The Institution of Mechanical Engineers.

(Yorkshire Branch.)

FUNCTIONS AND TRAINING OF THE MECHANICAL ENGINEER.

ADDRESS

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It so happens that you have done me the honour of electing me as your Chairman at a time when the industry which our profession serves, and by which it is supported, is passing through a period of the greatest difficulty it has probably ever known. Not only has the economic ruin of the greater part of Europe deprived us of some of our most important markets, but this has come upon us at a time when we are suffering from an enormous burden of taxation, and when our own industry, forced into abnormal channels to supply the needs of war, has not had time to return to its normal courses, nor to recover the balance and proportion, both economical and technical, which it lost under the hastily devised, ignorant, and sometimes interested organization by which it was controlled during the War.

The situation has been further complicated by throwing on the market great quantities of machinery obtained for war purposes. Much of this machinery has been usefully adapted to peace condition, —much of it is useless, and much of it was imported from America or ordered in this country, in quantities wildly and recklessly in excess of any possible war needs. The ultimate destination of what

remains is the scrap heap, but until it gets there, its existence, now mainly in the hands of speculators, is a contributory cause of the present depression. Yet if we can, as I am certain we shall, win our way through our present difficulties, the Mechanical Engineer has before him a future of achievement to which the progress of the past century is merely an introduction.

The experiences of the last few years have awakened the nation to a new conception of what can be achieved by organized effort, aided by suitable appliances. The wave of depression will certainly pass, and we and the world will realize with a renewed confidence that this nation, tried as it has been and is being tried, can be safely trusted to come through its troubles, and the services that the Mechanical Engineer alone can render, will be recognized and demanded as the first essential to well-being and progress.

When Shylock stated that he made his money breed as fast as sheep and goats, his figure of speech was inaccurate. Shylock, like so many of his race, appears to have followed mercantile pursuits, and whilst he doubtless had the faculty of making his money attract to itself other people's money, and thus grow by accretion, there is no reason to suppose that he endowed that money with the power of reproduction. Wealth is produced from the sources of nature by the application of labour aided by tools and directed by brains. When the production exceeds the expenditure, the surplus becomes Capital, which, as is well known, is merely an aggregation of savings, commencing in its most elementary form with the "unexpended portion of the day's rations."

There are many ways in which one man's capital may be made to increase by attracting to itself other men's savings. Some of these ways lead to the House of Lords, some of them to Dartmoor, and some to either destination according to circumstances. But there are only two ways in which Capital can, in the literal sense, be made to breed—one is by using it for the enrichment of the soil, and the other by using it for the improvement of tools and appliances. The tools and appliances used by Labour in these modern days are the product of the inventive genius and the industry of the Mechanical Engineer. His function, therefore, is to breathe the breath of life into the dry bones of Capital, and endow it with the characteristic function of life, the power of reproduction.

The claim so vociferously made by shallow, ignorant, or interested persons, that all wealth is produced by manual labour, takes no account of the enormous reproductive power of Capital when invested in machinery. This reproductive power is most easily appreciated by the example of modern machine-tools, which have

the capacity of reproducing more numerous, powerful, and accurate machines of their own kind, with the aid of a continually diminishing proportion of manual labour and with a continually augmenting rate of increase, or birth-rate. Unfortunately for the machine-tool maker, the power of reproduction is maintained in many cases to extreme old age, and machine-tools long past the allotted span may still be found pouring out their progeny upon the world.

In an ever-increasing degree, the other branches of the practical arts, whether concerned in the improvement of transportation by road, railway, sea, or air, in building, in the manufacture of daily necessities, and even in the oldest and greatest of industries—agriculture—depend upon the labours of the Mechanical Engineer.

We hear much in these days of the desire of the masses of our people for a fuller, freer, and more comfortable life, a desire in fact for a greater return in comfort, happiness, and culture, on a smaller expenditure of effort. It is a natural desire, and is not confined to one class. It can be fulfilled by no other means than by the increase of machinery, and by making the fullest use of machinery. This desire is utterly inconsistent with the refusal to work machinery to its full capacity, and its fulfilment is negatived by the policy of many of the English trade unions, devised for the purpose of ensuring that the output of efficient machines and capable men shall not exceed the average of the inefficient and incapable. So long as the good things of life are produced slowly and by hand, so long are they available only to the few; when they are produced rapidly by machinery, they become available to the many.

The use of machinery up to its limit, whenever we arrive at that stage, will carry with it the discardment of old and inefficient plant. Thus the policy of restricted output is the greatest enemy to mechanical progress. It is not worth while to make improved machinery if its output is to be limited by artificial restrictions. In the millennium imagined by the Engineer we shall find our workpeople employing the best of ever-improving machinery up to its limit of output, and consequently earning a high remuneration by applying their minds rather than their muscles to their task.

Since, however, machinery can only be produced if capital is forthcoming to pay for it, and since capital can only be made available by saving, it is unfortunate that our national policy treats saving as a crime, to be punished by heavy fines, and improvidence as a virtue, to be rewarded out of the public purse. The vicious results of over-taxing a man's earnings and then taxing him again on any interest he may get on his savings, and adding a direct tax on capital in the form of death duties, so that we pay once on what we spend

and three times on what we save (if the first tax leaves us anything to save), seems to have escaped the notice of most writers on economics. A recent essay by a well-known Professor on this subject commences by drawing attention to the Author's audacity in condemning these unsound and ruinous taxes, which, although they cut the tap root of capital, have received the blessing of authority. For whatever be the form in which money goes into the Treasury, it is a fact that very little of it emerges in the form of capital.

My apology for introducing this subject is that of all the great industries, none is so completely dependent as that of the Engineer on the growth and investment of savings, this being the only source from which our employment can come, since we are engaged in making, not articles of daily consumption, paid for out of income, but the means of production themselves, paid for out of capital.

The effect of excessive taxation is readily seen when you consider that with income tax at six shillings in the pound, a company which wishes to expend £700 on an additional machine must earn, in order to provide the means, a surplus profit of £1,000, of which £300 goes in income tax. Thus, to obtain £700 worth of new plant, £1,000 is required, and the effects on the Mechanical Engineers' order book, and on the unemployment book of the Amalgamated Engineering Union, are precisely the same as though the cost of the machine were increased by £300, or as though an excise duty of similar amount were levied on the engineers' output. Of course, the war has got to be paid for—everyone knows that—but that exceptional charge ought to be met so far as possible by reducing, and not increasing, public expenditure, instead of applying to British industry that process of "searching its pockets" which our late enemies appear to be evading with remarkable success.

It is impossible to lay too much emphasis on the oft-stated, and as often neglected, fact, that the population of these islands, has, in consequence of our industrial system, grown far beyond the means of support furnished by our native agriculture, depressed and discouraged as the latter has been throughout the whole lifetime of most of us and longer, by an economic and social policy favoured by the town-dwelling masses. The majority have deliberately placed themselves in the position of existing solely by sending manufactured goods across the in exchange seas for food and raw materials. Having no natural monopoly in manufacture, what advantages have we possessed to set against the swarming cheap labour of Eastern Europe and Asia ?

Firstly, we have the inherited character, skill, intelligence and

common sense of the English people; these constitute our chief asset. If they should succumb to the continuous assaults of the demagogue and the doctrinaire, the social system by which we live will go down, and at least twenty-five millions of people must disappear from this island.

Secondly, we had cheap power produced from coal. The producers of coal decline, for the present, at least, to produce it cheaply; the demand of much more money for much less work has deprived us of that advantage.

Thirdly, we had a flying start in methods and in machinery. We have exported machinery, and others have acquired the methods —the flying start has gone. It is a condition of our existence therefore that we continually improve our machinery and our methods. We must be ahead of our competitors—we cannot rest nor stand still, we must keep in front or perish.

Fourthly, we have the British Empire—an organization of which we may still be proud, although our rulers appear to be so ashamed of it that they cast about for fancy names to avoid the use of the word. By whatever name we call it, it gives us a substantial as well as a psychological advantage in very great and valuable markets.

It would be well for us to cease giving encouragement to the breakers-up of Empire, with their parrot cries of "Self-Determination for the Soudanese," or "Hands off the Hindoo," and so forth, designed to deprive us at once of our markets and our opportunities for doing good in those countries, where the strong arm of England is the only thing which protects the toiling masses against religious and racial wars, and endless exploitation and oppression by native taskmasters. When the watchdogs make friends with the wolves, it is a poor look-out for the sheep, and a policy which alienates our best friends and customers in the hope of conciliating our most powerful rivals would seem to be of small advantage to the British Engineer.

If the skill, knowledge, and enterprise of the Mechanical Engineer are necessary for the economic life of this nation in peace, they are essential to its very existence in war.

In 1914, the German Army was equipped with mechanical appliances vastly more numerous and powerful than our own. When our Engineers were once started on the job, they made up the leeway, passed, and eventually out-distanced the Germans, but the change did not take effect until the flower of our people had been sacrificed to the strange illusions on the subject of peace and war which find such a ready soil in popular assemblies.

As our previous great wars have followed a similar course,

notably those of a hundred years earlier, as a rich and vulnerable State offers a continual invitation to attack, and as the nature of politicians does not change, there appears to be every probability that we shall be caught short in a similar way on the next occasion, and I suggest that young Engineers might well spend some of their leisure in studying the rôle they may be called on to play in any future war. Much food for thought on this subject may be found in the Presidential Address * of Captain Sankey to the Institution last year, in which he deals very fully with the work of the Mechanical Engineer in the late war ; and in a recent book " The Soul and Body of an Army," by General Sir Ian Hamilton, in which future developments are forecasted in a very interesting manner.

One frequently hears nowadays scornful references to what is called the " military mind." When you come to think of it, the mind of a Soldier very strongly resembles the mind of an Engineer, and the resemblance is strongest in that point which is most abhorrent to the political mind, namely, in an obstinate preference for knowledge as a guide to action, and a determination to face facts and master them, rather than to ignore them or explain them away. The scornful persons alluded to sometimes refer to Marshal Foch, the greatest Soldier and one of the clearest and strongest intellects of the present age, as a shining example of the military mind they despise so much ; and the rule he most dwells on in his " Principles of War " is that all decisions and all action must be based on ascertained facts and not on conjectures, a principle strongly held by Napoleon, and one equally important to the soldier and to the mechanic. There are many points in which the education and character of the Engineer and of the Soldier should be similar. The quick recognition of the real nature of the problem confronting you, and the prompt and direct attack upon the essential point, are the first conditions of success. The qualities most needed by both professions are intelligence, calmness, determination, candour, and simplicity. Other professions may bury or explain away their failures, but you cannot ignore or explain away a lost battle, a bridge which falls down, or a machine which will not do the job it was designed for.

The modern political processes known as " exploring avenues," and " finding a formula " do not meet these cases, and whilst we have been informed on very high authority that our soldiers are lacking in imagination, we, as engineers, must agree with the soldiers in regarding that quality as a very unsafe guide unless it is based on

* Proceedings 1920, page 1039.

and supported by, accurate knowledge and the power of clear and logical thought.

The Mechanical Engineers of this nation, including in this term the directors, designers, managers, foremen, and workmen, as well as the engineering professors, consultants, and research workers, are not inferior to the national average in intellect, training, and character. Nothing is needed but union amongst ourselves, and we can withstand all outside interference. I believe we are getting nearer to such union, and that we shall yet see the Engineering Industry managing its own affairs and the politician definitely warned off. We are, however, threatened from many quarters, and one of the most serious dangers is in the matter of education. We do not need educational doctrinaires to settle the system of training for the engineers of all grades.

There are provisions in the last Education Act, not yet put into force, with regard to part-time employment and part-time education, which reflect seriously on the sanity of their author. It is probable that they will never come into force. It will be found equally difficult to apply compulsion to the employer with regard to the half-day's work, and to the youth with regard to the half-time schooling. The time needed for self-improvement after leaving school would be better taken from the picture-house than from the workshop.

Equally tyrannous and ridiculous is the proposal that young men, after they have started regular work, should be compelled to attend evening classes. I do not see how technical instruction forced against their will on young men approaching full maturity can do any good whatever. The principle that everything which is good or is believed to be good, should be enforced by the law, is the principle of the Inquisition in Spain, of the Communist in Russia, and of every disastrous tyranny in all history, and will produce the usual reaction when men will stand it no longer.

In advocating compulsory technical education, the argument is used that there is great difficulty in finding men fit for responsible positions. The difficulty, however, so far as it exists, is not in finding men of sufficient education, but in finding men of sufficient character and brains. No school can furnish these essentials to the boy who comes to school without them, and the boy who has them will get the education all right if it is made available to him. Compulsory higher education is a delusion and an injustice both to the boy and to the taxpayer—to the boy, because it involves training perhaps 100 boys for one possible vacancy in the higher ranks, thus producing for every single success, ninety-nine discontented

and disappointed people, who will never realize that their own capacity is deficient, and will suffer through life from a sense of injury: to the taxpayer, because the money extorted from his industry is wasted in expenditure without adequate return; and at present the taxpayer works about eight months in the year for himself and four months for the Government, and consequently has to keep himself and his family for a year on the product of eight months' work. When the educational theorists of this country succeed in evolving a system of elementary education comparable either in results or in economy with the old Scottish parish school system, founded more than 300 years ago, or even with the system, founded in France by Napoleon, it will be soon enough for them to start on removing the ignorance of his craft which they attribute with some rashness to the English Engineer.

The boy who is kept too long out of the workshop will not, unless he has exceptional ability and determination, become a first-class workman, neither will he contentedly settle down to the daily routine of repetition work; and it is beyond question that such work has got to be done, and to be done by the greater part of the human race; a system of education which makes such work distasteful to the mass of the people leads nowhere but to State slavery, and forced labour. A sound system must recognize that the engineering industry contains numerous grades, and that each grade must be provided for. The claim for equal opportunity is not met by educating all for the highest grades and then leaving them to scramble for a footing; it is met by providing a ladder by which exceptional character and talent, can, if the ambition to rise exists, get through from one grade to another from the bottom to the top. The great number of men who, from the humblest origin, have attained eminence in our profession, proves that even before compulsory education of any kind existed, the difficulty was not so great as it is made out to be, and that technical education at the public expense is by no means essential to advancement.

It is suggested that the right system would include, for all grades, a sound general school education, followed by a practical apprenticeship, commencing immediately on leaving school. No boy can be said to have received a good elementary education unless he is able to express in writing, clear and definite ideas on a practical subject in clear and definite English. That is the most searching test I know of. How many English boys of to-day could pass it? The boy should be grounded in elementary mathematics, so that he can use and understand figures and symbols; of elementary chemistry and physics he should know enough to make him want to know

more. He should understand geography by maps and pictures rather than by words and figures ; he should know enough of history to appreciate the struggles, failures, and achievements of his race, and not be stuffed with the potted propaganda which too often passes for history ; and if he has acquired a taste for good literature, he leaves the elementary school with the keys of all human knowledge in his possession.

The main object of the Engineer's early education should be, not so much the direct acquisition of technical knowledge, as the development of the type of mind previously alluded to, which bases its decisions upon definite knowledge and proceeds in the acquisition of such knowledge by logical steps, thus fitting a man for the life-long process of self-education which has always, and will always, characterize the great Engineer.

There should be a limited number of public scholarships, sufficient for maintenance on a reasonable scale, tenable in the engineering departments of the various universities, to be competed for, and absolutely confined to men who have served not less than three years in a works, and are certified to be competent workmen.

In my opinion, aid from the taxes to technical education should be given in no other form than scholarships, the buildings and other capital being provided from local resources, and in other respects, higher education should be paid for by those who receive it ; but this opinion cuts across too many vested interests to be taken seriously to-day. On completion of such a course the scholar should be fit for a post as foreman or draughtsman, with greatly increased prospects of advancement. But there should, in addition, be classes open to adults of any age who wish to study any special subject, and arranged as to hours and fees so as to be available for the man who has himself to support and is willing to make some sacrifice for his own improvement. The whole system of engineering education beyond the elementary school, should be supervised by Engineers. For this purpose our branch of the profession might well be represented by the Institution of Mechanical Engineers.

As regards the course of study to be followed in the University or the Technical College, I suggest that there is a danger, in the desire to satisfy the so-called " practical man " outside, of devoting too much time to teaching engineering practice, to the detriment of pure science. The students' object should be to learn those things which can only with difficulty be acquired after he has started practical life, with its economic necessities and limitations, and not to spend time on things he can pick up in the office or the shop. For

example, he should become acquainted with all the fundamental mechanisms, and with the principles and theory of all the known means of transforming, transmitting, and applying energy; but it is waste of one's college time to learn the details of different makers' designs of lathes, locomotives, etc., which may be obsolete before he has the opportunity of applying them. Again, the purely routine art of mechanical drawing should occupy very little of the students' time, and the use of tools should be strictly confined to what is incidental to research and experimental work.

The Engineering Student should attend the regular courses of the Professors of Mathematics and Physics, and wherever possible Chemistry and Metallurgy should be included. Courses in potted science and mathematics specially expurgated for the engineering student are not advisable. Research work, testing of materials, etc., in the engineering and physical laboratories are of the first importance, and reports or theses on research actually done by the student should carry a large proportion of marks in examination. Perhaps the commonest and most deplorable fault observed amongst trained engineers, and especially amongst those who rely too much on book learning and sometimes pass brilliant examinations, is that they are often unable to remedy the defective working of a machine, or improve an unsatisfactory process, because they fail to observe exactly what is taking place, or to see the connexion between two or more recorded results and draw a sound conclusion therefrom. Much can be done to develop these important faculties in a well-equipped and well-managed laboratory.

It would also be of great value if engineering students were instructed in the principles of accountancy and cost keeping; the vital factor of cost is apt to be overlooked by designers, who usually acquire the capacity of estimating costs only after long and painful experience.

A thing to be developed during one's student days is the right use of leisure for the promotion of physical, mental, and moral health. School and college sports, games, and gymnastics, military training corps, literary and debating societies, so far from being waste of time are deserving of every encouragement; and the communal life of the student in colleges, hostels, etc., under University control should be developed so far as circumstances permit. Such a training is of the greatest value in view of the complex interaction of professional, social, and business life, in a modern community. Every man should have a working knowledge of at least one language besides his own, and a period of residence abroad is of course the best way of acquiring it.

Finally, the essence of the Engineer's art and the object of his training, is to achieve a given result in the most economical way; but the result must be clearly visualized. For example, the object of the designer of a locomotive is, or ought to be, not a cheap locomotive, but cheap haulage of trains. The object of the designer of a machine for boring tyres, not a cheap boring machine, but cheap tyres; of a testing machine, not a cheap testing machine, but a machine for the accurate and rapid testing of materials; of a loom, not a cheap loom, but cheap cloth; and although we are sometimes deflected from the path of virtue by the demands of a short-sighted purchaser of our machines, we ought to keep our professional pride so far as we can, and the general culture to which I have referred will help us greatly in the task.

It is not suggested that the system I have outlined will provide ready made, men fit for the highest administrative posts in large organizations, which carry great financial responsibility and require such exceptional force of character and intellect, as will, under almost any system, be bound to bring their possessor to a high position, even if he has not been specially trained to that end. Such posts are few in number, and the majority of men can attain a reasonable measure of success and perhaps more happiness and peace of mind without reaching them. In any case we may all rest assured that it is not lack of compulsory technical education which keeps us from such positions.

You are doubtless reflecting that in all these proposals there is nothing new. The Technical Schools and Colleges exist—the proposed scholarships are only an extension, on a wide national scale, of Sir Joseph Whitworth's idea. But in the whole of this Address I have endeavoured rather to restate old truths than to formulate new ones, and as we possess the bases or rudiments of a system, which have ministered to, and grown up with, the most rapid advance in mechanical matters in the history of the world, it would seem that there is perhaps not much wrong in principle, and that the happiest results may be looked for if the people most vitally concerned can influence the existing organizations, and set themselves to evolve order out of these somewhat chaotic conditions. The present tendency is for each reformer to create a new authority to co-ordinate the efforts of those already existing, the idea apparently being that in the end the pyramid of co-ordination, like the Tower of Babel, shall reach the skies, and the boss, or super-co-ordinator, will then find himself in Heaven—if the foundation does not give way in the meantime.

Whilst on this subject, we ought to bear in mind the development

which has taken place in the work and responsibility of the Draughtsman. It is of the first importance that draughtsmen should be not only trained in their youth, but should also throughout their career be kept in constant touch with the ultimate purpose of what they design and with the progress of every branch of work which affects their own. The man who possesses the necessary qualities of a first-class designer, should have before him the chance of satisfying a reasonable ambition within his own branch of work and it should not be necessary to transfer such a man to administrative work, for which he may be quite unfitted, in order to give him the position his merits deserve. It is particularly desirable that the best and most promising young draughtsmen should be brought into the Institution as Students and Graduates, and should realize that the Institution offers them the best means of co-operating with their fellows, and coming into personal contact with all classes of mechanical engineers, and thus improving their own professional standing and capacity.

Amidst all the vast output of technical literature, there seems to be still room for a philosophical study of the first principles of the Engineering Art, as distinct from the technical principles of applied mechanics. Such a study must have appeared more easily practicable fifty or sixty years ago, before the huge and almost incredible progress of recent years. When Smiles wrote his "Lives of the Engineers," he laid some foundation for such a study. Nowadays, no one would dream of writing the life of an Engineer, and no one would read it if he did. A biographical notice of half a page in the Proceedings of the Institution is as much as the most eminent of us will get. But such a study of the eternal principles, as distinct from the ever growing and changing technique of engineering work, would, if adequately done, help to start the student on true lines, and to keep the older man from wasting his time in re-exploring blind alleys.

At this point may I briefly draw attention to the subjects which, as it appears to me, will be absorbing the attention of Mechanical Engineers in the near future? Each of these subjects will affect, either directly or indirectly, the work of most of our members, and will, so soon as costs are stabilized and money is available, give rise to a large amount of employment.

1. The extension and reorganization of railways throughout Europe. The starting up of this work, which will be of enormous extent, depends largely on high politics.

2. Railway extension in the British Dominions, in China, and in Siberia.

3. Electrification of British railways, involving new locomotives, central stations, and a host of subsidiaries, such as modified brake and signal work.

4. Mechanical handling of goods at railway terminals, at present practically in its infancy.

5. Collection and distribution of heavy goods within our cities by means of the tramways, which ought to form the connecting link between the workshop and the railway or canal.

6. Ship canals, the next of which should connect Leeds with the Humber, as is now done on a smaller scale by the Aire and Calder Navigation, in themselves work for the Civil Engineer but involving an enormous amount of work for the Mechanical Engineer also.

7. The substitution of internal combustion for steam-driven marine engines.

8. The extended use of machinery in coal mines.

9. The extended domestic use of electricity—the industrial use being already a going concern.

10. The rearrangement and enlargement of central electric stations.

11. The extended use of electricity and gas for metallurgical purposes, and the gradual abolition of coal or coke fired forges and cupolas, leading to the most necessary social reform of our time—the abolition of smoke.

Many of our members are machine-tool makers; and the machine-tool maker, as the handmaid of the engineering industry, will find ample employment in providing for the new needs which will arise when these greater movements are fairly under way.

The Yorkshire Branch of the Institution of Mechanical Engineers is now commencing its second year of life. Our Local Meetings have, in the past year, under the skilful guidance of your first Chairman, made an excellent beginning. The Papers read have been of great interest, and the standard of the discussions has been of a high order. There is often in such meetings a tendency for discussion to be rather confined to a small number of members, the majority remaining silent. I hope that during the coming year no member, whether senior or junior, who can contribute anything to a discussion, or wishes to put a question, will leave a Meeting unheard. With that object I hope that Papers will not be of excessive length; there is nothing more disheartening than an interesting discussion cut short on account of time, and there is no reason why the discussion and the Authors' answers and explanations on the points raised therein should not be even more instructive and interesting than the Paper itself.

In conclusion, I would remind you of the organization we have established here for co-operation with Kindred Societies, by which our members are enabled to take advantage of learning many things outside our own scope which nevertheless have an important bearing on our work; and I apologize for the shortcomings of an Address which has touched somewhat superficially on perhaps too wide a range of subjects.