

Some Suggestions for the Training of Engineers.

BY ANNISON S. J. HALL (Member).

READ

Tuesday, November 23, at 6.30 p.m.

CHAIRMAN: MR. J. B. HALL (Member).

The CHAIRMAN: I regret that the writer of the paper is unable to be present with us and our Hon. Secretary is to read it for him. The absence of the writer need not in any way detract from ample criticism; the greater the criticism the more valuable the result.

The HON. SECRETARY: Before reading the paper I may say that Mr. Annison Hall took a very great interest in our examination in connection with the Student Graduates and was instrumental in getting several Aberdeen apprentices to sit for it, and those who passed have united together and formed a Student Graduates' Branch. Mr. Hall has thus shown his very deep interest in the education and training of the young engineer.

"THE efficiency of a nation is the combined efficiency of its units," being a well-known expression, it is therefore of vital importance to train the units in such a manner that they will have as high an efficiency as possible.

A workable scheme of training would have to be economical to the Nation, the employer, and the employee, a point which, I think, is too often overlooked by the majority of those who attempt to frame a satisfactory scheme.

It should be fully recognised that the inherent ability of individuals varies greatly, and it is in many cases waste of time and money to try to fit certain of them for the higher positions in any vocation. Individuals may be divided into two classes, namely, the mental workers and the physical workers, and either of these is not restricted to any section of society; this being so, it is our duty to try to frame the scheme in such a way that every facility should be given to encourage those with the best intellects to work up the ladder, by open and fair competition, as fair competition is the only way for every one to find his true level, and as a consequence the most efficient reaches the top.

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In the engineering profession, however, it is of the utmost importance that everyone worthy of the designation of engineer should have a thorough practical training as well as a theoretical one, and the practice of working in the shops for a few months, or perhaps one or two years only, should be discouraged for those attending technical colleges or universities, as there is ample time for anyone to serve a full apprenticeship and at the same time obtain a technical diploma or university degree.

With your permission I shall digress a little, to see how the term Engineer has been evolved, and to see who would be considered legitimately entitled to the designation, as I cannot see why the term should not be restricted to certain persons who, by virtue of their qualifications, have demonstrated to some authoritative body or bodies their fitness to assume this title, and further, that it will perhaps give me a basis on which to write this paper.

The word "Engin," now obsolete, was I believe, derived from the Latin "Ingenium," meaning natural talent, ability, or skill, and was used in the time of Chaucer with this meaning only, but it came to be that any mechanical contrivance, which showed ability in its design, by the application of clever ideas, became known as an "Engine," more especially those which, distinguished from machines, were prime movers, and were worked by the agency of some physical agent, such as cannon, and later the steam engine, until at the present day we associate the term only with prime movers, which is the correct idea, as the term was primarily given to prime movers, because they seemed to be endowed with a power akin to mind.

The term "Engineer," which was at first spelt "Enginer," was originally exclusively applied to certain individuals in the army, who did the planning and designing, and superintended the construction of anything for use in the army's offence or defence, such as forts, guns, barracks, trenches, batteries, etc., and who had under them skilled workmen, who were not designated Engineers, but that of their trade, such as plasterers, masons, carpenters, etc.

In civil life, however, many individuals were engaged in the planning, designing and supervision of similar works, and these became known as Civil Engineers. I would define an Engineer then as an individual who practises the art of planning, designing and supervising the building of any mechanical structure

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as applied in commerce, or for the safety and convenience of man, in contradistinction to one who turns or fits or erects the parts, or he who tends an engine or machine.

The Institution of Civil Engineers was founded in 1828, and the Charter of this Institution will give one a good idea of what an Engineer should have been in those days when Engineering as it stands to-day was practically in its infancy. It states that the Profession of a civil engineer is, "The art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation, and docks for internal intercourse and exchange; and in the construction of ports, harbours, moles, breakwaters, and light-houses, and in the art of navigation by artificial power, for the purposes of commerce, and in the construction and adaptation of machinery and in the drainage of cities and towns."

It was quite possible for some individuals to be proficient as Civil Engineers in those days, as laid down in the charter, but inventive progress was so fast, and expansion so great, that specialisation had to be adopted, and we now have branches of the Engineering profession termed Civil, Mechanical, Mining, Marine, Electrical, Oil, Locomotive, Agricultural, etc.

Specialisation is the essence of efficiency, be it broad or narrow, and this can be applied to the arts as well as to individuals, and as it was found necessary to split civil engineering into branches, it is now time to alter the present system of mechanical engineering, as it is at the present day quite impossible for anyone to be proficient in all its branches.

In this country mechanical engineering, I think, consists too largely of engineery and not enough of machinery, the consequence being that the teaching consists too largely of engine design and construction, neglecting that which mechanical engineering primarily means, namely, the design and construction of machines as machines, and machine tools, the present system tending to narrow the field of commercial enterprise, not only in the engineering trades, but in those trades and industries which require a large amount of machinery.

The design of such machines is left in the hands of a few specialists, the principles and design of which very seldom come within the syllabus of a technical college; or else the teaching

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is restricted to certain areas, which is a great source of commercial loss to our country, and other countries profiting thereby. The specialisation of machinery for the various purposes of industry is the greatest source of a nation's wealth, and I would therefore recommend that mechanical engineers should specialise more in these lines than they have been doing for many years. Agricultural implement making, toy making, watch and clock making, are a few amongst many others that mechanical engineers would do well to specialise in, and there is nothing to prevent the making of these or the machines used for the manufacture of them outside the iron districts, and many industries could be opened up near seaports where the bulk of raw materials have to be imported in any case.

Civil engineers are also slow, and should by some means let the public know of suitable sites throughout the land, where water power could be made available for industrial purposes.

At a time like this, when the rising generation will have to bear the brunt of a gigantic struggle for commercial supremacy, I think that it is most important that something ought to be done in these matters, and general education from infancy onwards to be more of an industrial and commercial nature than has been in the past.

A distinct branch of Power Engineering would be a step in the right direction, and which would specialise in the management and design of prime movers, which is now a very large field in itself.

In the selection of suitable entrants to any trade or profession employers have often very little to guide them in their choice, as I think the subjects taught at elementary schools at the present day should be modified somewhat; on the other hand, the entrant has generally very little idea of the conditions and requirements of the trade or profession he intends to adopt, and I think it will be found that a vocation is generally taken up on the principle that he takes up that of his father, or his uncle or chum, or perhaps because he hears of someone's success in a certain line of business, and he probably thinks he is on to a good thing, or sometimes the conditions of locality in a way compel him to adopt it, although perhaps he is totally unsuited for it, either physically or mentally; but sometimes the blame rests with the parents who, with the best of intentions, advise him to take up a certain vocation without studying his capa-

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bilities; it is for this reason that some plan should be adopted by which both the employer and the entrant have some means of being guided.

Some subjects which are taught to a fairly high standard in the elementary schools, such as geography, history, and languages, could be left off earlier, and descriptive subjects of an every-day practical character substituted, deferring the higher standard of any subject until specialisation had been decided upon.

These descriptive subjects should be such as to give every boy and girl a fairly clear idea of the various trades and professions, the duties involved, the mental tools required before any one can hope to attain the highest positions in the different trades or professions, supplemented by lectures on raw materials, where found, how got from the earth, how carried from one country to another, what is made from them, a general description of how the finished products are produced from them, and where possible to show the various materials in their raw state, and at various stages of the manufacture of the product; commercial routine, banking, insurance, commission, elements of book-keeping, and in fact such general industrial and commercial knowledge as to be a guide to the choosing of a trade or profession, as well as to be of much value in after life. At the same time, we should not altogether lose sight of the classics, but I think more bias should be put on the teaching of elementary industrial and commercial subjects than is put on elementary classics, or details of some of those scientific subjects which are taught in elementary education at the present day.

The principal aim of education is to cultivate the mental power of individuals in such a way as to make them good citizens, the essentials of which are good character and high efficiency in their chosen sphere of action. After an infant has been taught to read and write, and in fact before that stage is reached, the greatest stress should be put on the building of character. This probably has been begun by a proper selection of proverbs and rules of manners for copy writing, which should in every case be explained by the teacher, and which, I am afraid, is very seldom done, and not only is this insufficient, but the pupils ought to be made to act them out as much as possible, being shown by the teacher how to act in every case; later, such books as self help, tact, push, and principle, and the biographies

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of great men, should be read and studied, the teachers explaining and pointing out the best characteristics, also the worst.

In the development of the mind and character it should be explained what WILL is, and suitable exercises given whereby it may be strengthened, by learning them to force themselves to do disagreeable things, conquering impulses to do wrong, for example, and also the teachers ought to create ambition, patriotism, etc., by leading their desires into proper channels.

A good memory is one of the most valuable assets that one can have, and that it can be cultivated by suitable and interesting methods, there is no doubt, such as describing minutely any article or articles shown to them for a few seconds, by the teacher, giving details of colour, size, shape, position, what it is, if they had ever seen it before, where, under what circumstances, etc., etc., or by making the class write down for home exercise a synopsis of the previous day's work in the class, stating anything that happened to take their attention, or a synopsis of class work of two or three days previous, or describing the external appearance of anyone who may enter the class room, what opinions they would form of their character and mood at the time, by deduction, from their walk, dress, manner, and facial expression. Numerous other exercises would occur to the teacher. Many of you will know cases where tradesmen, who have perhaps been working at the same part of a machine or engine, many times for many years, who could not describe it with any degree of minuteness if called upon to do so.

We cannot always place the blame of the inefficiency of an individual on the individual himself, but sometimes through the inefficiency of his teacher or teachers. The influence of a teacher on the young mind is great, also his responsibility.

He, in a sense, supplies us with the material from which we have to build up the future engineer, and he should not neglect to build character as well as train the mind. Scholastic attainments and training are not sufficient to license anyone to teach, but personality should count for much; before a teacher can be a really successful one he must have certain necessary characteristics, the principal one being a genuine interest in the future welfare of his pupils, and a spirit of patriotism, imparting to them enthusiasm, and as much of the Oliver Twist spirit as possible. Let him remember that enthusiasm is contagious; the principle should be for the teacher to bring out those characteristics that will train the boy to teach himself, instead

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of depending actually on what the teacher instructs him in. A teacher should have those characteristics highly developed, which he wishes his pupils to acquire, and therefore I think that in the choice of teachers, personality should be one of the deciding factors.

A general survey of the elementary school curriculum gives one the impression that it is largely biassed towards the classics and the fine arts, whereas, in my opinion at least, a balance should be brought about between these and those subjects which lead up to the useful arts. Between the ages of 12 and 14 the following subjects should be taught to everybody and made compulsory: English, arithmetic, algebra, euclid, drawing, elements of physics and chemistry, practical, plane and solid geometry, and a modern language. All practical work should be abolished except that which is shown by demonstration. It should be recognised that the best English is that which is best understood, and that it would save much valuable time if much of the English literature given between these ages was scrapped, and books dealing with much more useful knowledge substituted, which are perhaps written in quite as good English, leaving the classics until specialisation sets in.

When a boy has completed his 13th year at an elementary school he should know higher arithmetic, algebra as far as simultaneous equations, geometry (euclid), Book I., the elements of heat, magnetism and electricity and mechanics—the chemistry should be of such a nature as to give a fairly clear idea of the constitution of matter. Elements and compounds, chemical nomenclature and symbols, the atomic theory, valency, dissociation, and solution. Practical, plane, and solid geometry enters the field of many trades, and is a subject which I think is too much neglected, as many proceed to do drawings without having any previous tuition in the principles of projection or the drawing of sections.

I may say that I had all these subjects and more, and to a much higher standard than I have specified, before I reached the age of 14.

Any boy, who at the age of 14 has had an education something similar to the part syllabus I have just described will have had such a training as to fit him to enter any sphere of occupation, and will be well prepared to pursue further studies. At this age general specialisation should be decided on, with the guidance of the schoolmaster and parents, who will advise whether university, commerce, or trade should be taken up.

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Education should not be compulsory above the age of 14, and those who wish to pursue their studies further should be fee-paying; reduced fee scholarships should be awarded by competition, and restricted to those whose parents have an annual income below a certain amount, or, a grading of fees depending on the parents annual income.

Schools should only be supported by ratepayers for elementary education up to the age of 14, the compulsory limit, and every encouragement should be given for the establishment of private schools for all subjects, and to suit pupils from infancy upwards, State grants being reduced as much as possible.

The reasons why I have spoken at length on elementary education are because the elementary schools are the places for laying a proper foundation for the education required for all trades and professions, and I think, if the syllabus and organisation were in the hands of more capable individuals than those who are responsible for these as they exist at present, many of the difficulties experienced in the teaching of technical subjects in after years would be eradicated. The present system is a tremendous burden on the ratepayers, and seems to be framed more for the purpose of creating employment for teachers, filling up our universities, and beginning to give us a class of theoretical men, who, I am afraid, require much practical training to be of much use in industrial occupations.

For those lads who intend to be engineers it would be much better in every way if they stayed on at school until 16, but this should not be made compulsory; both day and evening classes should be instituted for those willing to take advantage of them. The evening classes should be open for at least nine months of the year, for those who leave school at 14, and the day classes for those who are wise enough to take advantage of them.

The syllabus for the day classes should be something after the following:—

1. English, including geography, history, the classics and commercial correspondence.
2. Pure mathematics as distinguished from practical mathematics, as I think that the teaching of pure mathematics is a much better mental training than practical mathematics, and not only that, but it is necessary to so teach the young engineer that he would be able to pass the matriculation examination for entrance to a university.

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3. Practical, plane, and solid geometry.
4. The elements of industrial chemistry and metallurgy and physics.
5. Theoretical mechanics.
6. A modern language.

Half the time should be devoted to practical work, and chiefly in those trades which it is essential for a good engineer to have a knowledge of, and which he has no opportunity of learning whilst serving his apprenticeship, such as the principles and practice of moulding, in so far as it is possible to give it. Pattern-making should be substituted for the ordinary wood-work, anvil work with welding, and, as apprentices in the larger shops have only either fitting or turning, both of these should be taught thoroughly, the instructor teaching each student individually in how to file, chip and scrape, grinding tools, fettling and tempering them, for both fitting and turning, giving lectures on the best cutting angles for various metals, and best cutting speeds, screw cutting, etc. A small milling machine should be in every establishment.

The teacher should be a thoroughly experienced, well educated practical man, who has himself served a regular apprenticeship to engineering, and not, as is often the case, a joiner, or a man with no practical training at all, but perhaps has a university degree, and not that of engineering.

A course such as I have detailed, given to a lad before he enters a shop to serve his apprenticeship, would be of much benefit to the young apprentice, and also the employer, as he will, from the very commencement of his apprenticeship be able to do efficiently many jobs that he could not, or perhaps would not, be allowed to try until he was into his third year.

The lad who left school at 14 and who is attending the evening classes, would have the same theoretical course, except the language and English, which should be optional to him, and no practical work.

At the age of 16 then a young lad starts his apprenticeship, and has had such a training as to give him every prospect of a successful career. If possible a universal apprenticeship of five or more years should be adopted by employers and employees, and nothing less should be allowed in any case.

I think draughtsmen should be selected from the works, by competitive examination amongst those who have served an

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apprenticeship of not less than five years; the examination should be such as to show the candidates theoretical knowledge, coupled with a practical knowledge of moulding, pattern-making, machining and fitting, so as to have a highly efficient designer; a thorough knowledge of all these is essential for economical production; not only is it necessary to know the processes of machinery and fitting, but the various shop methods of fixing the jobs for these purposes.

At the same time we have to organise a method to give every apprentice the opportunity to acquire as much theoretical knowledge as he possibly can. The system I would advocate is, evening classes until the apprentice has served a minimum of three years, the classes to be voluntary and at the apprentice's own expense, but that encouragement to attend these classes should be given by the employer, not only by freeing them from overtime, but by endowing scholarships and prizes, and by taking a lively interest in their shop progress.

At the end of the third year an examination should be set by the employer's representative. This examination should be of a fairly high standard, both in theory and practice, and a certain number of those with the highest marks, and who wish to attend a technical college or university, should be allowed half-days off during the last two years, or as an alternative six months off each year for the last two years.

Those who reach this stage will probably be from the ranks of those who remained at school from 14 to 16, and their practical training before entering the shop, from a time point of view, would be equal to one year, but more in my opinion from the point of view of experience; the half-time in the shops for the last two years would make up a total of five years apprenticeship time, but in any case it would probably be from this standard of man that entrants to the drawing office would be selected, and he could finish his college training whilst working in the drawing office, at apprentice's or improver's pay. If it happened that a successful competitor was one who had left school at 14, then any time off to classes during working hours, or rather, during apprenticeship time, should have to be made up by extending the length of his apprenticeship time.

Students should be allowed to enter a technical college as soon as they have commenced their apprenticeship, on condition that they pass an entrance examination consisting of English, mathe-

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matics, physics and chemistry, practical, plane and solid geometry to a standard equal to that at the highest class of the elementary schools.

As regards the different kinds of engineering, each kind ought to be separate and distinct and divided into four groups, thus: civil, mechanical, marine or power, electrical, each having a specialised teacher, who should be directly responsible to the headmaster.

I am not here going to frame up a syllabus for each group, although it was my intention to do so at first, but I shall simply state where I think differences should be made in the usual procedure. Civil, mechanical and electrical engineers should not be taught heat and heat engines until well on in their course, and then only in a general manner. In the case of mechanical engineering, the details and design of machinery used in the industries of the district in which the school is situated, or those of new industries which would be likely to be taken up in the district, should be substituted in the place of heat and heat engines. Marine or power engineering students should have prime movers taught them from the commencement of their course.

In the case of marine, mechanical and electrical engineers, as only a few reach the drawing office, I think that actual drawing should be left over until after a sufficient amount of hand sketching of details and proportions of parts has been taught, coupled with lectures on the properties and strength of materials, that would probably be the third year of the course.

The standard at the commencement of the day classes should be equal to that at the commencement of the fourth year of evening classes from commencement of apprenticeship.

The best definition, I believe, of a well educated man, is that he knows everything about something, and something about everything, and this should be our aim. To do this as quickly as possible we have to save mental effort, a point entirely ignored by many. It is much better in every way to try to know everything about something before we try to know something about everything, and with this argument I favour as early specialisation as possible.

The progress of the young should be tested periodically and should not be allowed to proceed until at least 75 per cent. efficiency is reached in the most important subjects.

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The truly efficient engineer is the one in which practice and theory are blended, and this should be an aim of everyone who has the inclination to be an engineer. In all the councils of education, from infancy upwards, this type of man ought to be found, the type who has risen through the various branches and positions by practical experience and ability. The representatives for the education of those in certain industries should be chosen from the Institute of those industries. It would be a great benefit to the country as a whole, if syllabuses for the education of those in each industry and profession, were compiled and recommended by each separate Institute. Marine engineering is one of the principal industries of this country, and it has always seemed strange to me why a degree in marine engineering has never been founded. Universities would do well, I think, if they specialised their engineering science degrees by suffixing thus, B.Sc.Mech.E., B.Sc.C.E., B.Sc.M.E., B.Sc.E.E., B.Sc.Mar.E.

The CHAIRMAN: The subject is now open for discussion, for which I am sure the paper supplies a wide field.

Mr. A. W. BRAWLEY: I think the training laid down by the author of this paper is a good grounding for a start, and is a very good foundation upon which to build; but it does not go far enough. It does not carry the training to the workshops, and it is really in the workshops where a lad begins to realise the extent of his knowledge. I do not think, generally, the employer has taken sufficient interest in the education of the apprentice. Speaking from my own experience, after I entered the workshops as an apprentice, we were more or less left on our own, as far as the employer was concerned. Of course, it was really up to us to attend the technical schools in the evenings, and often, when the foreman asked you if you would work overtime, by stating that you had a class to attend you got into his bad books. I think, therefore, that more attention should be paid by the master to the lads' training in the workshops, conjointly with the technical class work.

The CHAIRMAN: We have all had experience as marine engineers, so we all have something to say on this paper, as we have all been through the mill, and if each of us refers to his practical experience of the past, no doubt it will greatly help towards what this paper is intended to do.

Mr. F. O. BECKETT: I have pleasure in being able to add a small quota to the Chairman's remarks, as well as to the paper.

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I think patriotism is at the backbone of education. Mr. Annson Hall, in the early part of his paper, refers to the civil engineer and civil engineering, and to the Institution of Civil Engineers. That Institution was founded by a stone-mason. Thomas Telford was the man. He was buried in Westminster Abbey, and was one of the finest of men. While dealing in prospective engineering work his old leather apron, hammer and chisel were left on a shelf in case he had to go back to his tools. In his back room in a hotel in London the plan for the foundation was formed for the Institution of Civil Engineers and, as stated in the paper, the object in forming the Society was to develop the art of directing great sources of power. Since then great changes have come, and it is necessary to specialise for the different branches. What does the boy know at fourteen? In my own case I was not educated for engineering, but by an accidental happening I walked into it at 16. Mr. Brawley stated that he got very little information from his foreman or fellow workmen. This was my own experience. Most of my engineering knowledge was gained from outside, also advice; thus, it was a draper who advised me to attend the technical schools to study machine drawing and construction, for which I gained the Queen's Prize when about 17. With the guidance of my own experience, I had brought my late son up. I am of opinion that engineers are born, not made. They have a hard, up-hill fight, always finding out new things, or anticipating the problems that have to be solved. When my son was twelve I took him from the elementary school and put him to a technical school, where the master was a Whitworth Exhibitioner, and also taught a good foundation on subjects suitable for engineering. When we came to London he was nearly 16, and they would not accept him in the East London College because he was not 16, but at West Ham Technical College they took him in with open arms. I only mention this in passing to show what seems to be a short-sighted policy, regardless of ability. It was not until we had at least two generations of marine engineers that we really got a class of man worthy of following marine engineering. I am speaking now, of course, of ancient history. Those men who went as engineers in the sailing ship fitted with auxiliary machinery were courageous men. I always salute them when reading the early history of the steamship—the spade work, as it were, that has made it easier for us to-day. I agree with Mr. Annson Hall as to a good education, especially the subjects named for the boy of

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fourteen. That is a very great point, as we have so many difficult problems to deal with in connection with engines, boilers and machinery, time and speed, mileage to be covered in a certain time, etc. All the ground work is valuable to the entrant in working out the problems the future has in store for him. There is one very good point to emphasise as regards the principle or mode of education to equip the mental powers and bring them to bear upon character. The upbringing to manhood rests with the mother of the child until nearly 19, and she can do much to form his character foundation. From that time until twenty-one the father has more sway with regard to the future. It is in the formation of character that mothers have an influence, and it is the grounding of character that tells in the subsequent training and enables us to look the world straight in the face, and strengthens the youth to keep true to duty when many miles from home. The 2nd and 5th Commandments I look upon as combining to form a sheet anchor. The writer has referred to the question of character, and that is one of the important things that we should emphasise. Then he goes on to the development of the mind allied with character, and it should be explained what will is. It is no use for a youngster at nine or ten years of age to say he is going to become an engineer, unless he shows capacity for it. By will, I gather that Mr. Hall means the determination as to the career. In regard to the cultivation of memory, that is always good to keep in view. Then enthusiasm is referred to as being contagious; it is so, whether in the football field or the workshop. We do not want a youngster to be stuck at one job for five years, and then thrown on the world as an engineer. I consider that a youngster with any enthusiasm, and with a little kindly help from the workshop people, will find such beneficial to him and to his future associates in the routine, as well as the specialities in connection with his duties. I believe I heard the late Mr. Gray quote this: "That an engineer should know everything about something, and something about everything"; and added that we should never carry brittle glass bottles in a bag. As regards the truly efficient engineer, the one who studies theory at the sacrifice of the practical work is lacking in efficiency. Those who have the designing to do in the drawing office are all the better of sea experience, especially at overhauling and re-adjusting of working parts.

Mr. J. Downs: I appreciate the paper of Mr. Annson Hall on the training of engineers, but I think reference is wanted to

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the commercial side of engineering. He states that the truly efficient engineer is a combination of practice and theory, but practice and theory in engineering really mean the practice of knowing how the machines are made, and so far as theory is concerned knowing how to design them. But, generally speaking, engineers, both in their training and afterwards, very seldom know of the cost of a certain machine, and I think that should also be brought to the notice of engineers generally, or students, so that when they are designing or making a machine they must know the cost of the raw material, the cost of making it into its crude state, and the cost of production. I may go a little bit further, and say also they should know the cost of transportation. In addition to the cost of material you have also got, what I may call the clerical information that is required in all engineering. Engineers, as a rule, have served their time in workshops, and have seen general work being carried out. They go to a technical school for technical training, but so far as commercial knowledge is concerned they know absolutely nothing and they learn nothing at the technical school. As soon as they leave the ordinary elementary school at sixteen they get very little knowledge of costs, and they get nothing of this at the technical school. They learn about heat engines, mechanics, mathematics and machine drawing, but nothing about the cost of the material, how to write specifications, nor do they know anything about the cheapest method of producing the different articles required, say, labour-saving devices and other appliances. From the point of view indicated in the paper he is reckoning on an engineer being efficient when he is a good practical, also a good theoretical, man. He may then end his days in a drawing office. If he gets to the position of manager he has to come into contact with commercial men, and that, I should say, is a stumbling block to the engineer of to-day: when he gets into commercial business he feels lost. I think in the early stages he ought to be taught a little about these particular branches. I did not start to serve my time till I was about nineteen, but I learnt book-keeping, shorthand, French and commercial subjects. I thought they would be absolutely useless to me, but I find now I have the advantage over those who do not know anything of them. I should like to know the experience of others on the subject from a commercial point of view.

Mr. W. McLAREN: I may say that, with reference to our Hon. Secretary, this educational training is a pet scheme of his to

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improve the rising generation. What is the engineer at the present day? The object is to place a boy and educate him to be a good theoretical and practical engineer. One of the difficulties in the large workshop to-day is that he does not have so much opportunity to handle the tools. I was told in my day to take a good workman as a model and try to imitate him. By attempting to carry on work too cheaply you may get a man that has had a smattering of engineering, or who has heard something about it. Mr. Downs has spoken about the commercial side of engineering. Engineers were trained to work and not to talk, but the reverse thing now seems to be the order of the day—talking more than working. It seems to me that a commercial man has his own business to learn and deal with, and the important point is that an engineer should be an engineer who can tell the commercial man how work can be done to the best advantage. Take a seven years' apprenticeship. Some have been kept at the school, mainly the technical, and they have been over-educated. Their brains are too far ahead, and in the workshop they do not accept what is shown them. They have swelled heads. No wonder we are talking of the class of engineers we get. How few can grind a flat chisel, or modify the tools they are using to suit the job in hand. The education of an engineer should embrace this as part of the practical side of it. The civil engineer, after he has done some years of training at school or college, goes to the workshop for some two years. But he does not go to work. He turns out to be a designer. He is not a constructor. But when you go to the constructional side you find the practical workman. I am not against theory, but I think these allowances for time off work at school are not to the best advantage. A boy now works a 47 hours' week, and he ought to be able to put in six hours to educate himself or improve himself. We have had Presidents in this Institute who started by going out to work at six o'clock in the morning, and have come home at six o'clock at night. Then they have washed and gone to evening school afterwards to study. What brought these men up? It was not the university. Are we going to educate the engineer out of himself, or educate him as an engineer? This is what this paper is aiming at, and the last paragraph sums up the whole question. I have plenty to learn to-day. I had seven years' apprenticeship, but not at marine work. When I wanted to get abroad the question was: Have you been to marine work? My answer being No, I was told I was no good. It was a hard case to get a

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start, and it is by no means an uncommon experience, and an engineer is learning every day. What I would say to the young is: "Be observant, try to do your duty, and be faithful, proving to those in authority that you are worth something more than what you get." That, I think, is the true education we ought to instil into our youngsters. I have great pleasure in giving my personal thanks to the author for the paper, which supplies us with good food for thought. Some twenty-five years ago in Germany they trained their youngsters very thoroughly. They worked from 7 a.m. to 7 p.m., and even a part of Sunday. Compare that with what we have now and what are the results? We cannot beat the work we did 30 or 40 years ago, and have declined in ability instead of advancing. Referring to the influence of the mother, if the mothers of Germany had been a little more consistent in regard to their boys we should not have had the war, which has caused so much distress.

The CHAIRMAN: As I anticipated at the start, the criticism has widened, but I should like it to widen still further. I think Mr. Anson Hall ought to have added to the title "Hints to their Trainers." The syllabus he sets out here for young engineers is not, in my opinion, what we should call a general syllabus for everyone. During my apprenticeship I had, as most engineers should have, the study of being an engineer at heart, and I think that in my time apprentices could have been greatly helped by the employers. I, unfortunately, with many others, had to start and work a whole twelve months for nothing. Then I got the sum of 3s. a week, rising to 5s. and 7s. a week, and finally finished my apprentice at 21 years of age with 10s. a week. In pre-war days that was not sufficient to keep a boy in food, and after that there was his clothes and his study. On the other hand there are very few apprentices who, if worth their salt at all, at the age of 18, after having served three years apprenticeship, would certainly be entitled to more than 5s. a week. If you take as the basis the price paid for a fitter (in my time 33s. to 35s. per week), I certainly think the apprentice lad was honestly worth 12s. a week, if not more, and if he was serving a five years' apprenticeship I do think in the last year of his apprenticeship he should have received not less than six-sevenths of what the fitter was receiving. It is not right that apprentices should be treated as they have been. Leaving that and coming to another point: The more you think of the different points that have been brought out to you. Well! if ever

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there was a sad or sorry point for Britishers in pre-war days it was the fact that we were too old at forty. If you are going to learn your apprenticeship and finish your studies properly you cannot be an efficient all-round man at the age of 25. Why, at all ages an engineer is still studying and learning. But in pre-war days, when anything that was going worth the trouble of a marine engineer entering for it, he had not to exceed 40 or 45 years of age. Very frequently that cut out the man who had got the practical experience for such a post. Our friend was mentioning about commercialism; but I do not want to ground into the boy engineering commercialism and all the rest of it. That will come by degrees. You do not mean to tell me that there is a very strong point of commercialism when you get to the top of the tree and have to study the price of coal, oil, etc., in order that running costs may be kept down.

On the other hand, to show you that it is not actually necessary to teach commercialism, how many deck officers make a study of commercialism, and yet as masters of ships have to take up the commercial side when looking after the owner's interest in foreign ports? If you have any love for your work these very points will all come to you. Otherwise, will you consider yourself to be worthy of being called an engineer? Suppose you want some oil, well, are you going to take any oil given you, and not query the price?—but, where is there a man that does not? He asks about the oil and he asks about the price. Surely the comparison alone is commercialism. So, in no small way the point of commercialism comes with the lengthened service one has. Again, if the man is a marine engineer it may be not so necessary to teach him, or for him to study, that side of commercialism as if he were to leave the marine side after obtaining his diplomas—Board of Trade certificates;—and these, in my opinion, are the diplomas of B.Sc.Mar.E. A Board of Trade certificate is not the “simple” matter of getting it. For years the Board of Trade certificate was much easier to get than it should have been. We, in the Institute, are here to endeavour to do the best for the Marine Engineer, and there is no harm in saying that in the past the diplomas were perhaps easy to get, in comparison with the diplomas of other professions which our chums were getting or trying to get. But to-day that is not the fact, and it will be less and less the fact as time goes on. Those of you who so far have heard the papers read on the internal combustion engine

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will realise what is expected of Marine Engineers in the future, and you may be quite assured that the curriculum that you will have to study and pass to obtain the Board of Trade certificates will be much higher than it is to-day, and the higher it is the better for the status of the Marine Engineer in the future; it will be his B.Sc.Mar.E. But if that B.Sc.Mar.E. is going to be obtainable without sea experience, it is going to have the very effect that Mr. McLaren has put to you. It is going to make a man study the science of engineering to obtain the degree, to the detriment of actually studying the practice. That is not going to be for the benefit of marine engineers. It may give particular men the title of B.Sc.Mar.E. I know one or two to-day, and they are draughtsmen; it has not given them any higher ideals for practical work. They are theoretical men, and as theoretical men alone are not successes. Here in the paper it says that draughtsmen should be chosen from those who have served their apprenticeship. I take that to mean—"in the shops"; that being so, there was never a truer word said. In my days some apprentices went into the shop and some into the drawing office, and it was hard to get those out of the drawing office for others in the shop to take their turn. The old style then was, "I do not want to get dirty." They looked down upon us apprentices in the shop; and they could come at 9 and go at 5.30. There were a good many who never got their chance of going through the Drawing Office, or even of getting into touch in a small way with the draughtsmanship side. Before a man should be deemed competent as a draughtsman for any engineering work he should have to go through and acquire the practical part of it first. If that were done we should not have instances of nuts being shown on drawings behind the reverse sides of channel irons, which nuts the engineer has to set up with chisel and hammer, if he can! How many times have you had to do that? In my days, when we apprentices had to go out and work in a ship that had just been built, and fit the various sea-cocks and discharge valves, etc., why, it was a trouble when you had the plans sent down where these had to go. Frequently you had to reeve the valves under the reverse frames. Would a practical man have had it put there? If that draughtsman had gone through the same training as I and others had to go through, and had then passed into the drawing office after he had learnt the practical part, he would never have put them there. I dare say the shortest amount of thought will bring back to your memory recollections of happenings like these.

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There is another point in the paper which rather appeals to me, but I do not know if we might mention it, because it is perhaps somewhat out of the way or marine engineers. But the author makes a point here about State-aided free education. Now, gentlemen, perhaps I had better go back a few years and speak more definitely. There was a time when everybody had the glorious idea that everyone should be able to read and write and everyone should know something. It was fifteen years after the passing of the Free Education Act that I recall the firemen of the vessel I was then serving in, still "touched the pen." Presently along came a new Mercantile Marine Superintendent at the Board of Trade, and he put the direct question to the men, "Can't you write?" He further asked the men how old they were, and then he said "You must have been at school, so write your name there." And the men had to. Free education to-day is practically giving the same offer to every class, and there are some classes who take no interest in it. I would never let anybody want or lack education. Those who could not pay should have education, but everybody who could pay, should pay, and I think you would find that we should have one of the greatest stimuluses to people becoming educated. The man who was only earning small money would only have to pay a small fee, but having to pay makes a man look for a return for his money, whereas if it is free, he does not trouble whether the child learns. But if he has to pay for it he will trouble about it. I think it is very true where the School Board Officer's name is brought in. A mother had trouble with the children. Johnny is playing truant. She says to the boy, "All right, when your father comes in I shall tell him." Father comes in and he is told about it. He replies, "What is this to do with me? There is a man paid to look after him." That is the position to-day. If the father had to pay only 3d. a week he would look after it. I say that free education does not aid us in getting the results this paper wants. Then there is another point, which is this: the paper says that at the end of the third year an examination should be held. I maintain that before a boy is allowed to enter as an apprentice to engineering there should be an entrance examination. It would bear out very strongly what the author says. If a boy proved to be not suited for engineering he should not be allowed to go on. It would only be bearing out what is in force to-day in the Navy. The students all enter and go through a similar course, and they pass out either as gunnery, navigating, torpedo or engineering lieu-

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tenants, as they show themselves proficient. Surely the same thing would be to the benefit of the young lad in engineering. I think this is one of the finest papers for giving us food for reflection and thought in regard to the training of engineers.

Mr. J. J. SCANES: One of the speakers to-night has referred to the commercial point of view. My experience is that such commercial training is necessary to a certain extent. Without going into a personal story I may say that I made a failure of what might have been a great success through the want of that commercial training. I do not think a boy need be taught complete business, but some little training on the commercial aspect of engineering would be beneficial. The author says: "We cannot always place the blame of the inefficiency of an individual on the individual himself, but sometimes through the inefficiency of his teacher or teachers. The influence of a teacher on the young mind is great, also his responsibility. He, in a sense, supplies us with the material from which we have to build up the future engineer, and he should not neglect to build character as well as train the mind." It is just that point of character that I think should be a qualification for teaching. It is a very important qualification.

Mr. JAMES ADAMSON: I think the rule in most workshops is that an examination has to be passed by apprentices when there is likely to be a vacancy in the drawing office, and only those who pass are admitted. I think that holds good in most of the works.

The CHAIRMAN: I do not think it is general.

Mr. A. W. BRAWLEY: That was the rule in the firm I served my time with, Messrs. Robert Napier, but there might be six or seven applicants and one vacancy. When I went in for it I was up against a B.Sc. man. Of course, having to attend the Technical School after working from 6 a.m. to 5 p.m., it was impossible to compete against him.

Mr. BECKETT: There are places I visit where there are apprentices, and sometimes I put the question, "Do you like engineering?" I find likes and dislikes, and to the boys who do not like it, I tell them to get out of the gate as fast as they can, and get to something more congenial. To those who do like it I give five minutes' lecture, to guide them on their way, and point out what books to read and what to study. During the last few years I have found they are getting on very well. One, who

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has just been appointed sixth engineer to a ship, was being educated as a bank clerk, but did not like it. I think he will make an engineer worthy of our calling. The Chairman has referred to a man being too old at forty or forty-five for an appointment. It is a very rude awakening to come across, this age question. It is all very well to educate a youngster to become an engineer, but the real question is his future, his after-life. I have only one of my boys who is an engineer, the others prefer something else.

Mr. PLOW: Speaking of apprentices going through the shops and drawing office, I suppose most lads look forward to the opportunity of going into the drawing office. The firm I served with had a system under which the manager kept his eye on the results of the educational classes, and based on these, lads were passed through into the drawing office, so that there was no trouble. There were two classes of apprentices; the premium-paying apprentice, and those who were going through the shops on a small salary. In the majority of cases the drawing office jobs went to the premium apprentices, and that was a very sore point amongst the lads in the shop at the time.

The CHAIRMAN: You are not the only one that has felt that. I think the ideal apprenticeship is the old Guild style.

Mr. W. McLAREN: The ambition of a boy in the engineering workshop is to get to the marking-off table and show himself up to that degree that he can make a claim of six months run in a drawing office. If a boy shows himself as taking an interest in his work I do think the foreman would help that boy, by putting him at the marking-off table and, if he proves his fitness, speak for him to get into the drawing office.

Mr. WHITESIDE: We have had a very good paper to-night and I certainly think we ought to pass a vote of thanks to the writer and also to our Hon. Secretary for reading it. It would have been much more interesting if the author had been here, as we could have got on his track a little bit perhaps, and had his views at the different stages of the discussion.

Mr. PALMER: I have very much pleasure in seconding the vote of thanks for a very interesting paper. It opens up a wide question, and affords us food for thought and reflection, as our Chairman has already remarked.

The HON. SECRETARY: I shall have pleasure in conveying to Mr. Anson Hall the vote of thanks accorded to him, and may

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add that, when we were considering in Committee the results of the Student Graduates' Examination, the low percentage of marks in English gained by the majority of the candidates was very marked, except those in Aberdeen, who all passed the test. Commenting on this point in writing to the Principal of one of the Technical Colleges attended by several of the candidates, he replied as follows:—

“ I have to acknowledge the receipt of the results of your Student Graduates' Examination.

“ With regard to your remarks as to the low average in English, it is a point which I am continually emphasising as showing the extreme weakness of our system in Elementary Education. It lays no sound basis on which technical education can be built. In the paper I have just read to the Association of Technical Institutions at Cambridge, I condemn, as utterly failing in its purpose, our elementary schools, wherein we attempt to educate 60 boys or girls at one time under one teacher. Why not publish some specimens from your papers, and show the true position to the public and others? Even the Education Committees of this country have but the slightest acquaintance with the actual state of affairs, and so they are perpetuated.

“ We waste more than half what we expend in education, even in its higher forms, and revolutionary changes are absolutely essential in order that we keep even a fair position in the coming competition in every market. Societies like yours could do much to remedy the state of affairs which for thirty years have brought failure.”

It seems to me from apparent results and enquiries on the subject that there is great room for improvement. The cut-and-dry style of teaching, which may be likened to the making of, what used to be, penny pies, is bad and may be largely due to the Education Board eliminating the old private, or grammar schools, the masters of which took a keen personal interest in each scholar, encouragement being given, towards development of individuality, to take a pride in his work, building up at the same time a keen sense of loyalty and honour towards his neighbour, emphasising “ who is my neighbour? ”

The following article by Mr. A. F. Shepherd bears upon the subject of education in its more advanced stages:—

“ All psychologists appreciate that the mental faculties of the average youth only become ripe for rapid expansion at the age

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of adolescence, which, for convenience, can be taken at fourteen or fifteen years; an age when the majority of the nation's youth are expected to leave school. Unfortunately for many, this is just the dawn of mature understanding. Education before this time is frequently accepted as a burden to be borne, its "Whys" and "Wherefores" being beyond the range of interested comprehension. It is also the time for the formation of stable character, because the sense of responsibility has commenced.

Secondary schools, in raising, as they have done, their standard of education, have bridged the pupil over to the period of awakening. The longer experience of mental exercise and increased information in this new condition of ripened mind and body inspires in the brightest and best pupils a zeal for fuller and more profound knowledge, which is not deterred by the severer matriculation examinations instituted by the modern Universities.

Now that this wave of enthusiasm is bringing large numbers to the doors of the University, it is imperative that those doors be flung wide, and that the zeal of earnest youth shall not be damped by the despairing words "No room." It is probably reasonable that the test of entry should be made exacting, as it has been, so as to ensure that only men and women of capacity should take up the time and abilities of gifted professors; but once youth has filled this requirement, the rest should be made easy, for on the selected or super-minds depends the Empire's strength.

It is to its fresh and vigorous youth that the Empire looks for advancement, along the lines of those inventions, discoveries, improvements and developments that keep it in the forefront of the Empires of the world. It is by the development of such a class that we look for leaders and statesmen, and the permeation of public sentiment with such sound and solid knowledge that unsettling revolutionary, and wildly speculative, methods will be killed at their inception, for unconstitutional acts could never live among a people of whom an important percentage were more completely educated.

There is no doubt that as a nation we did not appreciate the enormous part that science would play in the great war. The blunder that sent many of our learned men into the trenches, some to be lost and others to be recalled, is evidence of blindness in this respect. This error of understanding cost us untold

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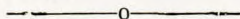
wealth and hundreds of thousands of lives, besides placing the Empire in the direst peril.

Yet can it be denied that, in spite of the initial mistake, our men of science turned the scale in the winning of the war? Hastily collected from the trenches, urged to greater pace in workshop and laboratory, backed by all the resources of the State, our skilled chemists and engineers, our men of theory, and men of imagination, made the contributions of applied knowledge that told so heavily and brought about the end.

Equally, can it be denied, that to the cramped stereotyped and inelastic education of some in responsible administrative positions, we owe much of the incohesion and disorder that nearly brought our nation to disaster. The learning that waxed eloquent on the music of ancient verse and was silent in research such as that into aniline dyes, nearly proved a costly curriculum to Britain.

The war taught us that the battle is not mainly to the soldier, but to the scientist and to the versatile mind. The great general depended at every turn upon the skill of men of knowledge. It was the mathematician who timed the advance of protecting curtain-fire and measured the fuse of shells, the engineer who devised the tanks and guns, the scientist who winged the aeroplane and dug the trench. It was the neglect of meteorology which cost us many disasters.

And now, in peace times, the captain of industry must turn to the scientist as his chief ally. There is scarcely a trade or calling now but depends upon the skill of chemist, engineer, and mathematician.



The Training of Engineers.

Mr. Annon S. J. Hall's Reply to Discussion.

If we were to carry the training into the workshops the manner in which it is to be done would have to be studied very carefully, as any extra expenses incurred in the working of an establishment would assuredly go a long way to prevent our capturing foreign markets. In those establishments where the number of apprentices employed is large it would be a simple matter for the employer to engage a practical instructor, whose duty would be to go round and see that the apprentices were using the tools correctly and making a good job, but this comes

within the province of the shop foreman, and is just as it exists to-day. The inefficiency of the apprentices rests with the foreman and his assistants, and the remedy is to see that he does his duty by the apprentices, to the mutual benefit of all concerned.

Many apprentices when they become journeymen will continue working in the shops as fitters or turners, as the case may be, for the rest of their life, and the theoretical training required will be very little indeed, so why waste time and money in trying to educate them, firstly, if they have not the intellect, and secondly, if they have not the ambition and grit. So that for this reason I would not favour an examination at the commencement of apprenticeship, it being a case of dividing apprentices into two classes, namely, those who will be fit to be mental workers and those who shall remain as manual workers, the selection being made according to the apprentice's progress in respect to the dictum cited by Mr. MacLaren: "Be observant, try to do your duty, and be faithful, proving to those in authority that you are worth something more than what you get."

It would be very unfair to keep an apprentice on any one job for a prolonged period, even though by so doing it be a gain to the establishment and a loss to the apprentice, but in some cases it is possible that it might be a gain to both, sound judgment being required on the part of the foreman. I do not see anything very far wrong in making a journeyman a specialist in certain jobs.

The apprentice wage question is a difficult one, and I am of the opinion that our Chairman is too generous, although I agree with him that they were not paid enough. It is not exactly a question of what an apprentice's monetary value is, but rather on the lines that he with the greater worth should be rewarded by greater facilities to learn more; in this case I think a better system would be to fix remuneration according to an average cost of a youngster's upkeep for clothing and food, the cost of study being defrayed by his parent or partly by the State.

Regarding the commercial side of engineering, I mentioned that the subjects taught in a general way in elementary schools should have amongst them commercial routine, banking, insurance, etc. . . . as well as to be of much use in after life. Referring to my own experience I had French, shorthand, and book-keeping before I commenced my apprenticeship to marine engineering at 15½ years of age, and I had first place in the prize list in each of these subjects in certain years, but none of them have

been of any use to me so far, but I'll certainly agree that they could have been made use of by me if I had cared to give myself more work than was absolutely necessary.

I think that estimating and the writing of specifications should be taught in the 5th year of evening classes from commencement of apprenticeship, but only in a very elementary way, as this teaching to one so young in experience would be a danger instead of an advantage.

I appreciate the efforts of the Board of Trade to raise the standard of the examinations for sea-going engineers, but do the Board of Trade in any way recommend that in an approved school the marine engineering department should be distinct in itself, and have a duly certified Board of Trade Marine Engineer as the responsible head of that department? I question very much if there is a single approved school in the kingdom in which such is the case. Is this efficiency? It is not! The general case, I think, is that the head of the department is a mechanical or civil engineer the marine engineering teacher being subordinate, and whose individuality is crushed thereby. I think this is a point of the utmost importance.

I wish to point out that I think Mr. Beckett misinterprets my meaning of *will*. By it I mean that strength of mind by which individuals can control their desires, and put them into the channels chosen by good judgment and not as he mentions, the determination of a career at an early age.

Telford, the Civil Engineer, was a great man, born in Dumfriesshire, I believe of humble parents; so also was his great countryman, Fairbairn, the Mechanical Engineer. Telford, in his inaugural address to the Institution of Civil Engineers, pointed out that the success of the Institution depended on the practical efforts and unceasing perseverance of the members themselves, and that its very existence and prosperity depended in no small degree on each individual member exercising his personal conduct and exertions.

I thank you, gentlemen, for the kindly way you have received and discussed my humble efforts, and let us all be enthusiastic in raising the status of the Marine Engineer; this enthusiasm will bring into being a determination and perseverance which will cause us to eventually bring them to the desired status.