

PRESIDENTIAL ADDRESS

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It is customary for the President of an Institution, such as the one to which we have the honour to belong, to review, on the expiration of his year of office, the progress and contemporary position of some phase of industry of which he is more particularly cognisant. In following this precedent, I should be led to deal with the subject of explosives, an industry with which I have been very closely concerned during the last forty years; but I have already written and spoken so much on this somewhat special subject that it would be superfluous to deal with it again on this occasion. Nor, though greatly interested in alcohol, of which the production is of some particular importance at the present time, shall I speak on this matter concerning which there is again adequate information available.

After careful consideration I have decided to address you on a quite different class of subject—that of “Industrial Efficiency” which is of such great significance under present-day conditions. By “Industrial Efficiency” I mean the application of scientific methods to industry in order to promote all-round efficiency in production, with consequent improvement in output and reduction in cost of finished products.

Great Britain herself produces less than half the total of cereals, meat and dairy produce required to feed her population; for the balance of her food requirements she is dependent on imports. These must be paid for by the export of raw materials and of commodities, and unless such raw materials and commodities can be offered at a price acceptable to purchasers, our food supplies must obviously suffer.

This is an age of keen competition, and those who can offer the best commodities at the lowest prices must command the markets of the world. Great Britain can offer the best; it is doubtful, however, whether she can any longer offer at sufficiently low prices.

It is hardly necessary to remind you that by far the most important of the raw materials we export is coal. The Report of the Royal Commission on the Coal Industry has dealt exhaustively and in a most masterly manner with the methods by which

science can come to the assistance of the coal industry, and has shown how essential to its continued well-being such assistance has now become. Scientific methods are no less applicable to other industries, and if our position as a great supplier of the needs of the world is to be maintained in the future, the aid of science must be enlisted to the utmost possible extent. There is no doubt that industrial efficiency has fallen behind in this country, with a consequent loss of prosperity. It is of vital importance, not only to retain this prosperity, but to increase it in every possible direction if Great Britain is to keep its position as the head of a great Empire.

In considering how best increased industrial efficiency and consequent reduction in the cost of commodities can be brought about, it will be convenient to divide the actual cost into its three principal components, viz.:—labour, materials and the general charges concerned with the working of a factory or business. To these must be added, to arrive at the selling price, interest on capital and an allowance for profits.

As the subject of cost reduction is a very wide one, one particular aspect of it, viz.:—elimination of waste, under the above three headings, will be more especially considered on this occasion.

Labour.—As has of late been frequently explained, it is a fallacy to assume that by lowering wages a reduction on this item of the cost of a commodity can necessarily be obtained. Low wages cannot conduce to satisfactory conditions in regard to labour, either from the moral or the material point of view, and it should be the endeavour of all employers to surround themselves with a contented body of labour who will give of their best, and who will have, in the same way as their employers, the interests of the business at heart. If proof were needed, one has only to look to the United States of America where wages are high and the costs of commodities are comparatively low. The position of America in this matter to-day is very clearly set forth and explained in a book recently published on “The Secret of High Wages,” by Bertram Austin and W. Francis Lloyd, two young engineers who visited the States last autumn.

The same matter from another aspect is dealt with in the reports of the Trade Union Mission that was in March last sent by the *Daily Mail* newspaper to investigate and report on working conditions in that country. One of its members found, possibly helped thereto by a not unnatural bias, that "there was a decided consensus of opinion in favour of the policy of high wages as a forerunner of greater and cheaper production, and consequently greater consumption and prosperity." Another found that engineering employers "not only pay more but they pay it eagerly, and on all sides have expressed a desire to pay still higher wages, providing, of course, that they receive higher production in return." Another, possibly a little unfairly, contrasted the American and British attitude towards payment for high production by saying "American employers pay high wages and then take care that they get the production they have paid for. British employers apparently want high production first and then the right to pay what they think such production is worth after they have got it." A member of the A.E.U. quoted, as the opinion of American employers that "high wages, and the fact that no limits are placed upon the workers' earnings, were the best incentives to high production."

To decrease the labour for a given output is not open to the same objection as paying low wages. Experience has proved that output, increased by the more efficient employment of labour, and therefore by an actual reduction in the amount of labour necessary per unit of output, means cheaper commodities, resulting in increased consumption, increased labour requirements, and consequent reduction in unemployment.

These statements are of the nature of truisms, but they must be recognised and acted upon if the so-called labour problem is to be approached and dealt with in the right spirit.

The use, throughout the factory, of machinery and of labour-saving devices, always kept up to date, is one of the recognised means for reducing the labour item of cost.

The importance of modernising plant as a means of promoting industrial efficiency and suggestions for doing so, were dealt with in a scheme for the establishment of a Council for Industrial Development, formulated last December, by Messrs. A. J. V. Underwood and C. S. Garland, both members of this Institution. The authors express the opinion that the remedies for industrial inefficiency are the bringing to bear on industrial problems of technical knowledge and experience, and the provision of capital for modernising plant.

Other well-known methods of reducing the cost of labour per unit of output are those of payment by results, i.e., piecework—periodical cutting of piecework rates, which entirely nullifies the object in view, should be avoided—profit-sharing, co-partnerships, the premium bonus system, etc. I do not propose to deal with this aspect of the question about which so much has been written, and so much discussion has taken place, but I would mention another aspect that probably owes its inception to a

movement, originated some fifteen years ago in the United States of America by F. W. Taylor, for greater national efficiency to be obtained by systematic management. The principles, and their application to this end, are dealt with in his books "The Principles of Scientific Management" and "Shop Management," and the opening paragraphs of the former, in which he explains the fundamentals of scientific management, are so true that it is more than worth while to quote them at some length.

"The principal object of management should be to secure the maximum prosperity for the employer, coupled with the maximum prosperity for each employé."

"The words 'maximum prosperity' are used, in their broad sense, to mean not only large dividends for the company or the owner, but the development of every branch of the business to its highest state of excellence, so that the prosperity may be permanent."

"In the same way maximum prosperity for each employé means not only higher wages than are usually received by men of his class, but, of more importance still, it also means the development of each man to his state of maximum efficiency, so that he may be able to do, generally speaking, the highest grade of work for which his natural abilities fit him, and it further means giving him, when possible, this class of work to do."

"It would seem to be so self-evident that maximum prosperity for the employer, coupled with maximum prosperity for the employé, ought to be the two leading objects of management, that even to state this fact should be unnecessary. And yet there is no question that, throughout the industrial world, a large part of the organisation of employers, as well as employés, is for war rather than for peace, and that perhaps the majority on either side do not believe that it is possible so to arrange their mutual relations that their interests become identical."

"The majority of these men believe that the fundamental interests of employés and employers are necessarily antagonistic. Scientific management, on the contrary, has for its very foundation the firm conviction that the true interests of the two are one and the same; that prosperity for the employer cannot exist through a long term of years unless it is accompanied by prosperity for the employé, and vice versa; and that it is possible to give the workman what he most wants—high wages—and the employer what he wants—a low labour cost—for his manufactures."

In America, industry has made great advances on lines advocated by Taylor and Gilbreth and others. Her industrial progress has been rapid, and the great mass of her people have attained standards of comfort and of culture higher than those of any other country in the world to-day.

In this country scientific industrial development is making slow progress, due in great measure to the conservatism of employers and the distrust of employés to any changes in their working conditions. There are, however, distinct indications that on the one hand employers are realising in increasing

measure the value of the application of scientific principles to industry, and on the other hand that organised labour is also tending in the same direction as evidenced by the contributions of labour members to the Conferences on Science and Labour held at the British Empire Exhibition in May, 1924, and subsequently. The physical and mental welfare of the human factor have come to be more and more recognised as an essential element of industrial progress.

Taylor's actual methods were not very suitable for application in this country and little was done. There are, however, two notable exceptions to which reference must be made, viz., that of Lever Bros., Port Sunlight Factory and that of the Cadbury Bournville Factory. The principles and facts of the Bournville Works business organisation are described in "Experiments in Industrial Organisation" by Edward Cadbury, published in 1912. In his preface Cadbury writes that in the organisation of the factory "the supreme principle has been the belief that business efficiency and the welfare of the employes are but different sides of the same problem."

About a year after the outbreak of war, namely in September, 1915, the Minister of Munitions appointed the Health of Munition Workers' Committee: "To consider and advise on questions of industrial fatigue, hours of labour, and other matters affecting the physical health and physical efficiency of workers in munition factories and workshops." The Committee issued a series of 21 memoranda, an interim report and a final report dated April, 1918.

This Committee was succeeded by the Industrial Fatigue Research Board formed at the end of 1918 on the initiation of the Home Office. It was reconstituted early in 1921 and placed more directly under the control of the Medical Research Council and the terms of reference were:—

"To suggest problems for investigation, and to advise upon or carry out schemes of research referred to it from time to time by the Medical Research Council, undertaken to promote better knowledge of the relations of hours of labour and of other conditions of employment, including methods of work, to functions of the human body, having regard both to the preservation of health among the workers and to industrial efficiency; and to take steps to secure the co-operation of industries in the fullest practical application of the results of this research work to the needs of industry."

The most recent policy of the Board is understood to be not so much to investigate intensively certain conditions in any one industry, but rather in a thorough and more comprehensive manner to study general problems of common interest to all industries.

In the same year—namely, 1921—the National Institute of Industrial Psychology was founded on an entirely voluntary basis under the Presidency of Lord Balfour. The opening paragraph of one of the Institute's leaflets runs as follows:—

"The most urgent economic problem of the moment is to reduce the cost of production, with improvement in working conditions and without

reduction of the producer's wages. By such means only can Great Britain regain her former position in the export markets of the world."

Recognising the fact that only through the study and improvement of the human factor can there be true industrial progress on the human side, the work of the Institute is directed to the promotion of the study of the human factor in industry and in putting into practice the results of such knowledge. The improvement of the human factor can be attained by, *inter alia*, ameliorating the environmental conditions under which work is carried out, by increasing the ease of movement, by improving other factors concerned in a worker's occupation, and by vocational selection.

To assist industry in these matters the Institute undertakes investigations under the following heads:—

- (1) Movement of the workers.
- (2) Arrangement of material.
- (3) Methods of training.
- (4) Distribution of periods of work and rest.
- (5) Effects of illumination, ventilation, etc., on efficiency.
- (6) The increase of interest in work and the reduction of monotony and worry.
- (7) Selection, by means of tests, of workers best adapted to different kinds of work.
- (8) Reduction of waste.

The investigations are carried out by specially trained observers who virtually live the life of the worker for some weeks or months, saturating themselves with the working conditions of the particular factory, until, through observation and experiment, they are able to recommend changes that promote greater ease of working and abolish needless fatigue, friction and boredom.

Experience has shown that from such investigations the employer benefits by increased output, and a more contented staff, and the employe by increased interest in work and reduced mental and physical fatigue, accompanied very often by increased wages.

In this respect it is perhaps of interest to refer to a personal observation and early experiment on industrial psychology made some fifteen years ago at the Ardeer Factory of Nobel's Explosives Company, Limited. In the manufacture of guncotton the nitrated guncotton had to be picked over by hand to remove impurities before it was reduced from the cotton waste condition to a fine pulp. The girls worked a continuous 4½ hour shift. By giving them an interval of a quarter of an hour in the middle of the shift, during which they were allowed to go out into the open air and more or less play about, their output was increased, notwithstanding the reduction in working time, and they were no doubt all the better and happier for the rest period.

A section of the National Institute of Industrial Psychology deals with vocational selection and guidance. Vocational guidance consists of the examination of the intelligence and aptitudes of those about to take up their life's work. Vocational

selection has for its object the choice, by means of tests, of the workers best adapted to a given job, thereby securing a guarantee of greater productivity and at the same time safeguarding the workers from drifting into jobs for which their natural aptitudes do not fit them.

In the report on the Trade Union Mission to the United States, to which reference has already been made, it is noted that "In all the large works visited by the Mission, every applicant for work is subjected to a rigorous medical examination. Only those who can pass the highest test are employed on the more strenuous productive processes. Men of inferior physique are, if they are wanted, employed on minor and less arduous duties."

In the course of his speech, at the dinner of the Institute on November 12, 1925, Mr. Stanley Baldwin said: "If anything can be found that will cause the man, the woman, the boy or the girl with a heavy or monotonous job to find ways of doing that job with as great or with greater efficiency, and with less strain, more comfort, more happiness—if solutions can be found along these lines, you will add more perhaps to a combination of human efficiency and human happiness than we politicians can hope to do by anything that lies within our powers." These words are a strong stimulus to a constantly widening realisation of the importance of industrial psychology and vocational selection as a means of ensuring the greater efficiency and happiness of the workers, and the production of cheaper commodities.

Material.—Passing now from labour, or the human factor, to material, the second component that goes to make up the cost of commodities.

The less material that enters into the finished product, the less its cost, other things being equal. In many products the raw materials go through several processes before the final stage is reached, and without proper control not only must waste occur, but also the indirect loss attendant on putting through these several processes more material than is required. This consideration applies generally, but is of special importance in the manufacture of commodities in which chemical reactions form the whole or part of the process.

This question of economy in the consumption of raw materials has, so far as I am aware, not been the subject of much systematic investigation or of general discussion, and I will, therefore, say a few words with regard to it in the light of experience gained as Director of the Propellant Supplies Branch of the Explosives Department of the Ministry of Munitions.

The Branch had control of the production of propulsive explosives in all the trade, and in some of the Government factories; it also controlled the Government factories and the industries that provided some of the raw materials. A special section of the staff dealt with economy in the consumption of raw materials, which was imperatively demanded, in the first instance, on account of difficulties in obtaining supplies, and equally importantly on account of its effect in reducing the cost of pro-

duction, since the cost of an article is a rough measure of the productive energy absorbed in its manufacture.

To secure this economy of consumption a system was worked out under which the whole process of any given manufacture was divided up into units, and returns of consumption of material were submitted, from which significant efficiency factors for each unit were calculated. For some time the figures were unreliable, and to obtain greater accuracy it was found necessary to carry out minor plant alterations to enable accurate measurements to be obtained, and to seek out and eliminate various sources of error in collating the manufacturing data. After the system had been thoroughly established, the manufacturers became convinced of the value of a close study of "process efficiency" as it was called, and of the marked success in reducing consumption of raw material per unit of output that attended its adoption.

To illustrate the effect of this process efficiency control, the following figures for fourteen factories of consumption of nitrate of soda and SO₃ (sulphur trioxide) per ton of the two kinds of cordite in use, may be quoted:—

	Cordite M.D.			Cordite R.D.B.		
	Aug., 1917.	Sept., 1918.	% Decr.	Aug., 1917.	Sept., 1918.	% Decr.
Nitrate of soda	1.31	1.075	18.00	1.565	1.210	22.68
SO ₃	1.42	1.115	21.48	1.665	1.275	23.43

The 1917 returns were in some instances not very accurate, probably giving a somewhat higher efficiency than was actually obtained, but the averages used in preparing the figures can be taken as fairly representing the consumption of nitrate of soda and sulphur trioxide. As illustrating the money value of this form of securing economy, it can be stated that the difference in the average efficiencies for August, 1917, and June, 1918, represented a saving at the rate of not less than £600,000 a year on these two raw materials alone, at the then rate of output. The trend of the results indicated that the saving would have been considerably greater if a similar calculation had been made at some later date.

Another instance of the application of process efficiency control may be quoted. Owing to shortage of oils and fats, a glycerine process efficiency section of the Propellants Branch was constituted in March, 1918, to ensure the production of the maximum quantity of glycerine from the raw materials used by the soapmakers and fat-splitters. During 1917 the percentage of recovery was 73.89 for the whole of the firms engaged in the trade, whereas the percentage recovery for the six months June to October, 1918, was 81.54, a saving of about 9.4%. It is only fair to mention, however, that, especially in the case of the big firms, the recovery in the pre-process efficiency control period was below the normal owing to the endeavour to put through as much raw material as possible when there was an abundance of it. The control disclosed a considerable wastage of alkali and acid which was remedied, and also showed that many of the glycerine plants were badly designed.

Of course the system requires accurate measurements or weighings at every stage, and in certain cases provision must be made for tests and analyses. These requirements should be borne in mind when designing a plant, and may require small alterations or adjustments when applying the system to existing plants. But these are minor considerations when it is realised that with accurate data obtained in this way there should be no difficulty in locating waste of material and in taking the necessary steps to prevent it. A well designed costing system, to which reference will be made presently, will materially assist the object in view. All important works should possess a small but specially trained process efficiency staff.

Before leaving this branch of the subject it may usefully be mentioned that in the United States of America, at the instance of the Department of Commerce, a National Committee on Metals Utilisation has recently been set up to supervise the elimination of waste.

Oncost.—It is somewhat difficult to give a concise name to the third element of expenditure which goes to make up the cost of a commodity. The term "oncost" is usually employed, and denotes the expenditure of an indirect character, that is, expenditure which cannot be charged directly as material eventually entering into the finished product, and as labour actually expended on such material. The chief items of general charges or oncost are: the provision of power, heat, light and water; the maintenance of property, buildings and plant; the transport and handling of materials and products; the salaries and wages of staff; general labour; offices and laboratories, welfare and safety devices, etc. Expenditure under all these headings can be reduced to a minimum only by constructing and working a factory on thoroughly sound scientific lines.

The most important factors in the construction of a factory are: its location in relation to suitable sources of raw materials, to their receipt and to the issue of the finished products; the general lay-out as regards inter-factory communication and the position of the various buildings in relation to one another to ensure materials going from operation to operation and from process to process in direct and proper sequence; the position of the power station with special reference to the supply of fuel, on the one hand, and to the distribution of the power and the accessories it produces on the other; the arrangements for the transport and handling of materials and products; the construction and relative positions of the various buildings to allow of any necessary expansion from time to time without interfering with the sequence of operations; the provision of heating, lighting, ventilating, welfare services, etc.

Time does not permit of any detailed examination of these various factors, nor of a consideration of the principles which should govern the design and construction of plant and apparatus so as to work on the most economical lines. These are all matters within the province of a chemical engineer whose presence on the staff of a factory is indispensable.

A factory must, moreover, possess an organisation based on sound business principles, and having a well defined chain of responsibility. These also are matters within the province of a chemical engineer.

An essential feature in the working of a factory is an efficient costing system, the objects of which are twofold, viz. :—

- (1) To enable the factory cost of all products to be arrived at with accuracy.
- (2) To enable the management to control the expenditure in detail.

To give effect to the second object, the actual cost figures, and how they are made up, should be supplied at frequent and regular intervals to those in direct charge of manufacture, to enable them to watch the expenditure on labour, materials and general charges, and so afford them the opportunity of investigating any abnormalities as they occur. Papers and a discussion on the very important subject of factory costing will be arranged for during next session.

I have endeavoured, in the short time at my disposal, to outline ways in which industrial waste may be eliminated by increased industrial efficiency. In factories where chemical engineers are employed, they should be able to deal with most of the problems of industrial efficiency in connexion with materials and general charges. As regards labour problems, however, industrial psychology is such a special science that it would be best to retain the services of experts, at all events in the first instance.

There are, however, many small factories unable to employ a chemical engineer, or an expert in industrial psychology, and there are also many small industries in a similar position. The question naturally arises, therefore, how the matter of industrial efficiency can be dealt with in these cases.

There are several influential organisations in existence, such as the Federation of British Industries and the British Chemical Manufacturers' Association. I do not know, however, to what extent their constitutions would enable them to take up this matter of industrial efficiency in its relation to the elimination of industrial waste.

In many of the important industries there are Research Associations established under the Government schemes for industrial research, and their objects, according to the Memorandum of Association would include the investigation of the problem of the elimination of industrial waste, and the employment of suitable advisers for dealing with it.

I have endeavoured to point out that, in the promotion of increased industrial efficiency as applied to the elimination of industrial waste, lies one means of decreasing the cost of our commodities, thereby improving our position in the world's market and ensuring our food supplies.

I desire to express the hope that a matter of such great importance to this country may receive the consideration it requires from all those bodies that are capable of dealing with it, and that concerted action on the lines suggested may be taken. Any assistance that the Institution of Chemical Engineers can render, I am certain will be most willingly given.