly from the shipyards, after spending one or two years in practical experience, but others may come direct from public schools or grammar schools under the Shipbuilding Employers' Federation scheme or from the various technical colleges, including the Dockyard Colleges. Throughout the period of studies at the university, which may extend over three or four years, students are expected to spend the whole of the summer vacation (apart from normal works holidays) and possibly also the Easter vacation of each Session, working in a shipyard. In this way, they should be able to complete an apprenticeship within some twelve months after graduation, and shipyards in the Tyneside area are usually willing to accept students as shipbuilding apprentices and to give them adequate training in the various departments, without premium, if they are not already attached to shipyards in other parts of the country.

Fig. 1 shows in graphical form the number of students resident in the Department of Naval Architecture at King's College in each year since 1907, when the first Professor of Naval Architecture, Dr. J. J. Welch, was appointed. It will be seen that the periods of national emergency are clearly reflected in the trend of the curve, as also the periods of depression in the industry. The remarkable rise in the number of students following the courses in naval architecture since 1945 is a direct outcome of the increased prosperity in the industry and the change in our national policy with regard to university education. Despite the increased numbers entering the profession in this way during recent years, there has been no difficulty in placing students after graduation, and the shipbuilding industry is still in need of well-trained young men of good education.

Apart from the formal instruction he receives, the main advantage which the student derives from residence at a university for the three or four years of his course is that he becomes part of a live community of young people who have arrived at the university by a process of selection which is fairly rigorous in maintaining a high standard, and who, for the most part, will be

preparing for careers which are entirely remote from his own, and whose eventual way of life may be quite different. If he is wise, he will take part in the many activities, cultural, athletic, and social, which are arranged by the student body, and will be drawn into discussions and debates on many topics of general interest. Consequently, he should learn to mix easily with his fellows, and should not leave the university without having acquired the ability to speak in public, if not with eloquence, at least without undue diffidence or hesitation.

No university discipline is easy, and while the student enjoys considerable freedom from direct supervision, he soon learns that he must think for himself, and that he must expend considerable energy in private study, in order to keep abreast of his fellows, and thus secure a good result in his examinations. The lecture courses move rapidly through the syllabus, and his intellect is continually alerted by the many new ideas to which he is introduced as lecture succeeds lecture, throughout his working day.

His contact with senior members of the university, whose enthusiasm for his own and other subjects will soon become apparent, should act as a spur to his imagination and encourage him to follow their example and thus, by a process of self-discipline and hard work, achieve that mastery of his subject and the all absorbing interest in his work which is the hall-mark of the true professional man.

At the same time, it is obvious that our university courses can only provide a very small part of the students' training in naval architecture and that practical work in a shipyard and wide general reading are equally essential. It is important that this practical training should begin as early as possible, and that the intending student of naval architecture should always spend some time in a shipyard before coming to the university, if this can be arranged. This is essential, in order that he should understand the make-up of a shipyard, the various jobs to be done, and above all the kind of work for which he is proposing to prepare himself.

Practical Training

There is obviously no best sequence of training, but I would like first to see him put into the drawing office, and, in particular, in that section of the drawing office which deals with practical plans and ship arrangements. This is usually called the wood and outfit office, or simply the P.D.O. Here he should learn to produce tracings and simple drawings, usually detail elaborations of plans already outlined roughly in the design stage. The chief draughtsman, or leading hand, will usually maintain a close control of the job as it progresses, so that the work consists mainly in making a complete and satisfactory working drawing.

At the same time as he learns to produce a good drawing, the student will automatically learn a great deal about the various parts of ships, the arrangement of accommodation, disposition of derricks, winches, bollards, fairleads, derricks and hatches, boats and davits, ventilation and pumping arrangements, etc. He will learn a good deal from what is said to him about his own jobs, and also from the other work which is going on around him. As a junior, he will probably be asked to accompany a more senior man on board the ships which are fitting out, to take measurements and to check details of the arrangements of fittings, etc. He should also come in contact with numerous catalogues and specifications, and will learn that even after a broad general arrangement has been made, there is still a good deal of detail work to be done.

The first move from this office, should in my opinion be a move to the steel office, where he will learn something about the structural work—arrangement of plating, end connections, framing, local stiffening, bulkheads, floors, tank top, hatches, pillars, tunnel arrangements, etc.

Unfortunately, this work usually requires a good deal of experience and initial skill. It is therefore sometimes difficult to find suitable work for a newcomer to do. This leads to his being put on to very simple tasks, and he may feel he is not fully employed or not doing useful work.

This is, however, an essential part of the training in a practical office where the object is to get the work through quickly and correctly, and a good section leader can usually arrange for a junior to work closely with a more skilled man and to do some of the repetitive or detail work. It is fortunate, in fact, that a good deal of the work is "similar" to that done before for a previous ship, and a junior can therefore be given a previous drawing to work from—to copy almost directly, or to adjust to fit the new circumstances. In this office, he should learn a good deal about the application of Lloyd's Rules, about standard shipyard practices, about rates and weights, equivalent girders, etc., and he should also learn how to draw out the various sections of the ship, or deck outlines, from the information given by the design office and the mould loft.

The next move should, in my view, be to the design office or to the combined design and calculation office, according to the organization of the particular shipyard. Here, the junior will come in contact with work for which his theoretical training should by this time have prepared him—such jobs as the calculation of capacities, centres of gravity and weights, hydrostatic calculations, flooding, freeboard and tonnage, cross curves of stability, local strength calculations, ullages, launching calculations, trim and stability, etc. If he is fortunate, and shows the necessary skill, he may also be put on to drawing ship lines, preliminary general arrangements, profile and decks, pillars and girders and the many other interesting tasks of the normal ship design office.

It will be noted that the period of practical experience in the yard has been left to the end. This has been done for two reasons. Firstly, because a youth who has had good drawing-office experience can usually play a useful part in the mould loft, for example, and the outside foremen will therefore not treat him merely as a spectator and a nuisance, and secondly, because he can learn more from a short stay in the yard at this stage, and at the same time, a change to practical work is a good antidote to his theoretical studies and a tendency to think in terms of plans and calculations rather than in terms of rusty steel and wood planking. In this connection, it is suggested that he be given a period in the mould loft, some time with the erection squad, the carpenters, joiners, riggers and other trades and, if he shows the necessary ability, that he should finally be attached to an under-manager to see what this kind of work entails. At this stage it should become clear whether he is going to be a useful man outside, and his further training can be arranged accordingly.

If he wishes to return to the technical or drawing-office side, then I feel it is best for him to return to the design or calculation office and that he be given an opportunity to work more closely with the staff of the naval architect or technical manager, to take some part in the preliminary design work, to make powering calculations, examine alternative designs, study the tank reports and other data, work with the estimators, carry out vibration calculations and analyse ship performance data, etc., and finally that he should be given an opportunity to carry out some preliminary design work on his own responsibility.

No doubt, he still has a long way to go before he can hope to obtain the position of primary responsibility to which he should aspire, but this opportunity will undoubtedly come to the right type of man, and it is then that his early theoretical training and sound practical experience will stand him in good stead, and enable him to play a valuable and fully absorbing part in whatever section of the shipbuilding profession he chooses, or is fortunate to find himself in—in research, design, construction, management, or in survey work.

As might be expected, the ideas outlined in these notes are governed very largely by my own training and experience. In particular, it is my firm belief that practice and theory should always proceed hand in hand, and the proposals I have made with respect to practical training cannot be regarded as exceptional because they correspond very closely with the opportunities afforded me some 35 years ago. Furthermore, I am quite sure there is to-day a large number of shipbuilding organizations in this country whose apprenticeship schemes include a planned rotation of experience in different departments, which, although they may not follow the precise sequence I have mentioned, would allow suitable candidates to obtain a similar range of experience.

National Certificate and Diploma Courses

The foregoing notes have been concerned mainly with the training of naval architecture students who proceed to a university with a view to reading for the B.Sc. Degree. Another course of studies which may ultimately lead to professional status as a naval architect, providing the student shows the necessary ability, is the National Certificate course. The Higher National Certificate, which is awarded jointly by The Institution of Naval Architects, the Ministry of Education, and the Worshipful Company of Shipwrights, is the culmination of a course of part-time studies extending over a period of five or six years. These courses are now available at many Technical Colleges in the important shipbuilding centres of Great Britain and Northern Ireland and may be followed during day release classes, or in evening classes, according to the facilities granted to their apprentices by the particular shipyards in each area.

The course for the Higher National Certificate has recently been completely revised, and the new syllabus came into operation in September 1956. The course now covers in its range of subjects most of the professional or technical items dealt with in the ordinary or pass degree course at a university, but is, of course, very much restricted in detail, and must be carried out in much less time. For example, the total time spent in naval architecture lectures and drawing-office work in each of the two years of the course is only 150 hours.

Nevertheless, for those students who are unable to obtain entrance to a University, the securing of a Higher National Certificate forms a very good basis for the further studies which are necessary to obtain an Endorsement to the Higher National Certificate, and in this way fulfil the minimum academic requirement for Associate Membership of The Institution of Naval Architects.

The total number of certificates awarded during the past five years is shown below:—

	Ordinary	*Higher*	*Endorsement*	*Total*
1952	84	69	8	161
1953	90	66	7	163
1954	126	29	18	173
1955	136	70	9	215
1956	141	79	15	235

With the increase in the past few years of the money which is available for technical education, the growth of the day release classes system, and the increasing awareness in the shipbuilding industry of the need for higher technical education, it may well be that the above numbers will soon be substantially increased.

In some Technical Colleges full day-time courses, arranged on the "sandwich" system, are available, which approximate to the course for the Higher National Certificate, but which allow considerably more time for the necessary drawing-office practice and theoretical studies. The certificate awarded, usually a College Diploma in Naval Architecture, may be considered to be intermediate between the Higher National Certificate obtained through evening classes, or through day release classes, and the ordinary pass degree from a university.

Preliminary courses in naval architecture are also given in the various Dockyard Technical Colleges which, although they do not cover the same range of studies as the Higher National Certificate course, form a suitable basis for further advanced studies at the Royal Naval College, Greenwich, or at a university.

Students who have obtained good marks in their final examinations of these various technical college courses are usually exempted from part of their studies at a university.

THE SELECTION, EDUCATION, AND TRAINING OF OFFICERS FOR THE ROYAL CORPS OF NAVAL CONSTRUCTORS

By Professor S. J. Palmer, O.B.E., R.C.N.C. (*Member, I.N.A.*)*

Summary

With but two interruptions, which together lasted twenty-six years, the Admiralty has trained its own naval constructors since 1811. How this was done at different times has been described in several papers read before the I.N.A., the last being by Mr. Lloyd Woollard in 1936. Since that date changes in the national education system and advances in warship design have led to new methods of recruitment and to changes in the programme and syllabus of the course, but the aim still is to train a small number of carefully selected students to become both ship designers and ship constructors. This paper describes the present methods for selecting these students and the education and training they receive before being appointed to the Royal Corps of Naval Constructors.

Introduction

Probationers for the Royal Corps of Naval Constructors have to be trained for careers in which they may be employed on any of the following duties:—

(*a*) The design of H.M. ships and auxiliary vessels at the Admiralty in the department of the Director of Naval Construction. D.N.C., who is the Head of the Corps, is the principal technical adviser to the Board of Admiralty and is responsible for the design of all H.M. ships, and in particular for the displacement, dimensions, layout, stability, strength, habitability, speed, and sea-worthiness.

(*b*) The economic and expeditious construction and repair of H.M. ships in private shipyards. The progress, cost and proper construction are controlled by a headquarters staff in D.N.C. Department and supervised by members of the Corps and their staffs at regional headquarters and at the shipyards.

(*c*) Research and development on ship forms, propulsion, manœuvring, and sea-worthiness at the Admiralty Experiment Works, Haslar, and on the design of ship structures at the Naval Construction Research Establishment, Rosyth. The Superintendents of these establishments are members of the Corps and their staffs include constructors and scientists.

(*d*) The construction, repair, and maintenance of ships in the Royal Dockyards. The Constructive Department is the largest department in each dockyard, and the Manager and his senior assistants are members of the Corps. They are responsible for the co-ordination of the general programme of dockyard work as well as for the management and control of an industrial staff which may number up to 7,000 men of a dozen or more trades. The Royal Dockyards are administered within the Admiralty by the Director of Dockyards, who is a senior naval officer. His deputy and several senior members of his department are members of the Corps.

(*e*) A number of posts with other Governments, the Royal Aircraft Establishment, Lloyd's Register of Shipping, the Atomic Energy Commission, on the staffs of Naval Commanders-in-Chief, and at the Royal Naval College, Greenwich.

During his career a constructor may be employed on several, if not most, of these duties, and in his training he must acquire the knowledge and ability to undertake them all efficiently. This calls for a high standard of education in professional and academic subjects, for the development of fresh and resourceful minds receptive to new ideas, and for training in those qualities of character, leadership, discipline, and hard work that lead to good administration and a high standard of professional ability. For the whole of his service a constructor is a civil servant, but when employed afloat or in shore naval appointments he is given a naval rank corresponding to his civil rank in the Corps. During his training he wears uniform and lives in naval colleges under exactly the same conditions as naval officers of his own age, so that, inevitably, he absorbs something of the discipline and self-reliance which these officers exemplify.

* Professor of Naval Architecture, R.N. College, Greenwich.

Brief History of the Training of Naval Constructors

The Admiralty started training its own constructors in 1811 at the first School of Naval Architecture, Portsmouth. This establishment was closed down in 1832, but a second school, known as the Central School of Mathematics and Naval Construction, was opened in 1848, again at Portsmouth, and existed until 1854, when it suffered the same fate as its predecessor. Then for ten years there was no higher education for Admiralty constructors until the Royal School of Naval Architecture was founded at South Kensington in 1864, and since that time the course has continued without interruption. In 1873 it was transferred to the newly opened Royal Naval College, Greenwich, and the main part of the course has remained there ever since, except for a few years in the last war when it was evacuated to Bristol University. The aim was always, and still is, to train a small number of carefully selected students both as ship designers and as ship constructors.

In 1937 a Constructors' Training Office (the C.T.O.) was established in Devonport Dockyard as a centre for giving entrants to the course instruction in dockyard administration, practical shipbuilding, and naval architecture. A student may now spend up to two years at the C.T.O. and three years at Greenwich, but these periods are reduced if he has graduated from a university or has had previous shipyard experience.

The essential framework of the course has needed remarkably little adjustment as the years have passed, but the syllabus has been developed continually to meet changing conditions, under the influence of successive D.N.C.s, of committees appointed by the Admiralty and by successive Heads of Departments at the Royal Naval College. From the inception of the course the instruction in academic subjects has been given by a permanent professorial staff, but naval architecture has been taught by members of the Corps who have been withdrawn from normal duty for a few years; this has helped to give to the work in professional subjects that sense of reality which the enthusiastic student needs.

Recruitment

Constructor officers are now recruited from apprentices in the Royal Dockyards and private shipyards, from sub-lieutenants at the Royal Naval Engineering College, from university graduates, and from boys at public and grammar schools—in fact the Admiralty has now done everything possible to give young men of suitable ability and education the opportunity to be considered for training for the Corps. A relatively high academic standard is required, particularly in mathematics and science, but where possible this standard is judged by the examinations taken normally during apprenticeship or at school or university. For example, graduates in mechanical science are required to have a first class or good second class honours degree, while candidates from schools must have passed the G.C.E. examinations at advanced level in mathematics and physics. In every case the final selection is made by an interview board of senior Admiralty officers. Some notes on the different methods of entry are given in the Appendix, and more detailed information can be obtained, on application, from the Admiralty.

The time spent in training the selected candidates depends upon their previous experience and education, and varies from one year at the C.T.O., two at Greenwich, and one at sea for university graduates, to two years at the C.T.O., three at Greenwich, and one at sea for boys who come straight from school. It will be seen that the boy who enters from school gains one year on his fellow who first takes a three-year university course, and this is because all his training from the age of eighteen onwards is directed to preparing him for a career in the Corps.

The present policy is to recruit about twelve students each year, but, due to reasons which will be considered later, only about half that number have been taken in recent years. The course is also open to private students and to constructor officers from other navies; since the war very few private students have entered, but on an average there have been two students per year from Dominion and Allied navies.

Preliminary Training at the Royal Naval Engineering College and C.T.O.

The successful candidates are first sent on a two-week divisional course at the Royal Naval Barracks, Portsmouth, where they quickly become accustomed to wearing their new uniform and to the etiquette and formalities observed by naval officers. At this stage they are usually between 18 and 24 years of age and have ranks of midshipman, sub-lieutenant, or lieutenant, according to age. All except the university entrants then join the Royal Naval Engineering College at Manadon, Plymouth, and stay there for one or two years, depending on their previous experience. During this time they have a course of instruction in dockyard administration and naval architecture at the C.T.O. and, concurrently, attend lectures in academic subjects at the College. From the C.T.O., which is in Devonport Dockyard, they visit ships, building slips, workshops, drawing offices and costings offices to study in detail the work of each trade and the organization and financial control necessary for the building and repair of H.M. ships. They also work on the drawing bench, fairing a set of ship's lines, having practice in the use of planimeters and integrators, and calculating hydrostatic data.

The entrants from universities also spend their first year at Devonport, but live in the Royal Naval Barracks. They have no formal instruction in academic subjects, but devote all their time to the work and administration of the dockyard, lectures in professional subjects, and work on the drawing bench at the C.T.O.

Before joining the Royal Naval College, Greenwich, all the students take short courses in diving and in the operation and construction of submarines.

Course at the Royal Naval College, Greenwich

This is a three-year course, but university graduates may go straight into the second year. All the students have the rank of lieutenant and live in the College, although permission to live out ("ashore") may be granted to married officers in the later stages of their training. There are three terms per year and each term is 12 weeks long. Lecture periods are for 70 minutes with a ten-minute "stand-easy" between. The full working week is 9 to 4.30 each day with half days on Wednesday and Saturday, but the students also spend a fair proportion of their evenings and week-ends working in their cabins.

An intensive course of lectures, with laboratory or design room work as appropriate, is given in naval architecture, mathematics, applied mechanics, chemistry, metallurgy, physics, and electrical engineering. Instruction in practical shipbuilding is given at shipyards during vacation courses.

The study periods allocated to the main subjects in the course are:—

	First Year	Second Year	Third Year	Total
Naval Architecture ..	264	360	540	1,164
Mathematics	216	216	216	648
Applied Mechanics ..	168	216	144	528
Chemistry and Metallurgy	108	108	—	216
Physics and Electricity ..	144	—	—	144

Naval Architecture

The lectures are divided into six subjects: ship design, stability, structural design, resistance, propulsion, and oscillations. Comprehensive notes on these subjects are written by the staff and are continually being revised and reprinted at Greenwich. At the end of each lecture the students are given copies of the notes that have been covered, so that, relieved of the task of taking their own notes, they can concentrate on the lecture and discuss what is being studied. Usually they are also given a sheet of examples which they work out in their own time and then hand in for criticism.

About once a fortnight the senior students attend lectures given by visitors from the Admiralty, the shipbuilding industry, and research establishments. These lecturers are invited to speak on questions about which they have detailed knowledge and experience, and afterwards the students are encouraged to ask questions and to join in a discussion with the lecturer.

It is important that at this stage in their lives the students should have practice in speaking to an audience, and from time to time they give short talks to their own classmates; the experience is heightened when these talks are recorded so that the speakers can hear their own voices played back.

A series of lectures on marine engineering is given by the Head of that department of the College, and naval engineer officers under instruction at the College collaborate with the constructor students for one term and prepare detailed layouts of the machinery installations for the constructors' ship designs.

On an average the students have about four lectures a week in naval architecture and the remainder of their time in the department (about five, six and eleven periods per week respectively in the three years) is spent in the design rooms. The main feature of the work here is the design of a warship, which is started early in the second year and completed by the end of the third year. The students work alone if they design a cruiser or smaller warship, or in pairs if they choose a larger ship. They decide for themselves what type of warship they will design and what its functions, armament, radar, speed, and endurance will be, and they do this with the minimum of advice from the staff as it is

important at this stage that they should create an original design. Then, in step with their lectures, they calculate the displacement and dimensions, draw out the form of the ship and small-scale plans of profile and decks, and decide the disposition of the armament, control positions, machinery, accommodation, and so on. Next they calculate the scantlings of the main structure and revise their weight estimates, and finally they draw one-eighth scale plans to decide the detailed layout of each deck and make a more detailed estimate of the total weight of the ship. When completed the design drawings resemble, although they are not in so much detail, the building drawings prepared at the Admiralty before a ship is put to contract.

In the first four terms of the course the students work on the designs that their seniors are preparing, and calculate for them the displacement, hydrostatic curves, stability curves, and longitudinal bending stresses by the standard method. This system, wherein the junior students work as assistants to their seniors, is most successful, both because they learn a great deal from each other and because this lightens the load on the staff of the department.

Apart from the members of the Corps on the staff who check the students' work and advise them on the important features of design, there is also a leading draughtsman who spends most of his time on the bench with the students. He checks their detailed layouts of spaces such as galleys, dining halls, mess spaces, and magazines, and runs his experienced eye over their arrangements for access around the ship, boats, accommodation ladders, and so on. They learn from him to appreciate the advice of an older man with many years of practical experience, advice which they will often do well to seek when they are later working at the Admiralty or Dockyards.

When naval officers and members of the Corps visit the department opportunity is taken to let the students show them their designs and hear what criticism may be offered, and at the end of the third year the drawings are carefully inspected by the Admiral President and by D.N.C.

Mathematics

Mathematics, pure and applied, occupies about one-quarter of the study periods and a greater proportion of the students' private study time. The standard in pure mathematics is beyond that of Part I of the mathematical tripos, and in applied mathematics (which includes hydrodynamics and theory of elasticity) it is at least equivalent to Part III of the tripos. This emphasis on mathematics is a traditional feature of the training of naval constructors and experience has shown it to be well placed. It is necessary for the understanding of the more theoretical branches of naval architecture, such as structural design, resistance, propulsion, and ship motion; it is indispensable for the constructors who are appointed to research establishments; it is an invaluable tool for ship designers, and it is, at the very least, excellent training in logical thought for any student.

Applied Mechanics

The students take a comprehensive and advanced course in dynamics, mechanisms, strength of materials, fluid mechanics, and vibrations. In the third year they carry out an engineering research in the laboratory, usually on a project of current interest to the Naval Construction Department who, if necessary, help by supplying apparatus or specimens for testing. Some useful investigations have been made, but the most valuable experience gained in this work is in seeking for experimental methods to solve new problems, in assessing the value of the results obtained, and in presenting a clear and concise report.

Chemistry and Metallurgy

Attention is mainly directed to the chemistry of corrosion and protection, paints and plastics, and to the metallurgy of iron and steel, alloy steels and non-ferrous metals used in warship construction. A good deal of experiment work is done in the laboratory and occasionally some research is carried out in conjunction with structural design investigations in the mechanics laboratory.

Physics and Electricity

The lectures and laboratory work cover electrical circuits, electronics, elementary nuclear physics, power supplies, motors and servo-mechanisms, the emphasis being placed on applications to warship design.

Examinations

Examinations are set at the end of every term and some of these count as early finals. The finals in mathematics and applied mechanics are set by external examiners from the universities, and those in naval architecture by the Director of Naval Construction and his staff at the Admiralty. To encourage the students to take a broad interest in their profession they are asked in one paper, called Naval Construction (General), to discuss and give their views on some of the more important problems which face warship designers and shipbuilders to-day. In addition, each student appears before an interview board of senior Admiralty officers at the end of every year.

A complete list of the final examinations and marks is given below:—

Preliminary Ship Design	150
Ship Calculation and Design	250
Structural Design of Ships	200
Resistance and Propulsion	200
Stability and Oscillations	200
Shipbuilding	300
Naval Construction (General)	200
Design Room Work	200
Interview	300
Mathematics I (Pure)	100
Mathematics II (Applied)	100
Mathematics III (Pure)	100
Mathematics IV (Applied)	100
Mathematics V (Class Work)	100
Hydrodynamics	150
Mechanisms and Structures	100
Hydraulics	100
Dynamics of Machinery	100
Strength of Materials	150
Experimental Engineering	200
Chemistry and Metallurgy	300
Physics and Electricity	200

The Admiralty award Professional Certificates to students who reach the required standard in these examinations, a First Class Certificate for over 75 per cent, Second Class for 60–75 per cent, and Third Class for 40–60 per cent. On an average about one-quarter of the students obtain first class certificates. The initial selection of students for the course is made with such care that it is almost unknown for any of them, except an occasional foreign student, to fail to obtain at least a second class certificate, which is the minimum necessary for entry to the Corps.

These examinations are in a sense competitive since the students' order of seniority on first appointment to the Corps is based on their performance in the Greenwich finals. They certainly take them very seriously—in fact their industry and enthusiasm for their work have become a tradition at Greenwich and add considerably to the pleasure of being appointed to the professorial staff.

Vacation Courses

In addition to occasional visits to works during the term the students spend nine weeks of the Easter and summer vacations

each year taking courses at dockyards, private shipyards, the Admiralty Experiment Works at Haslar, the Naval Construction Research Establishment at Rosyth, the Naval Gunnery School and the Damage Control School. The great value of the vacation courses, as with the preliminary training at Devonport Dockyard, is that the students become acquainted with the equipment, techniques, and craft skill of the industry, with the organization that manages it, and with the outlook of the men they may one day be called to control. They are also, of course, a welcome break from the concentrated academic study at Greenwich. The visits are carefully planned and, while some lectures are given by the staffs of the establishments, greater emphasis is placed on studying the work in ships, shops or laboratories and in not staying in offices except for the minimum time needed for making notes or studying drawings. During these courses the students prepare notes and sketches of the work they have seen in progress, and these are handed in for checking and criticism before they leave.

Sea Time

On successfully completing the Greenwich course all constructor officers are sent to sea for twelve months, and in this time they usually serve in three or four of H.M. ships of different types. While at sea they are required to study the behaviour of the ships they are in, the internal organization at various states of readiness for action, and the conditions under which officers and men work. Although not charged with any specific duties they usually take an active part in the life on board and spend some time working in each department of the ship.

During their year at sea they learn to appreciate what the designer can do to produce ships that will be efficient in action, will behave well in bad weather, and will be comfortable and popular with the ship's company. They also benefit from the communal life on board and the visits to foreign places, so that they return with increased confidence in their own training and experience, and eager to begin their careers in the Corps.

General Remarks

A naval constructor is thoroughly trained to do a job which is vital to the Navy, and during this training he enjoys a standard of living and an opportunity for social and other activities which are as good as in any university in the country. When his training is complete he is appointed to a succession of responsible posts, all of which are full of interest for the individual, so that he generally has a varied and professionally satisfying career. Further, the salaries paid to the Corps are the highest in the professional Civil Service. It might then be thought that there would be great competition for what would appear to be an attractive opening for young men of the right quality, but, in fact, there have been so few suitable candidates since the war that the Admiralty has been able to enter only about half the number wanted.

For the last twenty years the main sources of recruitment to the Corps have been the dockyard technical colleges and the universities, and there are different reasons for the failure of each to continue to produce the number of men required. With the dockyard entry it is largely due to changes in the national education system which enable many more boys from grammar schools to take scholarships to universities, and they generally prefer this to taking up apprenticeships. As a result of this the educational standard of dockyard apprentices has fallen and fewer have been considered suitable for entry to the Corps.

One reason for the failure to recruit more graduates from universities is that some are daunted by the prospect of three more years tough academic training. Another is that men with the qualifications required by the Admiralty may be offered better salaries by private engineering firms. When choosing a career, however, the varied experience and interest of the work, and the security and conditions of service, must also be considered, and on these counts entry to the Corps is an attractive opening for any young man who is interested in ships and shipbuilding. Certainly the graduates who have come in recently, an average of about two per year, have thought so, but the question is, why not more? A little experience in this field soon makes the reason quite clear—it is that in the greatest shipbuilding country in the world almost nothing is known in most of the universities about how ships are designed and built, so that very few undergraduates ever give any consideration to a career in shipbuilding. The anomaly becomes obvious if we compare with the aircraft industry, with its many university courses, and its large share of the output of graduates each year. Yet shipbuilding is of greater value to the country, both in turnover and in numbers employed, and there are surely at least as great commercial gains to be won by improved performance and economy of ships as of aircraft. Unfortunately the lack of interest in recruiting more graduates suggests that shipowners and shipbuilders do not appreciate that this would improve their ships, and that such improvement is needed and would increase their trade and profit. The Admiralty has not failed to realize the value of highly trained naval constructors, but the general indifference to a professional career in shipbuilding has contributed to the difficulty in attracting recruits from universities.

As usual, to define the problem is to indicate ways in which it may be solved, and this has led the Admiralty to make two important changes in its recruitment policy, both started last year. The first was to enter a new stream of student apprentices to the Royal Dockyards with more attractive terms of employment and the guarantee of at least a draughtsman's job at the end of the apprenticeship. It is hoped that this will appeal to boys of a higher educational standard and that it will be possible to select more constructor officers from the fourth year of student apprentices than has been possible from recent entries of craft apprentices. The second change in recruitment started last year was the direct entry to the Corps of boys from public and grammar schools. These boys must be between 18 and 19½, and their educational standard must be similar to that required for entry to a university—in fact it is hoped to attract boys who would otherwise go to a university to study mechanical science or engineering, the attractions of the Admiralty appointment being the salary, the high standard of living in the naval colleges, and a training which compares favourably with that of any honours degree course.

There are grounds for hoping that, with additional recruitment from these sources, the Admiralty will soon have the number of constructor students required to bring the Corps, in due course, to the strength necessary for its vital duties. Neither international politics nor the advent of new weapons gives any reason to suppose that the Navy will not be indispensable to this country for as long as can be foreseen, and the very existence of the Navy depends on a strong and efficient Royal Corps of Naval Constructors.

Acknowledgment

This paper is published with the permission of the Admiralty but the responsibility for statements of fact or opinion rests solely with the author.

References

RUSSELL, JOHN SCOTT: "On the Technical Education of Naval Architects in England," TRANS. I.N.A., 1867, p. 223.

WHITE, W. H.: "On the Course of Study in the Royal Naval College, Greenwich," TRANS. I.N.A., 1877, p. 361.

ATTWOOD, E. L.: "The Admiralty Course of Study for the Training of Naval Architects," TRANS. I.N.A., 1905, Part II, p. 231.

WHITE, SIR WILLIAM H.: "The History of the Institution of Naval Architects and of Scientific Education in Naval Architecture," TRANS. I.N.A., 1911, Part II p. 1.

WOOLLARD, LLOYD: "The Education and Training of Naval Architects," TRANS. I.N.A., 1936, p. 159.

APPENDIX

Entry to the Royal Corps of Naval Constructors

Probationers for the Corps are drawn from five sources:—

Source A: From Apprentices in H.M. Dockyards

The Royal Dockyards have a system for training and educating apprentices which is recognized as one of the best in the engineering world. The apprentices have part-time education at the Dockyard Technical Colleges, but only the most able and diligent are allowed to complete the full four-year course, the standard of which approximates to the ordinary B.Sc. degree course in engineering. Those apprentices who reach a sufficiently high standard in the final examinations are invited to appear before an Admiralty selection board and, if considered suitable, are offered appointments as constructor sub-lieutenants.

Source B: From Sub-Lieutenants at the R.N.E. College, Manadon

Sub-lieutenants at the Royal Naval Engineering College may apply to become constructor sub-lieutenants. If considered suitable they are transferred at the end of their fourth term.

Source C: From University Graduates in Mechanical Science or Engineering

Candidates usually apply during their final year at the university and then appear before a selection board. Their acceptance depends on this interview and on their obtaining a first class or a good second class honours degree at the end of the university course.

Source D: From Apprentices in Private Shipyards and Graduates in Naval Architecture

Candidates have to give satisfactory evidence of adequate academic and technical education, and of having been engaged in practical shipbuilding for at least eighteen months. In the case of university graduates less practical experience may be accepted. Approval has recently been given for young draughtsmen and technical grades in H.M. Dockyards also to apply for entry in this way. All applicants have to appear before an interview board and, if considered suitable, they have to pass the Greenwich Entrance Examination.

Source E: From Boys at Public and Grammar Schools

Candidates must be between 18 and 19½ and they are required to have passed the G.C.E. examination at Advanced Level in pure mathematics, applied mathematics, and physics. Passes at Ordinary Level in English and one other language are also required. Applicants appear before an interview board and those selected are offered appointments as constructor midshipmen.

TRAINING OF ENGINEER OFFICERS IN THE ROYAL NAVY

By Captain I. G. Aylen, O.B.E., D.S.C., Royal Navy*

Introduction

This paper is being presented at a time of particular interest and importance to the future of the Royal Navy owing to certain far-reaching changes in the officer structure which were announced last year. The Service is, therefore, in a transition period between the old and new schemes of training and this fact somewhat complicates the task of making a presentation on the subject. The broad principles, however, remain, and the professional standards will not in any way be altered.

The requirement is for an officer who has received full professional training, and been given the opportunity early in his career to obtain a knowledge of all sides of ship life, technical and human, so that he may later be able to play a larger part in the higher administration of the Service.

It is first necessary to examine the changes in the officer structure to see how they affect the duties for which officers are being trained.

Change in Officer Structure

These changes are required to compete with the revolutionary advances in ships, weapons, and aircraft. They are directed towards the ultimate improvement of the career prospects of all specializations, and in particular towards making full use of the experience and knowledge of more senior officers of the engineering, electrical, and supply specializations, who it was felt could play a more important part in the higher administration of the future Navy, given the chance of more experience in the junior ranks outside their special technical fields. This, indeed, accords with the trend of industry in this country.

Any cadet now entering the Navy does so as "an officer"—which is his prime function, and his early training is, to the greatest possible extent, common (except at present for the electrical specialization) whether he is eventually to become a seaman, engineer, or supply specialist. After later training for his specialization, every junior officer will, so far as his specialist duties permit, take part in the day to day duties of running a ship in harbour or a shore establishment. In the same way, however, as only a qualified aviator can command an aircraft, whatever the seniority of his passengers, so only a seaman specialist will be appointed to command sea-going ships. But for other normal working command problems, all cadet-entered officers of the four specializations are now included in a single list, known as the "General List" and will be placed on a similar footing. In fact, in the close confines of a modern warship, the interdependence in action of one department and another must be such that officers and ratings are "all of one company."

At the same time it is intended that improved careers should be offered to those promoted from the lower deck, whose undoubted specialized practical experience has proved invaluable through two world wars. Such officers, formerly known as Warrant and latterly Branch Officers, are now included in the "Special Duties List," with titles Engineer Sub-Lieutenant, Engineer Commander, etc. (their sub-specialization being denoted by a suffix M/E, A/E, or O/E, which is explained later). They are generally interchangeable within their own sub-specialization with the General List officers in the lower ranks. There are in addition a few exceptional ratings called Upper Yardmen who have been selected at an early stage for promotion to the "General List." Fig. 1 shows the relative numbers of officers of the engineering specialization at present in each rank, and the relationship between the "General" and "Special Duties" lists.

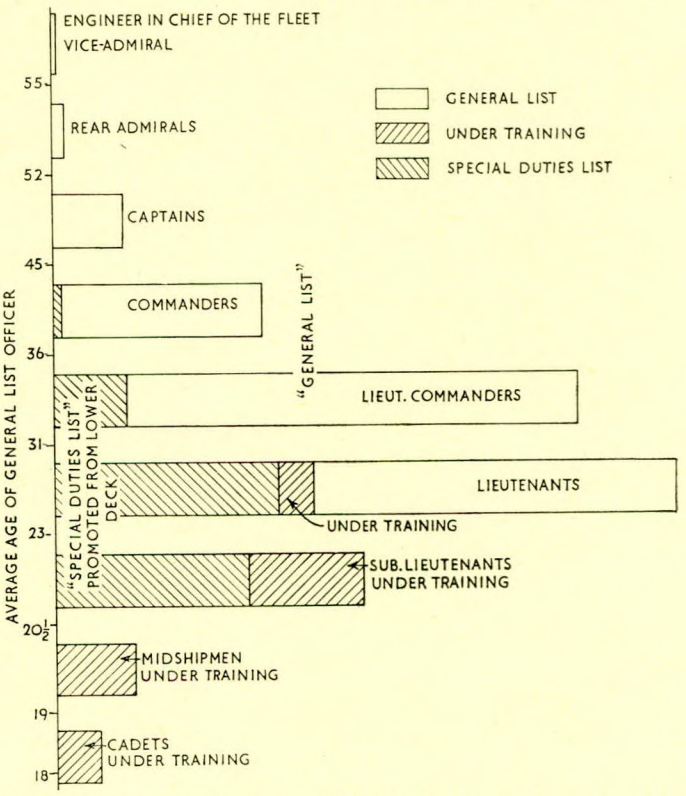

Fig. 1.—"General List" and "Special Duties List" officers of the engineering specialization

Substantial changes of this nature will take some years to implement fully, but they will be progressive and indeed have already started to take place.

Nature of Duties

The engineering specialization is at present split broadly into three, marine engineers (M/E), air engineers (A/E), and ordnance engineers (O/E), with a fairly free interchange in the higher ranks. On the material side the marine engineer sub-specialist deals mainly with the propulsion and the associated auxiliary services of ships, submarines, and coastal craft; the air engineer deals with aircraft, airframes, and engines and he may be a qualified pilot; the ordnance engineer deals with gunnery equipment, torpedoes, and guided missiles. All are responsible for their own personnel in the performance of their technical duties.

Fig. 2 shows the approximate distribution of duties in the various ranks of the "General List," with which this paper mainly deals.

* Assistant Engineer-in-Chief (Personnel), Admiralty.

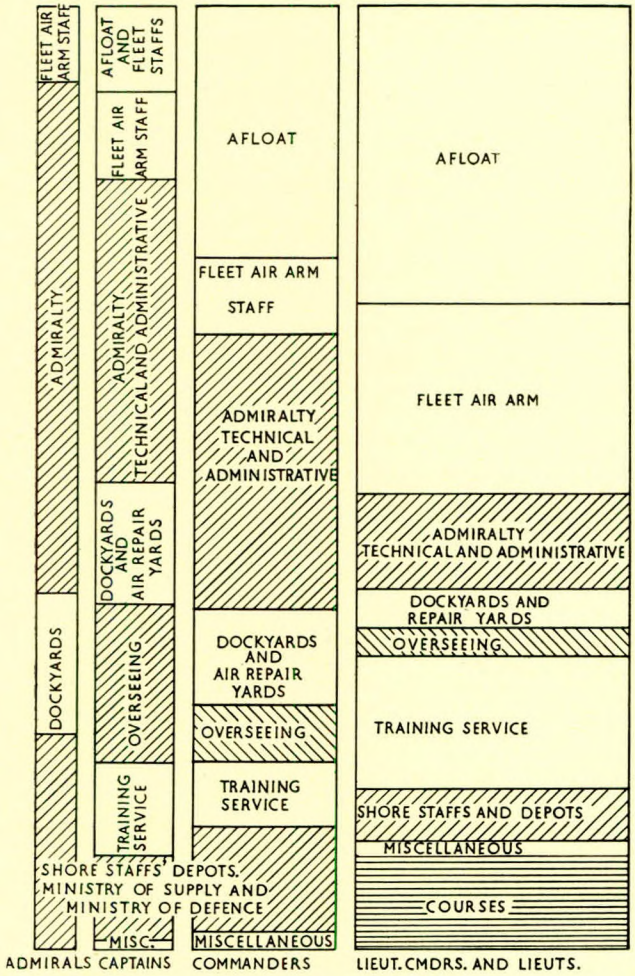

FIG. 2.—PRESENT NATURE OF DUTIES OF "GENERAL LIST" ENGINEER OFFICERS

It will be seen that a good deal of the time up to the rank of Commander is spent afloat (or, for air engineer officers on air stations), initially in a watchkeeping or junior capacity, and latterly in entire charge of main propulsion and auxiliary machinery, or of mechanical maintenance of aircraft, or of weapons, together with all associated personnel.

As an example H.M.S. *Eagle* (152,000 shp) carries the following engineer officers.

TABLE I

	Cdr.	Lt.-Cdr.	Lt. or S/L	Under Training	Total	Duty
M/E	1	3	14	7	25	Main and auxiliary machinery. Flight deck machinery. Damage control
A/E	1	2	5	1	9	Maintenance of aircraft squadrons
O/E		1	1	1	3	Maintenance of weapons

A *Daring* class destroyer carries as engineer specialists one commander and one lieutenant for the main and auxiliary machinery and one lieutenant for weapon maintenance.

A "T" class submarine carries one lieutenant or sub-lieutenant.

In sea-going appointments any of the commanders and below may be "General List" or "Special Duties List."

The most senior sea-going appointment is that of a Fleet Engineer Officer who is generally of captain's rank, serving on the staff of a Commander-in-Chief.

Dockyards and Air Repair Yards

Each Royal Dockyard, which may deal with the entire modernization of a carrier and the major repairs to all classes of ship, has a rear admiral or captain as the Manager of the Engineering Department, with a staff of specialist officers. There may be as many as 4,500 civilian employees under his control, even under peace-time conditions, and his job is comparable with that of managing director of a large industrial firm. Similarly, the air repair yards under a captain of the engineering specialization deal with repairs, modernizations, and conversions of naval aircraft, and employ civilian labour forces of up to 1,500 men. The Flag Officer Reserve Aircraft commands three air stations and three air repair yards, and he, the Chief Ordnance Engineer Officer, and the Assistant Director of Dockyards are rear admirals of the "E" specialization.

Training

From Fig. 2 can be seen the heavy load carried by the specialization, assisted by the highly qualified Instructor Officers, in training its own officers and technical ratings. At any time there are some 3,000 personnel under training, from the age of 15 onwards. Of all tasks it is perhaps one of the most exacting and the most rewarding. All engineering training establishments are commanded by an officer of the "E" specialization.

Technical Administration

The majority of these posts are in the Admiralty Departments of the Engineer-in-Chief, Director of Naval Ordnance, Director of Dockyards, Director of Underwater Weapons Material, Director of Aircraft Maintenance and Repair, and the Ministry of Supply; the functions of these departments are generally to translate the requirements of the Naval Staff into technical terms, to guide the various contractors to produce these requirements in the desired form, and to ascertain by shore and sea trials that the equipment functions correctly. Subsequently they must ensure, by a carefully planned maintenance programme, that all such equipment is ready for immediate use in war. It is natural therefore that in these departments many of the more able technical brains of the specialization will be found. It must be emphasized strongly here that the function of these departments and the engineer officers in them is not to design but rather to guide the designers and to criticize design proposals. They are enabled to do this by virtue of a higher standard of professional training allied to wide technical user experience obtained at sea. There is but little scope for the purely "back-room boy," since his place (and a very important place it is) is properly in research work or industry where his specialized talent can be drawn on as required, and since the continuity required for this type of work is incompatible with the wide experience necessary for a naval officer in the higher ranks.

General Administration

Under this heading come a variety of important tasks, not necessarily purely technical, such as the Admiralty staffs dealing with engineering personnel whose function is to advise the Second Sea Lord on the correct training and employment of officers and men of the technical specialization—Commanders-in-Chief's staff engineer officers, and officers appointed for intelligence duties, naval attachés, N.A.T.O. staffs, and so on.

It can be seen that a great variety of professional tasks may fall to a naval engineer officer. He may well find himself as the engineer officer of a solitary destroyer patrolling off Japan, then two years later training apprentices in Scotland, followed by taking charge of steam catapult trials in a new carrier. Or as a more senior officer he may be overseeing Admiralty gunnery contracts in the Midlands, followed by two years as the Fleet Engineer Officer in the Mediterranean and then in command of a training establishment of 1,000 young ratings. In general most appointments average two years, certain more specialized ones lasting three or four.

Ultimately he may rise to be Engineer-in-Chief of the Fleet, with the rank of vice-admiral; under the "General List" concept, an officer of the engineering specialization will on his merits be able to rise higher than vice-admiral and play an even more important part in higher administration; but at whatever age he retires it can never be said that his life has lacked variety.

Woven through all these duties runs the vital thread of the leadership of men. He can never hope to command the loyal respect of the men under him (be they sailors, scientists, or Chinese dockyard workmen), unless he has been brought up to think in terms of human relationships. A knowledge and understanding of mankind is just as essential as professional ability, whether he is in charge as a junior officer of a small party of men cleaning boilers, or as a senior officer in discussion with a leader of industry. Be he technically a paragon, his own personal character is of equal importance.

Probably no other walk of life may involve such high degrees of responsibility—responsibility sometimes of life and death—at such a young age. A submarine commanding officer in wartime may be as young as 22, and his engineer officer about the same. The engineer officer of a fleet carrier with machinery costing £3,000,000 may well be under forty. In many appointments the entire responsibility for welfare, discipline, and efficiency of many hundreds of men may rest with a technical officer—for whom technical training alone cannot be enough.

Broad Training in Fundamentals

It can be seen from the above background that it is an obvious requirement for the naval engineer officer to be trained as broadly as possible. Mr. Love, in a recent paper,[1] used a quotation from Milton: "I call therefore a complete and generous education that which fits a man to perform justly, skilfully, and magnanimously all the offices both private and public of peace and war," which, if "all the offices" is taken to mean the many varied duties described above, fits the naval aim most aptly. It is essential that the early training in fundamentals as a mechanical engineer is not allowed to be obscured by a welter of practical detail. The technical complexities of modern warships and aircraft are indeed so great that the young officer could readily become ensnared in a web of such detail, which in any case may well be out of date by the time he meets it. The mechanics of solids and fluids, the laws of thermodynamics and electrics, the nature of material and mathematical treatment do not change, whatever form of propulsion may be in vogue at the time, be it steam, gas turbine or nuclear, above, on, or below the seas. Without an understanding of such fundamental principles, coupled with training in *how* to think, or without the inculcation of creativeness and judgment, or without a knowledge of the humanities, the education will not be "complete and generous."

Professor Christopherson has given his opinion that the[2] standard of certain University examinations had risen by about one year for each fifteen that passed. This is probably true in most sciences, and certainly in relation to the technological advances in the Services. In eighty years a guided missile is replacing a muzzle-loading gun. Consequently the trend towards specialization becomes more and more compelling, but, if the senior technical officer is to play an increasing part in the general administration of the Navy, it must be resisted. "If his general experience and ability to take a broad view are proven, he will stay. If he takes a narrow technical view he will not. In addition there will always be scope for the brilliant engineer who can carve a niche for himself, enjoying the advantages of being his own master, but running the risk of mental loneliness which can afflict men at the top."[3] It is the general experience and ability to take the broad view on which the conception of the "General List" of naval officers depends.

At the same time, the principle that all engineer officers should sub-specialize in marine, air, or ordnance engineering is being retained, since it is not thought practicable for a young man to master the details of construction, operations, and maintenance of all three and to practise them effectively. Given a broad training in the fundamentals of mechanical engineering, with a sound grounding in one aspect of the whole profession, and his general naval experience, it is hoped to produce a man who can perform "all the offices."

Training and Entry

Fig. 3 shows the relative sources from which regular engineering officers are drawn.

The cadet and scholarship entries are drawn from all types of school; at the moment it happens that independent schools are providing the majority, but it is felt that there are many of the best boys from maintained grammar schools who are not coming forward as candidates.

For the scholarship entry and cadet entry, G.C.E. "A" level exemption by 2 "A" level passes (with 3 "O" level) has been

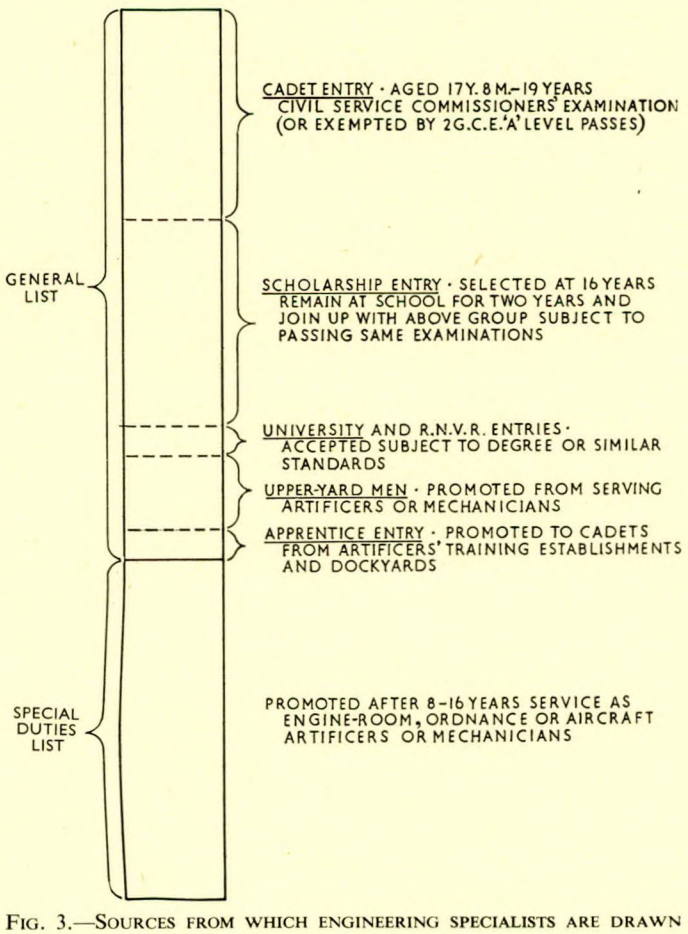

FIG. 3.—SOURCES FROM WHICH ENGINEERING SPECIALISTS ARE DRAWN

only recently introduced, and may become increasingly popular with schools.

The pattern of training of engineer officers to suit these requirements can now be considered in four parts:—

(*a*) Early general naval training based on the Britannia Royal Naval College, Dartmouth, to give the schoolboy a sound background for his naval career.
(*b*) Sea training in the fleet.
(*c*) Professional engineering training ashore in the Royal Naval Engineering College, H.M.S. *Thunderer*.
(*d*) Advanced engineering training (for a few selected officers) at R.N. College, Greenwich.

Britannia Royal Naval College, Dartmouth

It would be hard to find anywhere in this country an environment better suited for any young officer to start his naval career than the B.R.N.C., Dartmouth. The setting, the amenities and, above all, the tradition of the college which has supplied so many of our great naval leaders in the past make it one of the most treasured possessions of the Service. But those who knew it of old will find great changes. It is no longer a school for bringing up thirteen-year-olds to manhood in a naval atmosphere; it is now an adult establishment, greatly enlarged, with Sandhurst and Cranwell as its counterparts; with its combined naval and civilian staff the atmosphere is attuned to the new requirements.

A proportion of the officers under training are from old and new Commonwealth nations; all receive exactly the same training as officers of the Royal Navy.

First Period

For the first two terms the aim is to inculcate in all cadets a general naval knowledge and discipline, and with the wide diversity of academic attainments of cadets on entry, to ensure an adequate scientific and mathematical background and an ability to express themselves clearly in writing and speech. Some engineering is taught to all cadets, so that when they go to sea in their third term they can understand the principal items of the ships' machinery.

Sea Training from Dartmouth

The sea training is carried out in a squadron of three modern frigates and two minesweepers attached to the college specifically for the purpose, and affords general familiarization with all subordinate duties. Cadets live and work under exactly the same conditions as naval ratings, the aim being to acquaint them with the ship's routine as it affects the sailor and conditions on the lower deck.

A short air course is also undertaken in this period.

Specialization

For the first year cadets will have been trained as officers unallocated to any specialization. After this they will become either seamen, engineer, or supply specialists according to their aptitude and, as far as possible, their preference, due account being taken of visual fitness and the need to have a fair share of talent in all specializations. (Arrangements for the electrical branch are still under consideration.)

Last Period

In the last period of four terms at the college, as a midshipman, training continues on a nearly common basis, the aim being to teach the professional and technical principles which a young officer must grasp before going to the fleet, thus forming a nucleus round which the practical knowledge to be acquired whilst at sea can accumulate. He should by then be an efficient and intelligent understudy to a qualified ship's officer.

The distribution of subjects covered in this period is shown in Fig. 4. There is a slightly increased emphasis on mathematics, science, and mechanics for engineering specialists, while the seaman specialist covers more ground in navigation and communications. Otherwise the syllabus is common for these two specializations.

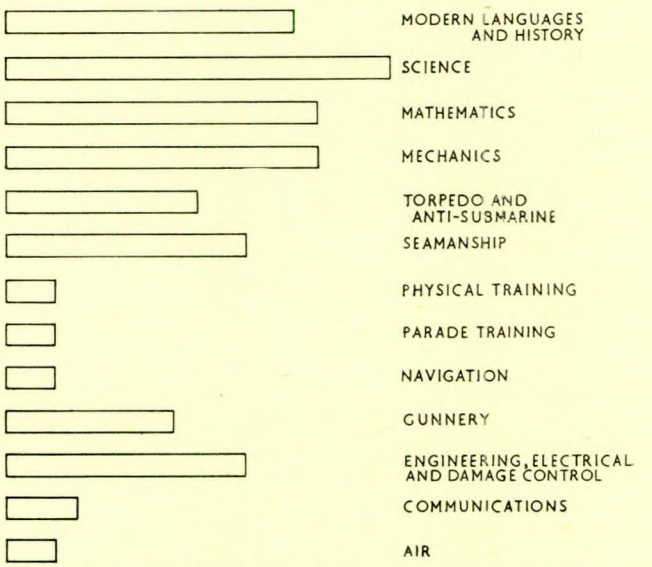

FIG. 4.—DISTRIBUTION OF SUBJECTS IN LAST PERIOD (FOUR TERMS) AT THE BRITANNIA R.N. COLLEGE, DARTMOUTH

It is at Dartmouth that the young officers' character will largely be developed. Great emphasis is placed throughout on getting to know the elements in small boats, on expeditions of an enterprising nature, and on a study of the humanities. This aspect will be referred to later.

Sea Training in the Fleet

On leaving Dartmouth, seamen, engineer, and supply officers will go to sea in the fleet as acting sub-lieutenants for a period of some eighteen months. This will be their first real contact with ships and naval ratings apart from the term in the training squadron, and it is a vital period. They will be required to obtain a "Certificate of Competency" to cover general experience in all departments of the ship, understudying on the bridge, in the supply and electrical and weapon organizations, and in the machinery spaces. The engineering specialists will devote the

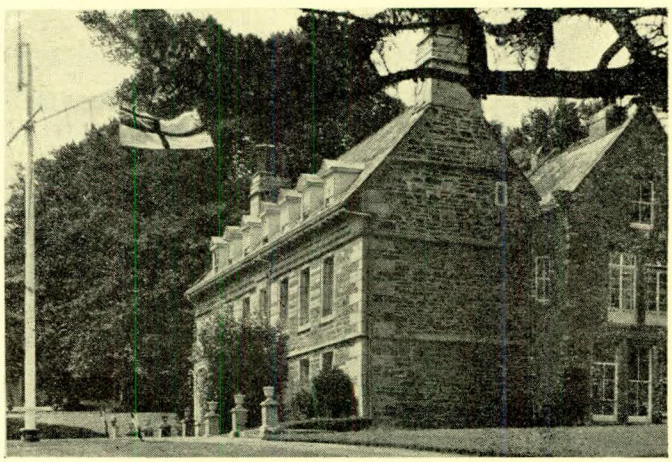

FIG. 5A.—THE CAPTAIN'S HOUSE

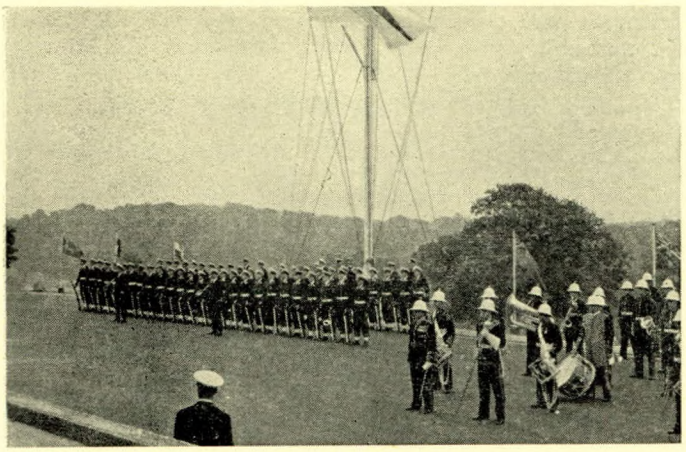

FIG. 5B.—MIDSHIPMEN'S GUARD AND ROYAL MARINE BAND AWAITING ARRIVAL OF THE FIRST SEA LORD TO LAY NEW BLOCK FOUNDATION STONE, JULY 1956

last twelve months to the engineering side of their profession. They will be required to obtain progressively certificates signifying that they are capable of taking charge of a steaming boiler-room, watchkeeping on all varieties of auxiliaries, charge of a unit of the main engines, and finally an Engine-Room Watchkeeping Certificate, signifying that they are qualified to perform the practical duties of a junior engineer officer of the watch. It could be argued that it is anomalous to award an Engine-Room Watchkeeping Certificate before professional engineering training. This is not so, since the officer's earlier Dartmouth training will have covered the practical side to some extent, and there is much advantage in practical experience forming a first side to the training "sandwich." It may be compared with learning to drive a car before absorbing the mechanical details. Officers learn the principles of operation and maintenance of machinery, and become versed in lighting up and shutting down routines and rapid power changes while manœuvring. They emerge from the school atmosphere and learn to take responsibility.

Professional Training

At this point it is necessary to depart from discussing the present scheme of training, because the final pattern of future professional training has still to be determined. The transition is now taking place—the old scheme is still running with some years' worth still in the "pipe line." Fig. 6 illustrates the old and the possible development of the present scheme. The old scheme will, therefore, be described, since it will not finally die out until 1961, and the new final product will not differ greatly *technically* from the old, the aim being to enhance the present high professional standards of "General List" engineer officers.

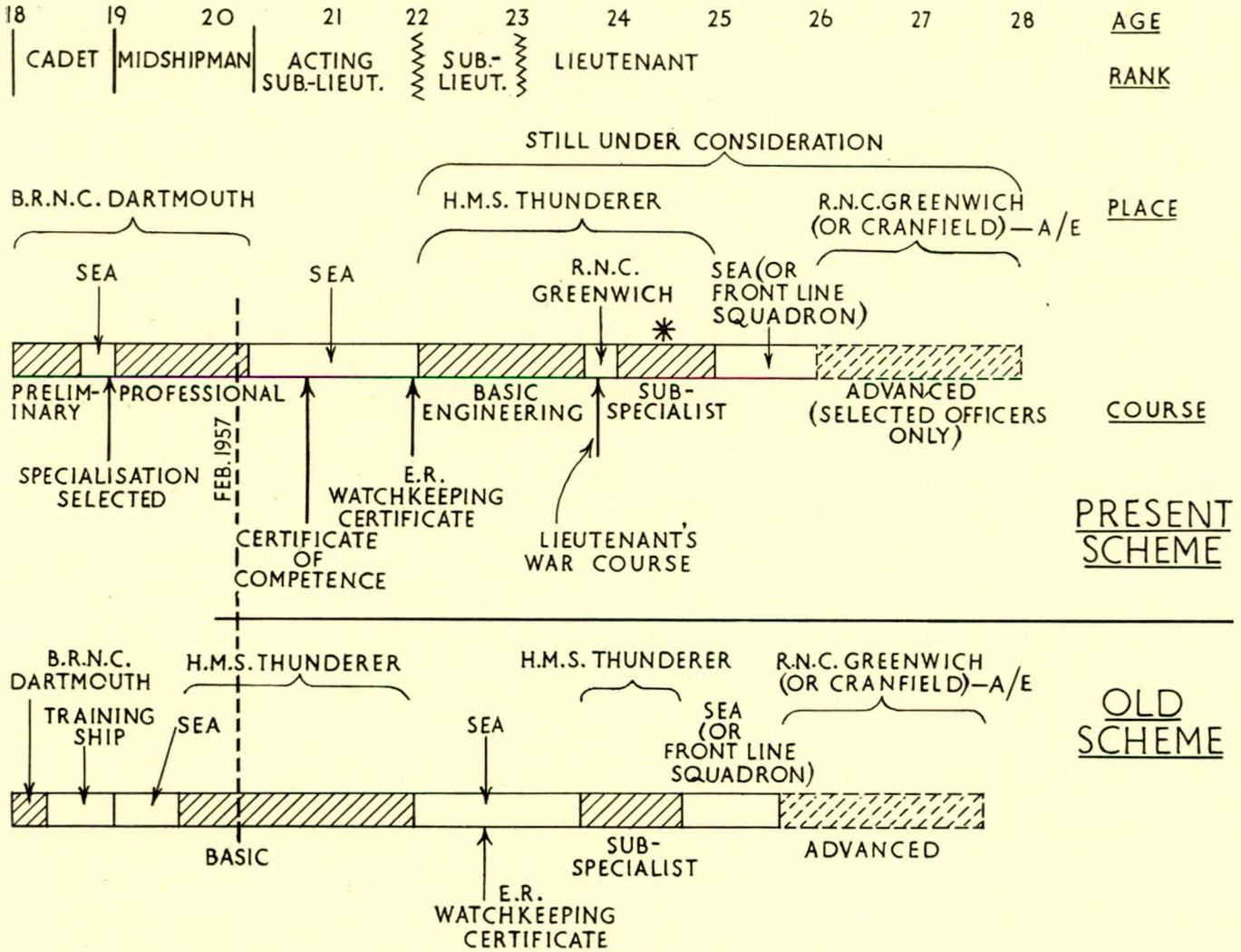

FIG. 6.—*O/E SUB-SPECIALIST'S COURSE IS FOUR TERMS, INCLUDING PERIODS AT H.M.S. "EXCELLENT" (GUNNERY AND GUIDED WEAPONS) AND H.M.S. "VERNON" (TORPEDO AND ANTI-SUBMARINE)

H.M.S. "Thunderer"

Professional training is carried out mainly at the R.N. Engineering College, Manadon, near Devonport, which is an independent command known as H.M.S. *Thunderer*, and is the Alma Mater of the engineering specialization. The facilities afforded in H.M.S. *Thunderer* have been fully described elsewhere.[4] Suffice to say that it offers, with its extensive workshops, laboratories, demonstration rooms, hangars, test shops and playing fields in its 100-acre site, as fine a training for mechanical engineering as any in the country. The illustrations show some of these facilities. The final stages to make it virtually self-contained have been started with the building of an extensive accommodation block, the foundation stone of which was laid by the First Sea Lord in July 1956. On completion, the old R.N.E.C. at Keyham, which has trained engineer officers almost without a break since 1880, will be taken over for other purposes.

The total officer complement at present is about 60 staff with 360 officers under training.

Professional training falls into two main phases, a common basic course covering 7 terms (2⅓ years), at the end of which the sub-specialization in marine, air, or ordnance engineering is selected, followed later by a sub-specialist course of 3 terms (or 4 terms for ordnance engineers). Between these two courses 5 terms are spent at sea in the fleet (which under the newer scheme will have already been served before joining H.M.S. *Thunderer*—see Fig. 6).

Basic Course

This course was evolved in consultation with university and otner authorities to provide a sound grounding in mathematical and mechanical sciences, to aim to teach *how* to think, to develop a broad understanding and sense of judgment, and provide the requisite background of knowledge for later courses.

Study during working hours is divided into lectures, practical laboratory work, workshop practice and technique, and tutorials. All officers require a number of hours of private study each week according to their ability, to keep abreast of the syllabus. Failure at progress examinations entails back-classing and special coaching in weak subjects.

The distribution of academic subjects taken is shown approximately in Fig. 7. In 7 terms of 14 weeks each, the pace in which is intensive, some 2,360 hours' instruction is given, which is a little less than that given at London University and technical colleges—but further instruction in the later sub-specialist course, especially in chemistry, metallurgy, and design subjects brings this total to about the same.

Mention has previously been made of Upper Yardmen promoted from the lower deck on passing a stiff educational examination and the Admiralty Interview Board. They phase into the last four terms of this basic course, and thereafter are indistinguishable from their contemporaries.

Standards

It has always been the policy of the Engineer-in-Chief of the Fleet that all cadet-entered engineer officers must be trained to professional standards generally recognized in the country. Without such a background they will not be able to talk on level terms with their colleagues in industry, nor indeed to carry out the many varied duties which will later be their lot. The final examinations of the basic course are therefore keyed to those set by the Institution of Mechanical Engineers. All papers are set by examiners from Cambridge, London, or other universities or the Royal Naval College, Greenwich, to satisfy these minimum standards. Those who fail the progress or the final examinations at a second attempt are withdrawn from the Service. It follows that after the further requisite practical experience, all officers qualifying are later eligible for associate membership of the Institution of Mechanical Engineers if they wish it, being exempted from the qualifying examination for graduate membership by virtue of passing the Admiralty examination. They are similarly exempted for admission to the Institute of Marine Engineers or the Royal Aeronautical Society, as appropriate, and are also eligible for associate-membership of The Institution of Naval Architects.

Nearly all academic and laboratory instruction is given by serving officers of the Instructor specialization (most of whom possess First or Second Class Honours degrees) or fellow engineer officers. With a 2–3 year tenure of staff appointment, a degree of continuity as well as a "feed-in" of recent sea or air experience is assured.

Sub-Specialist Courses

After the period of sea training mentioned above, about 50 per cent and 30 per cent undertake the marine and air engineering three-term course respectively, and about 20 per cent the four-term ordnance engineering course. These courses are more practical than academic, although principles of machinery are learnt rather than details of individual equipment. It will be noticed from Fig. 7 that an appreciable amount of time is spent on electrical subjects. Although of major importance for the ordnance engineer specialist, the principles of electronics and automatic control of machinery are now considered as the tools of all.

The general aim of these courses is to equip officers with the

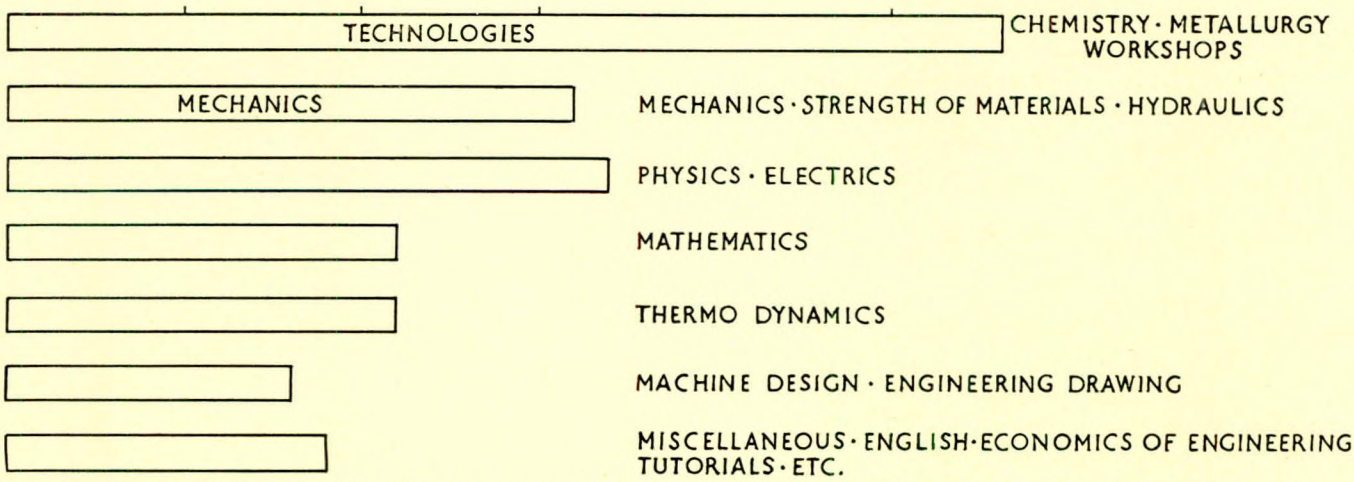

FIG. 7.—DISTRIBUTION OF SUBJECTS IN BASIC COURSE H.M.S. "THUNDERER" (7 TERMS OF 14 WEEKS—33 PERIODS (55 MINUTES/WEEK))

ability to maintain overall operational control of machinery, based on a sound understanding of its design, its limitations, and its construction.

An interesting final task in the course has been to give to small syndicates broad requirements of a piece of equipment to fulfil a specified task. They are then required to devise, design, make completed drawings, cast and forge the necessary components, carry out all machining processes, and finally test the finished equipment to meet the required specifications. A cost analysis and a sales brochure is prepared, as if intended for production. The variations in approach have proved most illuminating, and valuable experience of the proper perspective of design and development has been gained. (See Figs. 8 and 9.)

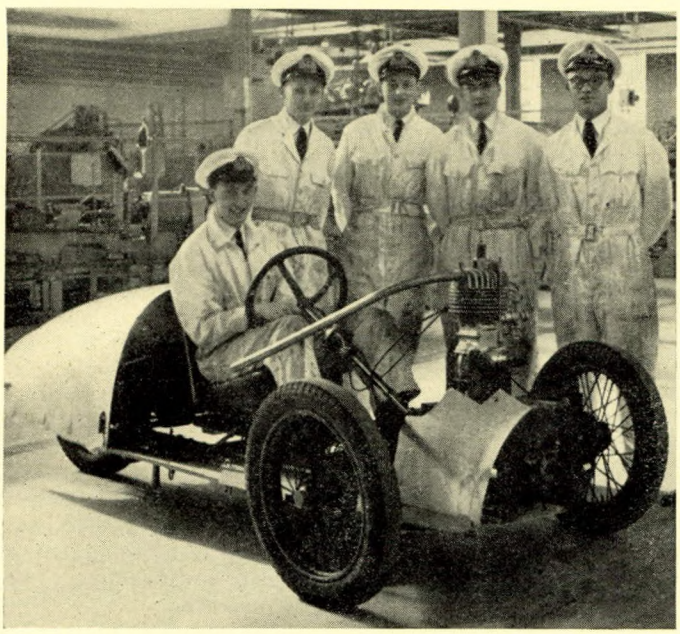

FIG. 8.—AN EXAMPLE OF "DESIGN AND MAKE" TEST WORK. A 250 C.C. AIR-COOLED ENGINE MOUNTED IN A TEST VEHICLE

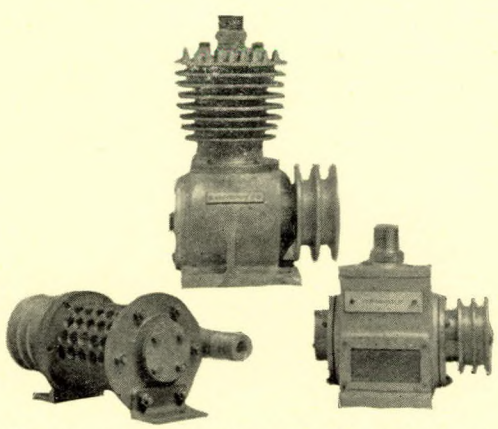

FIG. 9.—"DESIGN AND MAKE" TEST WORK. THREE DESIGNS OF L.P. AIR COMPRESSORS PERFORM A SPECIFIED DUTY

During these courses some practical experience is gained in running under test conditions auxiliary machinery likely to be met in the Service. The air engineer officers have the use of a Bolton and Paul "Balliol" and an Airspeed "Oxford" aircraft at a nearby airfield as "flying test shops." (Those selected and who volunteer may later qualify as front-line pilots, and may ultimately become maintenance or Empire Test Pilots.) The ordnance engineer officers spend part of their course at other specialist schools learning the intricacies of guided weapons, conventional gunnery, and torpedoes.

At the end of these courses officers are generally considered fitted to go to the fleet or air stations in a junior complement billet, carrying with it definite responsibilities. It is impressed on them that learning is a continuous process, and all their former training has been directed towards enabling them to learn for themselves thereafter.

The advent of a small ship fleet has brought with it considerable accommodation problems. There is now little room to carry officers or men under training at sea—and however much one may wish to carry round supernumeraries for training, it is only possible to a limited extent. Every man must go to sea ready to assume a responsible job.

Leadership Training

At this point it is appropriate to mention one of the most important aspects of the training of engineer officers—indeed of all officers—not only in the Navy but in all the Services where man himself is the vital factor. This is the training in leadership. The problem is not entirely analogous to that obtaining in industry, where employers and employees do not live together, and where a man can usually give up his job at short notice to seek a better one. Nevertheless, industry has considered it necessary to make vast strides in caring for the well-being of its employees, and great pains are taken by most firms to foster loyalty which can only stem from contentment in the job under wise leadership, stemming, in turn, from confidence based both on mutual respect and on the superior professional ability of the leader. How much more necessary must be this leadership in a ship, where men are living for long periods at very close quarters, and where the ultimate trial in battle can only be successfully achieved as a result of ordered preparation, perfect discipline, and confidence in the officers; nothing will be achieved without leadership of the highest order at all levels.

There can be no formal way of developing leadership—it cannot readily be taught in a classroom or from a book, since the prime requirements are those which should develop naturally in an early background in which the value of Christianity and human relationships are constantly stressed, coupled with self-confidence, readiness to take responsibility, initiative, and courage.

Discipline is comparatively easily instilled; the normal formal parades and physical training instill in addition a high degree of self-confidence in the young officers placed in charge. Ability to take responsibility is not so easy to inculcate in what is normally a well-regulated shore establishment, nevertheless the out of working hours organization of 360 junior officers in H.M.S. *Thunderer*, some of them Asian and foreign, allows a good deal of scope, and towards the end of their training period officers under instruction are in entire charge of everything which happens in the establishment out of working hours, as well as all the normal extra-mural activities common to a university. It is naturally these officers who set the tone and standards of behaviour for the more junior officers.

Some 60 or 70 periods during the course are devoted to the pure mechanics of being a divisional officer in charge of ratings, every aspect possible being covered. Each officer spends one week as an assistant to a divisional officer for Engineering Mechanics in H.M.S. *Raleigh*.

One important innovation has recently been made. In their early terms all officers spend at least one week-end (including a night) on Dartmoor, regardless of weather, with some definite organized objective. The members of the third term then themselves organize an expedition to Scotland, usually to the Cairngorms or Glencoe, where the most rigorous conditions of ice and snow are sought, and set tasks are performed in groups of two

or three. In their last terms they organize further expeditions on Dartmoor in charge of small bodies of Naval Apprentices or Engineering Mechanics.

Officers qualifying as skippers are encouraged to take the college yachts across the Channel during the leave periods, and have been very successful in the Royal Ocean Racing Club races.

The value of such character training is untold, in increasing self-confidence in learning to plan ahead, and in stimulating the will to endure by presenting the opportunities of developing capacity to face hazards, hardships, and difficulties.

Lastly, opportunity is taken to present lectures and talks on subjects of current interest outside naval affairs; every attempt being made to interest officers in such vital subjects as "the Christian answer to Communism." Perhaps it would not be indulging in heroics in the presence of organizations so predominantly maritime as the Institute of Marine Engineers and The Institution of Naval Architects to quote from John Buchan[5]:—

> "The sea has formed the English character, and the essential England is to be found in those who follow it. From blue waters they have learned mercifulness and a certain spacious tolerance for what does not affect their craft, but they have also learned in the grimmest schools, precision and resolution. The sea endures no makeshifts. If a thing is not exactly right, it will be vastly wrong. Discipline, courage . . . and contempt for all that is pretentious and insincere are the teaching of the ocean and the elements, and they have been qualities in all ages of the British sailor."

The final aim is to produce a young officer who as well as being technically sound (and certainly occasionally capable of improvising makeshifts!) is essentially balanced in outlook, and able to measure up to the high words of praise given by John Buchan to the seafaring community of Britain.

Advanced Courses

After one to two years' sea experience about 10 to 15 officers yearly are selected as a result of their performance at H.M.S. *Thunderer* and at sea, to undergo two-year advanced courses at the Royal Naval College, Greenwich (or at the College of Aeronautics at Cranfield in the case of air engineer officers). Their ages range from 24 to 27 at the start of the course. They are indicated in the Navy List by a dagger against their names, and hence are known as "Dagger" officers.

The aim of the advanced engineering course is to equip officers for leadership in research, development, and design which in later life they will be required to initiate, administer, and criticize. While they will not actually execute designs themselves, they will need experience of design work coupled with judgment and a broad background, including acquaintance with industry.

Hence the scope of the course is similar to that of an honours degree with additional emphasis on design methods, particularly towards an analytical approach to varied problems.

Advanced teaching in subjects such as mathematics, applied mechanics, physics, and chemistry is given by civilian professional staff, while serving engineer officers give instruction in design work and related subjects and administer the course as a whole.

Close contact with industry is fostered by visits to firms engaged in current Admiralty work and by lectures at the college from members of the firms and organizations concerned. It is appropriate to record here the Admiralty's great appreciation of the very willing help that is given by industry in this way.

Installation design for warships' machinery is a prominent feature of the second year work. This is done in conjunction with students of the naval architecture department, future members of the Royal Corps of Naval Constructors. Many of the Royal Corps of Naval Constructors have already spent a year living in H.M.S. *Thunderer* whilst studying in the constructors' training office at H.M. Dockyard, Devonport, before going on to Greenwich, and thus the early acquaintance of these two closely coupled branches of the service is fostered into co-operation.

The ordnance engineers study advanced gunnery techniques and guided weapons, while the air engineer officers study advanced aeronautical engineering design and production problems at Cranfield.

Comparison with the United States Navy

It may be of interest to compare the system in force in the United States Navy.

It is considered that all officers must have a sound technical background. All regular officers undergo a four-year graduation course at Annapolis (or other civilian university) of which about half, therefore, is devoted to mechanical engineering.

They then proceed to sea as "Line Officers," and may undertake any junior duty on board, from the bridge to the engine-room. After two to three years, those interested in mechanical matters apply for a course at the Massachusetts Institute of Technology: those who qualify become engineering duty officers (E.D.O.) and, with few exceptions, after reaching the rank of lieutenant-commander are employed in the Bureau of Ships, shipyards, in laboratories, or overseeing. The posts of engineer officer of most ships and all commands at sea are filled by "Line Officers," who normally will not have had formal technical training beyond that at Annapolis: they will have had wide technical experience of all parts of a ship from the radar to the turbines and their specialized technical staff may consist largely of officers promoted from enlisted men.

It is noted that this scheme denies to the E.D.O. above the rank of lieutenant practical experience of administering a machinery installation and the handling of technical ratings at sea. Recently an E.D.O. has, however, for the first time been appointed as engineer officer of a fleet aircraft carrier.

The "E.D.O." is indistinguishable from the "Line Officer," and, according to a vice-admiral in the U.S. Navy, "he can only be recognized by the slightly more erudite expression on his face." He may be a dual "constructor-engineer" specialist. (The ordnance and air specializations are quite separate.)

The U.S. Navy scheme is somewhat similar to our own "Selborne-Fisher" scheme of 1902, whereby all except a very few selected (E) officers were interchangeable in any duty, command or technical. (For political and other reasons the scheme died in the Royal Navy after the 1914–18 war.)

Comparison with the German Navy

It is of interest that the new German Navy has quite independently evolved a scheme for officer training not unlike our own. Its main features include entry to a common list and common training for the first three years, including 4 months' training under sail and 3½ months' workshop training for all.

Special Duties List Officers

From Fig. 1 it can be seen that these officers comprise over 25 per cent of total strength of the engineering specialization. They are promoted as a result of a professional and educational examination and on their personal qualities. Their considerable practical experience at sea and in air stations is of the greatest value, and they are regarded as a most important mainstay of the Navy.

On promotion to officers they also are trained at H.M.S. *Thunderer*, where they play a very full part in the life of the college. Their six-months' course in their own specialization

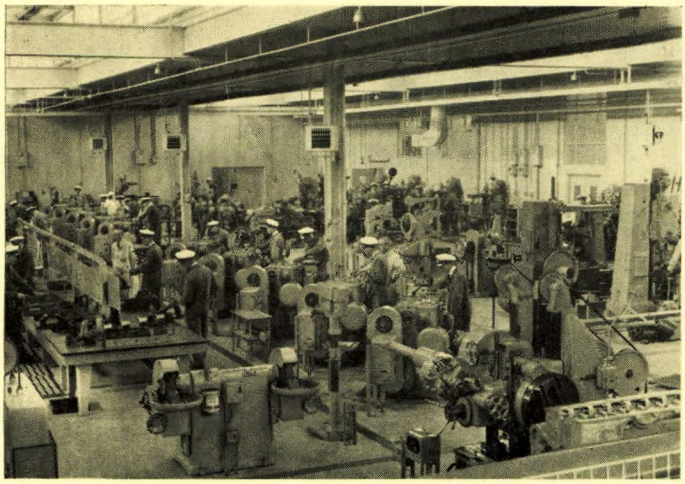

FIG. 10.—WORKSHOPS—MACHINE SHOP. TERMS I AND II

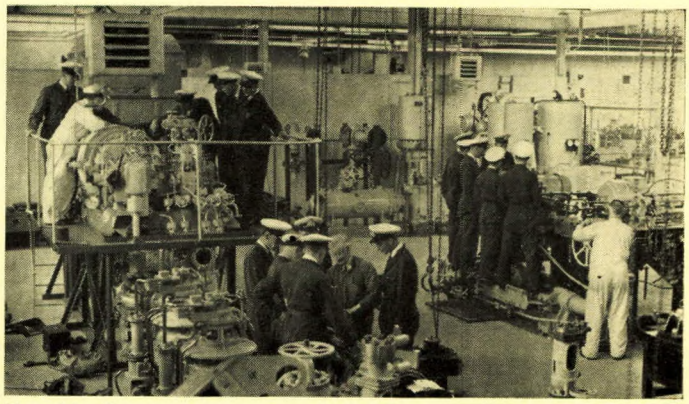

FIG. 11.—INSTRUCTION IN THE AUXILIARY MACHINERY STRIPPING BAY OF THE WORKSHOPS

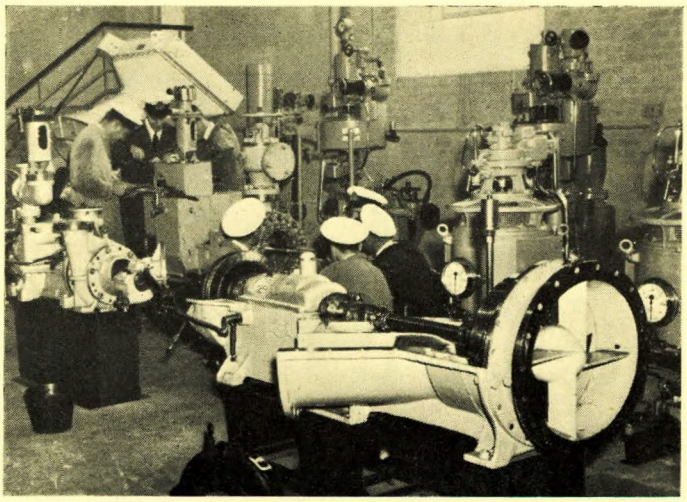

FIG. 12.—AUXILIARY MACHINERY STRIPPING BAY. EXAMINATION OF TURBO FEED PUMP

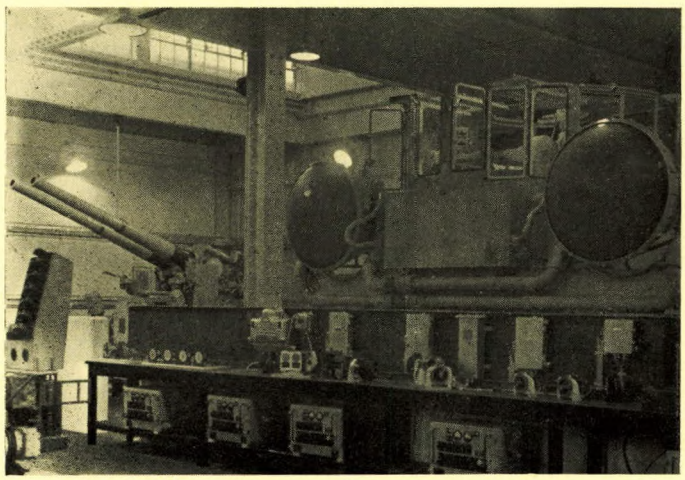

FIG. 13.—THE ORDNANCE ENGINEERING LABORATORY

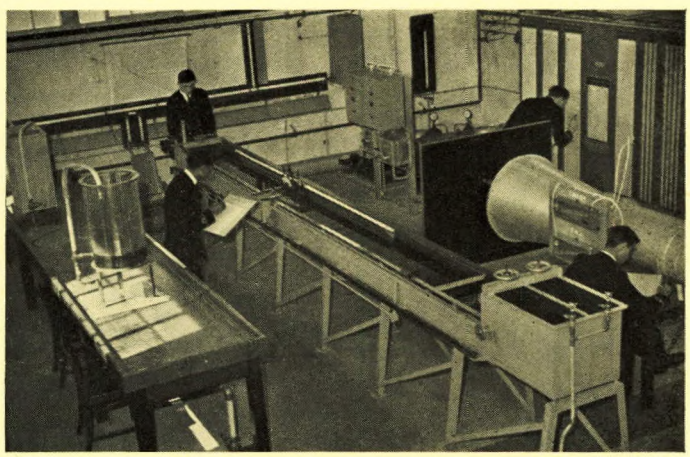

FIG. 14.—FLUID MECHANICS LABORATORY. EXPERIMENTS ON SHIP RESISTANCE AND AIR FLOW IN PROGRESS

brings them in close contact with their contemporaries on the "General List," broadens their somewhat limited technical knowledge, and enables them to acclimatize themselves to their new role. Thereafter they are generally interchangeable with their "General List" equals in rank, for most appointments of practical nature, but because they have not had the advantage of the wider earlier academic training, and are older, their career is limited.

Due to their proved services, it is intended that a still greater proportion of "Special Duties List" officers will be borne.

The Past and the Future

How has the training in the past stood up to the requirements of the Service, and of the country as a whole? Although it is axiomatic that the technical standard of a Service cannot rise superior to that of the industry upon which it depends, the use to which the achievements of industry are put in development and design for the Navy is the responsibility of its technical officers. Under the guidance of naval engineer officers some conspicuously successful projects have been carried through—the mirror sight for deck landing on carriers, the Deltic lightweight diesel, the steam catapult now in use in the United States Navy and the Royal Navy, and the lightweight Y.100 steam installation for new frigates, to mention a few: and in the gas turbine world the *Grey Goose* was the first ship to be driven solely by gas turbines. There are many other examples in the ordnance and air worlds. Their success shows that the early training and experience of the officers concerned enabled them to make contributions in their own spheres towards the engineering and general industry of the country, on which the life of the Navy depends. And perhaps the results of two world wars have been appreciably affected by the role of the Navy, including its technical officers.

In 1828 the First Lord of the Admiralty, Lord Melville, wrote: "Their Lordships feel it their bounden duty upon national and professional grounds to discourage to the utmost of their ability the employment of steam vessels as they consider the introduction of steam is calculated to strike a fatal blow at the supremacy of the Empire."

Happily Their Lordships of to-day are of a different mind and now encourage to the utmost the employment of advanced methods of propulsion and new weapons. Their acceptance of a concept of a "General List" of officers has shown the value they have put on the achievements of technical officers in the past, and by this recognition, the trust they put in the technical officers of the future being able to play an even greater role. It is to fit them to be "all of one company" not only within the Service, but in the technical life of the country as a whole, that the training of officers is now directed.

Acknowledgments

The author wishes to thank the Deputy Engineer-in-Chief (E.A.P.), Rear Admiral P. C. Taylor, C.B., the Deputy Engineer-in-Chief, Rear Admiral G. A. M. Wilson, and the Commanding Officer, H.M.S. *Thunderer*, Captain Sir John Walsham, Bt., O.B.E., R.N., and many other officers who have given valued advice and help.

This paper is read by permission of the Admiralty. Crown copyright of photographs is reserved.

References

(1) "A Criticism of Technical Education of Recently Qualified Engineers," read by P. P. Love, B.Sc., Wh.Sc., before the Institution of Mechanical Engineers on November 11, 1955.
(2) "Reflections on the Education of Engineers in a University," read by Professor D. G. Christopherson, O.B.E., Ph.D., A.M.I.C.E., M.I.Mech.E., to Imperial College of Science and Technology, University of London, February 14, 1956.
(3) *Engineering*, Editorial, July 13, 1956.
(4) *The Engineer*, August 6, 1954, pp. 201–4.
Shipbuilding and Shipping Record, July 29, 1954, pp. 139–140.
(5) BUCHAN, J.: *Naval Episodes of the Great War*.

THE TRAINING OF ENGINEERS FOR THE MERCHANT NAVY

By S. F. Dorey, C.B.E., D.Sc., F.R.S. (*Past President I.Mar.E., Hon. Vice-President I.N.A.*)*

Having accepted the invitation of the Institute of Marine Engineers to give a paper on this subject to the Symposium, I first of all sought out what had recently been written and my first impression was that the subject had been dealt with fairly thoroughly in recent years and there appeared little I could add of a constructive nature.

It is necessary, however, particularly so far as technical training and education are concerned, to look forward to prepare for the future as well as look back at what has been accomplished in the past, since we are in an age of rapid technological progress and must be prepared to tackle the problems that will be brought forward, in order that progress in new prime movers shall be on the right lines of efficiency and economy. There arises also the need for a review of the amount of emphasis to be placed on certain subjects, the importance of which may increase or decrease with time according to the trend of engineering invention and development and a country's resources for the supply of fuel.

It is with this view in mind, and in order to stimulate discussion on the subject, that I have prepared this paper. Since it is one of a symposium, I decided to limit its scope by not going into much detail regarding the various schemes of training for a marine engineer in the Merchant Navy, but rather to state briefly the methods adopted and to endeavour to make suggestions for improvement in the hope the discussion will bring forth constructive comments. In passing, mention might be made of a paper by W. N. Sergeant, B.Eng., entitled "The Training of the Marine Engineer Officer," given in the first edition of the *Journal of the Liverpool Engineering Society*, Vol. 1, No. 1, 1955, which, in my opinion, gives most of the detailed information required and also a number of very useful constructive suggestions. This lecture was a joint affair with the local section of the Institute of Marine Engineers.

I would like to emphasize at the outset that I can think of no better training for a young man desiring to become a mechanical engineer than undergoing a well organized apprenticeship in a first class marine engineering works. It is a type of apprenticeship not usually found in other branches of engineering and is broad enough in scope to give opportunity in the future for a successful career in the many branches of mechanical engineering.

The following may be stated to be the general systems of training:—

(1) Serving an apprenticeship of four or five years in an engineering works and nothing further.

Normally the apprentice remains in the industry as a journeyman and may go to sea but, due to absence of technical qualifications, is unlikely to remain there for any length of time. In the larger ships which employ mechanics, he would be a useful member of the staff, but he will not have the qualifications for running a modern machinery installation.

(2) Serving an apprenticeship of five years in an engineering works with evening classes up to ordinary national standard (S3) in five years. The apprentice leaves school at 16 and may not have a school-leaving certificate.

This is the most fruitful source of future marine engineers. The apprentice has a sound practical training and his standard of technical education should, with subsequent study and keen application, enable him to obtain a First Class Certificate of Competency in due course.

(3) Serving an apprenticeship of five years in an engineering works, attending evening classes for the first three years, and in the last two years attending a technical college one day per week (Day Release System). This apprentice may have obtained his school-leaving certificate before leaving school at 17 years of age, and could obtain a Higher National Certificate at the end of his five years' apprenticeship.

This apprentice may or may not proceed to sea at the termination of his apprenticeship. Assuming he has obtained the Higher National Certificate and serves at sea, readily obtaining his First Class Certificate, he will probably seek shore employment in the management side or drawing office of a marine engineering firm. Alternatively, he may go direct to this employment without sea experience.

(4) Serving an apprenticeship of five years in an engineering works, two years of which are spent in full-time study at a university or senior technical college. This student should gain a degree or its equivalent during his period of apprenticeship. This is termed the "Sandwich System."

This apprentice, or better termed student, will normally not proceed to sea, and as marine engineering firms in general do not offer him much encouragement, he naturally turns to some other branch of mechanical engineering. Positions open to this student in the marine field where his technical knowledge could be used to best advantage are to be found in the few large research establishments, e.g. PAMETRADA and Vickers. Experience has shown that the average marine engineering firm does not appear to be able to absorb him into their managerial structure, but it may well be that with the technological advances which are now apparent, the need for these higher trained engineers will be required both at sea and on shore. In any case, it is considered that provided satisfactory sea experience is obtained leading to a First Class Certificate and an Extra First Class, good prospects for the future will arise with shipping companies, marine engineering firms, Lloyd's Register of Shipping, and the Ministry of Transport.

The technical training gained during this sandwich system should enable the young engineer to obtain the M.O.T. certificates in the minimum of sea time, and I can recommend no better balanced training for a marine engineer seeking a good shore position in the future, than an apprenticeship and university education combined with sea experience on the lines suggested.

(5) The independent apprenticeship of certain Merchant Navy companies.

This apprentice serves the first two years at a technical college and attains a standard just below Higher National and gains a Diploma of Engineering. Following this

* Lately Chief Engineer Surveyor, Lloyd's Register of Shipping.

he serves 12 to 18 months at sea as a cadet marine engineer, and finally 18 months in a marine engine building firm usually associated with his company. This is a 4½ years' apprenticeship.

Sufficient time has not as yet elapsed to prove this system, and it remains to be seen whether cadets of this calibre will be content to remain as sea-going engineers. Also there may be some doubt as to whether the degree of practical training which they obtain is sufficient to satisfy the needs of a competent marine engineer.

The programme of practical work in which any apprentice should be trained is easy to compile, but often difficult to obtain in the average marine engineering works unless the apprentice is privileged. It will also be confined to the types of machinery constructed in the works. In some works apprentices will only get experience in the building of oil engines, and at another, steam reciprocating engines, and a further one, steam turbine machinery.

This means that when he goes to sea, the trained man will naturally, at the commencement, serve in ships having machinery with which he is familiar and get little experience in other types. His future prospects will depend on the breadth of his experience, and that will in turn depend on the man himself and the opportunities afforded him by the shipping company.

It is evident, however, that in view of the short period, namely, eighteen months' practical training in scheme (5), careful consideration must be given to its content. Is it intended merely to provide the opportunity of gaining experience as a mechanic, or should it consist of a general training in a properly equipped marine engineering works? What certainly is wanted in every practical scheme is interest by the management in the apprentice.

Unfortunately, it is not possible for all apprentices to serve in marine engineering works, but it would appear doubtful whether, as is known to be the case, the whole of the eighteen months spent with, say, a steering gear manufacturer is what is intended in the scheme. An interchange arrangement between different works would be a great help in giving wider variety of scope. In other words, the management in a marine engineering works should take as keen an interest in these training schemes as the shipping companies, for it is the former's products that the apprentices will ultimately have in charge.

These remarks naturally apply to all practical training. It is also most important during the sea-going experience that the Chief and Second Engineers are willing to treat the apprentices as such, and not as the most suitable candidates for all the more odious jobs, as bilge cleaning, etc. Deliberately training apprentices the "hard" way may achieve more discontent than satisfaction in one's job. Well organized sea-training in the shipowners' scheme may well produce some better engineers than those at present drifting into the industry, and also better men and officers. There are many, particularly of the older school, who doubt whether this scheme will produce the first-class engineers that are required; in other words, will the scheme produce engine drivers or engineers. Certainly there is room for all, provided they thoroughly understand their respective duties. And these duties change with the times and the type of service required. The new type trainee may well help the tanker owners in their immediate manning difficulties, but their workshop experience may have been too brief to be of much practical use should the vessels in which they are serving encounter machinery trouble. But, here again, it depends on the individual. Certainly some will require many years of sea-going experience before acquiring such all-round competence as the best colleagues who have served normal apprenticeships, and in any subsequent shore appointments may be poor judges of standards of workmanship.

The question might well be asked for what exactly are we training these prospective marine engineers? If principally for a sea-going career, then let it be fully intended for that purpose and for the mode of life to be lived. Will the future types of machinery require to be overhauled by those in charge of it? Is it necessary to have a knowledge of the physical properties of all the materials used in the construction of the machinery, and suitable working stresses for the parts, and how the various operations used in the production of the materials are carried out? Part of the answer was given to the author some years ago by an Engineer-in-Chief of the Fleet, who said the principal job of a naval engineer officer is to be able to drive the machinery under his control at full speed in time of war, and to keep it running.

If mechanics are provided on board for running repairs and the port repairs are left to the shore staffs, there may not be much left for the watchkeeping engineer officer to do in the way of manual work.

Improved machinery conditions may no longer call for sea-going engineers to perform so many repairs at sea as they were relied upon to do in the past, and the increasing tendency to more complicated power plants demands that the present-day marine engineer be more conversant with the theoretical side of the profession, and the training of apprentices for marine engineering should be done with this in view. A suggestion has been made that a course of study in "Engineering Knowledge," based on Ministry of Transport examination syllabus and made available as either an alternative or extra subject to the National Certificate might be included. Another suggestion is that something might be done to establish some measure of interchange between the Engineering Degree courses and the Higher National Certificate courses, so that a man who has gained the latter qualification might continue to obtain a degree without having to revert to the matriculation stage. This could be adjusted by having as supplementary or extra subjects English and a foreign language in the Higher National Certificate.

For the young man who is determined to succeed, membership of the Institute of Marine Engineers is one of the most profitable means of obtaining and extending his engineering knowledge. It is necessary to emphasize, however, that practical training should not give place to theoretical training to an extent which would impair the engineer's ability to maintain reliability of the machinery and keep it running.

Whilst modern marine installations tend to become more complex, simple steam reciprocating machinery remains orthodox in many types of ships, and these do not require operating engineers with a high theoretical training.

Consideration, however, must be given to some new aspects of the marine field: boiler feed and fuel-burning control and the intricacies of machinery to accomplish it; increase in size and complexity of plant to obtain maximum efficiency in both steam and diesel practice; more efficient burning of fuel in diesel engines and boilers, and the study of fuel and lubricating oils. To understand and, more important, to operate efficiently the new additional machinery, the sea-going engineer must have a sounder technical education, a standard higher than the present-day engineer, for he will yet have to cope with gas turbines, free piston engines and, later, nuclear energy driven machinery. And, in addition to a sound knowledge of the working of prime movers, it is necessary to understand the functions of a variety of auxiliary machinery, which in large cargo liners and passenger ships may be quite complicated and extensive. Fortunately, this can be learnt, or should be learnt, in the first year or two of a sea-going career, if the young engineer has a little initiative and determination to get on and depending, of course, on the type of vessel he serves in. Enough has been written to give a general picture of the requirements for entry into a sea-going engineering career in the Merchant Navy and the relative importance of technical and practical training.

It is often the case that at the commencement of apprenticeship the young apprentice has no clear idea what he wants to become. At the age of 15 he probably rejoices in the fact that he need not attend any more classes, while if he leaves at 16 or 17 he has more defined ideas. Often the extent of his training is largely governed by the amount he is able to find out for himself—if he feels so inclined—and this varies from yard to yard and shop to shop. He will certainly find out by the last year of apprenticeship what he has missed.

In some yards sufficient care is not taken to see an apprentice works in all the shops necessary to give him a complete and balanced training. Most firms now give time off for classes in technical colleges, but very little encouragement is given to those who find the going hard. Those who do really well are the only ones to whom credit is given, but many others may well have all the qualities that are required of a good sea-going engineer and on whom a little encouragement would be well worth while. I have stressed this point because it is important that a young apprentice should appreciate as soon as possible what opportunities he has for his future career. It is a decided attraction of the shipowner's scheme of training that the young apprentice knows that a well-planned apprenticeship lies before him leading to a definite career.

For the youth who wants to go to sea, who has a good general education and has the opportunity of serving an apprenticeship in a good marine engine works or ship repair establishment the following scheme is recommended.

The apprentice should obtain as broad an experience of the various engineering trades as is reasonably possible during his four to five years of apprenticeship. This should include some time in the machine shops and boiler shop, and, wherever possible, in pattern shop and foundry.

Not less than about two years in the fitting and erecting shops or on outside repair work.

Some six to twelve months should be spent in the drawing office, preferably at the end of the apprenticeship.

Evening technical school should be attended throughout the apprenticeship, with day release part-time, ending with at least an Ordinary National Certificate.

With the foregoing training a young man at age 21–22 should be competent to go to sea in any modern good class ship as an engineer officer, and in due course obtain his M.O.T. certificates without difficulty. These men then form a pool of competent trained men from which the future superintendents, surveyors, consulting engineers and works managers can be recruited. This wastage is naturally to be expected, and it still leaves many who will prefer the sea-going life. It is very desirable, however, that the latter should be a way of life which compares in all possible respects with shore life in order to keep the engineer afloat after he has acquired his training and certificates.

In addition to this general training some suggestions for additional training are considered necessary, either during apprenticeship or subsequently. Emphasis must be laid on the desirability of some experience in electrical machinery and associated protection gear, for, with very few exceptions, marine engineers have very little knowledge of a modern electrical installation. An intimate knowledge may not be necessary, but a chief engineer is responsible for all machinery, even if an electrical engineer or engineers are carried. A knowledge of refrigerating and air-conditioning plant manufacture and design would be useful, and a short period of training in modern welding technique would help the young engineer in the future when faced with repair problems.

On the technical side it has been suggested that for students who are to operate expensive and complicated machinery economically in the future the emphasis needs to be on the subjects of heat engines, combustion and fuels, lubrication, basic metallurgy, rather than, say, strength of materials and other branches of mechanics which are more the concern of the designer. Time taken to study is an important factor and while wide technical knowledge is of advantage, care must be taken that the curriculum is not too long and too advanced in all its subjects to dispirit the average marine engineering student.

So far I have dealt almost exclusively with the preliminary training of the future marine engineer officer, and it might be claimed that some comments should be made on such an occasion as this respecting the existing conditions for advancement in the profession. If there is little I can add, it is felt the opportunity presents itself during discussion for constructive criticism which will no doubt be forthcoming.

If what immediately follows is known to the members of the Institute of Marine Engineers, the excuse for its inclusion is for the matter to be perused on a wider scale.

After completing his apprenticeship, the young engineer may apply to a shipping company for appointment as junior engineer. Prior to taking up sea-going duties, the engineer must apply to the Ministry of Transport to be graded as being suitable for sea service. In this, the prospective engineer is interviewed by a Ministry Engineer Surveyor and after taking into consideration the applicant's training, education and qualifications, the young engineer receives official notification saying that he is suitable for sea-going service, and at the same time as to what length of service must be served before taking the Second Class Engineer's Certificate.

Engineers at sea are graded Junior Engineer (5th, 6th, etc., according to type and size of vessel), Fourth Engineer, Third Engineer, Second Engineer, and Chief Engineer.

Except in small ships and home coasters, a Chief Engineer must hold a First Class Certificate of Competency and a Second Engineer must hold either a First or Second Class Certificate. Examinations for these certificates are held twice monthly at the principal sea ports in Great Britain. Each examination is divided into two parts, A and B. The examination for Part A of the Second Class Certificate may be taken at any time after completion of apprenticeship but before taking Part B of this certificate, eighteen months' watchkeeping service at sea must be completed by the engineer.

In the case of the First Class Certificate, Part A may be taken any time after obtaining the Second Class Certificate, but before taking Part B, a further eighteen months' sea service on watch in a senior position must be fulfilled by the engineer. Both First and Second Class Certificates are graded steam and motor according to which type of vessel the engineer has served in, but there is also a Combined Certificate which is granted to an engineer who has served the required period of service on both types of machinery. Above the First and Second Class Certificates, the M.O.T. has the Extra First Class Certificate and for which no qualifying sea service is required after obtaining the First Class Certificate. This certificate is for engineers who wish to prove their superior knowledge and although this certificate is not required for sea-going positions it is a highly esteemed qualification for some professional and government appointments.

Training for all these types of certificates is obtainable at many technical colleges throughout the country and are generally about three to four months for First and Second Class Certificates and about nine months for the Extra First Class Certificate, but the time spent is dependent on an engineer's previous experience and training.

For both apprentices and engineers the time spent at a technical college is devoted principally to the theoretical side of engineering. By this, the theory thus learned is then applicable to the every-day work in the engineering works or on board ship. At least this should be the case, but how often it is found that knowledge supposedly gained by a young engineer is not in fact appreciated at the time, although he may be working with a varied and interesting type of work. And so it may be, after the

marine engineer has obtained the two M.O.T. certificates, that arrangements could be made for a short refresher course giving him the opportunity of obtaining first-hand information as regards marine engineering and associated trades' production methods, and improvements in boilers and machinery, with a view to improving his appreciation of the valuable machinery in his charge at sea. This could include a brief series of lectures on ship economics, enabling the operating engineer to have a better understanding of the shipowner's problems in the running of ships. This should not be difficult in these days with so much tonnage under construction, and so much machinery and boilers being built with marine engineers standing by during construction. While this is largely the concern of the shipowner, it is not expected he would be slow in recognizing its future value to the shipping industry.

As the title of this paper indicates, I have dealt almost entirely with the training of engineers who will spend some years of their life at sea, and I have endeavoured to keep to this aspect of marine engineering, for what is wanted now are engineers to go to sea and also remain there. So often, and perhaps rightly, it is thought necessary to stress the opportunities of shore jobs in the future.

The marine engineering profession does, however, give opportunities of a good career to a much wider extent than a life at sea, and those with all the qualifications dealt with in this paper will find opportunities for advancement as engineers in a very wide field on land.

Marine engineering is a branch of mechanical engineering; indeed, one of its most fascinating branches, for anything suggestive of the sea has not only an element of adventure in it, but often a touch of romance. The training from apprenticeship to gaining M.O.T. certificates produces sound practical and technical engineers, with qualities of leadership as well, and with sufficient competitive spirit in it to act as a spur to the ambitious man.

So far as shore positions are concerned outside the shipbuilding repair, and marine engine building industry, marine engineers will be found everywhere, for one of their chief assets is their knowledge of the running and maintenance of machinery and its associated problems. So they will be found as chief engineers of steelworks, chemical works, and in oil refineries, margarine and sweet factories, in hospitals and in power stations, and in all varieties of works of an engineering character or requiring engineers having the varied and high training to be found in fully competent marine engineers.

In conclusion, I have to thank a number of my colleagues and others for the helpful advice they have given in the preparation of this paper.

DISCUSSION

The President (*I.N.A.*), **Viscount Runciman of Doxford, O.B.E., A.F.C., D.C.L.,** opening the proceedings, said: The word "symposium," if I remember rightly, originally meant a drinking party. Plato's, the most famous one of all, which gave its name to those which came after, went on right through the night and until the following morning. We are in some danger of doing the same thing. I therefore propose, and I think you will agree, that we set ourselves a pretty strict timetable, and I shall do my best to stick to it. We want to finish soon after 4.30 p.m. This will allow ten minutes each for the six authors to present their papers, five minutes each for the large numbers who have sent in their names to contribute to the discussion, and finally ten minutes each for the authors' replies.

This timetable was agreed to.

Mr. E. L. Champness, C.B.E., M.Sc. (*Honorary Vice-President, I.N.A.*): Professor Telfer desires his paper to be "wrath-provoking" so perhaps he will forgive me when I say it is irritation he provokes when he refers to "the general absence of high quality" in the same breath as a reference to our losing world supremacy in production, with its inference that this is due either to lack of quality or educational matters.

He must know that that is due to steel supplies and other factors. Some of the emphasis at the present time might give the impression that this country is falling behind in the matter of scientists, technicians, etc. in the shipbuilding world, and the general public may be in some danger of accepting that without much thought.

Mere numbers are not the proper yardstick to apply, and counting of heads of those who have gone through universities and technical colleges (as nearly all do in the newer industrial countries) ignores the vast numbers of those in this country trained in the practical atmosphere of the works themselves, or indeed in the school of experience to a very high level. Many of these are at least the equal of the heads counted abroad.

Not by any means does all scientific and technical advance come from those with university degrees and we should be careful not to belittle our achievements, which in quality, invention, and pioneering still lead the world and stand all comparison.

There is not so much wrong in an industry which can produce imaginative ships like the new P. & O.—an industry quick to adopt all new materials and to change completely its constructional practices as it has done, and there is no reason to think we are falling back.

Nor do I share Professor Telfer's apparent general discontent with the attitude of industry towards higher trained men. It seems to me he is tilting at a 1936 minority opinion in days very close to a major depression, and on the erroneous assumption that industry thinks the same to-day.

What do we expect to achieve as the outcome of these discussions?

I have the uncomfortable feeling that we may just be re-hashing the past and the dish is much the same despite some of Professor Telfer's controversial garnishings which may, however, provide some diversion.

I hope we may hear something from those younger graduates telling us frankly their opinions.

May I throw a few bones into the arena in the form of questions which bear on training or recruitment and do not criticize the results of our present training methods in the universities, which if viewed in the proper perspective, is quite a proud record.

(i) Will Professor Burrill venture an opinion as to whether his equipment and staff, together with the new engineering laboratories at Newcastle, offer civil students as good advantages as those at Manadon and Greenwich do for naval students. If not, what would he desire in equipment and staff to give an equal opportunity?

Manadon has obviously involved large expenditure, but industry is not exactly poor at present and progress on parallel lines should not be lacking if required. Now is the time to say so.

It may be noted that the Admiralty establishments at Haslar, Rosyth, and elsewhere are available for short courses to trainees. Have we any equivalent at N.P.L. or B.S.R.A. establishments?

(ii) What real effort does the industry make in publicity which reaches at the right time our public schools and other higher schools to show young people at an impressionable age the vital interest and constructive nature of our profession and industry? These are the main sources from which we are likely to draw men of the type to whom no doubt our President referred in the remarks which Professor Telfer queries. The mere availability of odd pamphlets on the subject, to be had on application or sporadically issued, is not sufficient. It has to be planned and sustained effort by skilled staff who believe in it and are trained in publicity and know how to get it by film, radio, T.V., and other means.

I suggest we have yet to learn that it need not be undignified to keep on blowing skilfully on one's own trumpet in these modern days.

(iii) It is possible to detect in Professor Telfer's paper that there still persists a lingering belief in "two B.Sc.'s per annum for the whole industry": or a notion that the possession of a degree is a passport to an immediate senior job instead of a visiting card with eventual advantages, or that qualifications might condemn one to a life as a backroom "boffin."

If so there is certainly scope for publicity.

(iv) Have we yet realized that the die-hard who insists on a rigid interpretation of the requirement that "Graduates should complete a recognized course of apprenticeship" may be quite out of date to-day?

Even with a four-year university course, time is already crowded if it is to allow the full benefits of university life, by no means unimportant, and the additional time needed for apprenticeship could be far better spent in a stream-lined practical course for men of this calibre.

Need we really be so shy and disguise the fact that there is and always must be an officer class in industry which needs differentiation between graduate trainees and trade apprentices?

(v) Conscious as we are of research, we are also conscious of the needs of practical industry.

The prophet Hosea referred to Ephraim as "a cake half-turned." If you quote research men only you are likely to give colour to the 1939 paragraph 11 comment and be accused of producing too many Ephraims cooked on one side only, with the impression that they cannot fit into the hurly-burly of industry.

The industry should not judge the universities by research men only, so give us the whole story and include the pass degree men as well and the proportions will show up the real contribution the universities have made to industry.

I do not comment on Professor Palmer's paper, knowing full well the results of Admiralty training, except to raise two very minor points.

I confess that a first reading of his remark that most British universities knew nothing of ships gave me some surprise, but then, realizing that there are some twenty universities or university colleges here, it is of course correct.

However, since his paper may circulate abroad, I had rather he had qualified it by giving the exceptions as the Universities of Cambridge, Durham, Glasgow, and Belfast. His comment, however, lends force to my plea for publicity.

I reflect whether, if his paper could have been entitled "Training of Constructive Officers of the Royal Navy," there might be any cause to complain of recruitment.

Mr. Stewart Hogg (*Member of Council, I.Mar.E., M.I.N.A.*): My remarks will be on the excellent paper by Dr. Dorey.

Unlike the Royal Navy, shipowners had no scheme of training for their engineers until 1952, when the shipowners' Alternative Training Scheme was introduced. The majority of merchant navy engineers still receive their pre-sea training as craftsmen, student or technical apprentices, or graduate apprentices in one of the many large and small engineering firms, maintenance departments in collieries, steelworks, factories, and even in hospitals up and down the country. Some of these engineering firms have excellent training schemes which are costly, while others simply regard apprentices as a form of cheap labour.

It would also be a great mistake to think that many of the 3,000–4,000 young men who go to sea each year belong to Systems 2, 3, or 4, which are given in the paper, or that they started their apprenticeship with the idea of becoming marine engineers. Fortunately for the nation, the mechanical engineering industry, etc., as a whole still trains more apprentices than can be absorbed. The Merchant Navy attracts a relatively small number of the annual throughput of the well-trained engineers, as measured by the author's yardstick, i.e. those with National certificates, diplomas, or degrees, who wish to supplement their training with experience of operating and maintaining machinery at sea. Most of these young engineers or technicians who do go to sea stay only long enough to obtain First Class or Extra First Class Certificates. I do not think the shipping industry should despise these men, who should and do form the hard core of marine engineers. Usually they are knowledgeable, enthusiastic, eager to learn and at the zenith of physical fitness, and they give of their best for four or five years for the valuable experience gained by service at sea. A steady flow of these men who spend only a short period at sea improves promotion prospects for the few who wish to make the sea their career. A few of those who leave the sea return to the shipbuilding and repairing industry, where good use is made of their experience. The great majority of first voyagers belong to System 1 in Dr. Dorey's paper, which I would like to qualify, for many engineers in this group have in fact reached the S2 examination of the Ordinary National Certificate or one of the City and Guilds' examinations. It is unfortunately true that a large number in this group have received little or no technical education.

The author did not mention that the quality of the craftsman from this group is changing, particularly in the fitting trade. This is the machine shop age, and the skill or the opportunity to acquire the proficiency needed in former times cannot be obtained, as it is no longer necessary in many engineering works.

Many firms have introduced apprentice training shops in which the apprentices are taught to use bench tools and to operate small machine tools for periods up to six months before being allowed into the fitting or erecting shops or on to other production work. This training, I am told, compensates in some measure for the lack of some of the opportunities no longer available to acquire craft skill.

The author does not appear to be happy concerning the practical training received in the shipowners' Alternative Training Scheme. Perhaps it is rather early to pass judgment on this experiment, but constructive criticism from such an authority is always more than welcome. The author stresses the shortness of the period of workshop service and asked if it were the primary intention to give these boys, in the final phase of their training, further experience as mechanics or general experience in a well-equipped marine workshop. The object is definitely the latter.

I would also like to make it clear that these apprentices also receive workshop training during the two years spent at the technical college and during vacations, and this is also supplemented by the 18 months' sea service, when they should be employed usefully on machinery overhaul and maintenance. The training may not compare favourably with the ideal four or five years' apprenticeship served in a first-class marine engineering works, but may be superior to many other forms of apprenticeship served by the majority of present-day marine engineers. In order that the scheme should operate satisfactorily, the apprentices should be guided and encouraged to take full advantage of all the available opportunities. I will then have no doubt that they will be reasonably good craftsmen and that the scheme will produce engineer technicians of a better quality than the average sea-going engineer to-day.

I have some misgivings concerning the workshop training received at a few of the establishments where these apprentices serve Phase III of the scheme. There appears to be a tendency to allow the boys to wander about the shops and act as observers, rather than to give them real productive work which will be not only in the best interest of the shipowners but also of the shipbuilders of whose products they will be in charge when serving at sea. We must also remember that we live in a changing world and the majority of technical advisers to shipping companies place more emphasis on technical knowledge and less on craftsmanship than formerly. In their opinion modern machinery is more reliable in service, provided you have technically qualified people to look after it, and with this I entirely agree. Dr. Dorey himself, during his long and distinguished service as Chief Surveyor of Lloyd's Register, played no small part in the great progress which has been made in the field of reliability in service and the discovery and elimination of intrinsic weaknesses in design.

The author would note with satisfaction that an effort is being made in the shipowners' scheme to teach apprentices some electro-technology. This subject is not included in most training schemes for many reasons, but it is most important for chief engineers in modern ships to know more fundamental electro-technology.

I find it very difficult to understand the drift of the author's remarks about Higher National Certificates and "engineering knowledge." The Higher National Certificate courses in technical colleges are planned on the requirements of local industry in the areas which the colleges serve, and as far as I know they do so. In the districts where marine engines are built, the emphasis is laid on appropriate subjects suitable for apprentices engaged in the design and manufacture of heavy motive power engines. If the author were to study the details of the syllabuses for the Special O.N.D. course, the correspondence course, and the endorsement subjects in the Alternative Training Scheme, he would find his ideas already included, particularly the inclusion of engineering knowledge and electro-technology, which are made a feature of the part-time education for endorsement on the diploma.

The author warns about the danger of too much theory at the expense of practical training. Most of us would agree with him if that indeed were the case. The range of technical ability among sea-going engineers to-day is greater than ever, but the average ability appears from the examination statistics to be less than in former times, when the field of recruitment was generally limited to apprentices from marine engine builders and repairers.

The marine engineering industry has been in recent years and still is passing through a transition period. The type of workshop training is changing, much more emphasis is placed on technical

training, machinery is much more complicated than formerly, though generally more reliable if operated intelligently. I had hoped, therefore, that Dr. Dorey would have lifted the curtain that hides the future and given us just a peep of the training most desirable for the junior engineers in the next decades.

A number of engineers in modern vessels have told me that "preventative maintenance" should be the aim and that this can best be achieved by intelligent young men trained to the standard of the Higher National Certificate with average skill in the use of hand tools and small machine tools.

Sir Victor Shepheard, K.C.B. (*Vice-President, I.N.A.*): The most challenging of the papers is undoubtedly that by Professor Telfer and I find myself in agreement with him on most of the points he makes. There can be no doubt that there is an appalling shortage of skilled technologists in this country to-day, and this applies to all branches of engineering and applied science. The demand for engineering graduates with good degrees greatly exceeds the supply, with the result that the firms and corporations who need first-class men have to offer fantastic inducements in order to get them. I think that on the whole the Royal Corps of Naval Constructors offers a good career to graduates in the mechanical sciences; yet in recent years we have not been able to recruit more than one half the men we need. In fact, last year we did not get a single recruit from the universities.

The reason for this shortage is undoubtedly the very backward state of scientific and technological education in this country. Already, in this respect, we have fallen far behind the leading industrial nations of the world, full evidence of which was given in the Government White Paper published last year. This paper stated that out of every million of the population the United Kingdom produced 57 graduate engineers, Switzerland 82, Western Germany 86, the U.S.A. 136, and the U.S.S.R. 280.

This problem is now beginning to receive some attention from the Government and the industries concerned, but without any great sense of urgency. Even if better facilities for technological education could be provided to-morrow, it would be many years before industry could begin to reap the benefits. Meanwhile, we must face the very unpleasant prospect of becoming a second-rate or even third-rate industrial nation.

The trouble, in my opinion, stems from the fact that little, or nothing, is done in our public and grammar schools to encourage the best boys to consider science and technology as a career. Our education system is almost entirely in the hands of classicists with the result that scientific education in our schools is sadly neglected and the teaching of scientific subjects is generally not of a high standard. Science is looked down upon as being something inferior. Only last week I happened to overhear a conversation between two gentlemen of the Church who were apparently discussing science; one remarked: "Science, after all, is merely a convenient way of earning a living; it is not a way of life." I did not make the terse and perhaps ungentlemanly remark which immediately sprang to my mind, but I did think it is fortunate for them that some men are misguided enough to enter the engineering and scientific professions in order to provide them with a "way of life."

An eminent scientist recently expressed the opinion to me that at least one-third of the undergraduates reading the pure and applied sciences at our universities are not of the mental calibre suitable for a university education. Possibly he is right, but I do not think the reason for this is that the general mental capacity of young people to-day is lacking. The more likely reasons are either that the careers offered in engineering and science are not sufficiently attractive to young men, or, as I have already suggested, the schools are concentrating far too much on the classics and humanities to the exclusion of science, and therefore are not producing the right raw material for the universities.

Because of the shortage of suitable candidates from the universities, the Admiralty started last year a new scheme of entry into the Royal Corps of Naval Constructors direct from the schools, mention of which is made in Professor Palmer's paper. I am sure that the career we have to offer is an excellent one, and I hope that as a result of propaganda in the schools and advertisements in the Press, we may succeed in obtaining sufficient recruits of the standard we require, and at the same time do something to foster more enthusiasm for scientific education in our schools.

I am convinced that the problem of improving technological education in this country must first be tackled in the schools with the object of providing more and better undergraduates.

I agree whole-heartedly with Professor Telfer in his desire to see more graduates employed in the shipbuilding and marine engineering industries. Surely, no one would deny to-day that a good sound education in the applied sciences is essential to a man who looks forward to a successful career in any of the engineering professions, whether his future lies in design, production or in management. Also, I agree with Professor Telfer in his desire to see more schools of naval architecture and marine engineering. But I cannot see how these ideals can possibly be realized until we can secure a better flow of potential undergraduates from our schools.

In conclusion, I would like to compliment the Institutions for arranging this timely symposium which I sincerely hope will be the beginning of a determined attempt to solve the urgent problems which undoubtedly exist.

Mr. H. S. Pengelly, C.B. (*Member of Council, I.N.A.*): For one who has had, perhaps, more to do with the training of candidates for the R.C.N.C. than any other member of the Corps, past or present, the naval architecture papers have been read with much interest.

Professor Telfer's paper, as the title suggests, contains challenging statements. The paper appears to divide broadly into two parts:—

(1) Criticism of the 1939 report of an Institution Committee. It is, of course, not difficult in 1957 to criticize a report made in 1939. Although at this time many will not agree with all in the report, the membership of the committee gives confidence in the validity of its findings at that time. Little exception can be taken to the extracts quoted by Professor Telfer; surely the second extract should not be taken as a reflection on the men who had held the research scholarships? On the other hand, it is open to doubt whether the holding of the scholarships had any great effect on the subsequent careers of the holders, or on their ultimate status in the profession.

(2) Proposals to increase the number of first-class students of naval architecture. These may be summarized as follows:—

(i) "Get hold of the student just before he leaves school . . ." Does Professor Telfer really believe that the best brains can be attracted to naval architecture by catching young men before they have had time to think? Experience shows that the first-class lad (the potential honours man) looks ahead and examines whether a profession offers a reasonable chance of an interesting and profitable career in return for solid work.

(ii) More professors and schools of naval architecture. Some may think this is putting the cart before the horse, as at present there are not sufficient first-class students to warrant such increases. Nevertheless, the writer would welcome the institution of chairs of naval architecture at London and Bristol Universities and regrets the loss of the chair at Liverpool. He doubts if Cambridge would be likely to deal with such a specialized subject as naval architecture, nor does he consider this necessary.

(iii) An international conference of professors, apparently to teach (some of) them how to present basic principles and how to "put over" their knowledge to students. It may be thought that professors who need such help have missed their true vocations.

(iv) A research team in each shipyard with a research director on the board. A more realistic proposal, and one the writer would like to recommend, is that each shipbuilding firm should employ a naval architect (as such) of sufficient status to warrant a position on the board.

The brief history of the training of naval constructors given by Professor Palmer shows that in this matter the Admiralty were enlightened pioneers. The majority of the R.C.N.C. have been recruited from the Royal Dockyards via the Dockyard schools, now more properly known as technical colleges. Important principles laid down when the schools were instituted are worth stating:—

(*a*) Regular attendance at school is compulsory.

(*b*) In return for time off work to attend school, apprentices must give some of their evening time to school.

(*c*) Retention at school for the second, third, and fourth years depends entirely on merit.

Such principles may not be much in favour in these days of "welfare state" and "fair shares for all," but they still obtain in the Dockyard technical colleges, although there is now rather more day and less evening classes than formerly.

It is clear that to obtain the numbers required, no effort is spared by the Admiralty to widen the field of recruitment. Experience has shown that sources of recruitment A, B, C, and D (see Appendix to Professor Palmer's paper) have each proved their value, though the numbers from B, C, and D have been less than desired; in recent years the number from A (Dockyards) has been less than required. Although some shipyard training prior to the university course is of value, experience with scheme C (direct from universities) has shown that it is possible to overcome the lack of such early practical training.

Comparison of the various university courses in naval architecture may be invidious, particularly as the standard of students at entry will vary considerably. It is, however, worth noting that:—

(i) The highly qualified students attending the three-year Greenwich course receive instruction for a total of 2,700 periods (of 70 minutes) of which 1,164 periods are devoted to naval architecture.

(ii) Durham in its four-year course has a total of 2,718 hours' instruction, of which 1,380 hours are in naval architecture.

(iii) Glasgow in its four-year course has a total of 2,186 periods (of 50 minutes) instruction, of which only 560 periods are in naval architecture.

Few will contest the four major requirements for a good naval architect enunciated by Professor Burrill, nor his following remarks about human qualities, etc. It must, however, be clearly understood that the young men who measure up to these requirements will expect good career prospects in return for much hard work. Such men are being sought by many industrial and scientific undertakings who send scouts to the universities with tempting offers for First and Second Class honours degree men, of whom there is a limited number.

It is clear there is no difficulty in arranging a satisfactory scheme of training in naval architecture. Why then is there a shortage of first-class recruits and why do our scholarships more or less go begging? It is felt that some of the blame must rest with such shipbuilding and shipowning firms as do not consider it necessary to employ a first-class naval architect (as such) with appropriate status. This is a short-sighted policy even in these days of full order books and may well be losing the firms thousands of pounds a year. When order books are less full and international competition for orders becomes more keen, the lack of encouragement to the first-class young men of to-day to take up naval architecture as a career may well spell disaster to our great shipbuilding industry.

The industry should take steps to recruit its share of the yearly output of men with good honours degrees in engineering and the mechanical sciences. Perhaps the Shipbuilding Conference could examine the problem; the Admiralty would probably help in giving such recruits the necessary professional training by admitting them as private students to the Naval Constructors' courses. It must be emphasized, however, that the best type of honours graduate will not be attracted to naval architecture unless the career prospects are good.

Mr. John Brown, B.Sc. (*Member of Council, I.N.A.*): I should like to direct attention to the more solid matter of papers Nos. 2 and 3 and to ask your consideration of the virtues of the sandwich system. Professor Telfer has indicated that he thinks we have enough intelligence to realize that this has nothing to do with the luncheon habits of the workers! But some definition of it is required, and Professor Robb has offered it, indicating that the true sandwich system is one of six months' college work and six months' works training.

It would appear that the Newcastle and Greenwich courses could not truly be termed sandwich courses because, although they allow a practical training period during vacations, it seems limited and the main works training course will either have to precede or follow the college course.

Professor Robb quotes views expressed in other professional Institutions which favour a pre-university period of works training before a course of the English college type. Undoubtedly it is desirable that contact with the practical work and with his fellow workers in his chosen field should be the experience of every student. This can be readily attained if an apprentice is employed by a firm for (say) six months to one year before commencing his first term of the university course. The frequent renewal of that contact at six-monthly intervals is the major benefit of the sandwich system.

A study of the tabulated durations of the courses at Glasgow, Newcastle, and Greenwich lends some support to the objection that the sandwich type of course severely limits the time for university study. The relative values are about 2,000 hours, compared with 2,700 hours for the three terms per annum courses. We are concerned with the education and training of naval architects, and it may be contended that the benefits of regular training periods in practical production work outweigh the abbreviation of university time.

It is, however, more perturbing to note that whereas the professional subject in the longer courses is allotted about 40 per cent of the total time, in the Glasgow course it achieves only 27½ per cent of the available hours. As Professor Robb states, the degree is in engineering, and the time not devoted to naval architecture is largely absorbed in engineering studies to a relatively greater extent than in the English courses. If more of this time were devoted to the so-called additional subjects and if these comprised an introduction to economics, commercial law, industrial psychology and kindred matters, it could be said to broaden the course, but a concentration on more intensive study of specialized engineering subjects cannot be said to do this.

On the other hand, it may be considered that the three-term courses devote an unduly large proportion of the professional time to drawing-office work, which the sandwich student covers in his practical training in more realistic fashion. I do not suggest that there should be complete uniformity, but some compromise on the relative time devoted to professional subjects may be worthy of study.

Professor Robb has mentioned the conditions of entry into the Scottish universities, and there appears to be some scope for investigation here. There is a difference in the regulations in Glasgow and in Newcastle which deprives some students of the opportunity to go to the Scottish universities, while they are still admitted in Durham. I believe it is a matter of a language qualification. I suggest to Professor Robb that the regulations might be drafted a little more widely. As they are at present they might hinder the good Higher National Certificate student who might wish to proceed to the full degree course, and that would be a major loss.

Mr. D. G. Alcock (*Member of Council, I.Mar.E.*): As regards the Alternative Training Scheme for marine engineers referred to in Dr. Dorey's paper, the author doubts the ability of young men in various respects but, speaking from some experience, having employed large numbers of these young men, we have a scheme which we have found to be satisfactory and we ourselves have no doubt of the manual ability of the apprentices. Reports from our chief engineers show that they have been uniformly good and this scheme has given our company and other companies the opportunity to recruit their own young men and to establish a method of youth entry.

I would add that at this date the fears about the retention of the young men within the shipping industry are not justified. All of the first entrants to the scheme who have, or are just about to complete their apprenticeship, have signified their willingness to re-enter our service. To give some idea of the losses which have occurred, I think it is sufficient to say that despite a very poor start in the first year of the scheme, well over 90 per cent of the total numbers recruited are still serving.

I do, however, consider that the scheme suffers from a number of difficulties; it is far too rigid in its requirements, which are principally designed to meet the examination regulations of the Ministry of Transport. Unfortunately, statutory requirements do not constitute a sound basis upon which to build a training scheme. Any training scheme must satisfy the consumers' demand which, in this instance, is the operation and maintenance of ships' machinery at sea, not the ability to produce engines for sale, and it would appear that, with the experience to date, the workshop service periods are unnecessarily long.

It would be as well to bear this in mind when considering the subject under discussion. It is an operating engineer who is required afloat, a man with sufficient technical knowledge to interpret a technical instruction; sufficient manual skill to carry out preventive maintenance, and sufficient of the officer-like qualities to exercise command and control of personnel. If these requirements are to be satisfied it would seem that a revolutionary alteration in ideas about training of sea-going engineers must come about and at the risk of causing some controversy I would suggest that the training of sea-going engineers should be governed by the following factors:—

Firstly, that the basic technical qualification for marine and mechanical engineers is similar and that for sea-going engineers initially the Ordinary National Certificate standard, such as might be achieved in any technical college, is quite sufficient.

Secondly, that the only place to gain experience of a job is on the job and, therefore, that once sufficient manual skill has been obtained, the training ground for a marine engineer is afloat.

Thirdly, that this previous statement also applies to those who commence a career afloat after completing a works apprenticeship ashore.

Lastly, that if we require a man to perform efficiently duties of any nature, he must be adequately instructed in them, which, in the case of a marine engineer, could most efficiently be dealt with by attendance in a specially equipped marine instructional centre or college, after the completion of general technical education and the acquisition of sufficient manual skills.

I would like to add that the co-operation of the technical college staff, sea-going personnel, and the employers of the various engineering companies has been greatly appreciated.

In conclusion I can only say that I envy my colleagues who are responsible for the other methods of training described in this Symposium; they appear to be able to "paddle their own canoe" without the interference from those who carry no financial, professional, or other form of responsibility for the staffing of ships with efficient personnel but who, nevertheless, have much to say upon this subject and attempt to exercise an influence upon it far beyond that which would be tolerated by other industries.

Mr. J. Lenaghan (*Member of Council, I.N.A.*): Professor Telfer is most unkind to shipbuilders and overlooks much of the good work done by individual yards to encourage their apprentices and pupils.

I doubt very much if the shipyard is the right place for research, undoubtedly more development work should be undertaken at the yard, but research as such is much better in the hands of a central organization such as B.S.R.A., which serves the industry well.

The shipbuilding industry is, in total numbers employed, comparatively small compared with many others in the heavy and capital industries group. It is therefore doubtful if it could adequately support, in student numbers, more than three schools of naval architecture. In addition to Glasgow and Durham I personally would like to see the Royal Naval College at Greenwich more closely linked to private industry, even if only to undertake the education of naval architects as a sub-let from London University. This university for the present has no interest in naval architecture, but its interest might be encouraged if the professional side of the course could be taken at Greenwich.

Technical qualifications in the world of commerce covers a broad field. Commercial and financial qualities in a competitive industry are equally as important, in their proper place, as the technical qualification of the specialist, and to some extent, therefore, the road to the top is fairly open. In this respect shipbuilding is a classless society, but the all-embracing attribute of the successful shipbuilder is that he should be able to design, cost, build, and sell ships, and the education and training of naval architects must cover this very full course if the topmost rung is the ultimate aim.

The problem of greatest concern to shipbuilders at the present time is recruitment, and especially recruitment of young men with a good general education. Also the further problem of numbers of bright young men, after graduation and training, who drift away from shipbuilding to other industries. These problems no doubt will continue until certain changes are made. More opportunities for advancement are needed for both inside and outside staffs and towards this end it is suggested that some form of reclassification, embracing all that this implies, is needed. The different stages between the position of junior draughtsman and naval architect could be better defined, viz. draughtsman, technical assistant, assistant naval architect, naval architect. Progress upward from one stage to another would, in the transition stages, largely depend on experience and ability rather than certificates or degrees, but in the course of time with more entrants of better quality coming along academical achievements, other things being equal, at either the university or at the technical schools would be taken into count. "Ship draughtsman" is a vague, colourless title borne by everyone in the drawing offices, whatever their ability or the work they do. However, new names alone will not solve these problems, but they will go a good part of the way.

Outside appointments in the shipyard cannot now be regarded as solely the prerogative of the trained naval architect. Planning for production and efficient production for maximum output (quality not forgotten) is the aim, and in this machine age the highly skilled mechanical engineer has almost an equal chance with naval architects for a definite place on shipyard management staffs. Indeed the practice of shipbuilding is more easily superimposed on a mechanical background than mechanical engineering is on a background of naval architecture. This may be heresy, but personal experience tends to confirm there is much to commend this opinion.

Shipbuilding offers graduates equal opportunities with most other industries and provided those choosing this as their career are hard-working, well-balanced all-rounders, their road to the top is reasonably well defined and full of interest.

Mr. C. H. Taylor-Cook, B.Sc.(Eng.) (*M.I.Mar.E.*): My only

regret over this Symposium is the scanty reference to part-time education and to the work of the technical colleges.*

I would immediately challenge Professor Telfer's assumption that a university education is necessarily the best. There seems to be a tendency to refer to all the good points in university education and all the poor points in technical education without admitting that there are other considerations in both types. Great play is made of the "liberal" aspect of university education. I may be thought a heretic, but I consider that technical education, accompanied as it always is by workshop experience, can be just as true and complete an education. Is the ability to mix with other graduates as great an advantage as the experience of working with all other grades of industrial worker? Professor Telfer claims that the university course would produce a mature student. My own experience contradicts this as many of the graduates that I have met have been completely out of their depth in an industrial environment. I agree completely that a university training is essential for a pure research worker and for such work as advanced propeller design or resistance calculations. But a man trained in a technical college with a Higher National Certificate in naval architecture is quite able to take the results of pure research and put them to practical use. He can produce a set of lines and stability curves, carry out strength calculations, and make preliminary estimates of power requirements.

As regards Dr. Dorey's paper, I would like to amplify one or two points lest there be any confusion in interpretation. Whilst serving an apprenticeship starting at the age of 16, it is possible for a student to obtain the Higher National Certificate in five years by attending evening classes only—I did it myself. If a student attends part-time day courses, i.e. one day and one evening per week, he should obtain Higher National Certificate plus an endorsement. It is becoming more and more common for engineering firms to allow this during the whole apprenticeship and this is a very desirable development, as I am sure you will agree. In the apprenticeship scheme referred to in paragraph 5, known widely as the "alternative entry" scheme, the standard of any one subject in the examination is slightly above that of the Ordinary National Certificate, but the student must pass in four compulsory subjects and two out of three optional subjects, i.e. six subjects as compared with three in the National Certificate. Further, his education is continued by means of a correspondence course whilst he is at sea and by further part-time classes during his twelve months in industry.

The suggestion that a course in engineering knowledge and a foreign language might be added to the National Certificate course is interesting and offers some desirable features, but it could not be done without lengthening the course. The time available during the five years is all too short for the present subjects and additional subjects would have to be taken as endorsements subsequently. English is already included by most technical colleges in their part-time day courses although it is not recognized as a National Certificate subject.

Dr. Dorey made several references to M.O.T. certificates and suggests that, with a suitable apprenticeship, and an Ordinary National Certificate, a young man should obtain these without difficulty. It is only right that reference should also be made to the difficulties that do exist however. A marine engineer officer can obviously go to a marine school only at the end of a voyage and it is sheer coincidence if this is at the beginning of a school term. The colleges therefore have to receive (and lose) students erratically and it is very difficult to arrange the course of instruction. Furthermore, only a limited time is available unless the engineer is prepared to stay ashore at his own expense. Indeed, the majority of students for the Extra First Class face twelve months ashore without any earnings, although it is gratifying to note that some education authorities are now awarding county major scholarships for this course.

* [But see also writer's remarks on technical colleges in Written Discussion p. 383.—*Ed.*]

Mr. L. Woollard, M.A. (*Honorary Vice-President, I.N.A.*): The paper by Professor Palmer is very interesting to me for personal reasons. Since I first went to Greenwich in 1902 there have been many changes, and in my opinion there have been advances in many directions. Education there has been broadened.

In the brief time available I should like to refer to a point at the end of Professor Palmer's paper, viz. the new entry to Greenwich and the Royal Corps of boys from public and grammar schools. I do not think that sufficient publicity has been given to this means of entry, nor is it fully realized how important a departure it makes from every previous mode of entry to the Corps. Schemes have hitherto been suitable for older men or for men already partly trained either in shipbuilding or in mathematical or technical subjects. Now, however, a boy is invited to apply when he has no such training; and it will enable us to answer parents who have often asked me how a boy, interested in warships and in their design and construction, can get into the profession. Hitherto I have never been able to answer that question quite satisfactorily, and I hope, therefore, that this new scheme will be properly and fully publicized.

I agree with much of what Professor Telfer says, but I think he has over-stated the lack of interest in shipyards. To-day many of the shipyards are taking a very big interest in the training of their people, high and low, and are doing quite a lot to help them; and although sometimes and in some places more might still be done, a wholesale reproach is, I think, now undeserved, and commendation should be given in many quarters.

My final point is rather of a pedagogic nature. Professor Telfer states that the blackboard is an excellent medium for spontaneous explanation and discussion, but is a grossly abused instrument of university education. This seems odd to those of us who have had the pleasure of listening to Professor Telfer illustrating his own papers or remarks, and have noticed how his hand seems to stretch instinctively to chalk and duster. Nevertheless I agree with what he says. At Greenwich and elsewhere notes are now handed to the students beforehand, and there is a good reason for this change. Our profession has advanced enormously, and we naval architects stand on the shoulders of our predecessors. It is hardly fair to expect a student to start entirely from scratch; he must be given a sort of ladder to enable him to reach the heights we all hope to see him attain.

Mr. A. J. Sims, O.B.E., R.C.N.C. (*Member of Council, I.N.A.*): A key problem in obtaining recruits of an adequate standard for university training in naval architecture is the provision of the necessary practical experience in association with the theroetical studies. It would be unrealistic to believe that the apprentice system will continue to provide an adequate number of university students—the young men we want can by-pass apprenticeship and read other subjects if naval architecture fails to provide the attraction.

The Royal Corps of Naval Constructors met this problem in the middle 'thirties when it had to expand to meet the rearmament programme. The dockyard apprenticeship system—which had been the backbone of corps recruitment throughout its history—no longer provided adequate numbers and university men had to be attracted after graduation. Practical training was safeguarded by setting up a special Training Office at Devonport Dockyard and this scheme has worked well. Some such scheme may well have wider possibilities if the shipbuilding industry is not to lose the talent which the apprenticeship system formerly provided.

Professor Telfer asks how far the student should be lectured and professorially dictated to from notes which were already old when the professor himself was young. As a student, I was lectured in calculus by the professor of mathematics, although

I imagine the material had not changed much for many years. One reason was probably to ensure that we had a sound groundwork for more advanced studies. The professor of naval architecture must personally ensure that the groundwork in hydrostatics, stability, and strength are clearly understood by each student. Although the notes may be fairly static, the professor should be able to impart much experience to enhance the student's understanding. Advice on advanced aspects of naval architecture can often be obtained from experts, but there must be no loss of deep understanding of the fundamentals of our profession.

I wonder how many examiners realize the far-reaching effects of the papers they set? These do more than test the immediate batch of students; they set the pattern of future studies. Who can blame the harassed student if he examines the last few years of papers and guides his studies accordingly? A good memory is important, but a deep understanding is more so, and I believe that examination questions should emphasize the latter more than the former.

This is particularly applicable to practical naval architecture which—like English history—should be a fascinating subject but often becomes dull in the teaching. The reason is the same; the emphasis is often placed more on memory of facts than on understanding the reasons behind them. The examiner can play a vital part in ensuring that future instruction and studies are correctly channelled.

Finally I would like to refer to sub-university courses. In recent years I have been brought into close contact with the National Certificate courses. I realize the excellent object these courses meet, although—as an aside—I have a hankering after a nationally agreed course and a nationally set examination so that we are certain of uniform standards. There is, however, a gap between the National Certificate scheme and university courses. This is admirably filled at Sunderland by its diploma course and my impression is that the course stands in ideal relationship to the University at Durham on the one hand and the National Certificate courses in the Tyne area on the other. The diploma course is the correct sandwich system between practical and theoretical instruction as generally understood. Is there not a need for similar courses elsewhere in the country? I believe it will ultimately be found necessary for the better students of the Dockyard technical colleges. Is it not in keeping with modern conditions that the more or less equally apportioned sandwich system should apply at the level immediately below the university, leaving the practical experience of the university student to be gained by other methods?

Professor G. H. Chambers, D.S.C. (*M.I.Mar.E.*): There has, in fact, been for many years at Durham University a course in applied science related to marine engineering. The course is basically of four years' duration leading to a General or Honours degree. If one has a General Certificate of Education at A level or a Higher National Certificate one will probably qualify for exemption from the first year of the course. If one lacks such exempting qualification there is still the possibility of obtaining an Ordinary degree in three years.

I hope Dr. Dorey will forgive me if I suggest that he deals too modestly with the role of the marine engineer at the highest level. He only hints at current developments in marine installations and looks at them mainly from the viewpoint of the man who has to run them at sea. I feel sure he will agree that the role of the sea-going engineer is not the only one vitally concerned.

In the Navy it may once have been the main qualification of the engineer officer to be able to run his machinery continuously at full power. Captain Aylen intimates that now other jobs are equally important, such as the selection, in fact the inspiration, of new machinery installations. We have heard from Captain Aylen how qualified engineer officers undergo a two-years' advanced course to equip them for such work. I suggest that such work is of equal relative importance in the Merchant Navy. In fact, Dr. Dorey hints at it when he says that the sea-going engineer will have to cope with gas turbines, free piston engines, and nuclear engines.

Someone has to take the responsibility for the devising, approving, and ordering of such installations, which will be different from those now at sea, and very different from installations found ashore. I suggest that the paper could lay more emphasis on the training of men for such work, who will practise marine engineering at the highest level. It is noteworthy that an increasing interest is being shown in such training by those who build and install marine machinery, by superintendent engineers, research associations, and classification societies.

The people to do this work in connection with the new installations come under Dr. Dorey's fourth category. As well as practical training and experience at sea, they need education in fundamentals considerably wider than are met in normal mechanical engineering. Experience has shown that if British ships are to have the best machinery, the men who devise it must be able to rub shoulders mentally and intellectually as well as humanly with the top people in naval architecture and mechanical, electrical, and nuclear engineering. While there are several ways of achieving this, there can be no doubt that the most reliable way is through the university, where the man concerned gets his training in fundamentals alongside the people being trained in those other fields in which he will need to co-operate in later life. Such a university course has to be carefully dovetailed with practical and sea-going experience. The whole is not a short affair. The rewards for it, however, are potentially well worth while.

Further, I have no illusions about the difficulties of obtaining sea-going engineers. We have heard that this is one of the main reasons for the engineering cadetships which firms have instituted. I suggest that a firm of such calibre has probably posts for one or more graduates in its superintendent's organization. I further suggest that the firm's willingness to assist suitable cadets to such graduateships could have a very beneficial effect on its recruiting.

Mr. A. Silverleaf, B.Sc., (*M.I.N.A.*): The first point which seems to me to be fundamental to our discussions to-day is whether the shipbuilding, marine engineering, and ship-repairing industries need more highly qualified and trained people than they employ at present, particularly university graduates. To judge from the papers and our discussion this morning, there appear to be three points of view on this question. First, there are those who maintain, with Professor Telfer, that more such people are needed, and several Government reports and statements appear to endorse this view. Next are those who believe that the shipbuilding and allied industries not only need more such people but actively want them and seek them out. Professor Burrill paints an encouraging picture in this vein, and Mr. Champness seems to agree with it, if with qualifications. Finally, there are those in an opposed camp who say that while the shipbuilding industries certainly need such people, they emphatically do not want them. The industries themselves, in their assessment of future requirements for graduate engineers as quoted in the Government report "Scientific and Engineering Manpower in Great Britain," seem to confirm this pessimistic opinion. In their papers, both Professor Palmer and Dr. Dorey take this viewpoint, and Sir Victor Shepheard and Mr. Pengelly in their contributions this morning seem also to accept it.

Mr. Champness, in discussing this question, said that the opinions of those closer to their own training might be useful, and I should like to volunteer some comments. I spent thirteen years in the shipbuilding industry, the last five in charge of a shipyard design office, and for some of that time I taught National Certificate evening classes. I always did my best to encourage good apprentices and students to take university-type courses,

but with scant success, and I suggest that the reasons for their reluctance are very germane to our discussion to-day. As I understood them, these intelligent and lively apprentices felt that in shipbuilding and marine engineering there were no real incentives and few genuine rewards, and they had a strong feeling that anyhow the future positions of authority were already well booked. If one wanted success in status and salary as rewards for good qualifications properly applied, then, so they argued, the place to get on in this way was in one of the new modern engineering industries. The apprentices I knew happened to be in shipbuilding, as I was, for a reason which, surprisingly, has not been mentioned to-day—they liked ships. Indeed, they stayed in shipbuilding largely because they preferred to be connected with ships than with anything else. After all, this is important, but, although many of them were prepared to suffer in consequence, it does not follow that young men will continue indefinitely to accept such a position.

It is only too easy to quote instances and episodes which seem to justify these young men's cynical attitudes. For example, I know at least one major shipbuilding firm in this country which regularly receives its quota of six copies of each B.S.R.A. report, and as regularly deposits the parcel inviolate in a cupboard in the managing director's secretary's room, there to collect dust undisturbed. Is it that the work and results described in these reports is of no practical value? Or is it that there is no one in the firm capable of understanding and applying them? Again, a colleague of mine, after graduating with a first-class Honours degree, went back to the design office of his firm, and there, in the middle of a devastating war, he spent a solid year calculating tank calibration curves. That does not seem the way to encourage apprentices to study hard to gain degrees and diplomas.

The second point I wish to discuss briefly is the type of education and training we should aim to provide for those whom we can attract for one reason or another. It seems to me that Professor Burrill has expressed the purposes and methods of university education for naval architects most admirably, and has very wisely emphasized the most important point that what is wanted is a broad training in applied science. Professor Robb also insists on this vital point and makes it clear that the Glasgow course specifically aims at this broad approach, and, as I well remember, the students understand this clearly. The basic similarities of approach between the Glasgow and Durham courses are more important than their detail differences. For this reason I disagree with Professor Telfer's plea for more specialized university courses in naval architecture; specialist knowledge is better acquired after graduation, in practical experience which can well be aided by short post-graduate courses. Indeed, I think there is a need for an increased proportion of undergraduate time to be devoted to non-technical subjects rather than to refined technical specialization. This appears to be the trend in several leading technical universities in the U.S.A. I understand that at California Institute of Technology, for instance, up to 25 per cent of undergraduate class time is now given to non-professional subjects. We might well consider this point.

The third topic is that of recruitment of qualified naval architects and engineers. I do not think that we can honestly admit that the opportunities in front of the young man to-day are much greater than they were thirty years ago. A host of new and attractive industries have sprung up since then, and if they offer the young man a lot of things which the shipbuilding industries do not offer, should we be surprised when he does not go into shipbuilding? In spite of these counter-attractions, I think we *can* attract good young men if we can bring about a popular recognition that the shipbuilding industries are not only essential to Britain's life, but are here to stay, and that they are progressive and modern-minded industries. Well qualified engineers and scientists are needed in industry for a host of interesting tasks, as almost every other modern industry shouts out from full-page recruitment advertisements in to-day's newspapers; until our shipbuilding industries publicly adopt the same attitudes we shall not attract our fair share of good youngsters. In this connection, I commend the principle of entry direct from school into naval architecture university courses. If we limit ourselves to attracting young men through shipyards and engine works I am sure we shall miss quite a few valuable recruits.

Mr. J. D. Calder (*M.I.N.A.*): I would comment on a remark made by Sir Victor Shepheard with which I have a great deal of sympathy, concerning the amount of time spent on the classics and the humanities. Only last night I was speaking to an authority on education, and I ventured to ask him what he really thought of the modern curriculum. He replied, "I can best answer your question by a parody of words used by Mr. Winston Churchill during the war, by saying 'Never have so many been taught so little about so many different subjects.' " That is a point which I think educationists need to bear in mind.

Mr. Taylor-Cook comments on the lack of references in the papers to the technical colleges. I think that when considering higher education we should look on the technical schools as providing a very valuable recruiting ground. We do find a lot of difficulty in trying to work in the day release system and in its practical application, and I would like to draw attention to an interesting experiment we are carrying out in Scotland in the small craft side of the industry, where for obvious reasons day release is impractical. We have managed to persuade the employers that, instead of releasing a boy on one day per week, they should release him for one month in six. We take such boys to a properly equipped centre in Edinburgh for four consecutive weeks twice a year, and they put in the same number of hours per year as when they are released for one day each week. They seem to assimilate much more in that way.

Professor Telfer says that by far the greater number of those in control of British shipyards to-day are actually graduates of liberal universities. Almost opposite, in the next column, he draws attention to the fact that at the time of writing we have lost our pride of place as the world's leading shipbuilders. Is this juxtaposition intentional, and might not a suspicious mind suggest that it is a case of cause and effect?

About his suggestions to increase the number of professorships, I suggest he is on a rather shaky basis when he refers to the amount of tonnage under construction, because I have taken out the figures for the last three years of the actual production achieved in the various countries and I find that Scandinavia, Belgium, and the Netherlands have completed practically the same tonnage as the British shipyards. I suggest that some of the students might draw him a graph, and he will find it illuminating. To allocate professors on a tonnage basis is rather difficult, because first we have to consider the geographical distribution of students and also the nationalistic tendencies of the smaller countries—and I cannot see any country being satisfied with 0·5 of a professor! I am in agreement about having more professors, but I am not sure that we are not over-optimistic if we suggest so high a figure as seven.

I give Professor Telfer 100 per cent support, however, when he advocates the loose-leaf tutorial system. I think it offers a great deal of scope for time saving, and at Greenwich the system appears to be already in use. I emphasize that.

I emphasize also Professor Telfer's opinion that ship drawing work should be taught and learned in the shipyard. In analysing the Glasgow and Durham papers, particularly Professor Burrill's, I found what a lot of time is spent on drawing-office work; I think that at Durham it is 35 per cent. Having regard to the calibre of Professor Burrill and his associates I suggest it is rather like using a steam hammer to crack a nut, and that the time could be much more usefully employed.

With regard to Professor Telfer's remark that we should invite the trade unions to co-operate more heartily, in the Scottish scheme we have done that, and that co-operation has been of great assistance.

In Professor Burrill's paper there is a slight reference to the need for sea-going experience and that need is fully appreciated and catered for at Greenwich. Many years ago a famous Clyde shipbuilder said to me, "Every holiday you get and on every possible opportunity, go to sea and find out what the sea can do to a ship. There are too many naval architects whose idea of seagoing conditions is gained from a trial trip on the Clyde on a sunny day."

Lastly, a very famous Scotsman, speaking at a dinner in London to a predominantly youthful audience, once said: "Always remember, the day will come when you will know as little as your fathers do now."

Mr. B. Baxter, M.Sc. (*M.I.N.A.*): Professor Telfer states that competition for the various I.N.A. scholarships is poor. This may be so, but it is not attributable, in my opinion, to either fellow-apprentices in the drawing office or to the grants awarded by the various county councils. I have questioned about 120 students recently, and from them have reached the opinion that it is the older men who on rare occasions give the advice not to proceed to a university. This, in my opinion, is very bad advice indeed, but it is interesting to note that even more rarely is the advice given by a graduate.

The county council grants average about £230 per year, plus fees, and this is sufficient but not particularly generous. It is unfortunate, however, that this sum is greater than that provided by the I.N.A. Scholarship, and I think that the average student is not to be blamed for applying for such a grant, after fulfilling the necessary educational requirements. The alternative is to sit at an examination for one scholarship only, and many of the students are genuinely modest about their chances and prefer to leave the winning to the exceptional men.

To restrict the I.N.A. scholarships to children of members would further drastically limit the numbers and would not necessarily improve the standard of the winner.

Professor Telfer comments about the lack of Fellows of the Royal Society on our Council as compared with the early days of the Institution. This is correct, but he could take fresh heart from the fact that the percentage of graduates among members of all grades is continuously increasing as shown:—

	1925	1955
Members	14	26
Associate-Members	10	23
Associates	5	9
Students	8	17

The above figures are necessarily approximate, and include members of the R.C.N.C. and engineer officers, but no foreign members.

Professor Telfer suggests the founding of five new chairs of naval architecture. This may be desirable, but I see no opportunity of obtaining the money, the staff or, most important, the extra students for such departments. It may be safely assumed that in one way or another the existing university departments of naval architecture are obtaining the best available students, and such a growth of extra departments would appear to lead inevitably to a decrease in the standards. I would prefer to see the expansion of the present departments rather than the existence of many departments each with a small number of students.

Professor Robb tells of the system of classifying the degrees awarded at the end of the course as being based on the results of the final examination at the end of the fourth year. At King's College, Newcastle upon Tyne, the system is somewhat different, and many students enter the Honours School already possessing a good pass degree.

One of the most encouraging pieces of information given by Professor Burrill is the remarkable rise in the number of students since the end of the last war. There are now about ninety students in the department, and there has been no difficulty so far in the graduates finding suitable employment. In fact, some of them leave college with a choice of two or three jobs before them. At King's College there is a King's College Society of Naval Architects. This is a very active society to which all students in the department belong, and apart from social activities it arranges for lectures. The lecturers are mostly drawn from eminent naval architects employed by the Admiralty, Lloyds, B.S.R.A., or private yards, and their subjects are usually chosen so as not to conflict with lectures already given. Students also present papers at these meetings and these serve as a very useful step in their professional careers.

I am pleased to see that an opportunity is being given to selected young draughtsmen to apply for entry into Greenwich. There must be a wealth of talent among such men, and it is good that they should be given such a splendid opportunity. In some cases all they need is the chance to redeem themselves from a failure in a past examination.

One anomaly seems to apply in the university method of entry. Candidates who have an Honours Degree in naval architecture have to pass the Greenwich Entrance Examination. Candidates who have an Honours Degree in mechanical science or engineering are accepted after an interview.

Is there any reason for this difference, since the preliminary course for each degree is basically the same in any university?

The training of engineer officers in the Royal Navy appears to be thorough and systematic. Captain Aylen shows the sources from which the officer entrants are drawn, and this includes apprentice entries from dockyards. Does this mean that a dockyard apprentice who does very well in his examination at the Dockyard Technical College can now enter as an engineer officer? I think that this is a good opportunity but is it fairly new, as I know of some very good apprentices in the engineering department who either left Admiralty service to go to a university or were forced to remain as draughtsmen because of the then lack of opportunity of promotion.

Mr. Lenaghan's point about re-rating the design staff is one with which I thoroughly agree. More use should be made of the title "Assistant Naval Architect," in the same way as in many engineering firms which use "Assistant Civil Engineer" or "Assistant Mechanical Engineers."

Mr. Taylor-Cook has referred to the Higher National Certificate courses, and I think his main points have been covered by Professor Burrill. I have had some contact with Higher National Certificate students and I find that the drawback with most of them is the time factor. The standard of the Higher National Certificate course is comparable with that of a pass degree. The students are intelligent and comparable with the university graduate, but all the time they are up against the fact that they have to do the work in about a quarter of the time available to the undergraduate; they cannot get out of the course as much as the undergraduate does because they have not the time to assimilate the knowledge.

The President (*I.N.A.*) **(Viscount Runciman of Doxford, O.B.E., A.F.C., D.C.L.):** I think it would be churlish to Professor Telfer if I did not at least rise to the very juicy bait that he was good enough to cast for me. But I think I can answer him more effectively out of his own mouth than in any other way. What I was saying—not so concisely and not so well—is precisely what he says in Section 7 of his paper, that "scientific training, however good, is not everything."

Then I would like to say one thing about Dr. Dorey's paper.

Touching on the question of sea-going engineers, he commented, with some truth I think, on the number of sea-going engineers who leave the sea at a fairly early age; he went so far as to leave the impression that those who stayed on were not quite so intelligent as those who had the wits to clear out.

I think the problem of providing sea-going engineers is one which will be exceedingly important. I do not know how far it is an educational problem or how far a sea-going life—and this will apply equally to deck officers—is getting less attractive than shore life, under a welfare state with earlier marriages, and so on. But if the Institute of Marine Engineers can tell the shipowners how to persuade really high-class engineers that there is a career to be had in going to sea and staying there they will render very considerable service to this country.

If I understood Mr. Silverleaf rightly, he made a point which I too want to make, that if the desideratum is more scientific quality about the place you do not necessarily get it by more qualified men. There is a difference between breeding a large number of naval architects and improving the standard of naval architecture. That is no insult to the qualified naval architect. But I think there is always a limit to the number of people who can be fully employed, even if you help employment by proliferating research to the extent which I think Professor Telfer would like. Sooner or later you come up against the law of diminishing returns, and in the end you reach a point where people are searching for problems to research in—and the moment you begin research for the sake of employing research workers rather than to find out something specific, you are on the top of a dangerous slope.

That also applies to the problem of expansion generally. We were rightly told this morning that there are very attractive opportunities in the newer industries. We also know perfectly well that at this moment, and indeed as far ahead as we can see, if the British shipyards had greater capacity it could be used. But the physical difficulties of actually laying down more berths on the sites on which British shipyards are at present placed, and, at least for the time being, the lack of steel and suitable labour for shipbuilding, influence the number of graduates which these shipyards can employ, and we should not lose sight of that.

If you produce too many graduates you risk finding that, even if there are jobs for them at the start, a point comes about half way through their careers where their employers are at a loss to find suitable work for them to do. I do not know the answer to that problem which I have come up against in other undertakings. You lure a bright young man in, telling him the job has prospects, perfectly honestly. At first all goes well, but there comes a time when he ought, in your interest and his, to be assuming responsibility: the prospects must become realities. But, except in large undertakings and sometimes even in them, the work to be done may not justify an increase in the number of executives, and a vacancy must be created for the young man to fill. This too often means deliberately dividing one man's work among two, which is good for neither, or retiring men who may still be useful and able to contribute original thought as well as accumulated experience, or else keeping the young man waiting indefinitely; in which case, justifiably feeling he has been deceived, he will probably leave you.

I add that to what Professor Burrill called the political side of our discussion. If someone can solve that difficulty, then the problem of providing attractive careers for qualified naval architects would become more manageable. At the moment it is a difficult one, and until it can be solved you can only combine a high production of graduates in naval architecture with a high wastage rate. This may be a way of getting quality but is, by definition, wasteful. The alternative may be that graduates should be used on work for which they are not now thought necessary in this country. I suspect this may in fact be the solution abroad, but it means graduates accepting some undistinguished and relatively low paid posts. Will they?

(The meeting then adjourned until 2.30 p.m.)

Professor H. E. Jaeger (*M.I.N.A.*): I want to emphasize that I am not going to discuss your system of educating naval architects; I only want to make some remarks, which perhaps may be of some assistance, to solve the problem you have set yourself in this Symposium.

Firstly, some "facts." Secondly, some "suggestions."

I only want to speak about qualified naval architects. In the Netherlands even more than in Great Britain, there is a great difference between a naval architect and a marine engineer. The naval architects have their education at our department of naval architecture, the marine engineer at the department of mechanical engineering.

Facts: I think I may assume that you agree that Dutch shipbuilding and British shipbuilding are about on the same technical level and that, therefore, the qualified naval architects are about on the same level as well, or at least ought to be so, and that we speak about the same sort of education. Seeing that the output of your merchant shipbuilding industry in the last years is about three to four times our output, we have some basis for discussion.

Of your universities with faculties for naval architecture, I think the most suitable for comparison is King's College, Newcastle upon Tyne. Now Professor Burrill gave us a most interesting Table I, which is ideal for comparison. Though the parallelism in both universities is not complete, the table which I put before you is very well comparable with Table I given by Professor Burrill. It shows an analysis of the subjects followed in each year of our degree course in Delft.

For the sake of comparison I will follow the same subdivision adopted by Professor Burrill, and the figures given by him are shown in a separate column. When considering this table I think you will agree that both universities, apart from special differences, have the same tendency in their education. The fact that we have a five-year education against King's College four does not greatly influence this comparison, as our fifth year is actually a finishing year in which the students work on their own in our laboratories on the basis of what they have learned in the four preceding years. Furthermore, you must keep in mind that I have assumed 26 weeks courses against 24 weeks a year in Newcastle.

The subdivision after the second year in A, B, and C sections means that at that moment the students themselves have to choose the direction of their education. Section A is the section of constructional naval architecture (design and construction). Section B comprises the more economical side and management (yard-manager practical shipbuilder). Section C is called the theoretical direction of naval architecture (research-model basin towing-tanks).

However, there is only one degree for all these sections, and there is not an ordinary degree at the end of the second year. All Dutch qualified naval architects have the same certificate, which gives right to the title Ir. The student can finish his study in five years, but the freedom of study is such that if he wants to stay at the university for ten years or more, nobody can prevent him or send him away. This has led to an average time of study that is above five years and is now above six years. This freedom also causes a greater number of students to drop out; only about 50 per cent get their degree. These are the disadvantages of the Dutch system, which I will not discuss now.

What is important in the comparison of both universities, Newcastle and Delft, are the following conclusions:—

(*a*) The Dutch student has to work more. He has more weeks per year and more hours per year as well in the professional as in the non-professional parts of his education. This is also true

ANALYSIS OF SUBJECTS FOLLOWED IN EACH YEAR OF THE DEGREE COURSE
DEPARTMENT OF NAVAL ARCHITECTURE (TECHNOLOGICAL UNIVERSITY OF DELFT)

Figures after each Subject indicate the number of hours per Academic Year spent on that subject, assuming that Lectures are given for 26 weeks each year

FIRST YEAR	Delft	N.C.
Shipbuilding	52	(24)
Drawing Office	175	(144)
Total Professional	227	(168)
	Delft	N.C.
Mathematics	234	
Metallurgy	52	
Applied Mechanics	26	
Mech. Engineering	26	
Metallurg. Laboratories	84	
Mechanics Laboratories	70	
Total Non-Professional	492	(504)
Grand Total	719	(672)

SECOND YEAR	Delft	N.C.
Naval Architecture	88	(72)
Drawing Office	262	(216)
Total Professional	350	(288)
	Delft	N.C.
Mathematics	163	
Mechanical Engineering	52	
Metallurgy	39	
Metallurg. Laboratories	26	
Mech. Eng. Laboratories	70	
Physics	156	
Physics Laboratories	21	
Total Non-Professional	527	(360)
Grand Total	877	(648)

THIRD YEAR	Delft	N.C.
Naval Architecture	140	(168)
Drawing Office	262	(216)
Total Professional	402	(384)

	Delft			N.C.
	A	B	C	
Mathematics	52	52	117	
Mechanics (Theor. and Applied)	182	182	208	
Applied Mech. Lab.	14	14	14	
Electrical Eng.	26	26	26	
Mechanical Eng.	104	104	78	
Metallurgy	13	—	—	
Economics	26	26	—	
Total Non-Professional	417	404	443	(276)
Grand Total	819	806	845	(660)

FOURTH YEAR	Delft	N.C.
Naval Architecture	130	(144)
Drawing Office	262	(360)
Total Professional	492	(504)

	Delft			N.C.
	A	B	C	
Mathematics	—	—	52	
Physics	—	—	26	
Mechanics (Theor. and Applied)	65	39	91	
Electrical Eng.	26	26	26	
Mechanical Eng.	91	91	—	
Economics	26	130	26	
Total Non-Professional	208	286	221	(198)
Grand Total	700	778	713	(702)

FIFTH YEAR	Delft
Laboratories and Drawing Office	524
Total Professional	524
	Delft
Non-compulsory Mathematics and Mechanics	104
Total Non-Professional	104
Grand Total	628

Figures in brackets give the equivalent numbers of hours in King's College, Newcastle upon Tyne.

Minimum total of nominal hours in Delft: 3,730 (5 years).
Minimum total of nominal hours in Newcastle: 2,682 (4 years).
Minimum total of nominal hours in Glasgow: 2,560 (4 years).

4/5 Delft = 2,980 hours (4 years).
Delft first four years = 3,102.

when comparing the total amount of "nominal hours" with those of Glasgow University as given by Professor Robb.

(*b*) The subdivision in subjects is fairly well the same in both universities.

(*c*) The tendency to increase the professional part with advancing years is present at both universities.

(*d*) The decrease of the non-professional part after the second year is also of about the same order.

(*e*) Both universities have in common the teaching of mathematics and physics. For this reason a comparison is indeed possible and may be useful.

(*f*) The drawing-office hours, which are essential to the Dutch educational system, are about the same in number as at Durham. In this connection it may be noted that students entering our university never serve on an apprenticeship basis and sometimes never even visit a shipyard beforehand. The figure given for drawing-office hours in the fifth year indicates the time meant primarily for more fundamental work and not so much for acquiring drawing practice.

I will say no more about this table; it is the first fact I wanted to put before you and which may be of assistance in arriving at a common conclusion.

The second figure which I put before you is a supplement to Professor Telfer's Fig. A. I have set up a similar diagram (Fig. AA) for the shipbuilding department of the Technological University of Delft, which was created in 1905, about the same time as the department at King's College. The number of students is generally somewhat higher than at Durham and N.T.H., especially during the last decades. Taking into account a five-year programme in Delft instead of four years in Newcastle, I multiplied the number of students in Delft with 4/5. The number of qualified naval architects graduated at Delft up to January 1, 1956, was 259, of which 20 were or are working in foreign countries. During the last eleven years (when Professor Bonebakker and I held the chairs of Naval Architecture) 124 naval architects took their degree, of whom nine went abroad.

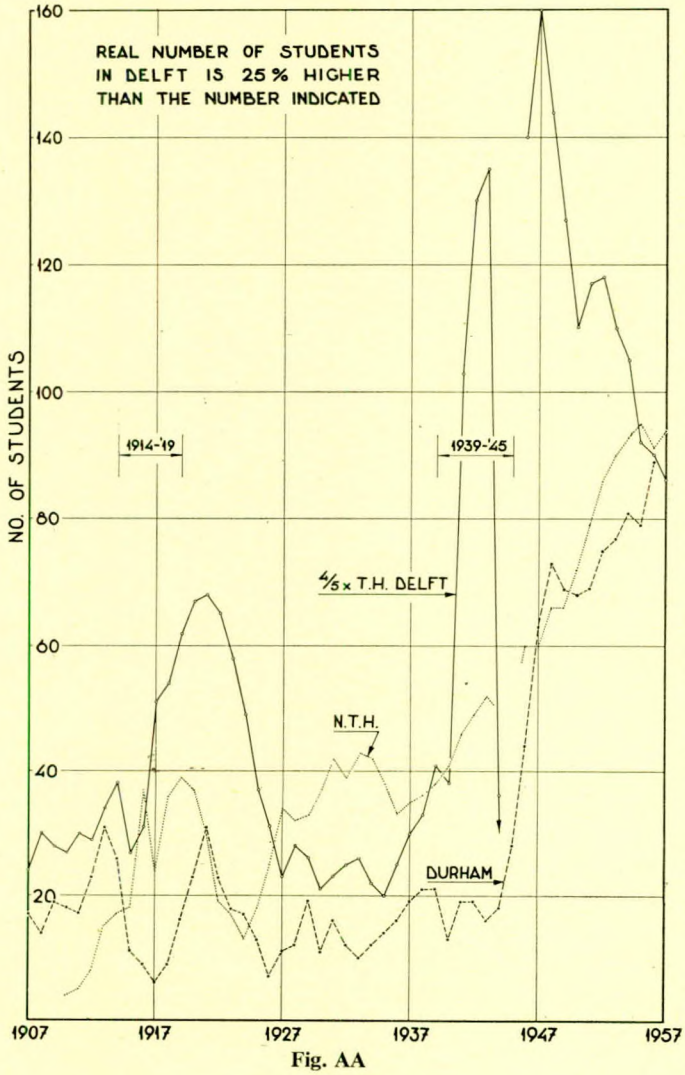

Fig. AA

So much for the facts. Now for the suggestions which I want to advance.

Suggestions:

If I am right in assuming that the University of Glasgow and the Royal Corps of Naval Constructors are about of the same importance as King's College with regard to numbers, the numbers of students in naval architecture when considered in relation to the output of the shipbuilding industries in both countries are about the same in Great Britain and the Netherlands. However, a comparison of the total numbers of some years ago indicates that the number of qualified naval architects in Great Britain is now too small. It may therefore be desirable for you to look for means of increasing that number as well as the number of students.

This is already underlined by Professor Telfer. He says that you should have at least five more professors in naval architecture. In my opinion that figure is right, but it may still be on the low side. But by departing from the system of having only one full professorship per university it might not be necessary to distribute your educational centres over five more universities.

Therefore, supposing you should have one more university with a department for naval architecture above the existing training centres at Newcastle and Glasgow (leaving Greenwich for the Naval Constructors), I think you would have sufficient staff, laboratories and educational possibilities if each of the—then three—universities were given two full-time qualified professors.

In Holland we do not have what is called in Germany a "university career." Professors are appointed by the Government and are chosen by the university from men employed in the industry or at the model basin.

So they have generally been engaged for a long time on other work than that at the university. Thus they maintain a direct contact with practical life. However, it may be difficult even in Great Britain to find five qualified naval architects, provided the yards will let them go, who are willing to be underpaid in comparison with their actual jobs.

In my opinion it would be desirable for your universities to accept financial assistance from the Government, which would make it possible to bring the salaries for educational personnel on to a sound level. I do not think you need fear too much Government interference. Our Government interferes less and less in the management of our Delft State University; we get our annual budget and put it to good use according to our own ideas.

Therefore, seeing that your educational programme does not differ too much from ours, I take the liberty of suggesting that it should be possible to set your students to work a bit more. Furthermore, the financial assistance from the Government is not as objectionable as the boards of directors of your universities seem to fear. I think that by accepting these notions it should be possible to arrive at a larger number of qualified naval architects within a few years. My suggestions of how to get the professors and how to get the students from outside the direct shipbuilding sphere is a question I will let you think over.

As Professor Telfer indicated, regulations about lending money to students would be facilitated if the State would occupy itself more with, what here in Great Britain is in the first place a national problem, the maintenance of British shipbuilding on a level equal to that of the neighbouring countries. I hope you

will excuse one of your neighbours for stating these few facts and making these suggestions.

Professor J. W. Bonebakker (*M.I.N.A.*): I fully endorse Professor Jaeger's remarks. Perhaps he and I are on ground where angels fear to tread.

In Section 6 of his paper Professor Telfer deals with the best way of teaching the fundamentals of naval architecture. These fundamentals cover broadly the technical work usually required in the ordinary shipyard drawing office.

These subjects may be rather elementary, but they are, nevertheless, the fundamentals of the training of naval architects. If this training is to lead to a university degree, these fundamentals should be taught by a senior professor, with ample experience in practical shipbuilding. He should be able to treat them from a broad and detached point of view, incorporating elements of the following subjects. For example, statical stability is a sequence to hydrostatics, structural strength is a sequence to hull construction. Such teaching will always have a personal touch. As we are dealing with university training and education, this is considered an asset.

Consequently, Professor Telfer's plea for the standard presentation of first principles is strongly opposed. An international conference of professors in naval architecture for pooling their pedagogical experience would be inopportune.

Even nowadays we can build and run ships without being confronted daily with scientific problems. However, we cannot go on like that, occasionally buying from experts the results of rapidly expanding pure and applied sciences that are becoming vital to the development of shipbuilding and shipping. Let me quote two examples.

Electric welding is faced with metallurgical, heat, stress, and electrical problems. One or two assistant managers in the shipyard should possess the scientific training required for developing an independent opinion on what the metallurgist and other experts tell him; he should be able to check their information with the experience in his own shipyard and should be able to coach the shipyard's own laboratory when investigating cases arising in the yard.

In shipping, propulsion and stability are merging into one group of closely inter-related problems of sea-keeping qualities. The shipowner should have someone on his shore staff, not in some sheltered corner, but actively engaged in the everyday work, possessing the scientific training required for developing an independent view on what the towing tank experts tell him; he should be able to check the results of their model experiments and theories with the service performance of his ships; he should be able to translate these results into the simple language of ships' officers and engineers; he should be the intermediary between the practical seaman of his own shipping company and the experts of the laboratories.

It will be understood that in my opinion these men could be graduated naval architects who did not spend 3–5 years as an apprentice in shipyards. No doubt this will be a handicap when starting as "a very junior junior assistant," particularly in ship-repairing or on the shore staff of a shipping company. But give them a chance to join the day and night shifts in drydocks and shops, or send them to sea for six months. If they have got the guts they will overtake in due time the majority of their colleagues whose careers are mainly based on their practical training.

If I am right, then a boy whose father and grandfathers may have been merchants, or lawyers, or even professors in the humanities should not be afraid to qualify, after his university education, for the executive top grades of the shipbuilding industry because—to quote Professor Telfer—"the shipbuilding industry is a classless democracy."

Mr. S. Livingston Smith. C.B.E., D.Sc., F.C.G.I. (*Member of Council, I.N.A., M.I.Mar.E.*): I would like for a moment to look at the question of university education in technological subjects from a more general point of view. You may possibly regard me as a heretic in these matters by the time I have finished; but, having spent my professional life in industry, in university teaching, and in industrial research, you will not be surprised that I have definite views to express. Some of you may even think there is half a chance that I know what I am talking about.

In the first place, and bearing in mind these years of experience, at this stage in my life I have come to the conclusion that the primary part the university should play is (1) to ensure that the fundamental principles of the engineering sciences are properly and adequately taught, and (2) to teach undergraduates to use their own minds and to think. Once these two matters are accomplished the details of the technologies involved are relatively easy to deal with. In fact a student of the appropriate calibre has then become a real student and is able to teach himself.

These views apply to all the engineering technologies of which I regard naval architecture and marine engineering as a part. The details of the technologies, as some of the authors have pointed out, are growing more and more, and unless the universities get back to the fundamental principles that I have just referred to, the courses will increase in length, and life is just too short. In my opinion, there is no place in the university curriculum for a force pump, pumping in details of technologies purely to help pass certain examinations. Don't misunderstand me, I still feel it is appropriate that the universities should have separate professors of, say, mechanical engineering, naval architecture, marine engineering, and civil engineering, etc., because the processes of teaching the fundamentals are best wedded to application, and the student in naval architecture, for example, finds their application under the professor of naval architecture, in this particular direction. In my view it would be far better for the student to return to the university after, say, two years in his particular profession to attend short post-graduate courses arranged by the specialist professor, who is an expert in that particular field, for by then the student knows in which direction his future may lie.

It is a favourite exercise of mine to divide the field of opportunity in naval architecture or marine engineering into four parts, beginning with the purely academic and ending with the most practical application. As I see it, these four are:—

(1) The more academic work, that might be carried out in the university.

(2) Applied research, e.g. *Pametrada* or the tanks or B.S.R.A.

(3) In the design office of a firm of shipbuilders, marine engineers, or shipowners.

(4) The actual building of a ship or the construction of machinery in the works.

But you will notice that I have included the more practical work and although many industrialists may doubt the ability of a university to provide for this, I feel that a man who has the appropriate university education should be ultimately more capable of leadership than one who has not.

It is, of course, within the province of the university to provide the appropriate courses and here I would say, at the risk of being criticized, that I have always been in doubt as to whether a successful engineer or shipbuilder need have a mathematical mind, and I feel that university courses should provide for both categories, those who have it and those who have not, for I have seen so many cases of men who have found the mathematical hurdles so difficult that they have failed in their university examinations and yet they have reached the top of the tree in industry. It is always the rogue spots from which the lessons can be learned, and this is one of them, which in my opinion needs looking into.

There is one further point and that is practical training. In my opinion nothing can take its place. It is essential for all four of the rough divisions to which I have just referred, from the

academic to the practical job, and it is no use trying to do bits of it within the university. I am not referring now to sandwich courses; but practical training in the university is useless.

There are many points in the papers which have been deliberately inserted in order to provoke discussion, and I hope the authors will bear with me while I fall into the trap. Whilst I agree with much that Professor Telfer has said, there are one or two points with which I entirely disagree.

He refers in Section 6 to the development in the actual teaching of the subjects normally understood as branches of naval architecture and suggests that the "putting over efficiency," as he calls it, might be improved by the students having first class notes in printed loose-leaf form which could be generated by a number of experts. It is so essential to put over the fundamental groundwork to the student in such a way that he never forgets it that I consider this the first duty of a professor, and the professor's personality enters into it: each one may have a different approach backed by his own processes of thought, and in putting this over he must have personality and enthusiasm behind him, and it is part of the education of the undergraduate to absorb these fundamentals by taking lecture notes himself.

I know it can be argued that the professor gets bored with saying the same things year after year; but it can be done, and it is his duty to do it, and it can be done as though the professor is doing it for the first time; and that is the key, in my opinion, to "putting over efficiency" and nothing can replace it.

In Section 7, Professor Telfer refers to the relationship between a research association and the industry it serves. I entirely agree that the existence of a central research organization does not do away with the need for firms themselves to be concerned with and engage in research. That is accepted in the shipbuilding industry, and it is not the intention that the existence of the B.S.R.A. should take away from the firms their own research activities. I do not agree with Professor Telfer, however, in his statement that every shipyard should have its own research department. As he knows, research can only be conducted on an adequate scale, and it would be beyond the capacity of many yards either to afford or usefully to employ such a department run on an adequate basis. Every firm can, however, have adequate means for ensuring that it utilizes to the full results of research work.

One final reflection follows from this and that is that the qualified naval architect who has spent his earlier years on research should not be regarded as unable to return to the more practical side of the profession and the industry.

Sir Stanley V. Goodall, K.C.B., O.B.E. (*Honorary Vice-President, I.N.A.*): As one of the few survivors of the 1936–39 Committee on which Professor Telfer has exercised his wit and his considerable powers of derision, I accept his challenge to speak for that Committee.

The subject of this Symposium is "The Education and Training of Naval Architects and Marine Engineers." The Committee of 1936–39 was called upon to report on "The Education, Training and Employment of Youths and Apprentices for the Executive Grades of the Shipbuilding Industry." Notice the difference in these two titles. Naturally, the papers read this morning deal largely with technical education. Professor Palmer takes a somewhat broader view, and Captain Aylen further enlarges on the fact that to train engineer officers for the Royal Navy something more than technical knowledge must be encouraged. The view of the 1936–39 Committee was that to become a successful executive qualities additional to those which can be inseminated by professors are necessary. If the title of this Symposium had been the same there would have been other papers dealing with training schemes. For example, that of the Shipbuilding Employers' Federation.

Professor Telfer is not quite fair in straining to score a point. He quotes a paragraph of the Committee's report which states that graduation is an experience which should prove a great asset; and later he disregards that to say the Committee pleaded the non-essential value of graduation. I am sure the Committee wanted to assure the ambitious young man who aspired to become an executive that he need not despair if he had not had the advantage of a university education.

There is one other particular in which Professor Telfer leads us astray. He speaks of the nostalgic days of 1936–39. All the members of the Committee, alive or dead, recalling those days, would think of them not as halcyon, but as nightmares. It may seem incredible to some young men to-day to know that one Friday morning in those pre-war years a shipbuilding employer called on his bank manager to beg for an increase of his overdraft in order that he might retain the services of some of his key men whom he hoped to keep off the dole a little longer. Experiences such as this were in the minds of the 1936–39 Committee. Now we live under entirely different conditions, with the Welfare State, full (perhaps over-full) employment, progressive debasing of the coinage, and until recently a seller's market. We should be wise to wonder whether such a state of affairs will prove a perpetual paradise for this crowded little island surrounded by competitors. Perhaps twenty years hence somebody will read a paper here criticizing as ridiculous the statements made by Professor Telfer twenty years ago, when circumstances were so different and shipbuilding days were halcyon.

Professor Telfer's panacea for the better education and training of naval architects and marine engineers is, naturally, more and better professors. I agree. But where are they to come from, who is to pay them, and how much will they cost? I do not ask those questions in any facetious sense. I well remember a time when the Council of this Institution was greatly perturbed because there were three chairs of naval architecture in the country and all were vacant. I approached one or two men whom I thought would be good occupants of those chairs, and was told that they could not possibly think of the financial sacrifice which would be involved.

The glib reply to my questions is "The Government must pay." Already the Government is doing a good deal, but there is a limit to which the State can go in financing education. Professor Telfer rightly points out that those who pay the piper call the tune. We have been told of the situation in the Netherlands, but in this country I think our shipbuilders and shipowners would like to have a big say about the chairs of naval architecture and the professors to occupy them.

Added later in writing:—

In further defence of The Institution's 1936–39 Committee I must record that it is wrong to believe that with the advent of the war the result of the Committee's work was entirely lost. The ideas expressed by various members of the Committee at the meetings bore some fruit. For example, Source C for entry to the Royal Corps of Naval Constructors (see Appendix to Professor Palmer's paper) dates from that time. So does the Apprentices' Prize Scheme of the Worshipful Company of Shipwrights. I believe, too, that the Shipbuilding Employers' Federation Scheme, or something like it, was first mooted at those Committee meetings.

Professor Telfer's suggestion that this Institution should sponsor an international conference of professors and the valuable contributions of Professor Jaeger and Professor Bonebakker bring home to me the value of our international membership and our meetings abroad. It would be a great advantage to our younger members if more of them attended those meetings. But, of course, the cost is a difficulty. Could they be assisted in any way? This Institution could not do so. The money is not there and the By-Laws prohibit such pecuniary gifts to

members. But I suggest that shipbuilders and shipowners would be well advised to help young members in this way.

Professor Palmer mentions the sad fact that the educational standard of dockyard apprentices has fallen. I think it would add to the value of his paper as a work of reference if he would give a more detailed statement of the entry and training of the student apprentices to the Royal Dockyards.

Professor Robb speaks of the change of attitude towards apprenticeship. I regret that the old system whereby a youngster went through the grind of work out in the yard is falling into desuetude. The Scholarships and Publications Committee has often interviewed candidates who are apprentice draughtsmen who, questioned about their yard experience, admit that it has been confined to "walking round the yard during the dinner hour." It is a pity, but this trend must be faced. I hope that some arrangements are made whereby a young man ambitious to become an officer serves for a time in the ranks and learns something not only of the craft but also of the craftsmen.

When I was a youngster I was thrilled by reading biographies of the great engineers of the past, some of whom were in charge of men and work almost before they were out of their 'teens. I felt that was good training. By the time I was twenty-four years old I was sick and tired of being trained and having to pass written examinations. We wanted to get into the world of real work, be given a job, and made responsible for it, so that we could show the mettle of our pasture. I knew my education was not complete and that I should have to go on learning all the time. Are not these training courses too long for some types of student? What I should have liked but could not have was a post-graduate course which I could have taken later in my career when I had made up my mind in which line I wanted to specialize. Some of our universities offer advanced courses in engineering. I know of no such course in shipbuilding and naval architecture. Is this not a defect in our training schemes that ought to be remedied?

Mr. A. Logan, O.B.E. (*Vice-President, I.Mar.E.*): I am very happy to take part in this discussion, particularly of Dr. Dorey's paper, and while I have studied his review with interest, there are several important issues on which I do not share his views.

We all know the standard form of 4/5-year works apprenticeship which, with day and night school attendance, produced a marine engineer handy with his tools and with sufficient technical knowledge to run, maintain, and operate a ship's plant—in fact, many of us here to-day entered the marine engineering field by this form of training. The question is, are such men being produced by the marine engine works in sufficient numbers to man our ships in the future? My answer is "No."

My next question is: does the apprentice in a modern marine engineering firm get the broad scope of training quoted by Dr. Dorey? For while in the old days by filing, chipping, fitting and turning, an engine or a machine was ultimately produced, to-day in a modern engine works with its jigs, precision machine tools, etc., the finished article in the main is a standardized unit which is erected more or less by the assembly of finished parts. Far from me to belittle the men coming forward from the normal works apprenticeships, but I would ask: how many of the boys to-day serving in the works take advantage of the educational facilities offered and on completion of their apprenticeship time have reached the Ordinary National Certificate standard? I am afraid the percentage is very low.

Some years back some of us felt the shipowner himself had to be interested in the selection and early training of his engineers and that an alternative training scheme was worthy of adoption, and while Dr. Dorey suggests this scheme may well help tanker operators in their immediate manning difficulties, let me point out that the gross tonnage of tankers to other vessels in the United Kingdom merchant fleet may within the next year or two represent up to 50 per cent of the British merchant fleet tonnage. With the support of the Ministry of Transport endeavours were made to formulate a scheme which would produce a type of man who in the future would be able to hold an executive engineer's rank, having been trained to operate present-day propulsion equipment.

The day when the passenger liners and large freighters were the only ships with big propulsion plants is past, and if the shipowner is to operate ships with modern engine-room plants costing, say, well over half a million pounds or more, the engineers in charge must be of high calibre and be on a suitable salary scale. Surely the day is fast passing when qualified marine engineers should have to hammer away at top and bottom ends, and I can say the modern propulsion plants in the ships under my charge with their automatic controls have been and are being designed to meet the modern trend—i.e. continuous machinery operation with the minimum of maintenance by ships' staff between drydocking periods.

It has been suggested the Ministry of Transport is setting too high a standard for the marine engineer. This, in my view,

SHELL TANKERS LTD.

ANALYSIS OF ENGINEER APPRENTICES SERVING UNDER THE ALTERNATIVE SCHEME OF TRAINING FOR MARINE ENGINEERS

	1952	1953	1954	1955	1956
Number commenced Stage 1 (Technical College)	200	160	120	100	100
Number sat for Ordinary National Diploma ..	169	144	103	85 will sit in 1957 (15 left Company)	96 will sit in 1958 (4 left Company)
Number of Passes (percentage in brackets) ..	124 (73·37)	103 (71·5)	79 (76·7)		
Number of Referred's	22 (13·02)	16 (11·1)	6 (5·9)		
Number of S.3's	13 (7·69)	4 (2·77)	9 (8·7)		
Number of Failures	10 (5·92)	21 (14·58)	9 (8·7)		
Number commenced Stage II (Sea-going) ..	169	144	103		
Number completed Stage II (Sea-going).. ..	160	144†	(Still at sea)		
Number commenced Stage III (Workshop) ..	157				
Number completed Stage III (Workshop) ..	*				

* Of these 157 apprentices, 28 have now completed their apprenticeship and are being appointed as junior engineers in our fleet. The remainder will be doing so within the next few months.

† Now entering Stage III.

is incorrect. The Ministry must satisfy themselves that the engineer in charge has reached the necessary degree of competence, and it would be sacrilege for the shipowner to risk his costly ship and plant to incompetent personnel. It has also been said the boys under the Alternative Training Scheme are possibly reaching too high a standard of technical education. All I can say is I hope it is so! If some of these boys desire to go ahead and eventually obtain an Extra Chief's Certificate or a university degree, they should be encouraged, for the marine industry must benefit in the long run and improved propulsion plants and operating results will be the outcome. I am not saying that the present Alternative Training Scheme is the complete answer, possibly amendments will have to be adopted in due course, but I am confident that, given a fair chance, the boys being trained under this scheme will turn out to be technically sound in both theory and practice, and looking to the future no doubt Lloyd's Register will be very happy to have some of them in the Society.

My one concern for the success of the Alternative Training Scheme was the eighteen months' sea period when the boys would be away from the supervision they obtain both during the college and the works periods. This misgiving has proved to be groundless, and I want to place on record my appreciation of the help received from the chief and senior engineers sailing in our ships, in fact but for their willing co-operation in the training of the lads at sea the results obtained to date might have been far different. Further, and equally as important, I would like to thank the managements of the engine works for the facilities they have made available for the trainees.

I fully endorse the importance of electrical knowledge stressed by Dr. Dorey, but he must not belittle the ability of the present-day marine engineer. My experience is that they are doing a good job; they are able to keep abreast of new innovations introduced into the ships, and when I say that, in spite of the fact that our company's ships do not carry electrical specialists, we have some eighty modern turbo-electric and steam turbine ships, all with up-to-date a.c. auxiliaries and even electric steering equipment, I suggest it is incorrect to say that, with very few exceptions, marine engineers have very little knowledge of modern electrical installations.

Mr. N. Hogben, B.Sc., Ph.D. (*A.M.I.N.A.*): Professor Telfer has suggested that we should increase the number of university courses in naval architecture. Professor Burrill suggested that in university education professors and lecturers are to some extent superfluous, thus disposing of the staffing problem. I do not say that I accept this view, but none the less, as Mr. Baxter has observed, there remains the problem of finding students.

What I wish to say amounts to a plea for greater attention to design as a specific and creative art in the training of naval architects, something analogous to the design training given to civil architects.

It seems to me that there is a certain magic about ships and that shipbuilding as a career has a great power to attract by the sheer interest and creative satisfaction of the work itself, a point well made by Mr. Silverleaf. I believe, however, that young men attracted to the industry may be greatly disillusioned not so much, as Professor Telfer suggests, by lack of financial reward for study as by their realization that so often it is men with years of experience, rather than those with academic qualifications, who mould the design of a ship. This is no doubt largely due to what may be termed the "Previous Ship" outlook on design and to the rather cramping influence of Lloyd's rules. Perhaps, however, it may also be due partly to insufficient emphasis in naval architecture courses on the art of designing.

Professor Burrill names four qualities which he considers to be requirements of the naval architect. I would like to add to these the ability to design. Professor Burrill may say that this ability is implied in the four qualities he has mentioned, but I would like to see it named in its own right. The important thing is to consider whether it is adequately represented in the curriculum. I may be out of date, but my recollection of college days is that a disproportionately large part of the drawing-office time was devoted to standard calculations such as hydrostatics, launching tonnage, and freeboard, the aim of which was to achieve the same answer as students in the previous year. Little or no time was given to creative design projects into which the student could put something of his own originality.

Would it not be possible to introduce at quite an early stage in the course projects, not necessarily ambitious, involving exercise in the art of designing, that is in moulding together a number of variable factors to create a good, consistent scheme satisfying specific requirements. I have in mind such projects as sketching out a cabin arrangement to fit a given accommodation space requirement, or drawing an approximate set of body sections to fit a given section area curve; jobs, in fact, which give scope to the student to express and develop his creative abilities.

Mr. D. M. Reid (*M.I.Mar.E.*): Perhaps I may make a few remarks on the training of the sea-going engineer, a field in which I have some experience.

First I would like to suggest four qualities that are desirable in marine engineers:—

(1) A thorough knowledge of the operation and maintenance of all types of marine machinery.

(2) Initiative, common sense, leadership, and a stable character generally.

(3) A genuine interest in ships and sea-going.

(4) Sufficient basic theory to understand the principles of marine machinery and ships' structures, though it is not essential that they be very highly trained in purely theoretical subjects. After all, they are operating machinery and not designing it.

It seems to me that we should first improve the present rather haphazard training to produce men with some, if not all, the characteristics I have mentioned. Next we must plan for the future by initiating a new training system which may develop and produce marine engineers with all the desirable qualities to meet the demands of the mercantile marine.

I would emphasize that great weight should be placed on training in the operation and maintenance of marine machinery; and I pay tribute to the examiners of the Ministry of Transport for the way in which they have borne those requirements in mind for many years. The general policy has been correct, although there are many points of detail which we of the marine colleges question.

Dr. Dorey recommends an apprenticeship in a good marine engine works or ship repair establishment, coupled with technical classes, ending in an Ordinary National Certificate, as a suitable background for a marine engineer, and I am sure that is correct; but there are far too few of this calibre.

In the London Marine College, of the students taking certificate courses, not including the extra first-class course, less than 50 per cent have marine apprenticeships and less than 10 per cent have Ordinary National Certificates. I do not imply that they will not make good marine engineers; my experience is that some of them develop into the best type of marine engineer, and I suggest this is due to their experience after the end of apprenticeship in many cases. With the present system of training this period is of vital importance; it is the period in which the young man changes from the craftsman to the operating engineer. This process will be naturally slow and uncertain, unless he is given some guidance, and I suggest that if junior engineers were sent to marine colleges before being appointed to a ship, both they and the shipowners would benefit greatly.

It is important, too, that when the young engineer comes ashore for a certificate course, he should be given every encouragement to complete it, for in my experience such courses play a

vital part in producing competent marine engineers. All too often, however, their time ashore is limited.

From the long-term point of view surely the correct step is to institute one or more colleges devoted entirely to the training of marine personnel; and surely this is not too much for a maritime nation such as ours.

Mr. L. J. Rydill, R.C.N.C. (*M.I.N.A.*): I should like to comment on one aspect of the constructors' course at the Royal Naval College, Greenwich, namely, how the total time given to lectures is divided between the main subjects covered in the course. This is shown in the following table:—

Subject	Proportion (per cent)
Structural Design of Ships	30
Ship Calculations and Design	25
Resistance and Propulsion of Ships	20
Stability of Ships	15
Oscillations of Ships	10

Apart from Stability of Ships, which is treated in fair detail during the preliminary course at the Constructors' Training Office at Devonport, I believe the proportions shown demonstrate the relative importance of these subjects to the naval constructor. The predominance of structural design of ships is a comparatively recent development and reflects the increasingly important part played by this subject in warship design.

It would be of interest to hear the proportions for the courses at Durham and Glasgow.

Mr. C. M. Stacey (*Student I.N.A.*): After only two years' experience as a student I support heartily Professor Telfer's remark about the necessity in lecturers for "putting over efficiency." Some of them seem to think that it is sufficient merely to dictate the material of the syllabus in condensed form, and they do not even achieve the results that can be obtained by the students' conscientious study of text-books. In the crowded National Certificate courses particularly, psychological, enthusiastic lecturing is a vital stimulant to those who might not be there at all but for their employers. A lecturer who knows and enjoys his job stands out a mile. At the same time, the necessary facts and information can be provided for home study by the loose-leaf note system.

And on an entirely different subject—university entrance—there seems to be little doubt that a broad and well academically founded education is highly desirable for the naval architect. But does a language, apart from its practical aspects, form the only standard by which the broadness of the prospective naval architect's education can be judged? Surely, if only out of fairness to students, art, music, and literature should be acceptable as alternatives to a language for entrance to a university. The study of Latin or Greek obviously has a far less broadening and artistic influence on the student than the study of music or English literature, neither of which seem to count for anything at the moment.

Mr. W. Muckle, M.Sc. (*M.I.N.A.*): In the first place, referring to Professor Telfer's paper, I do not feel that the present system of awarding county grants is necessarily bad, and I would suggest that the reason why the Institution scholarships are not so popular as they used to be is because their value has not kept pace with the times. I would refute the suggestion that anyone who cares to come along, and is poor enough, can get a grant, and automatically get into the university. After all, there are certain minimum qualifications required before entry can be obtained into the university, and in these days where there are in most departments more applicants than places, there should be no difficulty in selecting those with more than the bare minimum qualifications. It is often argued that because of means tests in county grants, the sons of professional people are unable to come to the university. In so far as the shipbuilding industry is concerned this should not be a barrier, because of such schemes as the Shipbuilding Employers' Federation Scheme, and the arrangements which many private firms make for suitable apprentices.

With regard to the suggestion that there should be many more chairs of naval architecture in this country, the writer, with others, has difficulty in seeing how these new departments would be staffed, and where all the extra students are coming from. It is not suggested that some increase in the output of naval architecture graduates is undesirable, but it would be difficult to see how double or treble the present number of graduates would find suitable places in the industry. It would seem inevitable that many of these would have to accept inferior jobs within the industry, and this would seem to the writer to lead to a drift away from the industry (and by that is meant the shipyard) to more attractive technical jobs.

It would certainly be agreed that there should be a nucleus of people in any shipyard, with the highest available technical training, but this need not mean that a large number of such people need be employed on this work. These people should be capable of dealing with those special problems which arise from time to time, and they could be usefully employed on such matters as trial analysis, ship model correlation, vibration problems and advanced structural problems as occasion arises. Except perhaps in the very biggest yards, it would not seem to the writer that a research department could be justified, and one would deprecate the situation where such a department was looking around to find jobs to keep it employed. The specially trained people already referred to should be capable of carrying out research tasks when they arise.

The possibility of an international conference on how to present certain fundamental aspects of the subject has been mentioned. The lack of agreement which has been achieved in certain other naval architectural fields where international conferences have been tried, would not suggest that this is likely to lead anywhere. After all, it is highly undesirable to have a standard presentation, and by so doing the individuality of the lecturer or professor concerned would be cut out.

During the course of the discussion it has been pleasing to hear the Diploma Course in Naval Architecture at Sunderland Technical College so highly spoken of. The writer was engaged in the teaching of this course for five years, and he can agree with those speakers who feel that other courses like it could quite well be established throughout the country. The diploma course caters for a different type of student from the university course, and a student who has attended such a course should be able to tackle very intelligently the routine calculations and design work in a shipyard and at the same time be capable of assessing the merits of new ideas.

The amount of drawing-office work in the course at King's College has raised some adverse comments. It should, however, be pointed out that this is only nominally drawing work. It consists of far more calculation than drawing, and we regard it as the practical application of what the student learns in lectures. Without this opportunity to do calculations, the student would be even more of a theoretical naval architect than he now is. It should be pointed out that much is done to reduce the amount of tedious and repetitive work by way of giving the students standard forms for calculations, and giving them a considerable amount of basic data in such matters as the strength calculation.

A point has been raised in connection with this by Dr. Hogben, and that concerns design. We all feel that the student should have more opportunity of doing design work, and it may be possible with the extension of the course to four years to include more general design work. However, the student must understand the basic principles before he can design intelligently, and

it is only lack of time which has made it difficult for the Pass Degree Student at King's College to try his hand at this work. The Honours Student does, of course, do a great deal of designing.

One word about the broadening of applied science education. The tendency is to give the student more free time to himself so that he can read up his subject. The inclusion, therefore, of formal lectures on, say, an arts subject in an applied science course would merely overload the course. Any student in a university has an unrivalled opportunity for broadening his own education, however. A glance at the notice board in the University Union will show the student all the things in which he can take part outside of his own subject, and which will have the necessary broadening influence.

One final word about practical training in so far as the naval architect is concerned. The writer favours some practical training in a shipyard before the student comes to college. This has the advantage of enabling him to appreciate much of the more advanced work, and at the same time eliminates the necessity of university time being spent on very elementary aspects of practical shipbuilding, which are, nevertheless, essential to an understanding of the subject of naval architecture. After leaving college, the student should return to a shipyard for a while, no matter what his ultimate aim is. Even a student whose aim is research work will gain much by this post-graduate practical experience, as he will learn that in designing and constructing a ship, many conflicting requirements have to be reconciled.

Mr. F. E. C. Jarrett (*I.Mar.E.*): My whole career, so far, has been with the mercantile marine on the engineering side, and during the last five years I have been a member of a team training sea-going marine engineers at one of the marine schools in the south of the country. I would like to make a few comments related to the papers of Captain Aylen and Dr. Dorey.

It is interesting to see, so closely in comparison, the training of the naval officer with that for the mercantile marine. When one considers the monetary value of the modern average merchant vessel, the value of the cargo, the complexity of machinery and equipment, and the fact that the mercantile marine man must carry out his own artificer work, the outline of training for the Royal Navy should at least apply broadly to the Mercantile Marine. It is certainly a measure of the extent of training that a modern technical seafarer requires. For the mercantile marine engineer, the most useful form of pre-sea assistance is the National Certificate course, though that course is not really designed for the sea-going man; but it will be of great help when day release system for appreciative apprentices becomes the normal part of the heavy engineering apprenticeship. For actual sea-going subjects, one can hardly expect too much in that direction; that will have to come as now from the marine schools. Anyhow, the extent of the range of training required means that any reasonable relevant pre-sea education is going to be useful and little harm done—as long as the good practical training is not neglected.

Since the war there has been a great deal of interest in technical education, and many papers have been read on the subject. Some of these papers have been much to the point. Dr. Dorey refers to one which is written with knowledge of sea-faring requirements; but other papers have sometimes missed the true sea requirements.

With the sea-faring man, the general requirement as it appears to me is that he should be—tough: belligerent—perhaps not quite the word, but it will imply what I mean. A wide range of education is no doubt required, but it must be applicable to the requirements of the service—we must not soften the man.

Fortunately, the general standards for the mercantile marine engineer is in the hands of the Ministry of Transport. They are excellent standards, completely tuned to the requirements of the sea; but the work of the Ministry appears to be well in the background and they appear to receive little publicity. I am rather worried that the surge of educational interests may affect their very sensible standards and that sea-faring interests may eventually suffer.

The scheme, number five, in Dr. Dorey's paper, appears to be an excellent development; if it becomes general, for the first time a marine apprentice receives pre-sea training which on the theory side is generally designed to meet the requirements of the sea service; but there the essential practical training appears to suffer. But then with all methods of pre-sea training, the final adjustments have to be made before obtaining the certificate of competency.

Despite claims that heavy and practical work may be less on the modern ship, I find that the old conditions still apply. I was away serving on board ship during the summer vacation, and I find that the old methods still apply. Sea-faring is hard work, and there is still the need for drive and vigour to keep the job going with practicable ability as ever well to the fore. At present the life is good for any young man. If he is keen to go to sea and has a good heavy practical training, he is not discouraged, and facilities are provided for him to acquire the required theory standards together with the specialized sea-faring knowledge. I should hate to see any general tendencies which would change the very common-sense general requirements as they now exist.

Mr. J. F. Allan, D.Sc. (*Member of Council, I.N.A.*): I was not here this morning and I do not know whether the question Professor Telfer raises with regard to hiring or buying mathematicians at two a penny was taken up. I personally think that the President is nearer the truth in this matter than is Professor Telfer. What you cannot buy or hire cheaply are inspiration and leadership, understanding and judgment. These are qualities with which one probably has to be born, but education plays a very important part in developing them.

In the past the leaders in the shipbuilding industry have not always been highly trained technically, but there has been a trend over the years for people with university training to reach the top positions. It is very important from the national, and more so from the international, point of view that the colleges should encourage the development of these qualities of leadership and judgment as well as supplying the technical training, and that these graduates should find considerable reward in the industry. The courses provided by the Service establishments cover this aspect of the matter more definitely than do the universities.

Concerning the number of graduates that may be required, Professor Telfer has suggested a large expansion of university facilities for training naval architects, but in my judgment—and I say this without any disrespect to present attainments—if we can improve and extend existing schools, and perhaps add one additional school, we can cope with the requirements in this country. There is a limit to the capacity of the industry to absorb highly trained technologists, and too much expansion in this direction could easily lead to a top heavy condition. It is just as important to pay attention to training at the Higher National Certificate level as at the top level, and in some ways even more so. A great deal of routine work has to be carefully done in the design and construction of ships.

Another point concerns the curriculum which, broadly speaking, is not very different in the various schools, although the emphasis is different, and the intensity of the work seems to vary widely. Glasgow students would appear to get off fairly lightly as compared with others, but the figures in the papers may be misleading. After all, a great deal depends on what the student does in his own time. In the various courses in naval architecture there is a great deal of emphasis on mathematics. The tremendous importance of mathematics is recognized, but it is a tool and not an end in itself so far as naval architecture is concerned,

In view of the developments that are taking place in various directions to-day, it is suggested that more attention might with advantage be paid to modern physics and chemistry.

The amount of time given to drawing office work varies very widely from one college to another. It is appreciated that the hours spent in the drawing office may not all be devoted to drawing, but in my opinion the place where one should learn draughtsmanship and the proper laying out of drawing office work is in the shipyard drawing office under an experienced leader. A university drawing office does not provide a substitute for this training.

Finally, the suggestion that teachers of naval architecture should get together on an international basis with a view to comparing programmes of work and general experience, has had a rather mixed reception. This is somewhat surprising as on the face of it some benefit is bound to arise from any such exchange of experience.

Commander W. R. Stewart, R.N. (*M.I.Mar.E.*): The Symposium discloses a considerable difference between that thought necessary to-day for naval architects and that for engineers for the Merchant Navy. The former are required to think about and execute designs and constructions, and the latter, primarily, to operate and maintain machinery or to oversee and administer it with, however, some small possibility of participation in the design and selection of types of machinery.

For naval engineer officers all these types of requirement apply, with considerable emphasis on participation in the design and selection of types of machinery, with the additional "naval officer" requirement thrown in.

Professor Telfer refers to the "age-old squabble between highly theoretical training and management training." There is a third protagonist which might be labelled "highly practical and operative training" and is a requirement, in differing degree, for both Royal and Merchant Navy engineer officers. The terms in which the "squabble" is resolved in the various cases is very much the heart of the matter.

The Navy's answer to the question is to try to provide all three forms in varying degree. A balanced compromise is required. This is necessary both for the guidance of those who teach and direct the studies and for the students, some of whom may not be clear as to the real objectives they should pursue during their training.

In the case of naval engineering officers, the new concept of a General List of Officers, referred to in Captain Aylen's paper, may change the pattern of requirements and hence the appropriate balance of training. It remains to be seen how the new concept will work out in practice.

Captain Aylen gives the present aims of professional training for naval engineer officers. One further aim might be added and is, perhaps, particularly applicable to the advanced course at the Royal Naval College, Greenwich. It is to equip officers to analyse and interpret troubles, failures, and imperfect operation of machinery in service, and to suggest remedies. This is perhaps the one instance where the naval engineer cannot readily call on experts or back-room boys for guidance and reassurance. The problems may be diverse and to tackle them properly often requires extensive theoretical, or theoretical-practical, knowledge, particularly in the field of properties of materials. The value of a clear, well-informed report on such troubles and sound local action, or proposals for action, is very great. This might be called "advanced trouble-shooting."

Professor Telfer mentions the effect of incentives, or the lack of these, in inducing students to enter upon an arduous course of studies. Incentives are valuable in inducing students to continue their studies at a desirable intensity. Natural interest and curiosity for knowledge, and personal pride, are the best incentives, but it is unrealistic to expect these to operate all the time, especially when a set syllabus is to be closely followed. Alternative incentives, in the form of better prospects of interesting and remunerative work and preferments, for those who apply themselves well and successfully, would be most useful.

Professor Telfer's suggestion on pedagogic collaboration are very interesting. Improvement in "putting-over efficiency" in teaching is a point of great importance—especially for those naval officers, such as the speaker, who are only temporary teachers.

Mr. T. W. Longmuir (*Chairman of Council, I.Mar.E.*): It is my privilege to ask you to join me in thanking those who have presented papers to-day.

While it is not the function of the proposer of a vote of thanks to comment on the papers, I want to mention one point. Professor Telfer, in Section 5 of his paper, said it is conceivable that London and Liverpool, being primarily shipping centres, could well foster a user presentation of the subject. Professor Robb, at the end of his paper, asked is it possible to intensify the practical training so as to integrate it with the technical training?

A partial answer to Professor Robb is the Higher National Certificate course. An apprentice who is given part-time day release and who attends evening classes two evenings a week during the winter session during his apprenticeship will receive 1,600 to 2,000 hours' tuition. The right type of lad will obtain at least two ordinary certificates and one higher certificate before he has to go for national service. Some may obtain two higher certificates, and among these are potential graduates with a sound practical knowledge.

The majority of those here to-day are dependent for their livelihood upon the economical running of ships. This brings me to Professor Telfer's point. The operational side requires a different type of training and experience than the design side; the off, fair, and replace attitude of mind can only be acquired in the dry dock. There are many men holding important posts in shipping companies and repair firms whose qualifications are a Higher National Certificate, practical experience, and a knowledge of men. In this connection the thanks of both these industries are due to the Institution of Naval Architects for their policy, and to Mr. Lloyd Woollard for his personal efforts, for the manner in which the City and Guilds examinations in shipbuilding, the Ordinary and Higher National Certificates in naval architecture have kept in line with current practice.

I now ask you to show your appreciation to those who have given so much thought to the preparation of the papers and to their presentation and also to those whose contribution to the discussion have helped to make this Symposium such a success.

Sir Charles S. Lillicrap, K.C.B., M.B.E., D.Sc. (*Honorary Vice-President, I.N.A.*): Before the meeting dissolves, I think we ought to say "thank you" to our President, Lord Runciman, and to the Chairman of the Council of the Institute of Marine Engineers for their presence here to-day. I only hope that they have found it to have been worth while.

Written Contributions to the Discussion

Mr. C. H. Taylor-Cook, B.Sc.(Eng.) (*M.I.Mar.E.*): I would like to take the opportunity of submitting a written contribution to this Symposium by giving details of some of the courses that are running in technical colleges.

Technical Colleges

These fall into four groups: (1) City and Guilds courses (part-time); (2) National Certificate courses (part-time); (3) National Diploma courses (full-time); and (4) Courses for M.O.T. certificates (full-time). These will be considered in turn.

(1) **Courses arranged by the City and Guilds of London Institute.**—The particular course to which I wish to refer is that on

shipbuilding, which, in the words of the Institute, "is designed to help craftsmen engaged in the shipbuilding industry to advance his knowledge of general shipbuilding." The course was arranged by an advisory committee on which The Institution of Naval Architects and the Institute of Marine Engineers are both represented, together with other interested parties. The course consists of four years of part-time study, two for the Intermediate and two for the Final, the subjects being as follows:—

Intermediate	Final
Calculations, drawing and science	Calculations, drawing and science
Shipbuilding	Shipbuilding
Shipyard practice	Shipbuilding practice

The C.G.L.I. state that "A choice of questions in each paper should enable the more practical candidate to pass." At one college English is taken as an additional subject throughout the course, and welding is added to the fourth year.

(2) **National Certificate courses.**—A basic principle of the National Certificate scheme is that each course must be approved by the Ministry of Education and the appropriate professional institution who, whilst maintaining a suitable standard, will accept some variation in subjects and syllabuses to suit local conditions. Another fundamental principle is that the award of the certificate is not based solely on examination results, but demands an agreed standard of attendance, homework marks, and laboratory work throughout the course. It is common practice for the technical college to set the whole of the examination papers, but those for the final year of each certificate are assessed by one of the professional institutions. Typical part-time day courses are as follows (evening courses would deal only with the first three subjects in each year, these being the compulsory subjects):—

(*a*) *Mechanical Engineering.*

(i) Ordinary National Certificate.

First Year	Hr.	Second Year	Hr.	Third Year	Hr.
Mathematics	68	Mathematics	68	Mathematics	65
Engineering science*	68	Engineering science*	68	Applied mechanics*	65
Engineering drawing	65	Engineering drawing	65	Applied heat*	65
English	34	English	36	Principles of electricity*	61
Physics and chemistry*	34	Principles of electricity*	34		

(ii) Higher National Certificate.

First Year	Hr.	Second Year	Hr.
Mathematics	65	Strength of materials*	65
Applied mechanics*	85	Theory of machines*	65
Applied thermo-dynamics*	85	Applied thermo-dynamics*	65
Principles of electricity*	45	Electrotechnology*	65

For subjects marked thus *, one-third of time is spent in the laboratory.

(*b*) *Naval Architecture.*

(i) Ordinary National Certificate.

First Year	Hr.	Second Year	Hr.	Third Year	Hr.
Mathematics	68	Mathematics	68	Mathematics	65
Engineering science	68	Engineering science	68	Applied mechanics	65
Ship construction	65	Naval architecture	65	Naval architecture	65
Physics	34	English	54	Applied heat	65
English	34			Shipyard practice	54

(ii) Higher National Certificate.

First Year	Hr.	Second Year	Hr.
Mathematics	65	Advanced engineering science	65
Applied mechanics	65	Ship design	65
Naval architecture	65	Ship calculations	65
Applied thermodynamics	65	Applied thermodynamics	65

For all these certificates, subjects additional to the compulsory ones referred to above, can be endorsed on the certificate subsequently. The professional institutions grant exemptions from their own examinations to holders of these certificates on a subject-for-subject basis.

As an indication of the standard reached, the students tackle a real design during the final year. Dimensions for a new vessel are selected using data from existing ships and drawings (body, half-breadth, profile) are prepared and carefully faired with diagonals and buttocks. General arrangement, profile and midship section drawings are prepared. Detailed strength calculations are made for a box form and all curves are carefully drawn. A moment of inertia calculation is made for the design ship and finally a metacentric diagram is prepared and further checks on stability are carried out.

(3) **National Diploma courses.**—The course of particular interest in the present Symposium is that in connection with the training scheme recently adopted by some shipowners. The examination is taken at the end of a two-year full-time course at a technical college and a typical arrangement of the course is as follows:—

	First Year	Second Year
	Hours	Hours
Mathematics	133	133
Applied mechanics	133	133
Heat engines	133	133
Workshop technology	114	114
Principles of electricity	114	133
Physics and chemistry	114	114
Engineering drawing	114	133
English	114	95
Workshop practice	209	190
Naval architecture	95	114
Swimming and P.T.	57	57

To be awarded a Diploma, the candidate must pass in mathematics, applied mechanics, heat engines, and engineering drawing, together with two subjects from principles of electricity, work-

shop technology, and physics with chemistry. Naval architecture is available as an optional endorsement subject.

It will be seen that the course is very full (35 hours per week), particularly when it is remembered that homework and the writing up of laboratory reports, of which there are a considerable number, must be done outside college hours. Nevertheless, the students seem to thrive on the course and can find time for social and sporting activities.

To follow this course there is a correspondence course in naval architecture, power plant, and electricity which covers the period when the students are at sea. The lessons in this course have been specially designed to direct the students' attention to practical details.

(4) **Courses for M.O.T. Certificates of Competency.**—These courses are full-time but necessarily vary in length, since the students attend between voyages. The recognized period is three months for Part A or Part B of either the Second or the First Class Certificate. The Extra First Class Certificate course lasts for one complete session, i.e. September to July.

For all courses except the Extra First Class, students are admitted at any time and may leave at any time. This introduces particular difficulties into the teaching as every lesson must be self-contained. A typical timetable for one week is as follows:—

Second Class				First Class				Extra First Class	
Part A		Part B		Part A		Part B			
	Hours		Hours		Hours		Hours		Hours
Drawing	6	Naval architecture	2½	Science (lect.)	7½	Naval architecture	2½	Stress of materials	6
Science (lect.)	6	Electricity	3	Science (tut.)	7½	Electricity	3	Theory of machines	5½
Science (tut.)	6	Engineering know-ledge	24½	Heat engines (lect.)	7½	Engineering know-ledge	24½	Hydraulics	3
Heat engines (lect.)	6			Heat engines (tut.)	7½			Electricity	2½
Heat engines (tut.)	6							Thermodynamics	7
								Drawing and design	3½
								Naval architecture	2½

Correspondence courses are being organized so that a prospective student can do some preparation before coming ashore to attend his course. One of the most common weaknesses is in mathematics.

Mr. J. L. Kent, C.B.E. (*Member of Council, I.N.A.*): It is only in Professor Palmer's paper on the training for the Royal Corps of Naval Constructors that sea experience after the college course is mentioned as a definite part of the naval architect's training, and that what the post-graduate does during his year at sea is more or less decided by his professors.

Professor Burrill states that "it is desirable that he should have some sea experience," but presumably it is not a definite requirement for his degree. Possibly all four professors would regard sea experience as desirable, but should it not be compulsory before awarding the degree?

My own experience suggests that there is no adequate substitute in college or laboratory for the training obtainable in a few ocean voyages in carefully selected ships, and that if it is necessary the time for such voyages should be found by eliminating or cutting short the time at present spent on some of the less essential subjects of the college courses. I would suggest that those types of ships which have not the amenities of the large passenger liners should be selected, so that the uncomfortable living conditions in which the working of the vessel must be carried out, and which particularly exist during bad weather, are so impressed on the mind of the graduate, that in his future career he will never forget to do his best to provide really W.T. cabins and living spaces with good ventilation, adequate sanitation, decent galley arrangements, safe open decks where flooding during a storm is possible, and so on. He will understand, as he cannot in college lecture rooms, the gyrations which it is possible for a ship to perform in high seas, the straining to which the hull structure is subjected, with the possible experience of hearing a plate split (if he is lucky) when the ship is labouring in a bad seaway, the rather alarming fluctuations which occur in the torque of the propeller shaft, the annoying vibrations, etc., etc., and they will be impressed on his mind in such a manner that he never forgets them throughout his subsequent career.

In my opinion such sea experience should be compulsory and not optional for all student naval architects, and it should be undertaken after the full college course, so that the young man then knows what is essential in his study of the ship's behaviour, and what data to collect in all weather conditions. It is only after his college course that he will be fully equipped to judge for himself how closely his experiences at sea agree or differ from the theories he learned in college, and he will realize more fully the relative importance or unimportance of the different features of ship design upon the efficient and economic running of merchant vessels.

Mr. D. Shryane, B.Sc. (*A.M.I.N.A.*): Professor Telfer certainly deserves the support of us all in his main argument, but it is to two small points which he raised that I would now draw further attention. The first was the attitude of industrial chiefs to the young graduate in the shipbuilding industry. It is true that there still exists a tendency for a regrettably large number of leading men in the industry to belittle the achievement and potential value of the university graduate, and as long as this persists we are setting up an unnecessary obstacle to recruiting the best brains into our profession. I would emphasize, however, my use of the word potential, since it is well known that newly graduated men are of little practical value in shipbuilding until their B.Sc. degrees are backed by a wide and sound practical experience in the shipyards, extending over some years. A young graduate who failed to appreciate this could be a positive liability to his employer, and no doubt the senior industrialists now under criticism have bitter experience of this kind of thing, and have allowed their opinions to embrace graduates in general. Presumably these men are not graduates themselves, and would therefore not fully appreciate the considerable range of attainment covered by the Bachelor degree, from the borderline case in a Pass degree to the head of the list for First Class Honours, although of course both these kinds of graduate could be equally useful in a shipyard provided their scope of employment is wisely chosen.

The second point raised by Professor Telfer to which I would refer is his mention of the lack of professional protection afforded by both the industry and this Institution. I have an uneasy feeling that he is right, although it may be as well for me to be content with making this observation, and to say no more.

The differences in the degree courses at Glasgow and Durham are very interesting, and I notice that Professor Robb emphasizes

that the Glasgow degree is essentially engineering with naval architecture included (in fact rather like the newly instituted General Degree course at Durham), whilst the course at Durham is more inclined toward professional subjects. This distinction is, in my view, very useful in that each university might be considered particularly suitable for training students to fill different roles in the profession. Unfortunately, I think it is true to say that few students appreciate the difference early enough in their careers to take advantage of it, and it is a pity that this should be so. It is worthy of note, too, that the Honours school at Durham is quite distinct, whereas an Honours graduate at Glasgow is someone who has excelled in the same course and examination as a person offering subjects for an Ordinary Degree.

Professor Palmer emphasizes the importance attached to mathematics at Greenwich, and I think this is a splendid policy. There is considerable scope for mathematics, some of quite an advanced nature, in naval architectural subjects, and I feel that taken collectively, there are too few men in the profession able to embark on projects of a mathematical nature. This is particularly true of holders of the Higher National Certificate, who, through no fault of their own, have pursued a course of study lamentably weak in mathematics, which on occasion precludes them from undertaking many non-routine calculations in ship design.

Professor Palmer mentions the shortage of properly qualified candidates for admission to the Royal Corps. I dare say that a number of the present candidates are young men who are prepared to face up to the rigours of Greenwich in preference to a period of two years in the army, and from Professor Palmer's statistics it would appear that he very rightly declined to accept them. Among the more acceptable kind of likely candidates will be the man twenty-four years of age, just graduated with, say, First Class Honours, who considers the preceding four years' hard work to be well spent; but who might have different views on a further long period of training at Greenwich and elsewhere. He will look at the advantages of such a course, and find the security of employment to which Professor Palmer refers and also of course a satisfying professional career. But does such a man need, or more important seek, security? What he does need is a good salary immediately to provide a firm financial foundation for marriage, house purchase, and so on, and he would seem more likely to achieve this entering competitive industry at once, than by going to Greenwich. Whether or not he would die a richer constructor than a commercial shipbuilder, apart from being imponderable, is largely irrelevant to his immediate problem. In addition to this, there is the fear that if he entered the Royal Corps, his further progress may be governed to some extent at least by seniority lists and protocol, and less by his own initiative, and we must assume from what Professor Palmer says that the kind of man he seeks will have an abundance of initiative. My humble view is that the wrong kind of incentive is being offered for the type of recruit required.

I hope that some action may result from this Symposium so that, at least, future generations will not have cause to deplore our lack of foresight, as some of us now, according to Professor Telfer, regret the parochial outlook of the 1939 Committee.

Commander L. E. S. H. Le Bailly, O.B.E., R.N. (*M.I.Mar.E.*): I am concerned with that part of the training which is referred to in passing by Professor Robb, Professor Burrill, and to a greater extent by Professor Palmer, namely, that almost indefinable type of training called character or leadership training. It is refreshing to know that the need for this type of training to-day is at least acknowledged, although I must confess that after reading the papers I can find no suggestions, except in Captain Aylen's contribution, as to how this type of training should be encouraged.

1. The problem at the R.N. Engineering College is how to combine in a limited time the established professional engineering training with the development of those personal qualities which will convince such young men that their principal duty is one of total leadership of those with whom they serve, and of full personal responsibility for the welfare both of those men and of the great machines which, jointly with their men, they must control. This heavy responsibility is made more difficult to-day by the drift from religion and the lack of personal responsibility and moral courage engendered by the security offered in our national life.

Young men (aged about 20–23) have a dual task to achieve and in trying to do this a balance is made difficult by the inescapable fact that the professional standard is rigidly defined and (by removal from the Service or University for failure) rigidly enforced.

2. At the R.N. Engineering College we are trying already to cram a three-year university-type course into 98 working and 20 holiday weeks, and we therefore have little, if any, time for other types of training, whilst the out of hours work for the young officers is just as heavy as at a university, if not heavier.

3. Nevertheless, we feel it fundamental to the whole course that this "Character Training" should proceed and we have found time (it only takes about two weeks altogether) to introduce in a fairly intensive form, a type of training derived from some of the principles of the Outward Bound Trust.

4. We are finding that this is having a very considerable effect in stimulating in young officers those many qualities which we seek to give them. Also because they themselves have to write all the orders and carry out all the organization to take thirty or forty of them from Plymouth up to Scotland and to live on their own in the hills for a week or more, we find their foresight, sense of anticipation, and orderliness of mind have been greatly improved.

5. We did not adopt this training without some opposition from those who remind us of the evils of the Hitler youth and of others who immediately assumed that this was some type of evangelical crusade. It is neither, and it has grown up empirically as we have proceeded with the different schemes. The officers have to endure fatigue and hardship; they have to live together under rigorous conditions in a self-contained, interdependent community; many are fully extended for the first time in their lives. From all this we are certain they derive not only considerable satisfaction and an increase in self-confidence, but also an increase in many other personal qualities. The best and the worst is shown up in each and this too is a help in giving the training staff a more accurate knowledge of the potentialities of the various officers under training.

6. I know well that most universities have societies which carry out expeditions of a most rigorous nature. But generally speaking, these societies are confined to young men who have had an opportunity or are keen to find an opportunity of proving themselves. By making this type of training obligatory we try to give its benefits to those who, through lack of opportunity or self-confidence, have never left the "city lights."

Professor Harry Benford (*A.M.I.N.A.*): While educational problems in Great Britain differ in several respects from those in the United States, many of Professor Telfer's comments and suggestions strike responsive chords on this side of the Atlantic.

Of particular interest is the novel suggestion that an internationally agreed-upon set of notes be made available to students at the various institutions. Engineering curricula are seriously overcrowded as the result of our expanding sum of knowledge coupled with almost universal adherence to the now inadequate four-year programme. Teaching-aids such as these are badly needed under present-day conditions.

The dictum that the presentation of notes should be considered primarily from the standpoint of ease of assimilation is

worth noting. Many a professorially-written text betrays its author's predominant desire to impress his peers with his erudition. Some give the distinct impression that exceptional will-power was required to resist the temptation to write the entire work in Latin rather than the vulgar tongue.

Standardized notes would be of maximum benefit in the basic courses. The more advanced material would be much less adaptable to such treatment and some doubt therefore exists as to the effectiveness of such an extension.

Good teachers are born, not made, and formal training in education is no substitute for natural abilities. An educated and experienced naval architect should make a good teacher if he has the instinct and ability to express his thoughts in a clear and straightforward manner. Coupled with this he must have a sincere desire to impart what he knows to his students, and a sympathy for their problems. That he should set his charges a good example by his own integrity is so obvious as to be sometimes overlooked. Patience and imagination might head the long list of additional desirable traits. If a man can lay claim to most of these characteristics he should find little need for pedagogical training. If these factors are missing in his make-up, no amount of pedagogy will help. There may even be an element of truth in the take-off of Shaw's old canard: "He who can, does. He who cannot, teaches; but he who cannot teach, teaches teachers how to teach."

Professor Telfer has advanced a number of worthwhile thoughts for consideration by members of the shipbuilding profession. Let us hope they meet with approbation and that his will not be a voice crying in the wilderness of complacency.

Lieut.-Comdr. A. M. Tyc, Polish Navy (ret.) (*A.M.I.N.A.*): In my professional life I have graduated twice, twenty years apart; the second time being last year. Last year, I completed five years' employment on Tyneside together with part-time study, an experience which prompts the following remarks:—

Indifference in administration and lack of leadership in a shipyard is discouraging to youth, progress and advancement not being dependent on examination results. May there not be some truth in the assertion that it is more important who you know than what you know?

The mere "serving of time" as an apprentice which ignores personal achievement academically or otherwise, and classes both as of equal earning capacity, cannot be considered satisfactory.

It is not sufficient to mass-produce graduates without providing them with adequate outlets to show their individual skill, capacity, and opportunity to use their abilities profitably in the industry. Nor need such openings for advancement be necessarily confined to those with high academic qualifications; there should be appropriate professional openings for the man who fails in his schooling but who possesses real practical skill and has made good in his work.

As regards Professor Robb and Professor Burrill's paper, I personally favour Higher National Diploma course followed by a university degree, as each of these stages allow for abilities and financial resources. I would train all drawing-office apprentices by a sandwich course with the proviso that the responsibility for teaching would rest in the hands of a newly created Industrial Instructor, who as a technical teacher would, like the students, work alternate sandwich seasons in the college and the shipyard. To place responsibility for practical training on a "charge-hand" is to place too high a burden on a man already overloaded.

Part-time study for Higher National Certificate I would leave for adults who may be displaced from their usual occupation and may work for an opening in shipbuilding, or to others who decide late to acquire academic knowledge.

I am surprised that there exist no later qualifying or refresher courses. Due to the importance of preliminary design in basic training, all graduates seem to be poised for one or two vacancies in the shipyard, as assistant naval architect or chief designer, other shipyard appointments receiving fewer candidates. This should be remedied by the teaching of production, i.e. shipbuilding, in college by means of films and television.

Imaginative use of television should be explored. By methods of rediffusion in feeding television screens, the shipyard may become one of the college's laboratories. Endorsement courses for Higher National Certificate should be separated by a lapse of time from Higher National examination, or others. When a graduate settles in one of the shipyard's activities he should be offered a choice of courses in design, estimation, construction, management, survey work, etc., as the case may be.

Mr. Ian C. Bridge, B.Sc. (*M.I.N.A.*): Some years ago, a very well known shipbuilder stated quite bluntly that the man who had spent the whole five years of his apprenticeship in the shipyard was of greater value to the industry than one who spent a large part of that time at a university or technical college. Professor Telfer has some very pertinent comments to make on the two possible conclusions which may be drawn from this statement: either that the university education at present available to the naval architect is quite worthless or, alternatively, that the industry has so far failed to realize the potential value of the highly trained man; in either case, a situation which gives rise to some concern.

With regard to the poor response to the scholarships administered by The Institution, there is one obvious reason to which the attention of the Council has already been drawn. The competitive examinations in practically all cases include a paper, or papers, in naval architecture and mechanics and are, therefore, outwith the scope of a boy immediately on completion of his scholastic education, whether at public, grammar, or secondary school. This, however, is the type of student most likely to wish to commence his career by proceeding directly to a university. On the other hand, the student who has acquired sufficient knowledge of these subjects through attendance at evening classes has most probably left school without obtaining the necessary university matriculation qualifications and is consequently unable to benefit from such scholarships. There is a case here for the acceptance by the universities of certain evening class qualifications in lieu of normal matriculation for degrees in applied science.

This is a matter of major importance, not only to shipbuilding but to engineering and science as a whole. The increased demand for technologists envisaged in the Government's Survey of Scientific and Engineering Manpower just cannot be met in the immediate future by the number of science students leaving school with matriculation qualifications. It will be necessary to tap the vast reservoir of boys who, through domestic circumstances, bad advice, or impetuousness, leave school before reaching this standard. Many of these later attend evening classes and discover there a new eagerness and ability to learn, but are pulled up short at the level of the Higher National Certificate. While admittedly limited in outlook and deficient in fundamental sciences, these National Certificate courses are not to be despised and a first-class performance therein is usually a sound guide to ability to profit from a higher training. Having a more mature and experienced outlook, such a student is much better able to appreciate the potential value and application of his teaching than is the boy straight from school.

In this connection there is an omission from Professor Telfer's survey of existing and proposed schools of naval architecture. The Associateship with honours of the Royal College of Science and Technology, Glasgow, is recognized by the Scientific Civil Service, the professional institutions, and informed industry as equivalent to an honours degree. It is awarded on a four-year full-time course, taken on the sandwich system, with the addition of a small research problem on which a thesis must be submitted.

A system of transfer is available to students obtaining a good Higher National Certificate, and only in very few cases have such students fallen below the honours standard. The department of naval architecture of that College is staffed by a senior lecturer and two lecturers.

The author would appear to regard naval architecture drawing as an exercise in draughtsmanship, but surely, properly treated, it forms an indispensable part of the course. The theoretical work of the lectures can only be fully grasped by the student if he is required to prepare hydrostatic curves, stability curves, vibration calculation, a preliminary design for a ship and propeller, etc. Such items are more adequately titled naval architecture design and, together with a lines plan (perhaps the supreme test of draughtsmanship), provide ample opportunity to instil method, accuracy, and neatness into the student's work.

Here, too, in the less formal and more leisurely atmosphere of the drawing office, the lecturer-student relationship attains its maximum value. Working together in tracing a discrepancy or searching for a reference, the student will learn from a good teacher much that can never be formally taught, while the teacher can likewise learn much about (and sometimes from) his pupil.

Professor Telfer's suggestion of pedagogical collaboration at professorial level, while it has much to recommend it on the grounds of sound common sense, is hardly likely to be received with great enthusiasm by his professorial colleagues. It is difficult to conceive of men of the calibre and character desirable in a university professor being prepared to accept another's views on even the rudiments of the subject. Differences of opinion are by no means confined to the more obscure and controversial aspects!

If Professor Telfer succeeds in provoking sufficient wrath to result in any positive action—or reaction—by industry he will indeed, as he suggests in his concluding remarks, have accomplished a miracle. The writer ventures to wish him every success in this difficult feat.

Sub-Lieut. G. Ward, B.Sc., R.N.V.R. (*A.M.I.N.A.*): The accusation by Professor Telfer that students do not wish "to undergo the further indignity of having their particular talent tested" is hardly fair. Before students are awarded any kind of grant they must have had their "talent tested" to ascertain whether or not they are fit persons to enter a university; further, having been allowed to enter a university, they must satisfy their examiners at the end of each academic year before they are allowed to proceed in their course. It seems to me that students have their "particular talent" tested continuously.

The reason why the non-research Institution scholarships are not so popular is not the fault of the students, as Professor Telfer would like to suggest, but the fault of the scholarships. To do well in The Institution scholarship examinations, students must understand details of naval architecture and ship construction requiring a good deal of specialized knowledge and experience. As this in particular puts the boy not long left school at a disadvantage, is it not more reasonable to use university entrance requirements as a criterion for the non-research scholarship examinations? These scholarships, as they are at the moment, provide for the same training as local education authority grants, which, with a good General Certificate or good Higher National Certificate, can be obtained more easily. Therefore the conclusion would seem to be an alteration of The Institution non-research scholarships. A scheme similar to that arranged by the Shipbuilding Employers' Federation would be well worth considering. The Institution of Naval Architects could offer a scholarship which would provide for university training, shipyard familiarization, and research experience. Arrangements could be made with shipyards and research establishments, both in this country and abroad, to provide training facilities and possibly to finance the student's stay there. I feel sure that a scholarship which offered such a training would be popular, provided that student applicants straight from school were not expected to know much about naval architecture and shipyard practices.

Mr. A. Emerson, M.Sc. (*M.I.N.A.*): In reading the three papers on university education one regrets the absence from the Symposium of two "opposition" papers stating the cases for a non-technical university education and for a non-university training of future shipbuilding managers and directors. The naval architecture course at a university lies between these extremes. The danger lies in the tendency to allow too much effort to be spent in merely absorbing information. Examination papers suggest that most of the student's time is spent in learning and being able to reproduce the correct answers to a fairly limited range of questions. The intellectual discipline of mastering a subject is of great value, but certainly not of greater value than the exercise of critical judgment and imagination.

The correctives to this state of affairs are all present, but at too late a stage in the university course. They are: design; production of a thesis (which form part of the final Honours year of the course at Durham); and experimental work, which occurs in post-graduate research.

Although the student is not equipped to tackle a complete ship design until the end of the course, practice in the use of space and materials—the balance of conflicting requirements can be started with very little knowledge of naval architecture.

The production of a thesis on recent developments of a branch of naval architecture compels the critical reading of original papers. Although this is very much a matter for the lecturer himself, it is suggested that the reading and analysis of at least one newly published paper per term would be a stimulating change for the student.

The use of experimental work to teach observation and measurement is at present regarded as the province of the "other subjects" in the course. This has a limited usefulness as the experiments tend to be "set pieces." To find out by experiment, or to check an idea by planning a research programme represents a much more advanced stage of development. There seems to be a clear case for experimental work in naval architecture throughout the course, ranging from a standard model inclining experiment to alternative structural arrangements or methods of erection tried out on model scale.

The time for these additions to the course must be obtained by reducing the time spent on other parts of the course. Without going into detail, the best way of doing this is to make better use of the "sandwich" system. It takes little time to explain how and why a routine calculation should be done. The practice is best learnt in a shipyard.

The diversion of attention in the three ways described are intended to produce a graduate able to think for himself at the possible cost of knowing less.

Mr. R. M. Cameron, B.Sc. (*A.M.I.N.A.*): The equal shipbuilding and marine engineering qualifications available in Norway, which Professor Telfer mentions in Appendix II of his paper, appeal to me greatly. Perhaps an indication of the form of the corresponding practical training could be given.

The point of view that ship drawing and standard ship calculations are best learned in a shipyard rather than a university has my strong support. The reality supplied there is invaluable. Even if this system were increasingly adopted, all the time saved could not be used for lectures without leading to mental indigestion. It should be made available for a more active participation in the social life of the university than at present possible.

The six months' sandwich system, all of which counts towards an apprenticeship, seems to me to suit the particular conditions of shipbuilding very well. The university time available in a

four-year course of this type is short. I suggest that it is too short to attain degree standards, bearing in mind those advances in knowledge which must be incorporated, and the need to devote in my estimation more time to commercial subjects. Therefore I feel that the adoption of the five-year sandwich course is essential, at least for honours. Even then the total time spent at university will be no longer than that spent there by other students in a four-year course. This point of view is not original, but it has not been expressed in the papers. An up-to-date use of shipyard time would justify the five-year apprenticeship being equally divided between shipyard and university.

The National Certificate courses have been mentioned. Surely this is where any expansion in facilities should begin, to allow some full-time education, for example six months, for all Higher National Certificate candidates.

The Greenwich course is mainly of post-graduate standard. In my opinion post-graduate courses of short duration should be made available at Greenwich, without an entry examination, to suitable graduates in naval architecture, who do not intend to make the R.C.N.C. their career. These could be anything from two weeks to a year in length and have a syllabus with a bias towards strength of ships (in which branch the average naval constructor has more responsibility than his counterpart in merchant shipbuilding), design of warships and Admiralty organization and procedure. Such courses would benefit those to be employed in building warships, to the Admiralty, and to the country in time of war. The interchange of outlook and ideas among the students at Greenwich would be valuable.

Constr. Lieut.-Comdr. R. J. Tirard, B.Sc., R.C.N. (*A.M.I.N.A.*): I would suggest that the training at M.I.T. and the Webb Institute of Naval Architecture should be studied. The latter is the only school I know of which caters exclusively for naval architecture and marine engineering, and I feel that much could be learned from their methods.

The Symposium also set me to evaluating my own experience with the sandwich system as practised in Newcastle and with subsequent experience. I am glad to see from Professor Burrill's paper that much of my criticism of the course would nowadays be ill-founded.

We suffered at the time from a course which, though satisfying from a point of view of the main subject, seemed to be somewhat haphazard in the subsidiaries, which were tuned to the requirements of the type of engineer for whom they were the main subject. I know that this situation is difficult to avoid and I feel that all concerned on the teaching side would agree with me, but I also welcome, since my day, the addition of electrical engineering as a subsidiary subject to the course. The revision of the course from three to four years for an ordinary degree is probably essential in these days of increasing complication, and I should like to ask Professor Burrill if this has enabled the following, which I have found lacking since I left Durham, to have been included:—

(i) Welding processes and materials, including prefabrication and welding sequences.
(ii) Steel-making methods and their influence on shipbuilding steels and alloys.
(iii) The structure of wooden and composite hulls.
(iv) Corrosion and paint composition.
(v) The historical background of naval architecture.
(vi) Shipyard layout and machinery.
(vii) Costing and estimating.
(viii) Design and construction of planing hulls, possibly including hydrofoils.

Regarding the number of chairs of naval architecture, I am a believer in the rules of supply and demand. I feel that if the increase in the number of students continues, it will be necessary to find the number of professors, departments, and lecturers that the increase warrants, but let us not use an inland university. I agree that Southampton, as a south coast centre covering the requirements of this area, would be a likely candidate, but I should also like to ask how much of the increase on Professor Telfer's and Professor Burrill's graphs stems from the closing down of the department at Liverpool?

Looking now on the recruiting of students, is it not possible that the working conditions in the shipbuilding industry compared with those in many other industries may have something to do with the shortage. When one compares the polluted rivers and atmosphere and generally gloomy surroundings of many shipbuilding centres, and the dirty conditions around ships on the berth and fitting out, with those pertaining in other industries, it is small wonder to me that many promising youngsters with a basic love of ships may be frightened away.

Finally, in these days when technical training starts at a later age, some of the difficulties of compressing an inordinate amount of detail into a short period without interfering with the necessary teaching of first principles might be alleviated if use were made at public school age of the training ships *Worcester*, *Conway*, and *Pangbourne*. All these establishments cater mainly for deck officers for the mercantile marine. I can testify that their training for one who is going into shipbuilding or marine engineering is extremely valuable, and I feel that this is at present being overlooked by both the Royal Navy and industry.

Mr. D. W. Lang, B.Sc., A.C.G.I., R.C.N.C. (*A.M.I.N.A.*): The four papers dealing with the training of naval architects have each produced their own ideas as to which is the best method of training. It is an interesting reflection that the Royal Corps of Naval Constructors now embodies the majority of these schemes in its five methods of selection, and it would indeed be presumptuous of me, as a very junior member, to say which produced the best Corps officer. However, as the officer at present in charge of the Constructors' Training Office, I can say that in a year in which we have a cross-section of each type of entry, I have found that the free exchange of ideas between the students does help enormously to increase the "putting over efficiency."

Not entirely divorced from that idea is the importance of a Corps probationer living in naval messes and mixing freely with his naval contemporaries during his training period. By so doing he does learn to appreciate and respect the views of naval officers, and the friendships and contacts which he makes in this early part of his career prove of immense value to him for the remainder of his service life. For the ex-apprentice this aspect of his training has a special significance. For four years as an apprentice he has been trained to fulfil a general function in the dockyard organization. It is true that if he does well throughout his time at the Dockyard Technical College he will expect to be considered as a future constructor officer and that, failing this, he can without much extra effort become a draughtsman or an inspector, but this is speculation, not a certainty. Consequently it is not surprising that of those chosen to become constructor officers there are some for whom the life in naval colleges is especially valuable, as they have the opportunity to develop those qualities of leadership and self-assurance which are so admirably brought out by naval training.

The advent of the student apprentice entry should have the effect of producing more candidates of the right calibre, since on the one hand a higher academic standard is required at entry, and on the other from the outset these apprentices are being trained as future officers.

It is interesting to note that whilst a final examination in shipbuilding is set at Greenwich, no formal lectures are given in this subject and the student relies upon the knowledge gained at the C.T.O. and in subsequent vacations. It would be of interest to

see a comparison between the final examination papers set at Glasgow and Durham and those set at Greenwich; also if any paper on shipbuilding is included in these, and whether formal lectures are given in this subject.

Finally, I am in complete agreement with that part of Professor Telfer's paper dealing with the need for some pedagogical training of those who have to do with the teaching of naval architecture.

Professor Ing. Stanko Šilović (*M.I.N.A.*): I welcome most warmly Professor Telfer's suggestion for an international meeting of professors of naval architecture and gladly accept this proposal. In spite of specific differences between various countries, the methods of shipbuilding are the same and the final products, the ships, are also the same. Ships are constructed under the supervision of the same classification societies and according to their rules, which are applicable in all countries.

I think it would be possible to diminish the existing differences in the education and training, which the various universities and faculties throughout the world offer to the young people who in the future will be leading personalities and managers of the shipbuilding industry and scientific workers in shipbuilding research.

The proposed international meeting of professors would be the first step in this direction, where the problems set by this Symposium could be discussed in more detail; present experience about the university education of naval architects and marine engineers could be exchanged, and constructive conclusions and decisions for the future agreed. Our Institution, as sponsor of such a meeting, would contribute a great deal to the further development of shipbuilding in general.

The Symposium shows that in Great Britain there seems to be a striking difference in the education and the selection of highly qualified specialists for the Royal Navy and for the Merchant Navy. I wonder what are the reasons for such a difference. Technically and economically the design and the construction of ships, and especially of merchant ships, is a very important job. If the people who are doing these jobs are better educated and better prepared for their future career, better ships will result. Can we boast that all ships built up to now are really first class? Or, in other words, would it not have been possible to make them better and more economical? A ship already completed is generally quite impossible, or at least very difficult, to improve.

It is an important problem how to combine a well-grounded theoretical knowledge with an efficient practical training.

All of us, whose daily pursuit is the education of young people, ponder about these problems, and every one of us has certain definite notions and methods of his own which are, however, mostly inherited. At a joint conference we could exchange our views, and I am sure we would come to useful conclusions.

Mr. J. H. B. Chapman, R.C.N.C. (*Member of Council, I.N.A.*): We are asked to look into the future, always a fascinating task calling for the exercise of considerable wisdom and judgment if action is intended. Even if decisions can be reached quickly, it will be ten years before those now about to commence training find their feet and some twenty years or more before they reach the higher positions in the industry.

What will the industry be like in twenty years? What sort of men will it need? Will there be gradual technological progress, similar to that of the last twenty-five years? Will the ships we build then be similar to those we build now or will the advance of science and technology produce significant changes? Naturally we think of nuclear propulsion. Are other changes in the offing, caused by economic, political, or technical circumstances or advances?

What Professor Telfer says in his paper can be summarized, I suggest, as follows:—

(*a*) The present methods of training need improvement.

(*b*) There is a need for a great increase in the number of graduates in naval architecture.

(*c*) The number of university chairs should be doubled or more.

(*d*) The outlook of the industry upon the employment of university graduates needs a change of heart.

None-the-less, from the papers it is evident that the number of students at Durham have increased since 1945. Similar particulars for Glasgow would be of interest if Professor Robb could provide them. Is the industry taking all the graduates it can get or are they finding employment in other industries or abroad?

We have to clear our minds, therefore, about the need for change in our present methods of training. Are changes necessary at all? If they are, should they be in the direction of increased numbers or higher standards, or both? Are immediate changes needed or should there be a gradual build-up? I suggest that only a determined look into the future can give us the answer to these questions. First, the industry should clarify its requirements. Discussions could then take place between the industry, the universities, and the Ministry of Education to hammer out a solution.

I personally believe that the British engineering and shipbuilding industries will need all the technologists and technicians they can get, with an increasing proportion of the highest calibre, if we are to hold our position at home and against foreign competition.

The Admiralty has been faced with a training problem for a long time. It can fairly claim, I suggest, that it has been in the forefront, if not a pioneer, in many respects. I do not need to remind you that the naval constructor has to combine the attributes of the naval architect, shipyard manager, surveyor, and scientist as well as possess marked administrative talent.

We are proud of the traditions of the naval architecture course at the Royal Naval College, Greenwich. The method of training has withstood the test of time. It is modified from time to time to suit modern developments. Always we find that the time available is not enough, always the difficulty of maintaining the correct balance between theoretical and practical instruction. Although sometimes tempted—and often pressed—to allow more time for subjects of direct value to particular parts of the students' subsequent career, I am certain—and I am glad to see that Captain Aylen agrees with me on this—that it is the true purpose of university education to instil the fundamental principles and an ability to use them. We fully recognize, however, the importance of practical training and make full use of the period before Greenwich and the vacations. We must always be conscious of the fact that we are training not only naval architects but naval constructors.

The standard of training is high and I am convinced that it would be wrong to lower that standard.

You will note that our recruitment has become increasingly wider as changes have occurred in the social, industrial, and educational structures of the country. I would draw your attention particularly to the new Schools Entry, Source E, which we started last year.

It is a very significant fact that the excellent training given at Greenwich and the career offered in the Royal Corps still do not attract enough candidates of the right quality. Some of those we do get and train soon leave Admiralty service for industry. It is perhaps still more significant that most of those who leave do not enter the shipbuilding industry despite its prosperity.

The changes in training of the naval engineer officer referred to in Captain Aylen's paper may mean that Source B will not be available to the Royal Corps in future. That will be a matter of great regret as many distinguished members entered the Royal Corps by that channel. I mention especially Sir Stanley Goodall.

At one time there was a regular flow of private students through Greenwich. Many have since gained important positions in the industry. The flow has virtually stopped in recent years, which is, I think, a matter for concern. It may be because a degree is not conferred upon successful students, although the professional certificate granted is of high standing.

So long as a navy is needed—and I am convinced it will be—the constructor will have a vital part to play. The more scientific and complicated the art of war becomes, the greater will be the need for men of the highest calibre. The position for shipping and the shipbuilding industry as a whole is perhaps not so clear-cut. The papers and the discussion, with their inevitable consequences, will, I hope, be of great assistance to those responsible for appraising the needs of the future.

Mr. R. V. Turner, B.Sc. (*A.M.I.N.A.*): It is interesting to attempt a numerical analysis of the possible future requirements of the shipbuilding industry assuming that for a long time to come the present total labour force of some 200,000 employees will be maintained.

In a medium-sized shipyard with, say, 1,500 or so employees, it would appear that there are approximately seven to ten appointments whose status and salary are sufficient to attract the permanent ambitions of a first-class graduate in naval architecture. If this ratio of attractive appointments to total employees may be taken as applying throughout the industry it would seem that the total number of such appointments is of the order of 1,000. Further, assuming that approximately one half of the graduates each year eventually leave the industry for other forms of employment, it would seem reasonable to say that an annual output of some eighty first-class graduates would be sufficient to ensure that recruits will be available for all the responsible positions falling vacant in this country each year. With reasonably efficient selection of entrants to university courses it might be possible to produce these eighty first-class graduates with an annual intake of some 120–140 freshmen.

Thus it would appear that if Professor Telfer's plea for five new chairs is a little ambitious, the present facilities are by no means adequate. But it must be borne in mind that there is the fundamental assumption here that *all* the senior posts in shipbuilding (excluding the clerical departments) will eventually be filled by graduate naval architects and one has only to glance down the list of posts given by Professor Burrill on p. 341 to realize how far this assumption fails to hold true at the present time.

There is every reason to believe that in the future the channels whereby the present occupants of these responsible posts reached their exalted rank will be blocked by the availability of free university education and that practically all the brilliant young men of the future will be funnelled off by the educational system to take a university degree of one form or another. Hence, while it was perfectly true in the past that one could have a first rate management without any graduates, in the distant future it is more likely to be found that, unless one has a large number of graduates, one cannot have first rate management.

One cannot but agree with Professor Robb that the emphasis at a university should be on "understanding why" rather than "knowing how," but to a large extent this should surely also apply to the work of the technical colleges. If leaders in the industry have the right approach towards training and have their office techniques reasonably well organized, the proper place for an apprentice to learn how to calculate and draw is his place of employment, and it would appear undesirable in many ways to allow any form of educational establishment to take up too much of its time with the practical aspects of naval architecture beyond the S.3 level.

Mr. John Cook (*M.I.N.A.*): The concluding section of Professor Burrill's paper makes reference to the National Certificate and Diploma courses which provide most of the training for students of naval architecture unable to read for a university degree. This matter was also referred to by Mr. A. J. Sims in his contribution to the discussion when he made particular reference to the Diploma course at Sunderland Technical College. This course, which is of the sandwich type, extends over a period of three years, with six months at college, followed by the six summer months in the shipyard. These courses have been in existence for many years. Indeed the system was introduced at Sunderland in 1903 and has provided a high standard of training, approaching that for a Pass degree, for a large number of students, many of whom have attained positions of responsibility in the industry.

From personal experience I can endorse the value of this course at Sunderland, particularly in the combination of practical shipyard training with academic studies during the winter. A condition of entry is that a student should have two years' practical apprenticeship training before entering college. This procedure undoubtedly enables a student to become familiar with shipyard operations and acquire the necessary technical vocabulary; if this pre-college period is spent in the shipyard drawing office, as is frequently the case with naval architectural students, the necessity for teaching drawing at the college is considerably reduced or even unnecessary; and in this I would concur with Professor Telfer in his concluding remarks in Section 6 of his paper.

Sunderland Technical College is, I believe, unique in this country in that its naval architecture department also possesses a fully equipped mould loft. This it owes to the generosity of the late Sir Robert Bartram, the local shipbuilder. This forms an additional valuable means of combining practical and theoretical training.

The nature of the whole course has much to recommend it for those who may not require the highly technical training offered by the university, and who seek posts in shipyard organizations where the practical application of established fundamental principles is of greater importance than the more specialized activity such as Professor Burrill lists under the heading of Research Assistants.

Professor Telfer suggests the formation of new schools of naval architecture at a number of universities, including the University of London, and further suggests that at London and Liverpool these might develop a user presentation of the subject rather than a producer presentation. At the Sir John Cass College, London, which is closely linked with the university, the department of navigation provides courses for the training of senior officers of the merchant navy studying for Ministry of Transport certificates. The syllabus for extra master grade includes both theoretical and practical naval architecture at a fairly high level, as will be seen from the revised syllabus recently published by the Ministry of Transport. It might well be that should the suggestion made by Professor Telfer be pursued then such courses as these, catering as they do for the user personnel, could be further developed along the lines envisaged.

Mr. P. H. Tanner, B.Sc. (*A.M.I.N.A.*): There is an old shipyard saying to the effect that "if a man can design a ship, he can do anything." The converse of this, that it takes a man of "all round" ability to design a ship, is also very true. In this connection the writer finds himself in unaccustomed agreement with Royal Naval methods in the prominence given at Greenwich to that universal tool, mathematics. The two university syllabuses outlined in this Symposium make a very poor showing in comparison, Durham devoting 14 per cent of the total time, and Glasgow even less—12 per cent—to this important subject. In Glasgow, it is true, an additional course in advanced mathematics is available, but this is included in the final year timetable, and only a small number of students, which very rarely

includes a naval architect, ever seems to be able to spare the extra time required. A study of recent papers presented to The Institution shows the importance of mathematics to the modern naval architect: it is surely most unrealistic for it to be classed as a "non-professional" subject in the Durham syllabus. An improvement in the status of this subject must surely be the first move in the raising of technical standards as a whole.

In other respects the Durham and Glasgow syllabuses show a considerable divergence in the emphasis placed on "non-professional" subjects. While both courses probably dwell on the theoretical aspects of naval architecture to the same extent, Durham appears to devote considerable time to shipbuilding practice at the expense of the general course. Perhaps the answer lies in Professor Burrill's table of appointments, in which one might expect a preponderance of Glasgow graduates in the categories on the left-hand side, and Durham on the right.

In the matter of practical training, the writer cannot agree entirely with Professor Robb that this should precede the university course. Assuming that it is the really good men who come to the university in the first place, the role of practical training is not primarily to teach them *how* to do things; there are few shipyard techniques that cannot be picked up within the week by a good quality undergraduate, but to call attention to the reasons *why* these particular techniques are employed for particular operations. Probably the sole field in which the shipyard section of the course is irreplaceable is the experience given in applying classification society rules, load-line regulations, and the like. These are no more subjects for university teaching to naval architects than the Factory Acts are for mechanical engineers, and are best dealt with in the shipyard. Here again the man who is already equipped with some part of the theory will be at an advantage. Professor Robb's conception of an "educational ladder" with the university as a shining goal at the top has considerable attraction. However, any arrangement which tends to reduce the student/teaching staff ratio as this would is quite out of the question at present, when it is difficult enough to find the staff to man the existing courses.

There is one large gap in the practical training of naval architects, and that is experience in the actual operation of ships. The writer graduated as a "sandwich" apprentice and spent a further three years in the design office at the same yard. Yet the only time he has ever been under way in a vessel built by this firm has been as a fare-paying passenger on the Clyde steamers. Since he had a certain amount of "extra-mural" maritime experience, the writer was not unduly inconvenienced by this, but he cites it as an example of how a man can become a trained naval architect without ever having seen a ship at sea. It is not really necessary for the aspiring naval architect to go to sea, but the writer feels that there is a strong case for part of the practical period being spent in the marine superintendent's office of a good shipping line where he will become familiar with the problems of cargo handling and general operation of ships, and will gain first-hand knowledge of all the unnecessary little delays that arise from faults that can often be avoided in the initial design of a vessel. He would also come into direct contact with the ships' officers who would leave him in no doubt as to the disadvantages of a particular design.

So far the writer has referred solely to university education, being himself a graduate and at present employed on the staff of a university. The majority of the members of this Institution are, however, products of other systems. Yet they are none the less entitled to the description of naval architect. The writer feels that this Symposium would have been greatly strengthened by the inclusion of a paper dealing with the National Certificates.* The main strength of shipbuilding in the future will derive from holders of these certificates, as it has in the past, and any improvements in this field are needed not so much in the courses which are really good of their kind, but in the means of encouraging young apprentices to take advantage of them. While a lot is being done in the way of direct encouragement in the form of day release classes to ease the tedium of night school work, and premiums for the successful passing of examinations, the only real incentive lies in the treatment of the man once qualified. If apprentices are to undertake the severe drudgery of the National Certificate course, they must be convinced that success will put them in a favourable position with respect to the unqualified man. It will do no good at all to improve and increase the training facilities for naval architects unless it is also made an obviously worthwhile profession to follow. This does not necessarily involve financial inducements, although these have their uses, but it does mean that promotions within an organization should quite clearly be based on considerations of experience and ability, and that no restrictions should be set on the man who sees an opportunity of bettering himself by changing employers. Unless these conditions obtain in the yards, we will continue to educate our apprentices to the ultimate benefit of other industries who are prepared to give due recognition to quality.

* See p. 383, contribution by Mr. C. H. Taylor-Cook.

Mr. A. S. Thom, B.Sc., Ph.D.: The education and training of naval architects and marine engineers is merely part of the main national problem facing us at present—how to attract a larger proportion of young men of talent into scientific engineering. At first sight the answer would appear to be: increase the salaries of present scientists and more entrants will be forthcoming. This method of raising the status of the engineer in the community is not, however, the complete answer. Men do not always work entirely for monetary reward. Congenial, satisfying work is preferable at all times to an unpleasant though more lucrative occupation. Unfortunately, in this materialistic age, status and salary are inseparable in the minds of many and it must be admitted that the scientist is not given sufficient recognition. Could not the Institutions themselves take a greater interest in the professional protection and encouragement of their members? Why should promising young men not be encouraged to move from firm to firm instead of being impeded from seeking wider experience?

Scientific engineering talent exists in only a small percentage of the population, and it is fairly evident that at present tuition is being given to practically all the suitable men in the younger generation. Many believe that one person could be equally successful in any one of ten occupations, and it may be, that by approaching individuals early in their school career and encouraging more of them to think along engineering lines, some more talent could ultimately be utilized. Perhaps the early instillation of a desire to utilize personal talent would help. School instruction alone cannot impart this determination, as it depends to a greater extent on parental influence in the home. Talented pupils are frequently allowed to leave school far too soon. Their background makes them quite content to accept blind-alley jobs which, though unsuitable, give them a fairly comfortable living.

Specialization at too early an age is definitely wrong, but a good grounding in English, mathematics, and science is absolutely necessary. This raises the question of the quality of teaching of these subjects in schools. At present, in Scotland, there are more than 1,000 uncertificated teachers in primary and junior secondary schools. The rate of replacement of teachers in mathematics is completely inadequate. Only seven first and second class honours graduates are receiving instruction in Scottish training colleges.

It is commonly believed that the interruption of the habit of study caused by a year's suitable practical work between school and university is detrimental to the development of the student mind. Nevertheless, it may have the effect of reducing the great wastage of students in the first and second year university courses.

A year's close contact with industry might result in a young man changing his mind; he might be deflected from attempting an engineering course from which he would later be eliminated by examination failure. Much of the time of the teaching staff would, therefore, be saved.

The writer is in complete agreement with Professor Telfer that adequate university staff is a necessity. Methods of presentation vary from lecturer to lecturer and from subject to subject, but in Glasgow University at least no initial training is given to the newly appointed lecturer. Somehow he is expected to know exactly how to "put it over." An honours graduate of a few months' standing may be asked to give a course of lectures. He will, naturally, receive willing help and advice from his supervisors, but at no time is he ever given any tuition in the art of lecturing. Recruitment to junior teaching posts in universities is exceedingly slow. Fortunately, exemption from national service is given to teachers of science in schools, but so far university lecturers in engineering are not exempt.

To advance in the future, the shipbuilding industry will require a greater share of the relatively small number of men available with an engineering bent. It is agreed, with Professor Telfer, that the best liberal scientific education is to be obtained in the universities. Where else, indeed, can the student learn better to think than in a "naval architectural atmosphere"? The best paid posts in the teaching of scientific engineering are not, however, obtained in universities. This is a position which must surely be rectified in the very near future.

Mr. R. F. B. Serbutt, S.B. (*A.M.I.N.A.*): A feature of present-day shipbuilding is its rapidly increasing complexity; the simple tramp now represents a relatively small part of the total output. Shipbuilders are confronted with such problems as the design and construction of very large tankers, the need for more efficient cargo-handling systems, demands for better speed in bad weather and for increased safety, and the application of gas turbines and nuclear-powered machinery. A knowledge of what has gone before is quite inadequate to deal with such matters; the demand is for men with a mastery of principles and experience in applying them in actual cases. It appears that a considerable number of men may be needed trained to a higher standard than would have previously been considered necessary. Furthermore, the increased competition existing in the shipbuilding industry will call for more planning of production and tighter control of the processes, in order to reduce costs and give rapid delivery. The shortages of men seem to be mostly among designers able to perform high-class work and among those trained in management and production. Such a situation is not restricted to shipbuilding, but it is evident there, and shipbuilding is a major industry.

It is worth while considering the American approach to this matter, since their system of scientific and technical education seems to be strong where the British one is weak (and vice versa). The Massachusetts Institute of Technology has managed to win a pre-eminent place for itself, and it includes the best known of the American schools of naval architecture and marine engineering. The M.I.T. is divided into the five main schools of science, engineering, architecture, industrial management, and humanities. Competition for places is severe, and the number of students admitted represents only a fraction of those who apply. Largely because of the research work carried out, the number of staff is large and may approximate to the number of students. The normal undergraduate course takes four academic years of eight months each, and during study terms an intelligent student is pushed ahead to about the limit of his ability. The first year is common to all courses, and even in the second year there is little time spent on specialized subjects. A thorough grounding is given in calculus and physics, and the fullest possible use is made of this in all subjects. Throughout the undergraduate course, the emphasis is on the mastery of principles rather than on the acquirement of specialized knowledge or techniques. About a fifth of the student's time is spent on English, history, economics, and some other arts subjects. The school of management is a large one, and students may spend considerable time in it, and even major in this work.

The course in naval architecture and marine engineering makes no attempt to separate undergraduate students into naval architects and marine engineers. The equipment available to this department is limited compared with that in some of the big departments, but considerable work has been done with the propeller tunnel and the testing tank. Despite the large amount of support from industry, tuition fees are very high; they may be ten times the figure that a British student would expect to pay. The British type of apprenticeship is not usual in the United States, but students commonly work in industry during the four months of the summer vacation, and many of the big companies provide lengthy training courses. The lack of demarcation removes one obstacle in the way of gaining practical experience. An institution of this type consists, to begin with, of the buildings and equipment (no small matter); the staff (whose names will determine the prestige of the institution); and intangible, but no less important, a continuing tradition. The M.I.T. tradition appears to be one of scientific discovery and of the manipulation of nature to man's ends. Most graduates go into industry, some to remain on technical work, others to become involved in management to a greater or lesser extent, and the results of their outlook must be widespread. Even now the M.I.T. is a part of the folk culture of the United States.

Though there is little likelihood of anything comparable with the M.I.T. coming into existence in this country, it does seem that such an institute would fit very neatly into the pattern of requirements, and would help to balance the educational system. As already suggested, the education of naval architects and marine engineers is only one particular case of scientific and technical training, and is not too difficult to provide in conjunction with an already existing engineering school of good standard. In an autonomous institution of this type there could be more provision made for students who would either perform design work of a high class, or work in management, than is possible at any present British establishment.

Professor Edward V. Lewis: Among the many interesting ideas, the non-British reader notes particularly Professor Telfer's suggestion for international co-operation among professors directed toward combining their best ideas into an improved presentation of the "standard" basic naval architectural principles. Such a development would certainly be of world-wide value to the profession if it could be managed. Meanwhile, the preparation and revision of comprehensive textbooks is a step in this direction—such as the Society of Naval Architects' "Principles of Naval Architecture," which is now undergoing much-needed revision. It is believed that textbooks, as used in the United States, can accomplish to a considerable degree Professor Telfer's goal of providing a uniform, authoritative presentation of a subject, leaving the professor "more time for high-lighting, additional explanation, and the answering of the students' professorically invited questions or discussion."

Members are undoubtedly familiar with the long-established courses in naval architecture and marine engineering offered in the United States at Massachusetts Institute of Technology, Webb Institute of Naval Architecture, and the University of Michigan, all of which are somewhat similar to those offered in Glasgow and Newcastle. A different sort of programme has recently been inaugurated at Stevens Institute of Technology which may be of some interest and, in fact, might be applicable in Britain. The scheme involves a Master's Degree curriculum

in "Nautical Engineering" to follow a Bachelor's Degree in naval architecture or in civil or mechanical engineering.

Traditionally the undergraduate programme at Stevens Institute of Technology has been a general engineering course, covering the fundamentals of mechanical, civil, chemical, and electrical engineering. Only a limited degree of specialization is permitted in the final or senior year. A single introductory course in naval architecture is now available as an option, covering some of the elementary principles and a limited amount of drawing room and towing tank work. The twofold purpose of the course is to provide an introduction to the subject for those seeking a career in ship design or research and to attempt to interest other engineering students in the field.

The post-graduate programme in naval architecture is designed mainly to meet the needs of men working in naval architects' offices and shipyards in the New York metropolitan area. The Master's Degree curriculum in nautical engineering was inaugurated in 1956 in co-operation with the Stevens Experimental Towing Tank—the title of the curriculum having been selected to parallel "aeronautical engineering" and to distinguish it from the more conventional programmes in naval architecture. Lectures are given in the evenings and laboratory work on Saturdays, so that engineering graduates can complete the curriculum in three years while working full-time in their regular employment. This involves an average of two evenings, or one evening and one Saturday morning per week. If they prefer, students may attend one class per week and extend their work over a six-year period. It is also possible for students in residence at Hoboken to complete the entire curriculum in one year by devoting full-time to their studies.

A summary of the curriculum follows (each course meets for 2½ hours once a week for a half-year; most are offered in alternate years):—

Applied Mathematics for Engineers, I and II.
Hydrodynamic Theory.
Principles of Naval Architecture, I and II*.
Laboratory in Naval Architecture (Drafting room and towing tank work).
Dynamic Aspects of Naval Architecture, I and II (Ship motions and stresses in waves, propulsion, vibration, and control).

Major Electives: Two courses in:

(*a*) Structural Analysis, or
(*b*) Propulsion, or
(*c*) Fluid Dynamics, or
(*d*) Power Plants, or
(*e*) Hydrodynamics of Seaplanes.

Thesis I and II (making use of the Experimental Towing Tank or other laboratories of the Institute).

The thesis is a requirement for the degree, since it is believed that the working out of an independent project is of greater value to mature students than the equivalent time spent in taking additional courses. In addition a course in marine cargo handling was introduced this year for those who are not degree candidates, and it is planned to repeat it as a major elective in the nautical engineering curriculum in future years.

In view of the fact that students are graduate engineers engaged in active professional work in the field of ship design, the emphasis is on theory and research rather than on fundamental engineering principles or practical aspects of ship design. It is of interest to refer to Professor Burrill's outline of the four requirements for a well-trained naval architect:—

(*a*) An understanding of basic scientific principles.
(*b*) A knowledge of facts and procedures relating to ships.
(*c*) Experience and practice in a shipyard.
(*d*) An aptitude for technical work.

The curriculum at Stevens is aimed at the extension of (*a*) beyond the level of undergraduate engineering training, and the intensive treatment of (*b*). It is assumed that (*c*) and (*d*) are or will be provided for in the students' professional work.

This year there are nineteen students enrolled in various stages of the nautical engineering curriculum. It appears to fill a need for advanced training in naval architecture for both naval architects and engineers who have become interested in ship design after graduation or were unable to attend a university offering an undergraduate programme in naval architecture.

Dr. A. Hunter: Amongst those who have listened with attention to these papers, I am probably alone in having no knowledge of nor direct interest in naval architecture or marine engineering. I nevertheless represent a class which ought not to be forgotten in your deliberations, namely, the parents of potential recruits to the shipbuilding industry. Scant mention has been made of the problem of recruitment, but this is of course a necessary preliminary to the training and education that are the nominal subjects of discussion at this gathering. "First catch your hare" is as good a maxim in the shipyard as in the kitchen, but it seems to me that one is in danger of neglect.

It is common ground that the old-fashioned sort of premium apprenticeship is fast dying, if not dead already; and we have heard something of the schemes that are displacing it. At the higher levels of entry, shipbuilding must compete directly for university graduates against younger and perhaps more superficially attractive industries; and the plain fact is that there are not enough young men to go round. It is no use relying on the alleged glamour of designing, building, or working ships. I am an astronomer, and you might think that there is plenty of glamour in using big telescopes and perhaps contributing something to our widening knowledge of the universe. Nevertheless, British astronomy is short of recruits and we are forced, as I think you also will be forced, to trawl the universities annually in an endeavour to capture undergraduates in their final year. We also have to run vacation courses, not because we like them (the youngsters are frankly just as much a nuisance in an observatory as I imagine they would be in a shipyard), but because only by thus casting our bread upon the waters can we hope to get recruits of the right calibre later on.

At school-leaving level the technique must be somewhat different. Here the people to tackle are the careers masters and the parents, in that order. Make no mistake about it: you must begin at rock-bottom. I speak from experience when I say you may have to start by disabusing careers masters of the idea that a naval architect is a chap who designs barracks in H.M. Dockyards. And, further, you will have lost the race for capturing the parents' interest unless you not only provide probationer schemes that are academically and financially attractive, but also give them maximum publicity. The schemes run by the Shipbuilding Employers' Federation and the Royal Corps of Naval Constructors are admirable in their way, but they are not, in my opinion, plugged as they should be through the schools to the parents.

My own experience here may be thought relevant. My eldest son is so keen on naval architecture that main force would have to be employed to keep him out: my function is reduced to directing his enthusiasm into the best channels. I cannot do this without advice, so I consult an acquaintance who is a naval architect. He goes to no end of trouble to tell me what is available and to introduce me to other colleagues who are equally helpful. But they are uniformly ignorant of the existence

* Students having studied introductory naval architecture substitute other courses in engineering or economics.

of the R.C.N.C. scheme. Admitted that this is a new scheme; admitted that it is designed to cope with only a small proportion of the total intake; but it *was* introduced to open a new entry into a profession dangerously short of recruits, and the profession apparently isn't told about it! I learned of its existence through the historical accident that the Royal Greenwich Observatory is an Admiralty establishment. As an Admiralty servant it is my duty to peruse the Fleet Orders by which My Lords Commissioners govern all Admiralty establishments. And there, modestly nestling in the pages of a publication labelled threateningly "RESTRICTED—FOR OFFICIAL USE ONLY—*Not to be communicated to anyone outside H.M. Service*," are full details of the scheme. To attract potential naval architects away from nuclear physics, electronic engineering and the like, these details should surely be distributed to every public school and grammar school in the country, not left to blush unseen in Admiralty Fleet Orders.

Professor Palmer will, I know, forgive me if I have been unfair to the efforts I am sure D.N.C.'s department has made to publicize this attractive scheme. But this intervention from an outsider will perhaps not have wasted your time if it has emphasized the vital importance of publicity for suitably attractive recruitment schemes in the scramble for the capable youngster.

Mr. James M. Tanton (*Student, I.N.A.*): It is intended here to convey the views of the honours year students in the Department of Naval Architecture at King's College in the University of Durham. This Symposium has, however, been received with such extraordinary interest and has given rise to such a diversity of opinion that it is difficult to put together a representative criticism.

Explanation has been sought as to why applications for Institution Scholarships have been disappointing. It is agreed that the local county councils have offered more attractive grants and have made them comparatively more easy to obtain. Until recently the standard of mathematics required by The Institution was too high and, except for boys from H.M. Dockyard schools, was completely out of reach. Certainly the standard was out of proportion to that subsequently found in the first year at university.

Professor Telfer's suggestion that the shipyard at which a student takes employ should thereafter be responsible for providing the money which was to have been paid by the local county council, overlooks the basis upon which the latter award was made in its true perspective as part of the nation's benefit from subscription to the Welfare State. Furthermore, such payment by the shipyard would impose upon a student a feeling of obligation towards that firm, thus restricting the field of opportunity open to him on graduation.

Professor Telfer's reference to the work of the shipbuilding industry in time of war raises a question. Why is it that students of naval architecture are given unlimited deferment from national service if, on leaving university, they enter the aircraft industry, whereas the shipbuilding industry, from which no one is called to arms in time of international hostilities, is not generally able to offer such deferment? Those two vital years following a university course are a great loss to the industry.

It would perhaps help if students were required to complete at least one year in the shipbuilding industry before entering university; the work of the first year at Durham could then be readjusted with the aim of relieving the overburdened later years. Thus lectures and examples on tonnage and freeboard and perhaps the production of hydrostatic curves could take the place of the drawing of ellipses, camber curves, bollards, fairleads, etc., at present included no doubt for the benefit of those who have not had any drawing experience. The present work is training and the place for training is the shipyard.

The figure of 360 hours allotted to honours year drawing-office work at Durham is no doubt based on theory. Actual tests have shown that this figure is about half that actually required to complete the work set. An explanation of this discrepancy would be welcomed.

With reservations, the use of printed notes would be very helpful. Too often the aim of the lecture is not apparent until the end, and sometimes not even then. Thus an hour is virtually wasted. Had there been an opportunity of glancing through the work and looking through suggested references beforehand the value of the time spent in lecture rooms would have been much enhanced. Such notes should not, of course, be complete unless this was felt desirable by the lecturer.

During his salad days at university the student of naval architecture does not wish to be spoon fed, nor does he wish to be trained. He wishes to be educated. He looks forward to the day when he can join with his fellows in other faculties in reading for his degree instead of memorizing for it. Whilst rushing madly through his daily round of lectures and drawing-office duties he pauses occasionally to reflect upon such oft heard phrases as "liberalizing influence" and "broadening of the mind." He lives in hope.

Mr. E. C. B. Corlett, M.A., Ph.D. (*M.I.N.A., A.M.I.Mar.E.*): Professor Telfer has deliberately and rightly made his paper in the Symposium controversial. To be controversial may be constructive and there is no doubt that this paper draws attention to several anachronisms and anomalies inherent in the present educational system in the field of naval architecture.

Paragraph 11 in the 1939 report, quoted by Professor Telfer, is, of course, a disturbing one if taken literally, but it must be remembered that 1939 is quite a long time ago and these remarks may well have been a great deal more relevant then than they are now. Certainly, it does seem a great pity that no research scholarships in naval architecture are financed by the industry, and I, personally, feel that a valuable research scholarship would be a general one which could be taken up in one or two fields covering naval architecture, shipbuilding, production shipbuilding, and technical ship management. It is by no means inconceivable, for instance, that in the latter field a British shipowner might be persuaded to offer funds for a research scholarship which could be tied to practical work in ship management inter-related with ship design.

One can agree and disagree violently with Professor Telfer's criticism of Lord Runciman's statement and also, of course, with Lord Runciman's statement itself. There is no doubt that there is such a thing as the research mind and the research mind does not necessarily give a breadth of outlook which will enable its possessor to be anything more than a specialist in a particular field. On the other hand, research when entered into from a broad point of view and always keeping the purpose of the objective firmly in mind, can be a broadening experience, and indeed has been found by many people to be so. The crux of the question here is probably not to be too specialized. In other words, a research student, if possible, should cover at any rate two fields of investigation and these two fields should be as far as possible widely separated in both substance and outlook.

Regarding Professor Telfer's comment on the expected need for graduates, it is very interesting to reflect that a high proportion of those persons in control of the shipbuilding industry in this country are, in fact, graduates, and many are graduates of the old and great universities.

There is a noticeable tendency to-day for young men to choose employment which gives lasting security. This, in many ways, is to be regretted as a general principle, as real absolute security is a chimera. In any event, security of this type is not necessary or desirable for a young man, in preference to a wider opportunity to use what initiative and pioneering spirit he may possess.

I feel that Professor Telfer's suggestion that students' vacations could be spent in Continental shipyards is a valuable one. There is considerable interest taken in other countries in developments in British shipbuilding, but perhaps this interest is not reciprocated to anything like the same extent. In the past, British shipyards have taken a great many students from abroad, but it would be unwise to assume that this country would not benefit by an exchange with, say, the Scandinavian countries, Holland, Germany, France, Japan even and America, on the same basis.

Turning now to Professor Telfer's suggestion that the number of faculties of naval architecture should be expanded, this is controversial, but there is little doubt that if such an expansion were undertaken, it would be advantageous to include in London and Liverpool, as major courses in the syllabus, technical ship management, voyage estimating, cost estimating, and other aspects as important as a successful design in the provision of efficient ship services. London, above all, should be the home of a faculty, teaching such subjects as well as normal subjects, especially as the requirements for many liner trades are now so complicated that shipyards tendering may not have an adequate opportunity to go into the optimum design as fully as is desirable. A naval architect employed by the shipping company with a sound background in these matters could be a most valuable adjunct even to a small firm. Cambridge and Oxford have a most specialized atmosphere obtainable nowhere else in Britain. This atmosphere is conducive to the acquiring of a wide foundation upon which an educational structure can be built. There is an ingrained atmosphere of experience in learning, if I may coin a phrase, in these universities, which has borne fruits which are obvious in many fields and particularly in administration, both in industry and government. The training at the Cambridge (or Oxford) school should best, in my opinion, be concentrated on the fundamental sciences involved and these might well be taken rather further than at the other schools of naval architecture, with a lesser emphasis on the immediate application and technological aspects. Ideally, a man completing a Bachelor's degree at such a school could work in one of the other schools for a year on part-time post-graduate studies combined with work in a shipyard for at least half of his working time.

I should like to comment finally on two points. A fully qualified research director would be an extremely expensive luxury for many small shipyards. In many cases, this could be done on a co-operative basis or by the employment of suitable consultants, but it is probable that the research director of a large firm should best be integrated with other functions as a technical director with no responsibilities for production in any way but with, of course, due respect for the problems of the production side. Such a technical director should also have a working knowledge of the principles of ship management, as his department would, of necessity, be responsible for producing initial analyses of operational requirements to enable the design department to start with its feet firmly planted on the ground and with some of the more fundamental unknowns removed from the problem.

My final point is that it would be a very good thing if shipowners were approached by The Institution with a view to setting up a post-graduate research fellowship at, let us say, London University, this research fellowship being in ship management and technical ship control with outside work carried on in the offices of a London shipowner. I have no reason to believe that such a proposal would not be met with sympathetically and could well prove to be of great value both to the industry and also to the shipowner, from whence, one must emphasize, springs the *raison d'être* for the existence of the shipbuilding industry.

Professor S. C. Mitra (*Member*): Professor Telfer points out cleverly and aptly the defects of the present system of putting over naval architecture subjects whereby a professor cannot do justice to his students in spite of his great knowledge.

This is a matter of concern to all teachers at universities; how to present the subjects so as to accommodate the modern intensive curriculum, at the same time to present them effectively so as to create confidence and inspire the students.

I personally put more emphasis on the creation of inspiration, because it will create an urge in the students for acquiring ever-increasing knowledge in the subjects, thus enabling the professor to present the subject more rapidly and effectively, and leave him more time to deal with the advanced portion of the subject.

To create such an inspiration in the students is not an easy task and it will be less so for a new professor. I therefore agree with Professor Telfer that there should be a "pedagogical collaboration" on professorial level, whereby teaching experiences can be shared and a method evolved for more advance presentation of the subjects within the limited time at their disposal, rather than trying to come to an agreement for standardization of basic notes, diagrams, lantern slides, etc., at this stage. Even if we suppose that students, entering the universities, are decidedly more intelligent than the average youths of their age and have also attained a better standard of education as laid down by the university for entrance, it does not follow that the majority of them will respond to any set pattern of presentation of the subjects. Each individual student will respond better to the type of presentation of the subjects which is best suited to him, i.e. that each student requires individual care not only in tutorial classes but also in lectures. In order to accomplish this, the professor must find out the susceptibility of his students to any particular form of presentation and he must get well acquainted with the students in advance, to enable him to reorientate his notes and diagrams, etc., so that the presentation of the subject thus prepared will suit the majority, and also give him more time for "high-lighting, additional explanation, and answering student's professorially invited questions and discussions," as Professor Telfer puts it.

There is no short cut to this method and the only alternative is to increase the strength of teaching staff in the technological universities to obtain better results.

The following table shows an analysis of subjects and practical training followed in each year of the degree course for the Department of Naval Architecture at the Indian Institute of Technology, Kharagpur, India.

The syllabus has been drawn up by the joint efforts of industry and education and has been based on a system combined mainly from the British, German and American universities adjusted to suit local conditions.

It may appear that the teaching hours are more here than elsewhere and too much stress has been put on practical training and draughtsmanship. This has been done to meet the immediate requirements of the local shipyards and also to overcome certain initial difficulties arising from the students not possessing a certain fundamental background of the subject in general, a difficulty peculiarly akin to countries that are not well advanced in shipbuilding and shipping. This is expected to be overcome by industrialization.

We are fortunate here with the quality of intake of the students, but in general they are not so fortunate as their counterparts in other countries. Before joining naval architecture students here do not in general have the good fortune to visit a ship, neither do they meet anyone connected with ships. Some of them do not even get a chance to see an ordinary factory engaged in engineering work. Under the circumstances it is imperative for us to fill in the gap between the time when a student is ready for a university and the time when he is ready to respond to and appreciate the early stages of the subjects of naval architecture. At a later stage the students here develop surprisingly quickly.

THE ANALYSIS OF SUBJECTS AND PRACTICAL TRAINING FOLLOWED IN EACH YEAR OF THE DEGREE COURSE OF THE DEPARTMENT OF NAVAL ARCHITECTURE OF THE INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR, INDIA

FIRST YEAR

(July 1st to April 30th of the following year)

Subjects	Hours per academic year		
	Lectures	Tutorial	Total
English	35	70	105
Civics	35	—	35
Mathematics	105	70	175
Mechanical	105	—	105
Mechanical Laboratory	105	—	105
Chemistry	35	—	35
Physics	92	35	127
Physics Laboratory	50	—	50
Fluid Mechanics	70	—	70
Optional	70	—	70
Total hours for non-professional subjects			877
Naval Architecture, i.e. areas, volumes, etc., including Initial Stability	140	—	140
Ship Drawing	348	—	348
Total hours for professional subjects			488
Grand Total			1,365

SECOND YEAR

(May 15th to June 15th of the following year)

Subjects	Hours per academic year		
	Lectures	Tutorial	Total
Practical Training in shipyards for 13 months.			
Practical Shipbuilding	40	—	40
Freeboard and Tonnage	20	—	20
Total hours for professional subjects			60

Note: During practical training students have to submit their practical training report every fortnight.

THIRD YEAR

(July 1st to April 30th of the following year)

Subjects	Hours per academic year		
	Lectures	Tutorial	Total
History and Economics	105	—	105
Mathematics	70	35	105
Electrical Engineering	70	—	70
Electrical Engineering Laboratory	70	—	70
Applied Mechanics	210	—	210
Applied Mechanics Laboratory	105	—	105
Engineering Mechanics	35	35	70
Machine Design (Drawing and Lecture)	140	—	140
Optional	70	—	70
Total for non-professional subjects			945
Launching, Flooding and Stability at large angle	105	—	105
Rolling and Waves	105	—	105
Ship Drawing	210	—	210
Total hours for professional subjects			420
Grand Total			1,365

FOURTH YEAR

(May 15th to April 30th of the following year)

Subjects	Hours per academic year		
	Lectures	Tutorial	Total
Practical Training in shipyards from May 15th to October 15th	—	—	5 months
Humanities elective	22	—	22
Heat Engines	66	—	66
Heat Engines Laboratory	66	—	66
Ship Machinery	44	—	44
Optional	66	—	66
Hydraulic Machinery	44	—	44
Hydraulic Machinery Laboratory	44	—	44
Total hours for non-professional subjects			352
Strength of Ships	88	—	88
Resistance of Ships	88	—	88
Ship Drawing	330	—	330
Total for professional subjects			506
Grand Total			858

Note: During practical training students are required to submit fortnightly report.

FIFTH YEAR

(July 1st to April 30th of the following year)

Subjects	Hours per academic year		
	Lectures	Tutorial	Total
Humanities elective	35	—	35
Metallurgy	70	—	70
Optional	105	—	105
Total for non-professional subjects			210
Design of Ships	105	—	105
Shipyard Organization and Estimate	70	—	70
Propulsion and Steering	140	—	140
Ship Drawing and Laboratory work	840	—	840
Total for professional subjects			1,155
Grand Total			1,365

But it is still too early to make any further comments because our first batch of students will be graduating only in June 1957. We have to watch them for a further period of at least three to four years in practical life to enable us to take stock of our system of training. When this is done we shall be in a better position to make a substantial contribution to a paper of this nature.

Mr. R. F. Capey (*M.I.N.A., M.I.Mar.E.*): Regarding Dr. Dorey's paper, seemingly more apprentices are entering the profession than there were years ago; study classes have been made easier to attend, shipowners now assist financially when a junior engineer is studying for his tickets; conditions afloat, including pay, have vastly improved, and yet there is a shortage of the certificated engineer in almost every shipping company.

One does not hear of many ships being held up because of shortage of engineers, particularly the liner class, but the burden of keeping them running falls heavily on the certificated senior engineers.

If we can assume the number of applicants for a sea-going

career have proved adequate, the answer seems to be to increase this number, in an attempt to cover wastage, with the right type of youth, and selection should be made when he is sixteen or seventeen years of age.

"See the World as a Marine Engineer" slogan should appear in attractive picture form in every grammar, secondary technical school in the country, and also in any other establishment that reaches the G.C.E. standard.

Youth Employment Exchanges should be thoroughly informed of all the advantages that marine engineering can offer.

What other profession can promise the salary, the leave, and comforts, etc., that a chief engineer at age twenty-eight to thirty can obtain, and with early retirement in certain cases; all this to the average intelligent man.

Through proper advertising there should be just as much competition for the marine engineering profession, as there has been in the past for banks, insurance and shipping houses, etc.

A youth having passed the G.C.E. has learnt the rudiments of study, and with a will is able to continue his studies without much effort.

This has been proved by the "Alternative Scheme of Training." These young men are of the right type and take a great interest in the practical work. A foreman in a large engine repair shop where a number of these young men are doing vacational training, etc., said he wished all his apprentices would take as much interest in their work as these young men do.

With the general apprenticeship, unless father has gone before them, applications from boys with the G.C.E. are very few. Whether they are ill-informed one would not know, but the opinion seems to be if the boy has obtained a G.C.E. he should go beyond the bounds of a machine shop.

It is agreed that more opportunities are now offered for university training and many students proficient in mathematics, physics, and chemistry proceed to advanced level and on to a degree course, but there must be very many who do not attain these heights and who could very well serve the marine engineering profession.

In the past the Board of Trade Engineers' Certificate of Competency has been recognized all over the world and the author reminds us of the ex-marine chief engineers that to-day are chief engineers of steelworks, chemical works, and oil refineries, power stations, etc., and although this has been a wastage in certificated men, such positions in the future may be recruited from the vast number of university-trained men, in which case the wastage to the marine world might be lessened.

Commenting on the author's remarks on the general system of training, (1) "Serving an apprenticeship of four or five years in an engineering works and nothing further," is essential for the recruiting of the journeymen of to-morrow, but it is difficult for the employer to know at intake how many will remain fitters and how many will by study become marine engineers.

At present every apprentice fitter is a potential marine engineer, and if to improve the standard as is necessary the employer demands that a youth should have passed the G.C.E., then as time goes on there will be a shortage of fitters.

If the Ministry of Transport set a definite standard of entry to marine engineering, such as Ordinary National Certificate, then these apprentices without qualification could start as "apprentice fitters," and those with as "apprentice engineers," the training of the latter to include pattern shop, foundry, machine shops, and drawing office, with, of course, the requisite study time allowed.

In the existing system there is little incentive for the youth who studies (except that he may get his certificate sooner) as he may find himself as a junior in the same ship as the youth who idled his time and who may eventually get his "tickets." Would it be possible for the one to start as an engineer officer and the other one as an engineer petty officer, such as a plumber or carpenter, promoting him as he makes the grade?

The author's No. 2 system is at present working and has produced the majority of to-day's sea-going engineers, and indeed many of those certificated engineers in shore positions; it could produce more if the material was better at the outset.

The following table, the experience of a large ship-repairing firm, shows the number of passes and failures, etc., of apprentices in either day or night classes terminal examinations. All apprentices in the numbers listed were either recommended or selected from what was offering at the time of engagement.

Had there been a higher grade to select from, there possibly would not have been so many non-attenders.

In 1954, and particularly in 1955, there was an increase in the number of applicants holding the G.C.E., and those two years show an improvement in the technical school attendances.

It is interesting to note that four of the apprentices who started in 1951–52 and who were admitted into S.1 took five years instead of four years to reach A.1 grade. It will be seen from the Table that two passed A.1 and two failed (1955–56).

System 3 is a similar training to system 2, except the better grade is being recruited and not all will reach Higher National standard. One repair firm allows apprentices to attend day classes as soon as they are accepted for S.1 grade.

System 4 is an excellent system of training for an engineer, but it is questionable whether men so trained will be attracted to a sea-going career except to gain the qualifications of the experience and certificates. It can hardly be classed as training for the sea-going engineer of the Merchant Navy.

Time will tell the success or otherwise of the "Alternative Training Scheme." In theory these young men will undoubtedly

TABLE

Year	Number of engineer apprentices	Number attending night classes	Number attending day classes	Number who did not attend	Examination Results													
					PST. 1		PST. 2		S. 1		S. 2		S. 3 O.N.C.		A. 1		A. 2 H.N.C.	
					p*	f	p	f	p	f	p	f	p	f	p	f	p	f
1948–49	97	7	39	51	3	–	4	1	14	5	7	3	4	2	2	–	1	–
1949–50	79	2	36	41	1	–	4	–	8	6	9	4	2	2	–	1	1	–
1950–51	91	3	47	41	1	–	2	1	13	8	4	9	3	6	2	–	–	–
1951–52	95	5	44	46	1	–	4	1	9	9	9	7	2	5	2	–	–	–
1952–53	109	6	53	50	2	1	2	1	16	6	8	9	5	7	1	1	–	–
1953–54	98	12	56	30	4	1	7	1	10	11	11	9	2	6	4	1	1	–
1954–55	96	10	60	26	3	–	5	1	17	13	13	3	5	7	1	1	1	–
1955–56	93	9	59	25	1	–	7	–	17	10	9	5	4	11	2	2	–	–

* p = pass. f = fail.

be well trained, and from the practical side it will depend on how much is expected of them as regards running repairs.

Students from this scheme attached to large ship-repair establishments gain good practical experience in the overhaul of all types of engines, and have proved themselves very adaptable and good intelligent workers.

In the past the junior engineers who had not completed (during apprenticeship) the requisite training period on marine engines, were required by the B.O.T. to serve extra time at sea. It is suggested that in like manner the "Alternative Training Scheme" students will gain the practical knowledge required of them "at sea."

Those of the old school who hold doubts regarding these young men should encourage and not discourage them.

Dr. Dorey states that the engineer of the future must have a sounder technical education to cope with the complexity of plant and intricacies of machinery of the future. To this all will agree, but how will it be accomplished?

In conclusion, it is suggested the M.O.T. or the shipping companies give notice that in four to five years' time only apprentices having passed the Ordinary National Certificate (without the inclusion of an engineering knowledge paper) will be accepted as junior engineers. This should improve the standard immediately and the four/five-year period would enable the recruiting centres to adjust their training schemes, probably adopting the author's training schemes (2) and (3), and calling for the G.C.E. at commencement.

Mr. A. J. S. Bennett, M.B.E. (*M.I.Mar.E.*): The independent apprenticeship scheme referred to in Dr. Dorey's paper, known as the Alternative Training Scheme and often as "The Marine Engineering Cadets," has reached a milestone of progress, as the first group have just completed Phase III training. From the Tyne area about sixty have finished the year's work in the shipyards and the technical college and have been examined on the syllabus set. Being closely concerned with their work and interested in their problems, I submit some impressions from the cadet's part of the ship.

The first products of this scheme introduce new blood into the profession, since most of them originate from towns not connected with shipbuilding. Most of them have the necessary G.C.E. and National Diploma and have done a correspondence course whilst at sea leading up to Phase III work. Almost everyone who has had dealings with the cadets in college has been impressed by their alertness, and in many cases by their manner and bearing. The sponsoring companies have made an inspiring start and it is to be hoped that they are able to produce similar recruits in the future.

This, I believe, is the first full-scale contribution of shipowners towards the efforts of the normal educational agencies for the training of ships' engineers. It is an historical event of immense importance and coincides with the period of the most rapid technical advances in merchant ships. For the first batch there are naturally teething troubles, some of which appear as follows:—

Apprenticeship Training

With the Phase III period the cadets gain their first impression of the industry. Shipyards are mostly not large enough to carry the elaborate training schemes familiar in the larger industrial and Government establishments. Obviously they train their own men, but there is no obligation, although there is co-operation in the training of sea-goers. Moreover, they are private firms, competitive, and have their own problems, including labour troubles.

The first batch of cadets, on entering the various yards, ran into a fourteen weeks' overtime ban which resulted in many not being allowed to work normal day work, though they were treated in principle exactly the same as the firms' apprentices. Some were given satisfying work, and some were an embarrassment in respect of time keeping and attendance. During this phase they were widely dispersed in lodgings and were paid by their company and not by their immediate employer. Initially there were complaints about boredom at work, but these were effectively silenced by the argument of fair treatment. In the end most of them settled down and learned what they were offered, though discipline suffered in several cases. The only time they assembled as a group was in the college, where they accepted a rather higher standard of discipline than that demanded of other day students, and where they were given work to their full capacity.

One solution to this difficulty would be the organized interchange arrangement as suggested by Dr. Dorey. This idea is so good that one imagines that it must have been considered and found impracticable. The fact is that it is not done, and if for a good reason it is not introduced, then it might be worth investigating the value of doing craft training in the college. Ministry of Education pamphlet No. 8 (Further Education) mentions the need for such training in the case of production engineers, recognizing that modern production methods in the shops preclude a thorough all-round craft training.

Such training would be under the full-time control of qualified instructors in the various skills, together with appropriate teaching. Conducted visits to many works might be as acceptable to the works as having the cadets in the shops for a year. Other skills might be arranged, such as phasing and calibrating injection equipment, assembling and running small engines, possibly turbo blower assembly and adjustment of instruments. They have done one day per week craft work in the Phase I college and a suitable extension of this programme may be worth consideration for increasing craft skill. It is not presumed that this work should rank as an equivalent of engine fitting in the shipyards. This class of work is the time-honoured M.O.T. requirement for sea-going engineers, the one we all respect, the *sine qua non*! The suggestion is in lieu of not getting this work. If the majority are to be given good class work it would undoubtedly involve priority and it would be of no use saying "treat them all the same." The shipyards are already contributing to future sea training by selecting some of their own apprentices for the best work. Training by doing for a whole group is very expensive in more ways than one.

There are other alternatives which involve a reduction in time on Phase III. There may be doubts about qualifications on the craft side which the cadets must accept and attempt to overcome in time. They are not likely to favour a reduction of ultimate advantage which this scheme offers on the academic side. Less time means a lowering of standards and changing the phases around virtually amounts to starting another training scheme.

College Work

Another problem is sensed by the eternal question, "What do we get if we pass the examination?" They get an appropriate endorsement on the Diploma and consideration is being given to exemptions in naval architecture and electrotechnology in the Part "B" examinations. These are reasonable awards which show recognition, but they do not seem to impress. Strangely enough they seem to prefer the argument that an examination pass may, in time, gain in status according to their own reputation, which has yet to be established.

The point is that they are proceeding beyond Part "B" work in some subjects and are looking for the next target, though having been to sea already, they are quite aware that they have a long way to go before they gain their certificates and full self-confidence. It would be advisable to offer a target within the next few years. The sort of thing which will have a strong appeal is the £250 "Extra" scholarship recently announced by the Shipping Federation. We have also had what I consider to

be a windfall for the scheme in the long run, in that one cadet has been allowed to read for a degree under the newly installed Professor of Marine Engineering at King's College, Newcastle. A big incentive would be the offer of a limited number of special courses, say on instrumentation. The crux of this paragraph is connected with Dr. Dorey's question, "For what exactly are we training these prospective engineers?" The answer to this would settle a lot, especially if it were possible to reach agreement on it.

Time will tell, and the tide of events seems to be flowing in a direction favourable to this form of training, or it would be more equitable to say that those who launched the scheme knew what they were doing. Ships, especially tankers, are getting bigger, more specialized and complex. Automatic controls are becoming more conventional, there are special materials, special tools, and nearly every fluid except sea water has a treatment process. All of which add up to a premium on technical knowledge for the management of driving. Quite a number of special ships are already driven from the bridge. It is known that engineers are urgently needed for all ships, but it is thought that these additional recruits from outside are more likely to be forthcoming if a known purpose begins to become apparent.

This is the "angle" which has been given to the syllabus and it is thought to be logical since many cadets have sea acquaintance only with the latest equipment. The syllabus in all subjects, especially electrotechnology, in the South Shields College is of quite high standard, much useful practical work has been done and the cadets have shown a full response to extra voluntary evening and Saturday morning meetings for "ships' administration," "water treatment," various film shows, shipyard and works' visits.

Standards

A rather more important problem arises with those who did not succeed in obtaining the Diploma. The entry qualification for Phase I is "O" level standard of the G.C.E. in mathematics, physics, and one other subject. Of a dozen boys in this category, it was found locally that one appeared to possess the actual entry qualifications, though the others must have had equivalents.

In the South Shields College this group of failed diploma boys forms a special class on its own for Part "A" Second Class M.O.T. work. Now this appears to the outsider like marking time for a year until they are allowed to sit, as Part "A," though different, is not an academic advance on Diploma work. Work has been given to consolidate previous knowledge and to build up a good basis for a sea-going engineer. If, however, they were suitable to enroll for a Diploma course they are not likely to be employed to their full ability in this way. They are the same type as the others, will possibly make as good ships' engineers and probably for a longer period, but some special provision is required here.

There is a still more important problem with those who were "referred" in a Diploma subject, entered Phase III in expectation of passing, without in the end succeeding in the Diploma. These boys have literally nothing to show and have not done a Part "A" course. This is not favourable to anyone concerned and emphasizes the need for recruits who are likely to obtain the Diploma on which the whole scheme is based. When both parties pass Part "A" they temporarily at least almost overtake their Diploma counterparts for M.O.T. qualification. All three parties compare (many would say unfavourably) with conventional apprentices who pass Part "A" on a basis of S.1 or S.2 and a three-months' course on Part "A" subjects. This brings us straight back again to the old question, also to what I have called the "target" for the future.

As regards the first Phase III batch, I have no doubt at all that the majority will show a credit on anything they set their minds to, and will convert critics elsewhere, as they have done with us already. The scheme is an excellent scheme so far, but it is not yet complete in detail. It also needs stiffening against the dangers of reducing standards until it gets a chance to display its enormous possibilities to both the prospective recruits and to the other critics, the recruits' advisers.

Lieut.-Comdr. M. B. F. Ranken, R.N. (ret.) (*M.I.Mar.E., A.M.I.N.A.*): My first impressions after reading the papers were that on the one hand we had about the best possible systems available anywhere for training our naval engineer officers and the Royal Corps of Naval Constructors, while on the other we provided almost no special facilities for training merchant service engineer officers and naval architects. That this could not be the whole story is obvious to anyone who has seen or been on board any of our more modern merchant vessels, but it is nevertheless extraordinary that more attention has not been given to this matter by the shipowners and builders of this, the largest maritime nation in the world. No one would deny that there had been much stagnation in machinery, if not also in hull, development up to the end of the last war, and to some extent this applied also to warships, though for different reasons. Were the poor training facilities perhaps due to the tendency in the past not to insist on degree men to fill the more responsible positions?

Dr. Dorey rightly mentioned the need to decide between engine drivers and engineers in the true sense of that much misused word. Present conditions of training and employment in the merchant service seemed to emphasize the former to the detriment both of the latter and of the "officer" qualification. It was natural, therefore, that so many good engineers preferred to remain landsmen or "swallowed the anchor" at the first opportunity, and often before they had gained as much practical experience as they really needed to fit them for the many responsible posts in engineering ashore.

Lip service was paid to the need for more and more highly trained engineers and technologists, but, so far as much of industry and the commercial world were concerned, comparatively little was done to provide them except on a piecemeal basis. Often too little emphasis was placed on the need for broad practical experience.

Very little has been said about the so-called post-graduate requirements. Much more could and should be done in such fields as corrosion and its prevention, welding, fuels and lubricants, metallurgy, and production engineering and administration. So far as the merchant service was concerned, there were almost no proper facilities for training in refrigeration and air-conditioning, although Great Britain has by far the largest refrigerated tonnage afloat to-day. New passenger ships have an ever-increasing amount of air-conditioning, and refrigeration is being applied to more and more services. Some facilities existed in certain technical colleges and there were specialist courses available at the National College of Heating, Ventilating, Refrigeration and Fan Engineering, London, but none of these were ideal to meet the needs of ships' personnel in the detailed operation and maintenance of such machinery. Too much was left for the individual to pick up, often incorrectly or incompletely, from his seniors. A refrigerant circuit has much in common with the human body; refrigerant is as precious as blood and must be kept just as sterile. Fault-finding by trial and error may prove expensive, if not disastrous. We in the industry should do more to see that our equipment was run as it was intended to be, and was maintained at maximum efficiency. Organized practical training courses are required, not just a few days' walk round the works. Another subject grossly neglected is thermal insulation, both for habitability and for refrigerated cargo spaces. Insulation for hot steam pipes and the like was now highly efficient, but few of the builders or insulation contractors were at all familiar with the much more difficult subject of cold insulation for pipes and surfaces.

The old Royal Naval College training at Dartmouth was of a very high order, not least in practical engineering; so far as the writer was concerned, his Dartmouth training in the engineering trades was only supplemented at the Royal Naval Engineering College and he found himself to have a distinct advantage over his Special Entry contemporaries. Nothing could replace the hard practical training previously given as midshipmen, and it was to be hoped that the much greater age at which officers completed their training would not detract from their powers of absorbing the practical details, which were so often neglected, and might become more so in peace when sea time tended to be so much less frequent or continuous than of yore.

Captain Aylen described the implications of the new officer structure as "far-reaching." It was perhaps truer to say that many of the changes wrought were a form of consolidation, as many had necessarily become accepted practice in a service where so much depended on co-operation.

Narrow specialization was most undesirable in any naval officer, but this should not exclude the undoubted benefits of a really detailed and critical study of some subject a few years after completion of one's training. This aspect was well covered for those lucky enough to serve in a technical department of the Admiralty or some other naval establishment, such as a dockyard. The need was also to learn that no authority, however august or formidable, was necessarily always right in its solution or appreciation of a problem! Blind acceptance is no better than automatic rejection!

Finally, it is essential for all training to produce officers, whether military or civil, who were capable of making decisions based on sound knowledge and eventually on experience. They must also be prepared to change these decisions in the light of further or superior knowledge, without allowing pride or pique to colour judgment. Above all they must be prepared to make decisions, whether right or wrong, as nothing obstructed or prevented progress more completely than vacillation.

AUTHORS' REPLIES TO THE DISCUSSION

Reply by Professor Telfer

There can be little doubt that the primary purpose of the present symposium, that of inciting discussion, has been fully achieved. So far as my own paper is concerned whilst some, notably Mr. Champness and Sir Stanley Goodall, have doubted the prudence of the incitation, all should agree that the end has undoubtedly justified the means. It is felt that the high quality of the discussion allows it to speak for itself; and it would therefore be quite out of place to attempt any detailed reply. In such a symposium all are entitled to their point of view and these are best respected by subsequent consideration by an *ad hoc* committee set up for the purpose. The discussion undoubtedly calls for such a committee's formation, but extreme care should be exercised in the choice of its members. Youth requires direct representation as well as age, recent educational experience should be no disqualification, and all members willing to serve should be motivated by the passionate belief that only by greatly extended university educational opportunities in naval architecture will the shipbuilding industry receive that flow of eager graduates which other and generally younger industries are now so keenly absorbing.

It will be noted that I continue unrepentantly to emphasize the importance of university (i.e. the best) education. I am not concerned with any other or anything less, chiefly because so far as the shipbuilding industry is concerned their local and trade level educational problems are not nearly so acute or so unsatisfactory. To illustrate my point, however, I would in conclusion instance the following. With a party of my students, whose journey to this country was generously but wisely financed by Norwegian shipowners, I visited a world famous shipyard at present in the throes of organizational transition. There a young Cambridge graduate, not without family influence, had been given the task some two or three years ago of creating a planning department. Whether this task was intended to break him is not known, but the fact is now outstanding that his department has succeeded in increasing ship production by more than 40 per cent without any specific demands for higher wages on the part of labour, who actually are appreciative of the easier time they are now enjoying. What the real lesson is here I am inclined to leave to our *ad hoc* committee to elucidate. The graduate in question is incidentally the only one at present employed by the particular firm. This shocked me; and I remain shocked. As, however, the new chairman of the firm is himself a graduate, the organizational transition above mentioned may also include changes in staff recruitment policy worthy of the most far-reaching hopes behind the present symposium. We shall see.

Reply by Professor Robb

It does not seem to be desirable, even if it were possible, to offer detailed replies to all the contributors to the wide-ranging discussion. There are, however, some matters of general principle on which comments may properly be made. The first of these matters is the condition of admission to Glasgow University. The condition is determined by an Entrance Board representing the four Scottish Universities, and the insistence on a qualification in a language other than English is the maintenance of the Scottish educational tradition of a broadly-based curriculum rather than the more specialized curriculum characteristic of education in England. The Scottish Universities are not likely to relax their standards in this respect; the language test is not really severe, and there must be a lack in a student who cannot satisfy it. It has been suggested that, as alternatives to a language, art, music, and literature should be acceptable as indications of breadth of education. In fact, both art and music are acceptable as subjects in the examinations recognized by the Scottish Universities. English, a language other than English, and mathematics are compulsory subjects; for the other one, or two, subjects the wide range of choice covers both art and music. As for literature, that is covered by the examination in English, and to some extent by the examination in the language other than English. Incidentally the fact that English is the most important of all the subjects is indicated by the insistence that it must be taken on the higher standard, as far as examinations held in Scotland are concerned. So far the prescribed texts in literature have not included Hans Andersen's tale of *The Emperor's New Clothes*, but there is justification for the suggestion that it should be compulsory reading for would-be technologists.

It has been suggested that the shortage of students of technology may be associated with an undue emphasis on classical and humane studies in schools. The suggestion is at variance with a conclusion reached after a survey of the reading habits of boys and girls, as presented by a reviewer in one of the national Sunday papers during May. The survey covered 4,000 boys attending public-cum-grammar schools and secondary modern schools, with the former group predominating, and extended beyond the reading habits to the choice of career. In both groups of schools the majority of the boys favoured engineering. Moreover, the suggestion is not in harmony with some records of the Faculty of Engineering at Glasgow. At the end of the 1954–55 session 26 British first-year students were suspended, and at the end of the following year 29 were suspended; in each year the total admission to the Faculty was around 160. All these unsatisfactory students had at least one qualification in a science

other than mathematics, some in the examination for the General Certificate of Education. It may be permissible to conclude that the level of teaching in science is low throughout the country, but a more reasonable conclusion would surely be that even the more stringent conditions of admission to Scottish Universities are not yet stringent enough. And on the latter basis the high suspension rate seems to justify the suggestion, advanced on p. 340 and repeated below, that the Universities should be treated as the ultimate stage in an "educational ladder."

There is an absence of detailed criticism of university curricula, and some would have been welcome in view of the fact that major alterations in the courses in Engineering at Glasgow are at present under consideration. It is generally agreed that the time spent on the complete course should be increased, not only to extend the range of study, but also to reduce the intensity of the class-work; there is awareness of the criticism voiced some years ago at a meeting of one of the major technical institutions in the remark that "nowadays students do not go to a university to read for a degree; they go to be lectured into one." There are several ways of extending the course. One possibility is the abandonment of the "sandwich" system and the adoption of the three-term session for the whole, or possibly for a part, of the course. An alternative is the retention of the "sandwich" system, but with a five-year course, making university study and practical training span the same period; this alternative does not seem to meet with general approval. And there remains the suggestion, already advanced, that university study should follow the successful completion of an earlier "sandwich" course, so restricting admission to the university to those who have shown that they are capable of benefiting from it, and deserving of it on the record of their practical work. An advantage of such a scheme would be that a young man would have some knowledge of the industry, and of his inclination to remain attached to it, before he embarked on an expensive course of higher study.

It has already been indicated that the course of study at Glasgow is not narrowly specialized, and that character will probably be stoutly maintained. Not every fresh graduate desires, or is able, to remain in the branch of industry associated with his degree; and the broader the course of study the greater the flexibility of choice. Incidentally, it is an interesting fact that in the early 'twenties the then most powerful wireless station in the world was designed by a graduate in naval architecture at Glasgow; the dockyard school at Chatham shares the credit for his technical training. It is, however, fairly certain that in the revised course the mathematical content will be higher than it is at present. It is probable that less time will be spent on drawing. So far, however, as the naval architecture branch of the course is concerned a drastic reduction of the time spent on drawing can best be arranged if all students have some shipyard experience before embarking on the higher studies. And there is sure to be some consideration of the problem of embodying something of humane study. There is some awareness of what is being done in this respect at, for instance, the Massachusetts Institute of Technology, and there is full awareness of the attitude indicated by the American professor in the remark that "The technologist is not a god; he is not even a man." But many subjects that seem to deserve a place in a curriculum are crowded out by lack of time; hence the insistence on a fairly rigorous entrance qualification.

Whatever be the details of the curriculum the purpose must surely be to teach the student to think. It is not easy to state briefly and clearly all that is involved in the process of honest thought. For the technologist it probably means to some extent the proper relation of cause and effect. And a first stage toward it may be the development of the questioning mind; quite a few technological ideas might have been modified if the initiators had asked the question "Can this be right?" and then followed the question by examinations of *all* available evidence. Whether the development of the questioning mind has been successful or not may depend on what has been described as "putting-over efficiency." But the users of that phrase have overlooked the fact that there is no sure measure of that efficiency. The student to whom a subject is "put-over" plays a part, and it is possible for students to differ widely in their views on one teacher.

The major problem is not, however, what students should be taught, or how they should be taught. It is that of ensuring that there shall be an adequate number of students to be taught, however well or ill. The solution of that problem is the responsibility of the industry, and on a satisfactory solution depends the continuing prosperity of the industry. The solution seems to demand more than the mere attraction of young men toward the industry; the record of the survey of reading habits cited above suggests that there should be an adequate source of supply. It seems to demand consideration by the industry of adequate training schemes integrated with the regional facilities for technical education.

Reply by Professor Burrill

(*a*) *Verbal*

The notes about the Higher National Certificate and Diploma courses, which were included at the end of my contribution, are, I think, relevant to the present discussion, but we have heard Mr. Taylor-Cook say that he regrets the very scant reference which has been made to "part-time" education in this Symposium, and I would, therefore, like to suggest that The Institution should allow him to write a special contribution on this subject, which could then be laid side by side with the other contributions,—if he is prepared to do so. I feel it is important that the technical college type of education should be included in the Symposium, and this seems to be an admirable way of making up any deficiencies in my short notes on this subject.*

In presenting my written contribution, I am concerned mainly with the "domestic" side of the work of a University department, and I should now like to enjoy myself for a few minutes in talking about what I consider to be the "political" side of our discussions.

Relative to the number of potential naval architecture students in the country, I was informed just three days ago that there are already 79 applicants for entry into my department in October of this year. I also learned a little while ago that only six of the 89 students now in the department come from within 30 miles of Newcastle. These two facts, taken together, give some indication of the present demand for university places, and when I add that no more than 30 of these new applicants can be accepted this year, one must feel there is some need for further expansion in teaching facilities. I do not agree, however, that there should be five new departments and five new professors. I feel there is perhaps a need for one new department. Whether it should be sited in Liverpool, I am not sure, but it must be situated where there is a live interest in the subject, and on these grounds I would suggest that Southampton might well be the next university to have a department of naval architecture.

Turning now to the question of future career opportunities for graduates in naval architecture, I have, in terms of the opportunities offered to my own students, no complaints against the shipbuilding community. In the last two or three years, in fact, it seems to me there have been too many attractive vacancies for young men, some of whom are being drawn into tasks for which they are not yet ready. There is, for example, the extreme pressure for technological development in some of the larger shipping lines, and there is also a great lack of the right type of man for the higher technical and design posts in industry, arising from the "doldrums" of the 1930's.

I think every young man at present in the universities, who is worth his salt, will eventually get his opportunity. I am a little disappointed, however, by what has happened in the last ten

* See p. 383.

years or so, since I went to Newcastle, with the response of the shipyards in regard to the important question of retaining the young men who have started with them after graduation. Two years ago, for example, I very nearly landed in serious trouble with Lloyd's Register by suggesting to one of their Principal Surveyors, that he was "stealing" men from the shipyards. I was, in fact, genuinely concerned that a young man who was employed in a shipyard as an undermanager could be attracted away from what appeared to be an excellent opportunity for advancement by the offer of a relatively small increase in salary. I am glad to say this situation has now been reversed, and I was interested to learn that some shipbuilders are now attracting men back into the shipyards. Until a few years ago, progress in the shipyards had been very slow, and it was commonly held that no man was worthy of active responsibility until he was about 40 years of age. I would like to say, in this connection, that it is not only remuneration, it is also opportunity, which the young man seeks, and, in my view, one critical period is that between the ages of 25 and 30—or perhaps, under modern conditions, it should be 23 and 28—when young people are getting married.

This is the period when a young man, having a good technological education and background, sometimes finds he can earn about £200 or £300 a year more by moving out of the shipyard to somewhere else, where his immediate talents are more needed. If the shipyards could retain such men, even though they may not be worth the extra money at the time, I think they would be well worth keeping, for their future potential value.

Such a suggestion should be accompanied by something practical for the young man to do, and I would venture to say to the shipbuilders, firstly, that responsibility breeds character, and that they must, therefore, try to give younger men some responsibilities, and, secondly, that there is a great need for more "assistants" in all branches of the industry. We all know certain organizations and institutions which have seen the retirement of an important man without having a suitable successor to follow immediately in his wake. There should be more encouragement for the younger men by allowing them to become "assistants" to those holding more important posts; a wise leader will automatically see that the younger man gets some responsibility.

I do not agree with Professor Telfer when he says "there should be a research department in every shipyard." At the same time, when talking to shipbuilders, I try to impress upon them, in so far as I can do so, that it is a very lamentable fact that there is at the present time no one in their organizations who is doing what may be called "non-essential" progressive work. As in the most progressive Scandinavian shipyards, our own large organizations could very well employ some of their younger men in investigating special problems, such as structural strength and vibration, or resistance and propulsion, and these young men might well be called "technical assistants." They do not like being called "draughtsmen," and they could well become the equivalent of the "development engineers" in the aeronautical industry.

In several shipyards in Sweden I have met young graduates who are being employed in this way, and I believe that some of our own shipyards are beginning to realize the value of such work, in terms of new development possibilities.

With regard to the "sandwich" system of apprenticeship and college training I do not think anyone who has not personally known either the Newcastle or the Glasgow system can readily appreciate the difference.

Practically speaking, every student at Newcastle is associated with a shipyard before he comes to the College, and if this is not so, arrangements are made for him to spend his vacations in a shipyard, wherever possible. Most of the shipyards require these young men to work in the shipyard for three months in the summer and for one month at Easter, and some require them also to work during the Christmas vacation of four weeks. There is, therefore, not very much difference between the two systems, so far as effective time in the yards is concerned, and I would not mind greatly if we were required to change over to the other system of six months on and six months off.

From the educational point of view, the English University system is probably the better of the two, with its shorter periods of instruction and digestion, but from the practical point of view the longer works periods may be more desirable. Providing a reasonable planning of the work to be done by the students is arranged in advance, I can see no major disadvantage in the three-term system, and most shipyards seem to welcome the opportunity of giving the students useful work to do in these periods, if they feel they are seriously intending to follow a career in shipbuilding or naval architecture.

(*b*) *Written*

This discussion has raised so many interesting questions that it would be difficult to deal adequately with each point mentioned. I propose therefore to deal only with those issues which seem to have a direct bearing on my own contribution, or on our courses at King's College. The only point of major criticism is that some contributors feel the time allowed for drawing-office work in our time-tables is too great. This is a question which is frequently raised in discussions on university time-tables for applied science students, and is well worthy of reconsideration from time to time.

In the first place, I think it should be mentioned that we do no ship drawings, apart from the preparation of a midship section in the third year and some elementary drawing in the preliminary year. The remainder of our ordinary programme of drawing-office work is concerned with ship calculations, and includes, in addition to the basic hydrostatic and small- and large-angle stability calculations, the preparation of launching and subdivision curves, tonnage and freeboard examples, longitudinal strength calculations, powering and the design of body sections. A good deal of this work is of a kind which the young student would rarely, if ever, be given an opportunity to carry out completely in an ordinary ship drawing office. The work can therefore be said to implement and complete the notes given in lectures, and to supplement rather than duplicate the experience which the normal student is able to obtain during his vacation periods. On the average, the work entails about three afternoons per week in the drawing office, throughout the session, but the student is given a date for the completion of each task, which is based on the capacity of the slower rather than the faster workers; so that the more experienced students usually find they have time to spare, which can be used freely for other purposes. For those who are going to be employed mainly on technical work during their future careers, it is thought to be advantageous that they should become thoroughly accustomed to being engaged steadily on calculation work of this kind, but I agree that this view is not shared by all, and that there is room for the alternative idea that students should not be "bogged down" by too much routine work. Since the symposium meeting we have had numerous discussions on this subject, some with the students themselves, and it is quite clear there are many different viewpoints to be considered. In so far as it is possible to do so, these will be taken into account in framing our future programmes. There is no doubt the preparation of a full ship design to meet a given specification, such as is undertaken by most students in the fourth year of our Honours Course, represents a considerable amount of work, and it entails a good deal of overtime, but those who have followed this course will in later years be the first to extol the value of this experience, although they may find it rather exacting at the time.

With regard to the question of supplying the student with

printed notes, I should point out that this system is in use at King's College for some of the naval architecture lectures, up to the ordinary degree standard, and I consider this to be an excellent arrangement. Some lecturers prefer this system while others do not, and I think it should be left to the individual to decide whether his own lectures should be dealt with in this way, rather than that a rigid system should be imposed. In any case, I feel the lecturer should be free at any time to extend the printed notes, particularly with a growing subject, and that there should be less rigidity from year to year in the more advanced levels, where the object is to introduce the student to the most recent work, whenever this is possible. I have from time to time tried the experiment of requiring students in the more advanced years to read and report on current work, but on the whole this has not been too successful. This may be due to lack of time caused by other studies, but generally speaking I think it is due to the fact that papers written by experts in a particular branch usually assume on the part of the reader a very considerable knowledge of other work published elsewhere. On the other hand, I have found from experience that the student who is put on to a limited research programme, even in the final Honours year, very soon becomes acquainted with a wide range of published work. The Ph.D. student, who is able to devote a good deal of his time to general reading of this kind, is particularly favoured in this respect, and he very quickly reaches a position where he can cope with the most advanced work in his own line of studies, sometimes in fact drawing the attention of his supervisor to work of which he may have been unaware, or may not have studied in sufficient detail.

I was very interested in Professor Jaeger's remarks, and in particular to see the close agreement between the programmes followed at Delft and at Newcastle. It is also interesting to note that Professor Jaeger thinks we should "set our students to work a bit more." In other words, he does not find our drawing-office programmes to be excessive.

Professor Bonebakker strongly disapproves the plea for a standard presentation of basic lecture notes and does not favour an international conference of professors. Although I feel it is very useful to discuss such matters when the occasion arises, and to exchange notes from time to time, I do not myself think that any useful purpose would be served by having an agreed set of notes on each aspect of the subject, even if this were possible. Students vary from year to year and from class to class, and in good teaching there must always be an interplay of ideas between lecturer and students, so that the presentation of a particular item may require a different approach on different occasions. It is also very true that different lecturers may achieve the same result in quite different ways, and that any attempt at a standardized presentation would kill the very quality of personal initiative in presentation which is the keynote of effective lecturing at all levels.

Mr. Tanton suggests that students of naval architecture should have fewer formal lectures, and more free time for private study. In theory, this is an excellent idea, but I doubt very much whether it would work out well in practice because the bulk of our work is scattered in a large number of separate papers published in the transactions of the various professional Institutions, and is not to be readily found in textbooks as in some other subjects, such as medicine, law or economics, where the large number of potential readers justifies the frequent publication of such books.

I am not suggesting that students should not read the transactions of our Institutions—they are in fact encouraged to do so—but anyone who consistently reads a large number of papers will know that they contain a good deal of extraneous and conflicting material which would be confusing to the young student; so that one of the duties of the lecturer is to summarize the salient points in a number of such papers and to show how these fit together to make a general pattern of accepted knowledge. It is also true that the professional Institutions maintain a fairly high standard, and there is, therefore, a good deal of useful information which is below publication level, and yet finds a place in our lectures.

Mr. Hogben makes a plea for the introduction of simple design projects at an earlier stage than at present. This is a good point, and is well taken, but I think Mr. Hogben will realize the difficulty of devising a range of suitable "design" problems before the student has a proper appreciation of the many considerations involved in ship design work. I fear also that such problems would inevitably become as much a matter of routine as the present undergraduate work, and that some students would very soon tend towards achieving the same or very nearly the same result as students in the previous year. With regard to Mr. Hogben's practical suggestions, I think it should be mentioned that the design of body sections using two different methods of approach is included in our third-year programme, and that we will give consideration to his other suggestion in framing our future general degree programmes.

Mr. J. Brown refers to the difference in entrance qualifications between Glasgow and Durham, and I think it should be made clear that our regulations encourage the national certificate type of student to proceed to university studies in applied science subjects, by accepting these examinations for matriculation purposes, without a foreign language qualification, but that those offering the G.C.E. or "school leaving" examinations, must still include such a qualification, at ordinary level.

Finally, there have been some comparisons between our courses and those offered at the Massachusetts Institute of Technology, and other American institutions, but from personal experience, I do not think our students need fear that the courses available to them in our university schools of naval architecture fall in any way below the standard of those which are open to their American colleagues.

Reply by Professor Palmer

Mr. Champness, as a parting shot, said that there might be no difficulty in recruiting for the R.C.N.C. if its members were naval officers. I am not at all sure about that: the type of man we want for designing and building ships may well prefer to be a civil servant. And there is no doubt that more constructors would be needed if they were subject to some of the existing rules for naval officers, such as arbitrarily changing jobs every two or three years and early retirement. I cannot understand his reference to Cambridge as a University that "knows anything about ships." I am not aware of any course there that touches the subject in any way.

Sir Victor Shepheard has criticized public and grammar schools for not encouraging more of their best boys to study science. I believe that he is right and that too many of the more brilliant students choose to follow their teachers' examples and study subjects for which there is likely to be little demand in the future. Surely it is wrong for any boy to leave school at 18 without at least a broad appreciation of scientific principles and modern industrial conditions! It is equally wrong, of course, for boys to specialize in science at too early an age if they thereby fail to obtain a good all-round education, and this does happen at some schools.

Mr. Lenaghan would like to see some private students of naval architecture trained at the Royal Naval College. Our regulations allow this, and we are pleased to take private students who can pass our entrance examination. The fact that very few have applied to take the course in recent years is probably because those who might have done so can now apply to enter the Corps and take the course as constructor officers.

I agree with Mr. Woollard and Dr. Hunter that not enough publicity has been given to the new method of entry to the

Corps from schools. The Admiralty has sent a perfectly clear description of the new entry, plus an attractive poster, to some 1,400 public and grammar schools (including the one attended by Dr. Hunter's son) but, either because the number to be taken is small or because of lack of interest in naval architecture, these do not appear to have been shown to many students or their parents. There is no doubt that this is one of the most attractive openings for boys who are interested in science and ships, and when it is better known I think there may be considerable competition for the appointments.

Several speakers talked about lecture notes for students. At Greenwich we take the preparation of these notes very seriously and they are revised and reprinted every year or so. We give the notes to the students, chapter by chapter, either just before or at the end of each lecture, and this leaves them free to concentrate on what is being discussed in the classroom. They study the notes in their own time after the lecture, and if there are any difficulties they consult the lecturer in his study or ask questions at the beginning of the next lecture period. The Greenwich notes, which are produced in good style and are suitable for binding, are also sent to serving members of the Corps who ask for them (and most of them do) and we welcome any criticisms or suggestions they send back.

Mr. Baxter wants to know why a candidate who has an honours degree in naval architecture should be made to take the Greenwich entrance examination. The reason is that this allows the Admiralty to decide how much of the course a successful candidate may miss; the shortest training for the Corps is that of graduates in naval architecture who do well at this examination.

Sir Stanley Goodall asks for more information about student apprentices in the Royal Dockyards. Very briefly, 74 of these apprentices, between 16 and 18 years of age, are now being entered each year. Two-thirds are selected by a Civil Service examination held at various centres throughout the country and the remainder are taken from the best craft apprentices in the Dockyards. Student apprentices are given five years' training in one of the Home Dockyards. In the first year they have instruction and practice in bench work and in the work of the main trades of all departments. At the end of this year they join one of these departments and spend two years in its shops or in ships and then one year in the drawing office. The fifth year is spent gaining experience in costing, estimating, personnel matters and other duties of dockyard officers, and at the end of this year the apprentices become confirmed draughtsmen.

During the first four years of their apprenticeship they spend 16 hours a week at the Dockyard Technical College, covering approximately the ground required for an Engineering Pass Degree, with professional lectures in naval architecture, marine engineering, electrical engineering, or aircraft engineering, according to the department in which they serve. They have the opportunity of applying for posts in the Scientific Civil Service or commissions in the Royal Navy, Army, and Royal Marines, while those who do best at the end of the fourth year may be selected for Admiralty Cadetships in naval construction or electrical engineering. I believe that most of them will obtain posts of this sort or scholarships to universities, and that relatively few will remain in the dockyards as draughtsmen.

Mr. Hogben made a plea for more creative design in university courses. Actually more time is spent on creative design at Greenwich than on any other subject. This year the students' designs include a nuclear-propelled submarine, a nuclear-propelled icebreaker, a guided missile ship, and a helicopter carrier, as well as other more conventional types of warship. All these designs are original products of the students' own minds and imaginations, and the important thing is that each student creates something new. In doing this, of course, they run into all sorts of problems and the staff have to do a lot of hunting around to get reliable data for them. If they are incorporating new types of machinery or weapons the information they need will usually not have been published, and in this case we make the best estimates of sizes and weights that we can. In other words, we recognize that the students are engaged in an exercise in design and that in some details their work may not be as accurate as it would need to be for an actual design.

Dr. Muckle, when talking about the suggested new schools of naval architecture, said that he could not see where the new students were to come from. I can see where we can get them—from a greater output of science students from public and grammar schools. But perhaps a bigger question is where are they going after they graduate? That is not so easily answered and, as several speakers have said, the shipowners and shipbuilders of this country have first to realize that they need, and would profit by having, more graduates.

Several speakers have commented on Professor Telfer's suggestions for pedagogical collaboration and standard notes. While I would welcome the opportunity for more collaboration, I do not believe that many lecturers would be content to work from notes they had not prepared themselves. We find at Greenwich, where the Head of the Naval Architecture Department is changed every five years, that each new Professor at once starts to re-write the notes left by his predecessor. Not, of course, that the new notes become very different from the old ones, but each new man wants to add some points and delete others, or favours a different method of presentation. Surely all lecturers have the same dislike of working closely to other people's textbooks for any but the simplest of subjects!

Mr. Chapman's remarks on the need to look well ahead when planning the training of students are particularly apt for the Navy now that the White Paper on Defence has been published. I hope that any young men who may be thinking about a career in the Corps will not be put off by fears that there will be a reduction in the number of constructors. We need to maintain or improve the present rate of recruitment if we are to give to the ships of the future Navy the attention which their increased complexity will require.

Reply by Captain Aylen

I was pleased to hear the refreshing views of Dr. Livingston Smith, particularly the way he stressed the importance of early fundamental training and later post-graduate courses. This is the way the new type of naval training may go.

I note that he doubts the absolute necessity of advanced mathematics for *all*. Are there not now available many other forms of equally effective mental training, possibly of greater value to certain technologists who may in fact never be called on to solve abstruse mathematical problems? Sir David Pye, in his Presidential Address to the Institution of Mechanical Engineers, regarded mathematics as a possible mental straightjacket, and thought that many a jewel could be found in the refuse of the third-class pass degree. He concluded that an ounce of instinct is worth a pound of information. However, it would be presumptuous of me to air views on this highly controversial subject of whether advanced mathematics is an essential for *all*.

In reply to Mr. Baxter, there is an opening at Dartmouth for third-year apprentices in the Royal Dockyards.

I mentioned that the basic course at H.M.S. *Thunderer* covers 42 weeks a year; an opinion was expressed that this was far too intensive. This is certainly so, and the staff at H.M.S. *Thunderer* would like to ease the pace and extend the time in order to make it a little less of a struggle for the less able students. Unfortunately, however, if the time is extended it means that we must have a larger intake into the Service, and that means more taxpayers' money. It is another of those cases where the Admiralty and the Treasury do not always see eye to eye.

I sympathize greatly with the views expressed by Dr. Hunter. Even a popular service like the Royal Navy finds that it is

increasingly necessary to go into the field to interest careers masters and the young in order to obtain the very small number of high calibre recruits that are needed. The Director of Naval Recruiting has for this function a small permanent Schools Liaison Staff—too small perhaps to be able to compete with the methods used and the lavish inducements offered by many of the country's wealthier concerns. It is vital to enlighten the ignorant of just what is involved in the career offered. During an Admiralty Interview Board I recollect hearing a potential candidate for cadetship say that he thought a naval engineer officer was "the chap who built the bridges in the dockyards"! Fortunately, the introduction of common entry will now allow each cadet to obtain an insight into the specializations before he is committed to one in particular.

I agree wholeheartedly with the views expressed by Comdr. Le Bailly on character and leadership training. The methods employed at H.M.S. *Thunderer*, largely thanks to his personal efforts, are neither fanatical nor evangelical: doubtless many improvements will be adopted in light of experience, and there are many other ways of achieving the same object. The need for such training is, however, definitely recognized, and we feel sure we have started on sound lines, making use, as he says, of some of the principles of the Outward Bound Trust, which itself was a child of the Merchant Navy.

In concluding, I would like to thank The Institution of Naval Architects and the Institute of Marine Engineers for having arranged this Symposium. It has undoubtedly served to emphasize the value of the closest co-operation between those who design, those who build, and those who serve at sea, whatever sort of uniform, if any, they may be wearing.

Reply by Dr. Dorey

First I would like to say how much I have enjoyed reading Captain Aylen's paper, because it shows what fine schemes can be developed when the taxpayer has to pay for them! Nevertheless, the scheme described is an excellent one and I only wish it were applicable in more directions. Particularly I would make reference to that part of the paper which refers to character training. It is not often that one finds remarks in technical papers such as are made here, and I think there is very good reason for the inclusion of matters such as are mentioned for the future training of the naval engineer and, indeed, all engineers.

Now I must come to more mundane matters, because my paper really deals with more mundane matters, where people are perhaps expected to keep their feet more on the ground than to go into those seemingly flights of phantasy which have perchance appeared in some of the papers which have gone before, but may yet come to pass.

A number of contributors to the discussion have shown they are rather pleased at the number of sea-going engineers who have undergone the first scheme of training mentioned. It shows that ultimately these young men realize the importance of a certain amount of technical training. The qualities of scheme (5) have been emphasized in the discussion. I feel that it is an excellent scheme, and provided it is carried out in a way such as is being done by shipowners, particularly the tanker owners, there is no reason to think the scheme will not produce the type of engineers needed. In this connection, Mr. Stewart Hogg's remarks are well worthy of close study, bearing in mind his position at the Ministry of Transport. Provided the standard is maintained, most apprentice training schools I have seen made good craftsmen. I thoroughly agree with the remarks in the last paragraph of Mr. Hogg's contribution, particularly as so much maintenance work is now done in port by a shore staff.

Mr. Alcock, whose remarks are on similar lines to those of Mr. Logan, mentioned how much his company are satisfied with the manual training which the new trainees have had. This is a good omen for the results depend on the people who pay the bill, as well as those who are responsible for the course. When one considers the broad experience of engineer superintendents in the big shipping companies, I think one can rest assured that the training will be on sound lines to suit the standard of those particular ships whose superintendents appreciate their responsibilities for training good engineers.

Mr. Taylor-Cook has mentioned the advantages of a good technical education given at technical colleges, and perhaps this had not been sufficiently stressed. Quite frankly, I think the technical colleges are doing excellent work, and that obtains throughout the whole of the engineering industry. The Certificate scheme, in which practical training is combined with technical training at an institute or college, has one great advantage, that it does permit of continuity of technical training and practical experience. Management in industry is keen to retain those who have a continuity of experience which will benefit the firm in the future, without too much breaking away, which a four-year course at a university usually does. Mr. Taylor-Cook's written contribution is a valuable addition to this Symposium and which, no doubt, will be read by many outside of the industry.

Professor Chambers naturally indicated the importance of a thorough university engineering training. Of course, it must be agreed that my paper had to deal essentially with sea-going engineers, that is, those who intend to make their career as sea-going engineers, and it is well known that very few indeed of those who actually go to sea have a degree; some of them do, and I think they do very well in the end, but they come ashore after about six years.

A university course will produce some engineers for the highest level, and I consider, as I have mentioned earlier, that all who do a university marine engineering course should have some sea-going experience. Incidentally, for many years I have advocated for naval architects to have sea-going experience. Lord Runciman has mentioned the question of high-class engineers remaining at sea. In my opinion, those who go to sea and who have the right capabilities know whether there are jobs available at the top, and the shipowner will benefit in the future if he makes the incentive worth while. That is why I think shipowners should give the opportunity for some of their engineers to have refresher courses to keep them up to date and so be in a better position to give sound technical advice to the shipowner when he is considering new construction.

Mr. Logan has mentioned that there were not enough young men coming from the normal marine engineering industry to be sea-going engineers, and it was for that reason that this scheme was started. As I said earlier, the shipowners can make their own choice, and therefore can make the new scheme a success or otherwise. I only hope that more shipping companies will come into this, in spite of the cost.

It has been suggested that the majority of sea-going engineers have had a technological training. That depends largely on the attitude of shipowners, and what they do to see that their staffs are properly trained. I consider there should be a pre-training in general machinery operation and maintenance between apprenticeship and the time of going to sea as a junior engineer.

A point not exactly connected with marine engineering was raised by Mr. Hogben. He referred to Lloyd's Rules going rather against the training of the naval architect. Quite frankly, I think that what Lloyd's Rules do in the ship design office—of which I have no experience whatever—is to differentiate between the man who does his work only by using the Rules and the man who thinks for himself and looks a little deeper into the matter.

Commander Stewart made reference to the advance course at Greenwich from the point of view of equipping officers to deal with troubles in connection with machinery. In my experience, that is a matter which should be given more attention. It is a specialized subject; machinery breaks down, and if the same trouble occurs more than once a special investigation should be

made. Such problems can often be investigated and a proper solution quickly found by those trained for the purpose.

Mr. Reid made reference to the necessity for a marine engineer to get good sound running and maintenance experience. In the selection of surveyors I have always endeavoured to recruit people of sound technical experience, including operating experience. Too many highly technical men are not required, but good common-sense practical men who have sailed around the world and have learned their job. They do not learn entirely by books, although as the result of learning by books they profit by experience in a shorter time. Such men are the backbone of the industry.

Mr. Jarrett's general remarks emphasize that practical training is still a main asset for those who go to sea in the average class of ship, such as tankers, cargo ships, and coasters.

Commander Le Bailly has stressed the value of character training. In my opinion the new system of training, namely scheme (5), should help to bring out character in those who have it, if perhaps dormant, but some experiment should be well worth while. It is the absence of incentive in scheme (1) which is detrimental in the long run as it is often not until the young engineer goes to sea that he finds out whether he has the essential characteristics born in him or otherwise.

In regard to Mr. Capey's reference to making a sea-going engineering job attractive, this can be considered as part of the much wider subject of getting more students in the country interested in science and technology. While I agree the right type of youth should be selected when he is sixteen or seventeen years of age, it is at the age of about fourteen that the process of attraction really needs to be applied, and what better than based on a slogan, such as he suggests, and put across by those of experience in the marine engineering industry who have the proper flair for the job.

Mr. Bennett's remarks, coming from one who has had almost a lifetime experience in preparing candidates for their certificates of competency, are particularly valuable and worthy of special study, and some of his suggestions should be followed up by those interested in the scheme. It is satisfactory to note his experience—like Mr. Hogg, Mr. Logan and others—with the Alternative Training scheme shows it is working very well.

Lt.-Commander Ranken has stressed the need for wider technical knowledge in what may be termed the auxiliary subjects in marine engineering which do, however, play a very important part in the practical all-round running of a first-class ship, and so necessary after the fundamentals of driving a ship through the water have been mastered. Many, no doubt, will find in these auxiliary subjects something stimulating and an incentive for their future benefit.

Summarizing the discussion, I feel certain the Symposium has been worth while and has brought out many suggestions to consider in the future scheming for the training of sea-going engineers in the Merchant Service.

It also indicates that as a result of experience to date the Alternative Training Scheme (scheme (5) of the paper) was well conceived and has produced satisfactory results.

As might be expected in launching any new scheme, certain alterations, as a result of experience and discussion, will no doubt give some improvement, but it is evident to my mind that with proper co-operation between the marine engineering industry and the shipping industry this scheme will ultimately become recognized as the main and most proficient method for training young engineers for a sea-going career.

INSTITUTE ACTIVITIES

Section Meetings

Bombay

A general meeting of the Bombay Section was held on 13th August 1957 at 5.30 p.m. at the Nautical and Engineering College Hall, Bombay. Mr. W. W. Campbell (acting Local Vice-President) presided and twenty-five members were present. The following office bearers were elected: —

Committee: Capt. T. B. Bose, B.Sc., I.N. (Chairman)
T. Berry
P. D. Dadachanji
D. Dyer
W. Gay
Lieut.-Cdr. K. H. Patell, I.N.
P. N. Rabady
R. G. Sathaye
J. M. Trindade

Honorary Treasurer: S. Kasthuri

Honorary Secretary: C. S. Sundaram, E.6, Pannalal Terrace, Grant Road, Bombay.

Sydney

A meeting for students and apprentices was held at Science House, Sydney, at 8.0 p.m. on Friday, 19th July 1957. Mr. N. A. Grieves (Honorary Secretary) was in the Chair and there was an attendance of forty-four, comprising nine members and thirty-five students and apprentices. Mr. E. L. Buls (Member) delivered a lecture entitled "Marine Engineering as a Profession" which was followed by a good discussion. A vote of thanks to the lecturer was proposed by Mr. J. Munro and carried by acclamation. After the meeting supper was served and an opportunity thereby given to the young men to meet the members that were present.

On Wednesday, 31st July 1957, a meeting of the Sydney Section was held at Science House. Mr. N. A. Grieves (Honorary Secretary) was in the Chair and there were forty-four members and guests present. It was reported that Mr. F. J. Crew, a member of the Section Committee, had resigned from the Sydney Section, having left for England on 2nd July 1957. Mr. T. M. Devitt then presented a paper entitled "The Interpretation of Laboratory Analysis of Used Lubricating Oils". Messrs. Findlay and Sutton contributed to the discussion that followed and a vote of thanks to the author was proposed by Mr. E. L. Buls and carried by acclamation.

Victorian

A very successful meeting of the Victorian Section was held at the Kelvin Hall, Melbourne, on Friday, 9th August 1957, when a paper on the subject of tugs was read by Mr. Pritchard. Forty-five members and friends attended.

Election of Members

Elected 17th September 1957

MEMBERS

Kenneth Frank Alexander, Lieut.-Cdr., R.N.
Reginald Thomas Breeds
Frederick William Butler
Joseph O'Brien Canavan
Edward Stuart Clarke, B.Mech.E.(Melbourne)
Percival Dabreo
William Henry Darlington, M.B.E., Ph.D., M.Sc.(Eng.) (London)
Thomas Docker, Lieut.-Cdr.(E), R.C.N.
Sydney Gladstone
Frederick John Cossie Godfree, Cdr., R.N.
William Arthur Greenhill
Christian Eric Hansen
George William Hunter
Donald Livingstone
Frank Lynam
Hugh Gillan McNair
Wilhelmus Arnoldus Middendorp
Charles Henry Muir
Lawrence James Penny
John Rogers
John Douglas Rosser
Thomas Gillespie Shields
Ronald Alec Smith
William George Smith
Philip Edwin Spencer, Lieut.-Cdr., R.N.
Alfred Stephenson
David John Thomas, D.S.C., R.N.
Thomas Thompson, M.Sc.
Leo Francis Totten

ASSOCIATE MEMBERS

Mohammed Ajaib, Sen. Cd. Mech., P.N.
Ralph Deighton Armstrong
Mohammed Ashraf
Ronald Leslie Atkinson
Frank Banner
Stanley John Bassett
Gerhard Baumberger
William Bedlington
Wilfred Gordon Brown
Albert Edward Bryson
Don Mitchell Carley
Peter Michael Carr
Francis Xavier Coutinho
James Barnett Cowe
Gavin Robert Creais
Henry Frank Cross
Henry Albert George Deacon, Lieut.(E), R.C.N.
John James Faulkner
William Allan Flegg
George William Gilbank
John Anderson Greener
Albert Thomas Gribben
Anthony Peter Martin Grima
Edward Haagensen
Cyril William George Hawken
Alan Henderson
Arthur Louis Henry
Brian Ackroyd Hunter, B.Eng.(Sheffield)
Robert McAuslan Hutchison
Sheikh Mohammed Ismail, Lieut.-Cdr., P.N.
Reginald Alwyn Jones

William Montague Denman Lamming
William McQueen
Donald McRoberts
John Joseph Merriman
Stanley Denzil Mew
Terence James Morris
Ronald Graham Moscrop
Benny Motha, Lieut., I.N.
Raymond Oliver
Paul Leonard O'Sullivan
Reginald Austin Palmer
Michael Joseph Parkinson
Frederick Petterson
Alexander Thomas Porter
Ramesh Dinkar Raje
Alan Terence Seddon
Thomas Christopher Shaw
Frederick Smith
Darrell Stretton
Nigel William Harry Thompson
Raymond Ward
Graham Douglas Warland

ASSOCIATES

William Wallace Almond, Lieut.-Cdr., R.N.(ret.)
Saroj Kumar Chakravorty
Arthur Vernon Fisher
John Gordon Goldsworthy
Eric Green
Dnyaneshwar Balwant Kesarkar, Cd. Eng., I.N.
Joshua Melodysta
Douglas B. E. Mitchell
Philip Nicholas Barrie Quintrell
Jacob Rosenthal
Ernest James Rowe
John Henry Smeddle
Thomas Tod, Captain
Alan Jackson McLelland Tweedie

GRADUATES

Mitchell Andrew Anderson
Kevan Allan James Barker
Harry Cecil Barrett
Peter George Bashforth
Ian Campbell
John Leonard Carey
Inayat Ullah Choudry, Lieut., I.N.
Joseph Barrington Coope
William Alexander Cunningham
John Joseph Dunn
George Etienne Emberton, Jnr.
Arthur Edmonstone Findlater
Anthony Vivian Fuller
Stanley Howard Holding
Mehmet Deha Korkut
John Caldwell Macfarlane
Gavin McGregor
John Reginald Middleton
William Moorhouse
James Eric Page
Colin Raisbeck
Kenneth Raper
Syed Ashiq Raza
Andrew William David Ritchie
Donald Richard Thomas Roberts
Harold Swincoe Scott
Harbansh Lal Sethi
Alan Gordon Smith
Ronald Smith
Lawrence Taylor
John Travis
Francis Victor Wong

STUDENTS

John Askew
Clive Edgar Barkshire

TRANSFER FROM ASSOCIATE MEMBER TO MEMBER

Cyril James Kelly
Lionel Yorath Lynes

TRANSFER FROM ASSOCIATE TO MEMBER

Cyril Beason
Edward Alfred Burgess, D.S.M.
Edward F. Butler
Joseph C. Camilleri
Arthur Kracko
Alexander John Burnett Pirie
Paxton South

TRANSFER FROM ASSOCIATE TO ASSOCIATE MEMBER

Reginald George Allen
Thomas Alexander Beaton
Estanis Gallo
Clifford Somerville Harnett
George Kenneth Peace
John Alfred Powell

TRANSFER FROM GRADUATE TO ASSOCIATE MEMBER

Ernest Albert Adlington
Douglas Louis Braganza
Barry Thomas Duffield
Philip James Pike
David Gordon Hamilton Strahan
James Stubbs
Ronald Whittaker

TRANSFER FROM STUDENT TO GRADUATE

Maneck Pirojshaw Motawara

TRANSFER FROM PROBATIONER STUDENT TO STUDENT

Keith Charles Bull
Peter Hollands
Colin David Jupp
Alan Edwin Perry

OBITUARY

FREDERICK HUGO BECKTON (Member 9964) died in November 1955, aged fifty-four. He had served an apprenticeship with the North Eastern Steel Co., Ltd., Middlesbrough, from 1917/19 and with the British Chilled Roll and Engineering Co., Ltd., Middlesbrough, from 1919/20, and was then employed by Babcock and Wilcox, Ltd., for about two years. He served as fourth to second engineer at sea in various shipping companies until 1933 and obtained a First Class Board of Trade Certificate. He was ashore as maintenance engineer for the Anglo-Persian Oil Company until 1937 and then as plant foreman and maintenance foreman for two years with Athole G. Allen (Stockton), Ltd. From that time he worked for Imperial Chemical Industries, Ltd., first as assistant mechanical engineer, then as resident mechanical engineer, and finally as regional engineer.

Mr. Beckton was elected to Membership of the Institute in 1944.

ARTHUR HOWARD CRUICKSHANK (Member 4179) was born on 4th April 1888. He served an apprenticeship with Kingsland and Galbraith, Bluff, New Zealand, and then spent eight years at sea and obtained a First Class Board of Trade Certificate. He spent many years on the Gold Coast, in 1921 being an assistant mechanical engineer for the Gold Coast Government and in 1939 chief transport officer of the transport department and also principal examining and certifying officer under motor traffic ordnance. He died in January 1956.

Mr. Cruickshank was elected a Member of the Institute in 1921.

ROBERT MILLER DOWNIE (Member 5221), who died on 14th January 1956, aged sixty-six years, served an apprenticeship with the Shields Engineering Co., Ltd., North Shields, and in 1910 entered the Merchant Navy as a junior engineer officer. Whilst he was serving at sea during the first World War his ship, s.s. *Oakwood,* was sunk in August 1915 by enemy action off Southern Ireland.

He joined the British Tanker Company in December 1917 and was appointed second engineer of s.s. *British Light.* In 1919 he was promoted chief engineer and sailed in this capacity in a number of the company's ships. In 1926 he was appointed senior post chief engineer and a year later became an engineer superintendent for the company, serving in the North East area and at head office until his retirement in 1955.

Mr. Downie was elected a Member of the Institute in 1924.

FRANK AUGUSTUS FARNWORTH (Associate Member 5046), who was born in 1897, was apprenticed to his father as a motor engineer at the High Street Motor Engineering Company, Blackburn. Soon after the outbreak of the first World War he joined Cammell Laird and Co., Ltd., Liverpool, but left them after a few months to serve at sea in Elder Dempster Line steamships until 1919. He started in business on his own account as a motor engineer and extended it to operate a public passenger service in an area for which no such service had existed previously. In 1937, however, he relinquished the actual control of these undertakings and was appointed motor vehicles service manager to the Blackburn Corporation.

On the outbreak of the second World War Mr. Farnworth had already organized emergency transport for the area under Civil Defence and later he was appointed officer commanding the 2203 Motor Transport Company, Lancashire and Border Column, with the rank of major. He returned wholly to civil duties with the Blackburn Corporation in 1946 but in 1955, as his health was none too good, he retired from this appointment and for a short time became landlord of a country hotel in the Ribble Valley; when his health improved again he applied successfully for the position of technical assistant, transport and mechanical engineering, to the director of housing for the London County Council. Unfortunately his health again deteriorated and he died after an illness lasting two months on 4th August 1957. Mr. Farnworth had been a member of the Institute since 1924.

WILLIAM THOMAS TUCKER (Member 1754), who had been a Member of the Institute of Marine Engineers since 1904 and was also a Member of the Institution of Naval Architects, served an apprenticeship with Vickers, Sons and Maxim at Barrow in Furness which included two years in their engine drawing office. This experience was followed by two years with William Doxford and Sons, Ltd., Sunderland, in their drawing office while also attending Durham College of Science for a course of advanced technical training. He went for a short period to Southampton to the company that is now called J. I. Thornycroft and Co., Ltd., and then joined Mr. C. W. Murray as a consulting engineer.

Feeling the need for wider experience, Mr. Tucker spent five years at sea as a watchkeeping engineer in ships of the British India Steam Navigation Company and obtained an Extra First Class Board of Trade Certificate on coming ashore in 1903. He joined Babcock and Wilcox, Ltd., and during the next eight years he was in charge of many of this company's most important contracts in the marine field and in power station work all over the Continent of Europe and many of the successful early experiments in burning oil fuel were carried out under his guidance.

In 1911 he was appointed superintending engineer of the Union Steamship Company of New Zealand, being responsible for all new construction; under his guidance and influence much of the marine practice was developed that is standard today, including oil fired watertube boilers, the closed feed system, superheat for steam turbine machinery, methods of filling and venting oil fuel tanks, and emergency systems of electric lighting for decks and alleyways on passenger ships. When the Union Steamship Company was absorbed by the Peninsular and Oriental Company about 1932, Mr. Tucker retired from their service and established himself as a consulting engineer in Glasgow and also took charge of Messrs. J. Stone and Company's Scottish office, dealing with all their marine products. He continued with this work until the end of the 1939/45 war, when he retired finally. Mr. Tucker died, aged eighty-two, on 26th July 1957 at his home at Giffnock, Renfrewshire.