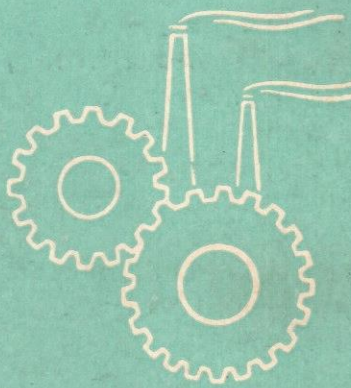
pecial Issue on Work Study

PRODUCTIVITY

JOURNAL OF NPC



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NATIONAL PRODUCTIVITY COUNCIL, INDI

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NATIONAL PRODUCTIVITY COUNCIL

The National Productivity Council is an autonomous organisation registered as a Society. Representatives of Government, employers, workers and various other interests participate in its working. Established in 1958, the Council conducts its activities in collaboration with institutions and organisations interested in the Productivity drive. 43 Local Productivity Councils have been established practically all over the country and work as the spearhead of the productivity movement.

The purpose of NPC is to stimulate productivity consciousness in the country and to provide services with a view to maximising the utilisation of available resources of men, machines, materials and power; to wage war against waste; to help secure for the people of the country a better and higher standard of living. To this end, NPC collects and disseminates information about techniques and procedures of productivity. In collaboration with Local Productivity Councils and various institutions and organisations it organises and conducts training programmes for various levels of management in the subjects of productivity. It has also organised an Advisory Service for industries to facilitate the introduction of productivity techniques.

NPC publications include pamphlets, leaflets and Reports of Productivity Teams. NPC utilises audio-visual media of films, radio and exhibitions for propagating the concept and techniques of productivity. Through these media NPC seeks to carry the message of productivity and to create the appropriate climate for increasing national productivity. This Journal is an effort in the same direction.

The Journal bears a nominal price of Rs. 2.00 per issue and is available at all NPC offices. Annual subscription (Rs. 12.00 to be sent by cheque in favour of National Productivity Council, New Delhi) is inclusive of postage! Subscription for three years, however, can be paid at the concessional rate of Rs. 32.00.

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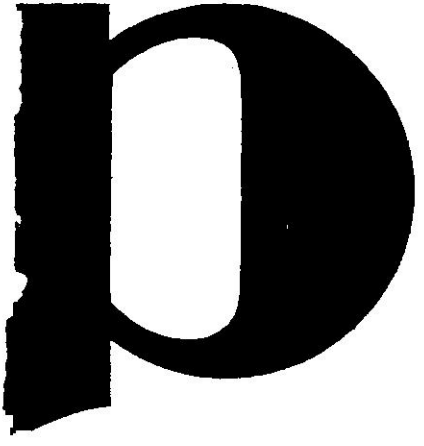

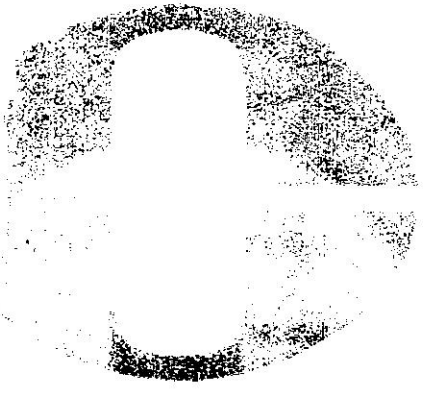

SPECIAL ISSUE ON WORKSTUDY

Jan-Feb

editor DH

Work Study is Productivity

THIS FOURTH SPECIAL ISSUE OF THE NPC PRODUCTIVITY JOURNAL DEVOTED ENTIRELY TO THE theory and practice of Work Study has been specially designed to furnish a foretaste of the infinite possibilities of Work Study as a technique for the improvement of the life and work of the Indian people in the various fields in which we are attempting to advance to a position of parity with countries of the West. The outstanding fact that marks out the importance of Work Study in the context of the Indian economy lies in the main differentiating factor between our society and that of the West: we have to confess that *we are a people not organised for work*, whether it be the government or the home, or industry or business. Under these circumstances, a continuous and relentless application of Work Study techniques alone could generate the momentum and the leverage for the TAKE OFF.

The Naivete of Work Study

A question is often asked as to how so simple and innocent a technique as Work Study—so *naive* in fact—could possibly accomplish anything corresponding to the apparently wild claims of its *connoisseurs*. Yet the classic cases—cited in this issue of the Journal—of Taylor's pig iron loading, of the massive increases achieved by Gilbreth the Bricklayer through a continuous simplification of the motions involved, the almost super-human achievements of Stakhanov in the Soviet Union in the simple process of mining coal: these are only an infinitesimal part of the many historic advances in the productivity of the human race over the last hundred years or so. In the interests of the common mass of people, this country has to be so rapidly organised as to *telescope* these achievements of the West in as short a period as we can make it. Work Study constitutes the starter for this process of rapid and continuous growth.

A Never Ending Technique

Work Study really is a never-ending technique. Work Study is not another name or a substitute for the old type of Time and Motion Study, for the work study expert receives his first orientation in the human implications of his technique. In what has now become the standard work on the subject, Mr. RM Currie[1] devotes a whole long chapter almost in the very

1 Mr. Currie and his colleague, Dr. Faraday, have been good enough to send their best and latest pieces on Work Study: Mr. Currie's article on How to Start Work Study and Dr. Faraday's What's New in Work Study have been published in this Special Issue.

beginning to the Human Context of Work Study. It is really a tragedy in the history of productivity that the purely technical and economic aspects of the Scientific Management of Taylor got undue importance while his humanism, his desire to improve the working and living conditions of the working class did not get sufficient importance. As a corrective to this lopsided impression, this issue of the Journal contains the famous Congressional Testimony of Taylor, which shows at once the grandeur, the historical perspective and the humanism of the Father of Productivity in the United States.

Ergonomics

Taylor is the real originator of Ergonomics on which a brilliant article by Sri SS Khera of the Indian Civil Service appears in this issue of the Journal. This carries the whole subject of Work Study into the long term perspective of nuclear developments and space travel. Sri Khera has drawn attention to the continuous disparity between sharp mechanical advances and *the strictly limited manoeuvrability of the human mechanism;* and this disparity has been painfully increased to an almost incredible degree by recent advances in technology: "...the relationship of the man to the process and to the materials must be studied, and extremely thoroughly studied, before there can even be conceived the idea of designing the process, the equipment and the workplace...To send a man—or an animal—up into space and to keep him alive, the whole enterprise must be designed within the parameters of his living conditions. The design of the space capsule, within the limitations of the weight, size and shape that can be sent up beyond the earth's gravitational force with the aid of rockets, provides some of the *most astonishing examples of ergonomics in practice*...."

The Social Perspective

Sri Khera's article points to two main conclusions (a) there is a compulsion to "work study" the whole industrial process with a view to bringing it effectively within the possibilities of human control and (b) within the governance of human values. This means that we have to *view Work Study in the larger social perspective*: a subject on which the Executive Director of NPC has contributed an article to this Journal: "...unless we are able to *make this new technology an acceptable part of current social experience*, we shall get, alongside rapid industrial development the misery and wastefulness, in a compounded way, of the Industrial Revolution.... The modern concept of productivity is that it is an integral part of the functioning philosophy of the whole social economy. We have to *make productivity a working concept*, an essential part of the mechanism of the Welfare State....It is obvious that we are *treading a ground of infinite* possibilities....." The essence of productivity is to make available to the large mass of people—not just a few persons—a growing range of commodities and services, to be produced with less and less effort so that they should have the leisure to enjoy a higher standard of living; to make available to them higher forms of cultural enjoyment, education and the like; in short, the means for a fuller enjoyment of the good life.

The Outdated Objectives

The primary objective of Work Study is not an increase in the workload or reduction in the volume of employment. They are *outdated objectives.* The provision of full employment is now the accepted policy both in capitalist as also in communist societies. The primary objective of Work Study on a purely physical plane is the elimination of unnecessary movements, the elimination of fatigue, the elimination of those handicaps which prevent the workers from contributing their best to the work in hand. This is apparent from some of the apparently callous calculations that we find in Time and Motion Study, as for example, *man is equal to half horse power.* If so, the use of purely manual labour has in fact to be reduced. The objective of reducing the labour content of work is not to reduce the volume of employment but purely to *reduce the workload in its essence* and to reduce working hours, as has been the actual experience even in the capitalist countries. A 40-hour week is now almost the universal practice: *eight hours below the ILO convention,* which was established after a considerable struggle. Work Study techniques have been the real means of not only implementing what was thought at one time to be a difficult convention but *the convention itself has become redundant.*

The True Nature of Workload

People of all sorts, including directors of companies, managers, workers, have often complained of excessive workload or *being killed* when really it is an indication of their *incapacity to organise work smoothly and harmoniously.* In this connection we ought to understand truly the nature of what constitutes a workload. The workload on a single, manually operated loom may in fact be heavier than on six automatic looms. It is not the number of looms that constitutes the workload but the fatigue, the attention and the responsibility involved. The workload in flying a jet aeroplane at above the cloud level might in fact be lighter than on a Dakota, flying at lower heights and lower speeds!

And the nature and the quality of workloads would also differ with different persons. One executive might find it much easier to be the president of a big corporation than the manager of a small company and *vice versa.* Then, there is the question of appearances: the executive, after planning work long before the day starts, and directing it as soon as men are on their jobs, may well relax, looking at pictures in a film magazine. *This is as it should be,* for if he does not do so, he will have no energy left when the next bout of work starts. Napolean used to be found sleeping just before some of his biggest battles started, and he won because he knew how to relax even while riding a horse. The Captain of Queen Mary might be presumed doing nothing, while resting in his beautifully furnished cabin or promenading the deck from the topmost part of his ship. *Apparently, his workload is NIL* but the great emergencies have shown what levels of genius these captains have risen to, when the occasion demanded.

Mechanisation and Employment

The real issue however is that the working class *equates Work Study with mechanisation and consequent unemployment. These fears are* genuine

and honestly held, as was in fact pointed out in the Testimony of Taylor to which a reference has been earlier made. In a passage of classic beauty reproduced in this Journal, Taylor points out how mechanisation of industry has been associated with increase in the volume of employment, undreamt of in the history of mankind. Yet workers have resisted and it is in the social interest to understand and appreciate the nature of working class resistance. We must convince the working class that rationalisation alongside necessary mechanisation—of course in the context of full employment, fair wage policies—constitutes the only means for the survival and the wellbeing of the working class.

This needs analysis. Inefficient, manual methods of operation do certainly protect the existing volume of employment but at the lowest levels of wellbeing, and they also *protect* us against adopting techniques which would certainly mean a higher standard of living, a lot more of leisure and a growing volume of employment, for *it is only a mechanised economy which would release energies and savings for investment for a full level of employment.* That mechanisation (taking not plantwise but in a whole economy) reduces employment is a fib, discredited by continuous historical experience. The pre-industrial revolution societies offered only part-time seasonal employment. For a large part of the year, men smoked and women spun. In any community, the volume of employment has invariably increased, at least proportionately, and sometimes more than proportionately to the increase in the degree of mechanisation. Postwar America, postwar Britain, postwar Germany, postwar Japan, postwar Russia: all offer to their peoples a far larger volume of employment than before the war inspite of —*rather precisely because of*—large scale mechanization of (not only their industrial but also agricultura!) processes. Highly mechanised postwar Germany has not only built itself and provided its workers with modern amenities (cars, radios, refrigerators, not to mention warm clothes, fruits, butter and the like) on a scale which they hardly dreamt of at any time. It provides full employment not only for German boys and girls, but for Spanish and other foreign girls and boys, for its mechanized economy demands more workers than this over-populated, over-crowded country can supply! *This has a lesson for us.*

Workers have often objected to work study because of the discrimination involved. Now it is accepted that there should be a *work study of management as well.* In fact the work study authorities have gone much further in their approach to the problem. A distinguished industrialist said in an answer to a correspondent: "It would seem....that you are under the impression that Work Study is primarily concerned with the operative, and more particularly with financial incentives for him. Whatever thinking may have been in the past, we have found the impact of Work Study travelling steadily away from the shop floor to the board room. We now regard it as symbolizing the analytical and progressive attitude of mind which is mainly concerned with making management manage better, rather than getting the workman to work harder."[2]

2 Currie RM, Work Study, NPC PRODUCTIVITY Journal, Volume 1, number 4, p. 248

A Universal Technique

Work Study in fact is a really universal technique applicable to all persons, to all sections of persons and all situations, particularly one of capital shortage, such as the one we are experiencing in this country. Economies on a scale, not yet thought of in the planning of this country's economy, are achievable through appropriate programming and utilisation of capital resources. As contrasted with western economies, we really need a shift of emphasis, because of the material difference in resource-endowment. We need, in our own way, a plan of ordered growth: so ordered as to fit the basic conditions of our own economy.

A large part of our Plan outlay—as much probably as 80 per cent—is directly on machines and materials, wages and other like payments accounting for only around 20 per cent. Thus massive economies can be achieved in those segments of expenditure covering machines and materials and buildings which exhaust 4|5ths of our direct outlay. Reduction in the cost of construction of buildings, better scheduling of machine time, improved maintenance, a scientific system of inventory control, would, while saving us enormous sums of money, which we can reinvest in further development along desired lines, save us simultaneously from the human resistance which we would strike against if we were to apply work study techniques with a view either to economise labour or to increase its workload.

Arbiet Physiologie

The essential technique of Work Study lies in making a complete record of the path of movement of men, materials and equipment. But *machines and materials do not mind movement, while men question why they are being moved.* Work Study therefore does involve a study of industrial psychology. One of the successful pioneers of Work Study to whom a reference has already been made (Gilbreth the Bricklayer) was associated in his work by his wife Dr Lilian Gilbreth who was a student of industrial psychology. In Germany, where these techniques have been carried to a limit of their possibilities, there is a whole institute of Arbeit Physiologie which makes a study of the relationship of physical movements with the activity of the mind; for the motor force of action lies not in hands and feet, but in the mind, which is the real locus of sovereignty in the affairs of men.

Work Study in the Soviet Union

At the time of writing, it is of considerable interest to record that a whole University of Work Study has been or is being established at Moscow. It is wellknown from the prewar technological literature of the Soviet Union to what perfectionist limits, the engineers of the Soviet Union carried time and motion study techniques. The sincere Webbs devoted considerable space in their authoritative treatise on Soviet Communism to Stakhanovism and such like productivity techniques. In fact the ideal students of Frederick Winslow Taylor are to be found more among the technicians of the Soviet Union than in the United States, where the experiments of Henry Ford, Elton Mayo,....McCormick have made considerable ad-

vances on the Taylor system. Most of the success achieved by the Soviet Union is due to the rigorous application of work study techniques to the mass of social and economic activities undertaken directly or under the sponsorship of the State. Among the results of work study applications should be catalogued the highly efficient programming, for which the Soviet planners have rightly earned a world reputation. In fact it is not sufficiently realised how the planners of the Soviet Union apply rigidly capitalistic forms to the management of their own concerns.

Engineer the whole Job

The main characteristic of the Soviet productivity techniques lies in the attempt to *'engineer the whole job'* which is really a complex of a number of social and psychological factors, as was found out in the famous Hawthorne experiments to which Sri Khera has referred to in his article. To the credit of the engineer it must be said that the whole industrial civilisation of the last 200 years or so with its amazing productivity and its infinite possibilities owes a debt to the talent and the perseverance of the engineer. As a result, however, of the very magnitude of the engineering achievements in the field of technology there has developed in the engineering mind a sort of absolutism, which in the social and economic sphere is self-defeating. To the credit of the engineer again it must be said that the large number of engineers, now organised as industrial consultants, have begun to use inter-disciplinary techniques compounded of a number of physical and social sciences. Operations Research and Ergonomics are only two of the many inter-disciplinary approaches that have been developed during the postwar years. In a segment of the engineering mind, however, the absolutist tragedy yet marginally persists, for there are engineers who yet hold that *standards are not negotiable, when they are in fact daily negotiated*, the industrial process being essentially a matter of continuous compromise and adjustment. There is, however, a difference that while standards were formerly a battlefield between employers and employees' representatives, they have now been taken on to a technical plane being negotiated between the work study experts of managment on the one side and of the trade unions on the other. Trade unions in the United States have their own work study engineers whose function is to question the work study findings of the management experts. This is as it should be, for the basic philosophy of work study is that there is *nothing sacrosanct*. Everything is to be interrogated, to be questioned as to its validity and position. Only, in the application of work study techniques, one has to be *fundamentally honest*.

Workers' Doubts[3]

Reference has already been made to the workers' suspicion that the objective of work study is to reduce the volume of employment. We have shown that against the background of full employment policies, this fear is

3 This is a euphemism. Workers organisations even in the United States have strongly expressed themselves against an essential part of work study, namely, work measurement: ".....Time Study, which is widely used for determining workloads and wage incentive standards, is an imprecise tool and lends itself to easy abuse. Of the whole field of socalled 'scientific management', time

groundless. On an individual plant basis, however, the workers' argument needs appreciation and understanding. The workers ask: "If methods study reaches the following conclusions in this order of priority: (a) making a costly machine redundant (b) replacing a costly building by a new one and (c) reduction in the volume of employment, what will the employer choose?" It is common sense that if work study involves the scrapping of costly machine or building, or reduction in the volume of employment, the employer would choose the last alternative because *human beings are things in which employers have made no investment.* The employer would think a hundred times before scrapping a costly machine or building even if that is recommended by a work study expert. But the moment the work study expert recommends reduction in the volume of employment, the employer takes shelter behind an expert finding and somehow immediately or ultimately, reduces the workforce at his disposal. This is of course putting the argument in an entirely onesided and uncharitable manner.

Whatever the thinking may be, the social situation as it now obtains has rendered obsolete the whole approach of Hire and Fire, either by law or otherwise. We have, however, to confess that in this country we have a lot to learn from the established practices of the Japanese employer who has built an industrial civilisation of the highest productivity consistent with human values. It has here been shown conclusively that *work study is no longer a purely engineering technique.* It is what the social scientists call a value-loaded idea: an idea surcharged with essential human values.

Work Study and Planning

Most of the difficulties that have been experienced with regard to the application of work study could in fact be avoided, if instead of being applied in an established situation with all its complexities and impossibilities work study is utilised at the planning stage. This point of view has also been put forward by Sri Duleep Singh of the NPC in a special article on the application of Work Study: "....It is with regard to the future, that is *at the planning stage that work study can be most fruitful.* It would enable us to avoid mistakes which if once built into a system are usually very costly, often difficult, if not impossible to eliminate. It is really at the preproduction stage that we build in most of the inefficiencies and unnecessary costs. Conversely, it is at the planning stage that we can really make improvements with far reaching consequences in terms of real social costs." In an article published in this Journal, quite a long time ago, Mr. Currie pointed out how his work study organisation in the United Kingdom was being put more and more to use at the planning stage than later. Insecurity of employment associated in the minds of workers with work study, is very largely due to the fact that work study is not undertaken at or before the time of recruitment, when modern technology through models and otherwise, makes it both theoretically and practically possible. *Work Study techniques are really built-in stabilisers of regular employment at a level*

study is the area in which most of labour's distrust and suspicions are centred. It puts a strain on the entire collective bargaining process, making it more difficult, more complex, more costly...." (AFL-CIO Collective Bargaining Report)

of productivity satisfactory for the growth of the economy and security for the individual worker.

The Philosophy of Work Study

Shorn of all technical jargon, *work study is really a human study.* The employers are now beginning to realise this truth. In the army, it was realised a long time ago. "'A cheerful, enthusiastic and willing operative, with an affectionate regard for the establishment in which he is working, is a much greater asset to us than a fabulous automatic packing machine ...." (Col. Pennathur)

Philosophically the idea of work study originates from Bacon's Novum Organum: the step by step logical process by which you prove or disprove the essentiality or validity of any proposition. Bacon proved that as in the highly scientific pursuits so in the affairs of men, doing jobs by hunch, instinct, fits and starts are not only fallacious but costly, tremendously costly, considering the scale on which the world's work is now done. *Work Study is really the substitution of the rational for the irrational.* It means the refusal to accept the going as the best. It means the constant questioning of the essentiality of every operation for the ultimate end in view to which we shall revert later. Nevertheless it is a technique, characterised by marked simplicity. If anything, *work study certainly is not black magic.*

The Importance of Procedure

All that work study really does is to emphasise the importance of procedure in the affairs of men. Procedure, however, has often been derided both on philosophical as also on practical grounds. The philosophical type hates procedure because he is allergic to all formalities. He wants *concentration on substance.* Similarly, the practical man, anxious to get a job done, wants to go right to the heart of the job instead of bothering about procedures and formalities which he thinks are subsidiary and not quite essential. In his opinion procedures just obstruct and delay the actual performance of work and therefore he does not attend either to the formalisation of procedures or the actual following of established procedures.

Actually this disregard of procedure and of laying down formalities, rules and regulations for the performance of a job is in every way costly, for the actual performance of job does involve charting out of rough and ready procedures everytime the job is done. This means a waste of time. It prevents the cooperation of a number of persons, who must follow certain procedures if they are to work together effectively and harmoniously.

Even from a philosophical standpoint, procedures and formalities are essential because they leave us so much more time and energy for the performance of the essential job. Formalities and routines and procedures therefore in fact save time and energy for the performance of essentially creative jobs.

Probably the types of mind necessary for laying down formalities would be different from those creative minds who work by fits and starts

With this issue of the Journal, NPC completes its fourth year; hen retrospect is presented here of the Personalities associated with Productivity Movement, organised by NPC. At the top centre is Prime Minister arriving to inaugurate the first annual conferenc NPC. To his left and right are the Vice-President and Russell Cu who brought a personal message for the Prime Minister from Mountbatten for introduction of Work Study in the defence serv

Prof. Galbraith, US Ambassador New Delhi inspecting NPC project in Industrial Engineering Indian Telephones Bangalore

Top centre: Principal Nagabhushana presiding Management Audit Conference, Mysore

Executive Development Programme Patna

and have no inclination towards laying down formalities. Genius apart, most of these creative minds are not averse to following routines and procedures, once they are laid down, though they themselves have no part in the working out of the procedures. It is necessary to understand this philosophy of Work Study because it would enable concentration on achieving the end product more rapidly, of superior quality and in larger quantities than would otherwise be practicable.

The Ultimate Product of Industry

This brings us down to fundamentals. What is the end-product of industry? Even hardheaded businessmen, those who make money, are slowly but surely coming to the realisation, in the very interest of business, that the ultimate objective of industry is not only to produce goods and services in increasing volume, but the increasing satisfaction of the people who consume them. If so, *People and Productivity with all its work study and other techniques go together.* The ultimate end of industry is not only to produce goods and services but also to produce citizens able and willing to contribute their best to the growth and development of an industrial democracy. Goods are only intermediate products. It is the *quality of citizenship that is the ultimate output of industry.*

PRIME MINISTER ON WORK STUDY

Work Study, almost a new idea, has now come to us in order to improve our administrative methods, to streamline them and make them more efficient and effective. Essentially, it is aimed at inculcating the spirit of self-development among the various grades of our administrators.....

Jawaharlal Nehru

Men and Machines

The Science of Ergonomics

SS KHERA*

The purpose of this brief article is to enlist interest in a scientific discipline of which a comparatively new consciousness has arisen abroad; and to draw attention to the need of applying scientific principles of human engineering to the design of processes and of equipment as well as to the operating procedures, in the interest of productivity and of human values.

ERGONOMICS IS A RATHER NEW WORD which has increasingly been coming into frequent use in western Europe during the last four or five years. It covers much the same field as 'human engineering' which is the term, more commonly used in America. Broadly it connotes a scientific approach to the problem of adjustment between man and machine.

Man is a tool-making animal. It is this feature in evolution more than anything else that set the new species, *homo sapiens,* above the other primates and on the path to command over and conquest of his environment. There is a line clearly traceable linking man's earliest efforts at tool-making: his sharpened flint for use as a cutting tool, his pointed stick to use as a spear for hunting and for defence, his discovery of fire-making by rubbing two pieces of wood together—with the artificial satellite of today and the space ship of tomorrow, and indeed with the whole galaxy of modern scientific and technological processes and attainments.

Man's discoveries and inventions have tended to aid him in influencing his environment, in controlling it and shaping it to his own security and to the satisfaction of his needs and desires. But not always. In the course of his adventuring in knowledge and technique, man has *sometimes succeeded in creating also an environment or a technology adverse to himself and his interest, and even to his own safety.* The invention of gunpowder is one example, leading man from simple battle to total warfare. The history of the industrial revolution is full of the story of man's exploitation of man. "The dark satanic mills" were a grim reality in the industrial prosperity of Europe. Finally, man stands today facing the great question mark: will his nuclear devices put a final end to man himself, and to the world which produced his species, a bare blink of an eye ago in the long stretch of creation?

Ergonomics is as old as man himself. The human body is contained within a set of fairly well defined physical measurements, the variations in each of its dimensions falling statistically into a regular Gaussian curve of distribution. This is true, whether we take a statistical sample along the course of human

* Senior member of the ICS: has held several senior positions in Government; at present, Secretary, Ministry of Steel, Mines and Fuel, Government of India.

history, or at any given point of time since the human species came into being. The human body is also mechanically a well defined set of parts which are combined in a certain way, and with equally well defined ways of movement and coordination. These facts enable us to consider human engineering in terms of scientific research and experiment and of technological application in industry.

The human body is possessed of a set of senses, again well defined and each within limits as regularly distributed. The average human ear will pick up as sound vibrations of the air ranging from a few cycles per second to something over 15,000 cycles per second. Beyond that, as anyone knows who has used a dog whistle, the human ear is "deaf" to sounds that some animals and insects can hear. The ear will also tolerate only a certain intensity of these vibrations. Although a rivetter in a boiler-making factory will adjust himself to the sound —and nature provides for several margins of resilience, adjustment and recovery—he will certainly go deaf if he keeps at it long enough. In fact the work of rivetting inside a boiler, with the sound reverberating and building up in the enclosed space, is a clear occupational hazard. About 125 decibels is all that the human ear can tolerate, and that also not for long periods. The modern aircraft jet engines with their 180 and more decibels are more than a mere nuisance to those who work or live close by.

The human eye sees a very small portion of the total range of electro-magnetic vibrations. Below the visual red, man is blind, while his radio set continues to "see" those wave lengths which are longer than those of visible light. Similarly, above the violet (the range of the human eye is of course the familiar "vibgyor"—for violet, indigo, blue, green, yellow, orange and red) man cannot see or sense these vibrations. Some of these are the rays, including those of cosmic origin as well as the results of nuclear fission and the familiar rays which enable the camera to photograph the inside of the body. These highly penetrative rays constitute one of the new occupational hazards of the nuclear age.

As with the eye and the ear, the other senses of taste, of smell, of feeling operate within fairly defined limits of sensitivity, of differentiation, and of tolerance, and according to definite curve patterns of distribution.

The mental equipment of man is in many ways similar to that of the lower animals. This enables a degree of communication between humans and animals. But the human brain has a capacity far greater than the animal's; and is also qualitatively different. This qualitative difference has enabled man to perform feats of induction and deduction, and of accumulating, storing, organising and using new bits of knowledge gained over the course of time, achievements that are for ever beyond the capacity of even the highest primates other than man himself. One has but to compare the results of training in chimpanzees, which at best produced somewhat elementary refinements of conditioned reflexes and short term memory storage, with the intellectual abstractions reached by man (and without which there would be no mathematics, no science, and no kind of technology whatsoever), to gauge the qualitative difference of the human brain.

The human mind and body are also the scene of a vast array of emotions and emotional patterns. Many of these appear to have their counterpart in animals. (The small chimpanzee named Enos sent up by the Americans in a two-orbit circuit of the earth last month was described as a *contemplative chimpanzee,* which apparently was a point of

some merit during the trying period of seclusion in the satellite capsule). But man's mental difference seems to transmute some of those emotions, and to provide fertile ground for others. Modern research and development of drugs promise new methods of influencing emotions and emotional attitudes.

The history of ergonomics has by and large kept pace with the development of technology and of man's tools. We make a division for convenience into four periods: (1) The period from the earliest times to the beginning of the industrial revolution of the 18th and 19th centuries. (2) The industrial revolution. (3) The global wars of the twentieth century. (4) The nuclear age. These time periods will be seen to be progressively shorter. But the rate of scientific and technological development was, on the other hand, more than conversely faster. And ergonomics, or human engineering, has tended to keep pace with the rate of this development.

Leaving behind the comparatively negligible technological advances during the long first phase, we see during the industrial revolution man increasingly making use of machines run by thermal instead of animal energy; machines designed and operated to run faster and faster; and machines more and more complex. This was characteristic of the steam engine, the spinning and weaving mills, metal-making and metal-working establishments, road, rail and water transport, and so on. The sheer pace of transformation would have been enough to upset the balance—often an intricate balance developed over the ages—between the man and the machine. The intimate relationship between the craftsman and his tools and workplace was replaced by an impersonal association between a machine and its attendant.

But that was not all. *The industrial revolution was an era which saw a peculiar brutalisation of men in the very societies where the greatest scientific and technical advances were being made.* In Europe it was the era of colonial expansion and domination in its most naked forms. In America it saw the slave trade and the use of slave labour at its greatest amplitude both of size and of horror; until the American civil war reversed the trend. Thirdly, with the final breakup of old, and still somewhat protective if feudal relationships between the aristocracy and the common people in Europe, a new impersonal relationship came about between the employer and his workman or labourer. The worker was now merely a working unit, amongst all the other units, human as well as mechanical, serving the single purpose of obtaining for the owner of the establishment the highest profit for himself at the least possible cost to him.

The growth of political franchise, of education and of consciousness amongst the people, led to the early factory laws, designed to provide the essential minimum of safety for the worker. Working conditions in mines and factories, protection against avoidable injuries from shafts, belting and moving machinery, control of dangerous chemical fumes, prohibition of employment of women and of children in hazardous occupations or tasks beyond their strength : these were some of the things now provided for by legislation.

But by and large, it would be true to say that during the era of the industrial revolution, *the tendency was to fit the worker to the machine,* rather than the other way about. Machine designers were hardly conscious of the fact that the machine would have to be tended, maintained and repaired by men. Sometimes this consciousness would be forced upon them by the machine simply not being found possible to work, or repaired after even a minor breakdown. Modern concepts of productivity in

terms of the man-machine complex were unknown. For all the capabilities built into them, many machines of the era were grossly unproductive. It was in the latter part of this era that the first tentative approaches were made, towards the science of human engineering; particularly the pioneering work of Taylor (1856-1915) and Gilbreth (1868-1924).

The thirty year period of the two global wars from 1914 to 1945 saw a phase change in technological progress, machine design, and in management. Aircraft came into use; as also underwater craft. Movement became increasingly faster. Machines and equipment were more and more complex. Measuring instruments and procedures became more and more refined and exact. Greater consciousness came about, of the need to study the human body, its capacities and limitations, its working environment, and the social consequences to the individual and to the community of conditions of work; in turn the consciousness grew, of the need to incorporate all these in the design parameters of processes and of equipment. Ergonomics in its modern sense came into being.

The nuclear age has introduced another phase change. No longer was it sufficient to keep in view the human operator in designing a machine. The new fire, man was now playing with, demanded entirely new sets of rules. In anything to do with radio-active materials or radioactive processes, the relationship of the man to the process and to the materials must be studied, and extremely thoroughly studied, before there can even be conceived the idea of designing the process, the equipment and the workplace. And the design from its earliest inception must proceed in accordance with the results of those studies. Where risks are taken, they must be calculated with a care and to a degree of refinement unknown before this era. This is true for the mining and processing of uranium and thorium, it is true for nuclear reactors, whether for power or research or as breeder establishments for plutonian, and it is true for nuclear ships and submarines, and it will be true for any nuclear aircraft. (Indeed, but for the hazard to the crew, against which the reactor must be clad with material heavier than the aircraft could carry) nuclear aircraft could be flying any time now.

The nuclear age is also the space age. And in space technology too, the same thing applies. To send a man—or an animal—up into space and to keep him alive, the whole enterprise must be designed within the parameters of his living conditions. The design of the space capsule, within the limitations of the weight, size and shape that can be sent up beyond the earth's gravitational force with the aid of rockets, provides some of *the most astonishing examples of ergonomics in practice.*

There is a wider aspect where more attention, and by more people, is necessary in research and application of ergonomics. As technical apparatus and processes have developed, especially as they are developing now, the process tends to affect more and more people who have nothing to do with it. We may consider here as an example the establishments and the programmes involving nuclear reactors as well as the development of rocketry. A nuclear reactor can be dangerous in a direct way to its whole neighbourhood. When the reactor at Windscale went out of control, the nuclear fall out from its waste-products stack contaminated quite a large area around it, and endangered the life of humans and animals living in that area. Mistakes and accidents will happen; in the case of nuclear establishments including nuclear power stations this hazard needs greater attention specially in densely populated areas.

The nuclear weapons tests which figure so much in the news endanger even larger areas, and indeed life everywhere on our planet. It is fairly well established by now that there is no threshold below which nuclear fall out can be regarded as safe. The increase in danger to everyone is in direct proportion to the amount of fall-out even from the smallest quantities. There have just been published the first results of experiments by Dr. JF Loutit of the Harwell atomic energy establishment on the absorption patterns of the radio-active isotopes strontium 90 and of strontium 85. These are two of the main radio-active isotopes in the fall out from nuclear weapons' tests in the air; they spread with a wide dispersion, and the length of their half-life makes radio-active strontium a principal hazard to life. Strontium 90 tends to be taken up and concentrated in growing vegetation, food crops such as wheat and rice, while strontium 85 tends to concentrate in milk amongst other things. It appears that the absorption rates of both strontium 90 and strontium 85 are about equal. These and other results of research are undoubtedly valuable in helping to minimise the danger and to enable at least some precautions to be taken. But the point to note is that nuclear explosions have been going on since 1945, their size and frequency has been increasing, and the last H-bomb nuclear tests have practically doubled the previous total in terms of megatons of high explosive and in terms of fall-out. Research in the effects of nuclear fall-out seems to follow behind the development of these weapons, and very much behind. Here is a field of relationship between human safety, and indeed the whole of life on earth on the one hand, and the machine represented by nuclear devices of all kinds on the other. That the danger is real and not merely a matter of academic research is signified by instances such as these: The United States of America appear to be engaged at present on a vast nation-wide programme of shelters to protect the people from the effects of nuclear war. Costly and futile as this effort is, it is a mark of the concern which should perhaps be more widely felt elsewhere also; but more towards an effort to abolish the threat of nuclear war rather than to prepare for it. Another instance is the grim reality of the situation in which Britain is placed in the present state of tension between the two giants, the USA and the USSR, when a nuclear war may be triggered even by accident. Britain would then be both the launching pad for nuclear missiles, as well as the expendable item in war's inventory, (within a few minutes of the start of a war). This has led to the campaign for nuclear disarmament in that country, and to the demonstrations against the establishment of the Polaris atomic submarine base at Holy Loch. Some of these demonstrations have been led by persons of the scientific eminence of Bertrand Russel. Thirdly we may note that some scientists of the highest standing and who know something about these things have been considering the question as to whether a large enough H-bomb explosion (such as the 100 megaton bomb referred to by the Russians after their 50 megaton bomb test recently) might even set fire to the air around in such a way as to start a chain reaction in the atmosphere. If that should prove true, then the surface of the planet would be reduced to a cinder before you could say "peaceful co-existence", and we shall have nothing more to worry about.

Finally a word may be said about the importance of local conditions and local circumstances in the designing of equipment and processes of operation and maintenance. This is particularly important in a country like India where industrial development is proceeding on a large scale and at an accelerating pace. A great deal of this development makes

use of foreign skills and foreign collaboration in the design and supply of machinery and equipment. Instances have been all too common where sufficient account has not been taken of the local conditions in which the enterprise is to be set up and of the workers who will have to operate and maintain it. With experience, greater attention is devoted to the relationship between the worker and the machine, in the design and construction of new plants.

The economically advanced societies have come a long way from the early days of adjustment between man and machine. The worker is no longer regarded as a mere adjunct to the machine and more readily expandable than the machine. As JG Crowther has said, the maximum that man can do with any machine depends ultimately on what he can bear himself. Machines and processes will in future tend to be designed in keeping with this inescapable principle. While there is no foreseeable limit to the ingenuity, complexity, size, and speed of operation of machines, man and his array of senses and physical and mental capabilities together with his emotional complex does not seem to have any prospect of changing faster than according to the slow and inexorable processes of evolution. The science of ergonomics, or human engineering should thus perhaps proceed from this as a major premiss.

"...How far away is the future? I propose to set my limit at the year 2000 AD and to regard the future as being the next 40 years... What does this mean in terms of production engineering? If nothing else, it means that our production resources must be increased during the next 40 years by a factor of 5. We are accustomed to living in an expanding economy; we think an annual expansion of 2½ per cent is satisfactory, 5 per cent good, 10 per cent exceptional but, during the next 40 years, we must achieve a world economic expansion of at least 500 per cent. There is plenty of evidence that the human mind is more than capable of encompassing such an expansion. Of all the scientists, engineers, and technologists there have ever been in the history of the human race, 75 per cent of them are alive and working today. Our rate of scientific and technological advance is such that, by the year 2000 what we now consider to be miraculous will then seem as commonplace as boiling a kettle of water...."

How to Start Work Study

RUSSELL M. CURRIE*

Work Study is a management exercise demanding whole-hearted effort. It is *no good thinking that it can be tried out as a casual experiment* without proper preparation and organization. If someone, untrained and inexperienced, tried to use the techniques '*to see what happens*', then inevitably the result will be disappointment and failure. Work Study techniques, though they appear simple in themselves, have far-reaching effects and can *eventually achieve dramatic savings* ; but in the hands of the wrong person they can cause a great deal of harm, particularly in labour relations.

IT MUST BE ACCEPTED that Work Study cannot be done 'on the cheap' and that its adoption must have the full drive of senior management behind it. Management should be quite sure that they understand the need for Work Study, and have a clear idea of the service it can provide within the management framework. They *should not expect sudden miracles* but be prepared to back the Work Study team in its efforts.

As an example let us assume that Work Study is to be introduced into a medium-sized, well-established manufacturing concern. The procedure would, however, be broadly the same in any organization. The first step is to appoint someone in full-time charge. Where possible, the position should be filled by promoting a suitable person from the existing staff and having him properly trained. If no suitable candidate can be found within the organization the position should be filled by *recruiting with the utmost care a trained person* from outside. It cannot be too strongly emphasized that the successful introduction and application of Work Study depends in the last analysis upon the calibre of the man appointed. The task requires enthusiasm, persistence and those qualities of leadership which command respect and trust both from management and men. A person of character and ability is essential ; an inquiring mind is needed, allied with plenty of common sense. If technical problems will be involved, then adequate technical training is a definite advantage.

While training and knowledge are essential, experience has shown that *the problems involved in applying Work Study are mostly psychological*, and therefore the non-technical qualities which should be looked for in an ideal Work Study Officer are of fundamental importance. These could be summarized as (*a*) power of logical thought (*b*) imagination (*c*) determination (*d*) tact (*e*) integrity (*f*) personal acceptability (*g*) power to inspire confidence.

One cannot expect any man to possess such a list of qualities in equal measure, but nevertheless thought should be given to them and the candidate assessed against the ideal with a view to making sure that he has at least some degree of each attribute. Although a man might fulfil the requirements in every other respect, *if he is tactless*, for instance, he will not succeed as a Work Study Officer.

As status is important, the Work Study Officer should be made directly responsible to the factory manager or to a higher executive. At the same time, it should be made quite clear from the outset that his job is advisory, and that he is there to provide a service to line management in the discharge

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of its functions and must on no account usurp that authority.

The number of personnel who should be employed on Work Study in any organization will depend on many factors. Besides the size of the organization, there will be the type of work involved. For instance, where a large number of people are doing exactly the same job, then the proportion of Work Study staff will be small. At the other extreme, when Work Study is being applied to non-repetitive work, such as engineering maintenance, the proportionate number will be much greater. In all cases, however, the economic return will far outweigh the cost of such staff.

Another factor in determining the size of the Work Study staff will be the extent to which it is economically justifiable to apply Work Study. In some small concerns one individual will be quite able to carry out all necessary investigations and make whatever studies are required. In such cases it frequently happens that he accepts responsibility for routine planning as well as carrying out the investigations and implementing them, working closely with line management.

In all countries it is the more progressive industries and managements that are adopting Work Study. It is also true that the more progressive the company is, the more insistence there is on the Work Study staff being properly trained. This can be done only by attending a first-class, well-established training course, which should last for a minimum of three months full time. Even after this the Work Study Officer will still need practical experience under guidance.

It has been proved that simply putting a raw recruit into a Work Study Department without formal training is a most misguided policy and, indeed, economically unsound. After the Work Study Officer is trained he must be provided with opportunities to keep himself uptodate by attending refresher courses where available, taking part in conferences, and maintaining contacts with other companies on Work Study techniques.

Management must also keep uptodate, with sufficient knowledge for executive control, and give constant encouragement to the Work Study staff. *No Work Study Officer should be regarded as infallible or treated as if he were.* The application of Work Study is a team responsibility.

As mentioned previously, the number of Work Study staff required by an organization will vary widely, and it is wise, particularly in the initial stages, to *concentrate on the quality of the staff* rather than the quantity. The quantity can always be expanded as savings start to accumulate. It should, however, be remembered that some part of the Work Study staff must always be engaged on the maintenance of existing Work Study applications. The remainder will, of course, be available to break fresh ground, but this in turn will need maintenance. Managements have to be prepared, therefore, to adapt Work Study organizations to meet this continuing progress.

Many firms have found it beneficial to employ a consultant to help introduce Work Study in the early stages. This policy can have tremendous value in giving confidence to a new Work Study staff and in building up for all employees a knowledge of the true purpose of the activity. A reputable consultant can advise on the selection of the permanent staff and indeed sometimes arrange for their training.

The choice of the consulting firm is of very great importance, for only the most reputable are good enough: it is *far better to pay 10 per cent more and get 100 per cent better results.* In all countries today there are far too many small outfits promising splendid results which, all too late, they prove unable to produce. There should be no danger of disappointment from a well-established firm, who will have a reservoir of experience to draw upon.

To gain a complete understanding of Work Study one must *start from the top and work downwards.* It is a discipline of very great power, instilling in everyone's mind at all levels a restless urge to improve. The

managing director must be prepared, in spite of all his multifarious duties, to spend whatever time is necessary to ensure that his senior staff appreciate the importance of Work Study. He will thus ensure their support in its application throughout the company. He should also make it clear that, whatever the results, there will be no recriminations for anyone. This is particularly true in the initial stages. Success or failure can depend almost entirely upon the care and thoroughness with which this is done.

If possible all management should attend some form of appreciation course—say, three days for the most senior and up to two or three weeks for middle management. Supervisors should be included, so that they too have a clear understanding of the subject. Interest can be stimulated by visits to other companies who have already made use of Work Study and applied it properly, extensively and successfully. Free and open discussion must be encouraged at all levels. There is *nothing to hide in the application of the techniques.*

It is a wise policy to time the appreciation courses to coincide with the completion of the Work Study Officer's training course. He will then be equipped to run the courses if they are done internally with, perhaps, outside assistance. All who attend the courses must clearly understand the answers to the first questions about Work Study: *What is it?... How does it work?... What benefits does it bring?.. Whom does it affect?*

For the purposes of Work Study appreciation courses, managements can be conveniently divided into three groups: (*a*) directors and other senior executives; (*b*) executives at the middle level; (*c*) junior executives. Administration, sales and research should all be included, as they must be made aware of the role of Work Study in increasing productivity and thus be prepared to co-operate in its application.

The most highly organized industries tend to have the highest degree of trade unionism among their employees; and since trade unions exist to concern themselves with the hours and conditions, including financial conditions, governing the work of their members, it is natural that they should pay particular attention to any changes in those hours and conditions that are proposed by managements. That is why many firms go to great trouble to make sure that, at the outset of the application of Work Study, the trade unions are brought into the picture at the earliest possible moment. By 'earliest possible moment' is meant the first intention to apply Work Study.

In such consultations there must be no hesitation in discussing honestly all the problems involved, and the ways of overcoming them. Since the basic principle of Work Study is to find and state the facts, the same attitude must inspire discussion with the trade unions, otherwise there can be no real understanding or the building of permanent confidence. This is a stage which cannot be left out, or even shortened, and hence adequate time must be found for it.

Just as management has its problems in gaining understanding and confidence in the true purpose of its intentions in applying Work Study, so the progressive trade unions have similar problems. Many organizations now find it most rewarding to include the senior trade union officials in their training programmes. In the United Kingdom *the trade unions are now running their own Work Study courses.* They realize that Work Study can provide opportunities for higher earnings by strengthening the economy of the company concerned.

Work Study and the Higher Echelons

Maj Gen BD Kapur*

Normally work study is applied to the worker on the shop floor but *the term is equally applicable to the most exalted executive.* As a senior director of a large British Company said: "We now regard it as symbolising the analytical and progressive attitude of man which is mainly concerned with *making management better rather than getting the workman to work better*".

DURING MY RECENT VISIT to the UK, I spent a whole day in the Work Study School of the ICI Organisation. It has now become a normal practice in the ICI to put all their directors through the workstudy course. In fact, some of the officers earmarked for top management even spend a period as instructors on the workstudy courses. In the ICI work study is *as important on the shop floor as it is in the board room.*

It is common knowledge that in complex organisations, such as the higher echelons of a governmental machinery and the headquarters of major industrial corporations, the vastness of the organisation leads to complexity and delays in reaching decisions. "A large organisation may frustrate ability by its own complexity. The proportion of time taken by *liaison* grows until it promises to exclude creative work ; the size of organisation delays decisions and multiplies the occasions of frustration." Any major organisation which works on a set pattern of thinking tends to regard itself perfect and thereby clog its activities. It is only when an analytical study is made that its imperfections come to light.

Let us now examine the functions of management defined by Henri Fayol, the famous French industrialist, as related to the stages in the development of complex actions.

Stages	*Aspects of Management*
1 Investigation of a situation	Forecasting
2 Consideration of alternative courses of action	Planning
3 Selection of one among the alternatives that is decision	Commanding
4 Provision of the necessary facilities, both human and material	Organising
5 Communication to all concerned and ensuring that each understands his part in the whole	Coordinating
6 Inspection to ensure that action has taken place	Controlling

We may now examine as to how the top executive operates in carrying out these functions. Within the framework of policy laid down, in the decision-making machinery are involved the Chief Executive and the operatives and "communications" linking the two. The "communications" can misinterpret or delay decisions. To control the activities, a system of feed-back takes place which also provides information for a review of decisions or for future guidance. In fact

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a loop system operates whereby the orders of the Chief Executive are conveyed through the office organisation to the operative, and through his office organisation the feed-back takes place to the office organisation of the Chief Executive.

To explain this further, a similarity may be drawn with the radar control gun system whereby the radar tracking the target feeds information to the gun to be ranged on to the target and provides a correction factor for the gun to aim more accurately its next round of ammunition. Thus each feed-back improves the efficiency of the system. What I wish to emphasise is that the feed-back is the most important single factor in highlighting the shortcomings and thus regulating and controlling the activities of an organisation.

The present system, however, is so organised that the executive have hardly the time for digesting the feed-back. In regard to performance, in a survey carried out as to how top management spent their time, 5250 observations were taken and this was the result*

Talking	*Percent*		*Percent*
consultation	10.5	letter-writing	1.4
deciding	9.4	notes	2.7
discussion	6.2	reading	13.2
interviews	3.0	thinking	2.7
telephone	8.8		
dictating	3.7		
meetings	9.4		
luncheon discussions	14.3		
visits	14.7		
	80.0		20.0

It will be noticed from the above that 80 percent of the time is spent on communication and only 3 percent on thinking. Routine planning and decision-making is included in the process of communication but certainly for creative planning separate time period is required. As is well known, the main responsibility of top management is to *forecast and to plan*. Feed-back is necessary for accurate forecasting and effective planning. Feed-back is not something which takes place automatically. It has to be ferretted out by top management and yet it is the only way to controlling the effort and for correcting the mistakes likely to have been made.

* Work Sampling by Bertrand, L. Hansen.

I would now like to dwell on the decision-making machinery. In a decision-making machinery the following principles of management need examination: span of control, the degree of centralisation and delegation of authority, line and staff relationship, the place of the specialist or adviser, group relationship and cross relationship.

Of these the span of control is the most important factor. "..administrative efficiency is enhanced by keeping at a minimum the number of organisational levels through which the matter must pass before it is acted upon." This statement is well understood and yet *the number of levels is on an increasing scale* most of the intermediaries either acting as stopping stations or bottlenecks or more post offices. On the other hand, the space of control tends to centralise authority with obvious disadvantages and delays, and accept the consequences of overload. Therefore both the span of control and the chain of control in the decision-making machinery need constant watch if efficiency of top management is to be maintained.

Delegation of authority is not only a means of quickening decisions but of relieving top management of unnecessary load. Yet there is a tendency to centralise authority in the top man thereby leading to a dissolution of responsibility of senior staffs. Consequently decisions are delayed and never made in time.

A slogan of a major American Company reads as follows:

> "To LOOK is one thing....To SEE what you look at is another....To UNDERSTAND what you see is a

third...To LEARN from what you understand is still something else but... To ACT on what you learn is all that really matters, is'nt it ? "

To conclude from above, the areas of work study in the field of top management are various and diverse. For example : (1) examination of the decision-making machinery (2) the organisation and efficiency of the offices which operate between the top executive and the operative. (3) the system of feed-back of information. It is a cross check on the decisions made and a basis for future decisions—thus a means of self-correcting errors. (4) the efficiency of communications.

The above areas of work study could apply equally to any major plan or organisation. Take for example, our plan projects. The Five Year Plans aim at an optimum utilisation of resources and the execution of plans with economy and efficiency. A case study on the formulation or any new plan such as the building of a multi-purpose dam or the raising of a processing factory or an engineering factory, could form an excellent basis for a work study on industrial management. Further the statement of Third Five Year Plan has brought out the failures that have taken place in the Second Five Year Plan. An examination of the decision-making machinery involved in those failures could provide an excellent basis for a thorough overhaul of both the basis of planning and the means of implementing the plans.

In conclusion I may say that firstly, study can only be carried out where there is work, and by work I mean effective work. Secondly, as Mr. Currie has stated in his Book on Work Study *the tendency is to apply work study on someone else and not on oneself.* In fact, it is best to start with work study with the top management itself. The advantages are obvious : relief in the load of work, quicker decision-making machinery and better control.

FARRELL: (Mkt) Well, Mr Pence, the bad weather we had all over the East really affected sales. I hope you called this to the Board's attention.

PENCE : (Pres) You can rest assured, Art, we'll see that at least it gets into our publicity release, but I'm not sure the Board wholly accepted bad weather as having caused all of our problems for the past year. I did bring it up—and MacLachlan (oldest Board member) gave me his well-known over-the-glasses look and said, "Tom, we appreciate the weather report, but are we to assume that more rain fell on our customers than on those of our competitors?"

What's New in Work Study

JOSEPH E. FARADAY*

The subject of Work Study is certainly one that is in 'the news' and articles on it are now appearing very frequently in the columns of the technical and also the national press. This is due in part to the rapidly expanding application of these very successful management techniques and to the fact that the subject itself is a dynamic one. The basic nature of the techniques that go under the label Work Study is such that they are constantly being applied in entirely new fields. In the last few years, for instance, the application has been made to such novel fields as the design of a research laboratory, the design of a mortuary, debudding, chrysanthemums, making beds, the servicing of an aircraft, a church warden's duties, among many others. It may be useful to highlight here a few of the recent developments which are carrying modern Work Study far beyond the primitive techniques with which it is often confused.

THE SUBJECT OF WORK MEASUREMENT HAS been taking on a "new look" in the last year or two. It is well known that in the last decade the founder technique of time study has been supplemented by Predetermined Motion Time Systems (PMTS), which is now being applied to any kind of repetitive work. In the same period also, in the sphere of non-repetitive work such as engineering maintenance and construction, Work Measurement has been introduced and is becoming widely used through data based on time study and PMTS supplemented by Analytical Estimating.

The usual practice in the use of these techniques has been to start to use them in an organisation to measure specific jobs and to continue in this way. This means that after a number of years many of the elements in jobs, being identical with elements in other jobs, have been measured over and over again. This is particularly the case in the *periodic checking of work values* that is so important in Work Measurement. Experience has shown that the particular ways of doing jobs seldom remain quite the same over periods of time and that the original value will tend to become more and more inaccurate as a measure of the amount of work now in the job. In consequence the job has to be remeasured at intervals. However, only some of the elements will have changed and those that have not, are repeatedly measured in the checks.

In the spirit of 'Healer heal thyself', therefore, there has been a development to try and eliminate this possibly wasteful practice of repeated measurement of identical elements. The modern trend is to design Work Measurement programmes to yield—in addition to the Work Measurement of the job for which the study is primarily undertaken—as many values for individual elements as are likely to recur in other jobs as possible. This does require a probably fuller description of the element than may be usual in the traditional type of Work Measurement practice and in particular the breakpoints from element to element must be carefully recorded.

When this new development has been adopted the practice of Work Measurement

*Associate of Russel M. Currie, Dr. Faraday played a substantial part in the big development of Work Study in the last decade. This article is printed by the courtesy of the ICI & Works Management

becomes the process of breaking the job down into the elements—as always—consulting the manuals of records for the values of as many of the elements as possible, and then and only then measuring only those elements for which there is no previously established and recorded value. The proportion of elements which have to be measured will tend to fall with time and very considerable economies in Work Study effort become possible.

Naturally very important features of this development are the manuals recording the values of the elements and an indexing system whereby they can be found with the minimum of effort on the part of the Work Study Officer. The values are useless unless readily accessible. Considerable thought must therefore be given to the filing and finding system employed. On any small plant with few operations the Work Measurement original documents themselves will form the records, but as the field of application extends so the system must extend and in the large organisation the efficiency of the recording system becomes vital.

While the system has obviously developed in individual organisations it is a simple step to visualise it extending between organisations and it may be that the day is not very far distant when such Work Measurement Synthetic Data—as these values are called—may become generally available to the country as a whole. This in fact may be the next significant step in Work Measurement.

While *financial incentive schemes are of course not part of Work Study* but one out of many management applications of the techniques, Work Study is vitally interested in the field of incentives. The problem that has emerged in the last year or two is the need for reconciliation of the situation arising from the quantitative factual presentation of Work Study results and the human problems thereby created, with the essentially humanistic philosophy of Work Study itself. The techniques reveal in many industrial operations that work loads vary from time to time and so therefore does the effort required of workers and in consequence, too, the amount of their incentive payment. But this, while scientifically justifiable, can be regarded as sociologically inequitable as a worker could be regarded as being entitled to a reasonably steady wage.

The ideal solution would be for all work loads through perfect planning to be ideal and identical—which is quite impossible in human affairs. However, the social conscience does manifest itself in attempts to adopt a wage structure whereby the incentive part of the wage is consolidated with the basic wage and is offered as a fixed weekly wage in return for a prescribed performance—also at incentive level. It will be noted that Work Measurement remains the basis of the assessment of work load. "Measured Day Work" or "High Task" are two names that have been given to such systems and managements in general will watch the results with great interest.

The fear that has been expressed is that the performance in spite of active and effective supervision will not remain at the prescribed level and what evidence there is tends on balance to support this view. Admittedly the fall in some cases may be slight, but such systems have not been in operation for very long. Again there is the problem of the action management takes if the incentive level of performance is not maintained. The ultimate sanction is "fire" and it may be extremely difficult to use effectively another sanction short of this return to "jungle law". Those firms who have introduced this system, particularly where production is not machine controlled, may be pioneering in difficult fields and may yet have cause to regret dropping their previous systems of a fluctuating incentive scheme.

However, the most exciting new developments are in the field of the application of the Work Study techniques, particularly *the stimulating discipline of critical examination, to project work at the formative stage.* This has developed logically from the application in the conventional fields. Study of a single

job by a man at his workplace, such as a man and his drill, led to a consideration of the layout of the whole workshop—to the question: "Was the workshop necessary at all?" Attention to a process worker and how he filled sacks led back to the process and its purpose.

And so today it has been proved beyond all doubt that *in new capital projects the Work Study techniques can play a vital part in economising capital* whether it is to be spent on a workshop, a hospital, a submarine or an office block. The only way to see that the almost dramatic savings available can be obtained is for all those concerned with the project, from research workers to the clerk of works, to have a proper appreciation of the disciplined thinking provided by the techniques and for a highly trained Work Study man to be available for specialised application throughout the project and, in large projects, attached to the same project team.

The techniques have to be applied at various scales and for convenience broad terms such as "Overall Assessment", "Coarse Scale" and "Fine Scale" have come into use. At each of these scales the rigorous questioning sequence of the Method Study Critical Examination is followed intensively and a complete record is made on the Critical Examination Sheet. This means that confidence can be felt that no practicable—or at first sight impracticable—alternative has been overlooked. As an example, the stage of "Overall Assessment" might embrace such matters as selection of site, availability of all raw materials and services, choice of product, manufacturing route, specification and the like.

Those responsible for the project have now to evaluate all the alternatives postulated, and a significant part of the success in this would depend on their technical abilities. Work Study can powerfully supplement their skill, but it can never be a substitute for that skill.

The principal charting technique at this stage bears some resemblance in appearance to a Method Study chart carrying only the "operation" symbol. The symbols refer to activities on a large scale however, e.g., "pour foundations", "test boiler", "purify", and so on, rather than the more usual "pick up spanner" or "fill bottle", etc. This initial stage of charting records the whole process and the stages are evaluated always with costing firmly applied, *the economic facts being the final arbitrators.* In this part of the study questions may be thrown up that can be answered only by initiating further research work and practical experimental tests.

The Method Study techniques have been applied successfully as described above to widely diverse projects such as canteens, machine shops, piggeries, bridges and chemical plants. It has been a common experience that if those responsible for the project work on these lines, the time required to bring the design to the best in the circumstances is shortened, because the investigations are undertaken concurrently rather than consecutively and constantly recurring late changes are reduced to a minimum.

Some idea of the savings that may be obtained over the first ideas about a project can be given from the case of a saving over 30% on a million-pound project, and from a dozen others of savings ranging from between 22 and 64%. There is one case of a new material which was to be made by a new process where the capital cost was reduced to £115,000 in comparison with the £220,000 which was originally believed would be required based on normal traditional methods. Here, surely, is *organised common sense on the grand scale.*

Finally, there is one topic that has been occupying Work Study people more than any other over the past twelve months, and this is the British Standard Glossary of Terms in Work Study. In view of the way in which the subject developed it is not really surprising that different terminologies came into use over the years. Work Study people attempted to practice what they preached when they asked the British Standards Institution to set up a committee to produce a British Standard Glossary. The task took longer than was expected and the Glossary

finally appeared in October, 1959. It aroused very great interest—indeed, over 15,000 copies have been sold throughout the world—chiefly because of its courage, for while endorsing a great many terms in common use it chose for some other concepts not the system in commonest use, or even second commonest use, but the most logical and economic in operation. The principal points, where this courage was shown, are in the selection of the 0-100 scale for Rating and for Performance and for the presentation of the results of Work Measurement to be made at the standard or "incentive" level.

As the techniques developed, for historical reasons which were not very logical the numerical scales 0-60-80 and 0-100-133 came into use where the standard or optimum figure is represented 80 or 133. It surely cannot be disputed that the most logical value for this is 100 and this the Glossary has had the courage to select. Admittedly to change means inconvenience, but this is merely a small price to pay for the subject to be on the logical basis for the rest of time. Would that the Government Commission which investigated the merits of the metric system in 1834 had had the same courage. Today all inconveniences of the change would be long forgotten and we should all be enjoying the benefits—whereas we are still timidly arguing about a decimal system for coinage as the first step.

What has been quite a study for students of human behaviour has been the reaction to the Glossary of many of those apostles of better methods—Work Study Officers. The number of Work Study men who have produced every conceivable argument for not changing to the Glossary is a fascinating study. They behave in exactly the same way as the recalcitrant managements they so often castigate for not willingly accepting the changes proposed by the Work Study people. Indeed, they reinforce the theory that human beings do not like change and prove once again the old adage "*There's nowt so queer as folk*".

REAL PRODUCTIVITY !

There was a chewing-gum firm in New York which used artificial flavours instead of real fruit flavours. This fact became known to the public and sales dropped off. Then suddenly huge advertisements appeared: "X—the only chewing-gum made with Real ARTIFICIAL flavour." People's imagination was caught and few would look at any other chewing-gum now.

Work Study in the Social Perspective

HD SHOURIE*

The productivity drive in India essentially means the compression in a period, say of 10 to 25 years, of the rich and varied experience of developed economies in the processes of technological development. But the same experience teaches us that unless we are able to make this new technology an acceptable part of current social experience, we shall get, alongside rapid industrial development, the misery and wastefulness, in a compounded way, of the Industrial Revolution. A social understanding therefore of productivity, its techniques and implications is essential to the success of the productivity drive itself.

THE MODERN CONCEPT OF PRODUCTIVITY IS that it is an integral part of the operative philosophy of the whole social economy. We have to make productivity a working concept, an essential part of the mechanism of the Welfare State. More than half the game will have been won, if the leaders of the State for example come to feel that the Welfare State is realisable only through the application of productivity techniques not only to industrial processes but to the entire range of social activity.

One of the happiest signs of modern India is that such a realisation is actively present in the very heart of Government: there is a work study cell in the Ministry of Finance itself and it has been working fruitfully at the ground level for several years. Work study is beginning to permeate within the Ministry of Defence itself. In fact from the point of view of social change, the introduction of work study in the Ministry of Defence is both interesting as well as significant. When the NPC invited Mr. Russell M. Currie, the Work Study expert of the ICI, he brought with him an exhortation from Lord Mountbatten for the introduction of work study techniques in various spheres of India's economy. There was ready acceptance of the idea in the Ministry of Defence among others, with the result that the technique of work study has started permeating the whole defence system.

It is thus obvious that we are treading a ground of infinite possibilities, and if we can convince the people that productivity is the most powerful instrument for their own welfare, the resources that now go into selling the idea could be more productively employed elsewhere. We shall therefore define productivity not in a mathematical or mechanistic sense, but in terms of welfare. We shall define productivity as the most efficient conversion of resources into goods and services that sustain life and make it every moment more enjoyable than it was. Putting this in a somewhat padestrian manner, productivity means the production with available resources of as large a quantity of goods and services as is necessary to fulfil physical and cultural requirements and aspirations of the whole community. Thus productivity becomes a need-based community idea.

Once it becomes a community idea, we will all be interested in making the

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resources go as long a way as we can make it; for if we can produce the goods and services that we want with less and less resources, more resources are automatically released for the enjoyment of life and the development of culture and civilisation. In fact the two processes become interacting. Such a phenomenon is in fact right before our eyes both in the capitalist and also in the communist countries: rising living standards, greater security against external aggression alongside more leisure, more books, more knowledge, more theatres, more and higher flights into space !

It is productivity that makes all this possible. But as said before, unless our people feel that it is their own technique to be used for their own welfare, they will not employ it; in fact they will resist it. Why should people agree to the reduction of work content, if it means either less employment or an increase in the work load? *We have to make it clear that it surely does not mean anything of the sort.*

Here it is that we in the productivity movement must look at affairs with a long social perspective. Labour—in fact we all are labourers—has a dual role in the production process. It is a resource that produces other resources and along with other resources, it constitutes the base of all productivity; but it is at the same time the enjoyer of the products of all resource—application. Reduction therefore in the quantum of labour applied in a given process can only be socially purposive, if the fruits of that economy are equitably transferred to the working class; and economising of the labour content would be self-defeating if it means unemployment and loss of income. We are interested in the economising of labour because we think it in the social interest to employ the economised labour in channels more productive from the point of view of the community; or we want to produce more leisure so that the people should have the time and the opportunity to enjoy life and the fruits of their work. It should therefore be laid down in the firmest and clearest possible language that work study including work measurement is intended either to make labour available for more productive employment or to make it less irksome, less fatiguing or less time-consuming. It is therefore a reduction in work load that is the social objective of work study. Leaders of society, of industry, of the working class, who understand Work Study in any other sense because of bad practices elsewhere or even in our own country, need to be reorientated in this true meaning and significance of Work Study.

THE FRUITS OF WORK STUDY

An American car is as big as a railway engine. There is a radio set in every car, cigar lighter, electric heater, air conditioner, a set of openly placed and hidden lights, nylon seat covers, electrically operated windows and convertible seats which may be used as beds. Now they are experimenting with a view to introducing running hot and cold water baths and a foot-bath for the driver for hot days, an elevator and a crane to save passengers from the fatigue of using their own feet when getting in and out. In spite of all these devices and gadgets, they still find a cute way of placing the engine somewhere.

A Brief on Work Study

K PENNATHUR*

What is Work Study ? There are two extremes of answers that you could come across. One is that it is nothing but plain and simple commonsense. The other is that it is a mystic art left to the specialist in that field. Both versions are exaggerated and the answer lies on a practical plane in between these two extremes. Basically, *Work Study is designed to bring out How Much Better a job could be done rather than show up how badly it is being done.* The task of finding a better method is termed as Work Study. Any approach to a problem has to be methodical and logical. Work Study is no exception. Hence certain set techniques of approach are laid down for the pursuit of Work Study. These are merely designed to lead you step by step in a logical, methodical and thorough manner to the evolution of the best method of doing a certain task. The ultimate aim of any Work Study is the most economical use of resources in performing a given task. We should now be ready to face a definition of Work Study.

WORK STUDY MAY BE DEFINED as one of the management techniques which can be applied to achieve the optimum use of the resources available to an establishment for the accomplishment of the work it is engaged in. Work Study gives us the best method. We find out the best method available to the wife to get ready quickly. But, for various reasons, we would like to know how long this 'best' method takes. This will help us to compare it with the existing method. We can hold it as a target for the wife for

*COL. Pennathur's personal account of how he came to Work Study makes interesting reading: "My enthusiasm for the management science of Work Study had been *wholly and solely motivated by my wife.* In years of married life, we had never been on time for any social function or party. It was immaterial who the hosts were ; some were cabinet ministers and some commercial magnates ; some were senior generals and some serving colleagues. They were all honoured with the same equitable privilege : of receiving us last in their party This went on quite steadily for years until one fine day I realised that we had not been invited to any parties for the last four months. It was apparent that our late-coming had, at long last, managed to get the goat of our entire social circle.... The solution to the problem was not all that simple. Let me take a typical example. General and Mrs..... had on 10 July invited us for a dinner on 24 July at 830 p.m. We had a clear 14 days' notice.. On 24 July at 7 pm my dress suit was laid out by my faithful bearer. My madam was playing rummy with her friends in our lounge. The crowd dispersed at 730 pm. My lady came in and after a frantic 15 minute rummaging of her wardrobe, she came to me with a hanger of *saree* and blouse in each hand. I was then tying on my bow. "Darling !" She asked sweetly "which *saree* shall I wear ? The eau-de-nil or the damask rose ?" I am a patient sort of a bloke. I said "wear the Damask Rose". She was not satisfied. "But, darling, you haven't even looked at the two *sarees.*" I turned round, examined the two specimens and returned the verdict of eau-de-nil. It was 750 pm. Five minutes later, there was a hectic activity of *chappals* being thrown all over in the box-room. This was a very familiar noise. This meant that the wife was searching for a pair of *chappals* to match the saree. At 755 pm, she came to me and said "I must wear the damask rose after all. I cannot find the *chappals* to match the eau-de-nil." At 805 pm another calamity descended on us. This time, the matching handbag could not be located. It was a question of either foregoing the handbag or choosing a different outfit. At 820 pm, it was finally decided that a french beige outfit was the most suitable since the matching appurtenances were also readily available. At 835 pm the Old Lady went for her bath. As an exist line she asked me to have the blouse pressed since it was crumpled at the left sleeve.... The rest was routine stuff. She came out of the bath at 850 pm left the dressing table at 935 pm and, after spending 5 minutes in the garden trying to get a matching flower, got into the car.... We reached the General's place at 957 pm with two chalans for overspeeding to my credit. Every cloud has its silver lining. We were just in time for the pudding !..... *After brooding over the problem for quite a while, I came to the conclusion that Work Study was the cure for my ills.*

future 'getting ready' operations. In any case, it is necessary that the work involved be measured.

Work Study can be applied to any task. It can be used to improve the production line of armoured fighting vehicles and it can be used to improve the domestic efficiency in your own home so that your wife has time to go out for walks with you.

The process of Work Study *should not* cost much. The improvements effected as a result of Work Study *need not* cost much either. Invariably any capital outlay required to implement a Work Study report should be reimbursed by the savings achieved within a reasonably short period of time, generally not exceeding two years. It is worthy of note that most of the Work Studies require very little investment of capital outlay and produce startling savings within a short while (sometimes, almost immediately).

Till one gets initiated into the technique of Work Study, one is apt to have preconceived notions of the scope and utility of Work Study. The engineers' apathy to Work Study probably emanates from the same source as the army officers' attitude to military appreciations.

Before we delve deeply into the technique of Work Study, I feel compelled to sound a strong note of caution. A slavish (thoughtless ?) imitation of Western ideas on Work Study might sometimes prove completely impracticable in India, if not disastrous. The main reason for this is that the cost of labour in western countries is very high. In England, the cost of direct labour works out to approximately 15sh per manhour, inclusive of overhead. (The lowest figure is 12/6d and the highest 17/6d). This is equivalent of an average of Rs. 10/- per manhour. In India, it would be in the region of Rs. 2.50 per direct industrial labour manhour (inclusive of all overheads). Thus the cost of labour in India is one fourth (and often less) of the cost of equivalent labour in the UK.

Assuming the cost of a labour saving device to be the same in India and in the UK (which is not the case), it will take us at least 4 times the period of time it will take a concern in the UK to make up its capital investment cost. Hence if a firm in the UK invests in a fork lift truck and makes up the cost of the truck in one year by savings effected on the wages of labourers, it will take a firm in India 4 years to make up the same capital cost. This '4 years' is an under-estimate since the ratio between the wages of a labourer in the two countries is much more than the figure 4.

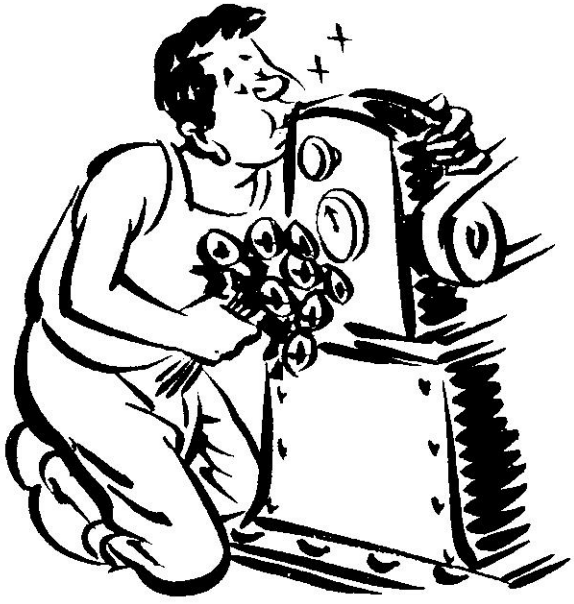
Now, let us take up the question of cost of capital equipment. Most of the modern equipment and machinery have to be imported for some appreciable time to come. Payment of the price in foreign exchange, the cost of transportation and insurance, the cost of export and import duties and allied factors render the price of the equipment atleast 50% more in India than it would cost a firm abroad. All this is subject to the proviso that the requisite foreign exchange is available. For utilising the same equipment, the management in this country have to invest 50 per cent more capital than a British firm would. Obviously, the time taken by us to recover the capital cost is going to increase by a further factor of 50 percent. Thus, taking the relative labour cost into consideration, it will take us 6 years to repay the capital investment on an equipment when it would take only one year for an industrial establishment in a western country.

One has therefore to be very cautious in reading the results of Work Study effort in western countries. Does that mean that we discard Work Study ? That would be stupid, for the obvious reason that work study does not necessarily point to large capital investments. What it does mean is that we should concentrate principally on two types of studies: (a) Quick studies likely to produce big returns ; (b) Studies (both

short and long term) affecting the workshop's principal commitments where installation of improved methods will not involve major new equipment or extensive projects.

Except in factories carrying out mass-scale production, cutting down one minute from a work that normally takes one hour should occupy the last place in your list of priorities. Stores and spares (especially those imported from abroad) cost a lot of money and it is in this field that a lot more can be achieved. A certain workshop in Germany work-studied the operations on bogie wheels. After a considerable work study effort they reduced the timing from 50 manhours to 40 manhours per set. Saving of 10 manhours per tank is nothing to scoff at. But their subsequent work proved more interesting. In the course of their studies they noticed that 92 percent of the bogie wheels were condemned and new ones drawn. They tracked the reason down to the fact of unnecessary high inspection standards prescribed for another type of vehicle. The standards were correct in relation to the latter type but were too rigid and even farcical in the case of the first type. A review of the inspection standards was carried out by a high-power committee. The result was that only 32 percent are being condemned now: a saving of 14 bogie wheels per tank.

By heritage we set a lot of store by human values. To most of us, a worker is another creation of God, just as important to Him as we are. So we would naturally be interested in studies that cut down unnecessary fatigue of workmen, create better conditions of work and infuse in the worker an enthusiasm for work. *A cheerful, enthusiastic and willing operative, with an affectionate regard for the establishment in which he is working, is a much greater asset to us than a fabulous automatic packing machine.*



Work study or work love?

Application of Work Study

DULEEP SINGH*

Fundamentally, we are all interested in the end result. We would like to see things done. We would do things that we easily can, within given resources. How things shall be done, is for most of us a matter of detail. After all, why should we bother? Aren't we giving them the things they need? If they want more, let them give us at least our rockbottom requirements of additional men, machines and materials. *How do they expect us to produce something out of nothing? Further, who are they to judge* whether we can produce more or not; we are the technical people; we work on the floor amidst dirt, smoke, fumes and what not; we know the story of blood, sweat and tears that goes around here all the time.....We have heard people say that means are as important as the ends but that applies to ethics. As far as we are concerned: "Ends we throw in the scrapbin and means are only the statistician's last hope of existence." While this is the story of most of us, there are a few—the coterie of work study fellows—to whom *ends are only the measure of the efficiency of the means.*

WORK STUDY IS NOT THE OUTCOME OF the other day. It has been the weapon of attack ever since man first fell in the pursuit of harnessing the forces of nature for his survival and happiness. It is the tool that has brought about the various inventions and discoveries on which our civilization is based. Work Study is only the art of creative and objective thinking about the things around us which make working a fruitful pursuit and living a joy.

The only difference between the present and the past, in respect of work study, is that while in the past, work study techniques were evolved as a result of the application of genius to the mechanics of industry, work study is now a technique to make life productive at all levels. "Once we had to wait for the accidental appearance of Edisons and Wrights. Now through education and organized effort in a laboratory or experimental shop we get something approaching the same results from much more common clay."*

Work Study now enables every one to accomplish at his own level, and continuously, what could only be accomplished at one time by genius and by chance; and statistically this is a lot more significant than the casual work of genius; for *if millions of people in millions of minutes 'work study' what they are doing in the ordinary course of life, we have a* MULTIPLIER *effect of almost nuclear proportions.*

Thus work study enables the common man to do for himself what the few gifted and the talented did for mankind in the past. In fact the whole objective of work study is to bridge the gap between the common and the gifted: to enable the common man to have an understanding of his own work and

* Training Director, NPC.

* John Kenneth Galbraith, The Liberal Hour.

through that understanding, to simplify and to enjoy it.

In its true sense, Work Study is the study of work in all its aspects. Work involves expenditure of energy and work study is a deliberate, systematic process of acquiring and analysing information with regard to the expenditure of energy. The idea is to so design work, methods, procedures and mechanisms and to so regulate the expenditure of energy that the ends in view are achieved in the minimum amount of time and with the least amount of strain and with the smallest possible consumption of materials and other resources. Thus Work Study fits in admirably as a major tool of a welfare society such as the one we are trying to build in this country.

Against the background of this analysis, we may now consider the issues involved: i) what types of goods and services should be produced so that they may best achieve the objective in view, namely, to contribute to the welfare and happiness of the community; ii) how to produce these goods and services with the least possible consumption of real resources or expenditure of energy; and iii) what is most important, how to give a momentum to this economic system so that at all times the required goods and services are always produced with the least consumption of real resources. This means *in-building work study into the economic system.*

Work Study in fact is concerned in a broad sense with all the issues stated in the preceding paragraph. It applies to the first step equally well, namely, the decision to produce certain types of goods and services because it is at that step that the community commits its resources. The second step, namely, the production of goods and services with the minimum possible consumption of real resources comes very clearly within the sphere of work study. This may be broken up into five factors: the basic process, the equipment, the raw material, the operation, and the service facilities required. Though in a limited technical sense, work study is concerned with operations, these cannot be studied in isolation as all the factors are really, complexly inter-related. The basic process governs the equipment, as also the raw materials and all these together determine the nature and magnitude of operations and service facilities. On the other hand the basic process, the equipment and the material govern the nature and amount of energy to be consumed. Work Study is entitled to open up entirely the very basis of the technical conditions imposed by the product, the basic process, the equipment and the material. Thus work study applies to all the five factors, the basic process, the equipment, the raw material, the operations, and the service facilities. In fact the whole of it involves planning and control and the establishment of reasonably accurate standards of expenditure of energy.

In brief, work study involves the study of expenditure of energy in every form and for every purpose. The objective essentially is to achieve, continuously, a *progressive economising of real resources.*

It has been said that work study has only physical application, that it cannot be applied for example to mental effort. This is not correct for two reasons: one, most mental effort is translatable directly or indirectly into physical terms, secondly, work study techniques are now so evolved as to make self-work study possible. It is true that certain kinds of mental effort cannot be studied by work study experts; but if a man is so inclined, he can make a work study of his own mental effort. It of course involves a degree of conscientiousness and integrity which is rare, but it is only at the very rare level that it is

difficult to measure mental effort. Hence we are likely to find a coincidence of self-work study being possible in cases of unusual types of mental effort.

What is more significant, work study knows no time bar. It is true that a study of the past will not improve the past but it certainly will enable us to understand and improve the present and the future. It is with regard to the future, that is at the planning stage that work study can be most fruitful. It would enable us to avoid mistakes which if once built into a system are usually very costly, often difficult, if not impossible to eliminate. It is really at the pre-production stage that we build in most of the inefficiencies and unnecessary costs. Conversely, therefore, it is at the planning stage that we can really make improvements with far reaching consequences in terms of real social costs.

In elaboration of his thesis on Work Study the author has furnished the editor with the following elaboration of his ideas on Productivity.

Productivity is a rather subtle concept ; and the many definitions and approaches that have been developed in recent years have instead of clarifying resulted in a good deal of confusion regarding the basic nature of Productivity. It is necessary in the social interest to rip open this shell of confusion, regarding an idea of potential application to every aspect of individual and social life. To put this confusion on the cards, one has only to recall the many conflicting ways in which productivity is expressed : higher output for given resources : less resources for a given output : harder work ; larger output per man hour ; tightening of belts ; better quality : easier work ; reduction in working hours ; higher wages ; lower prices etc. While all these definitions are meaningful each in its own appropriate specific context, taken together they only serve to create an incredible degree of confusion not only in the minds of the common man, but also the maker of policy, for these various aspects of productivity are apparently, mutually self-cancelling and in any case serve to put the whole problem of productivity out of focus. We may, therefore, attempt a clear and unequivocal definition of productivity ; Productivity means the conversion of resources into such goods and services as are needed for sustaining and enjoying life. More useful, lasting and enjoyable the produced goods and services, higher is the productivity of that economic group. The rest of the truisms such as the economising of resources, reduction in real costs and prices are only corollary to the basic proposition stated above. It follows from this definition that a community with a large volume of unemployment, idle machines, untapped natural resources cannot be called a productive society, however efficient be the men and women employed on jobs.

We may now think out various ways of increasing productivity in the manner defined above. The following list, though not necessarily comprehensive is as good as can be worked out, thinking along the lines elaborated above.

A. **Labour Productivity :** (1) Achieving higher labour performance while working within the given technical conditions (2) workers working more skillfully to reduce rejects and to make more efficient utilisation of other resources (3) workers working productively for a greater proportion of time (4) reducing the work content of a job by modifying the product design, eliminating unnecessary activities, rearranging or combining necessary activities, improving the material and rationalising the quality standards (5) increasing the proportion of workers on productive work. B. **Material Productivity :** (1) converting material into such goods as may add higher value to it. (2) substituting improved types or sizes of materials (3) reducing waste of material (4) reclaiming higher proportion of waste. (5) producing useful by-products. (6) reducing consumption of indirect material. C. **Equipment Productivity :** (1) Reducing process time of machine by improving the process or equipment design, eliminating un-necessary activities, rearranging or combining the necessary activities and (3) modifying the material. (2) reducing the idle time of machine and running it for greater proportion of time utilising the full capacity of machines and equipment (4) using a machine for manufacturing such products as will gain most value from its operation. D. **Power and Fuel Productivity :** (1) Improving power and fuel efficiency of machines (2) reducing the transmission and idle running losses. (3) using such sources for generating power as to produce it with least consumption of real resources. E. **Capital Productivity :** (1) Reducing carrying cost of materials including work in process and finished goods inventory (2) reducing maintenance cost of fixed assets (3) increasing life expectancy of fixed assets (4) making fuller use of fixed assets (5) investing capital into more productive ventures (6) increasing circulating—capital flow speed.

A critical analysis of the above ways of increasing productivity reveals that basically the problem of increasing productivity falls under the following heads: (*i*) designing goods or services that have higher utility and which can be manufactured or provided with ease. Or in other words the product design should be such as the product can be manufactured with least amount of *work* (expenditure of energy). (*ii*) developing such basic new process or adopting such an existing process as can manufacture the desired product by involving least amount of *work* (expenditure of energy), time and expenditure of other resources. (*iii*) Developing and/or installing such modern and higher capacity plant as can manufacture the desired product by involving least amount of *work* (expenditure of energy), time and expenditure of other resources, in both operation and maintenance. (*iv*) developing or using such materials for the manufacture of the desired product as involve least amount of *work* (expenditure of energy), enhance the utility of the product, result in least wastage and are purchased at most economic prices. (*v*) reducing the *work* content of the process. (*vi*) reducing all forms of wastage of resources such as ineffective time (the period when no *productive work* is done) of plants and operatives, rejects, material scrap, power losses, etc.

All these are direct ways of increasing productivity. It will be observed that the two most important common ways of increasing productivity in the above list are *reducing the amount of work to be performed and reducing all forms of wastage.* In order to study the various means of reducing the work and wastage it will first be necessary to examine the sources that generate work and wastage. The important work and wastage generating sources are the product design, the process, the method within a given process, the equipment the material, the skill and will of men and the system. In other words, the amount of work to be performed and the amount of wastage inherent in the manufacture of any product is determined by the design of the product, the process of manufacture, the methods adopted, the types of machines and equipment employed, the type and form of material used, the skill and will of men employed and the systems adopted. There are, obviously, therefore, three major means of reducing work and wastage namely: (*i*) Developing new products process or machines and equipment, materials and skills (*ii*) using the best available product design, process, plant, materials, skills and systems. (*iii*) improving the existing product design methods, plant, skills and systems.

The item (*i*) above involves basic and applied research such as Product Development and Market Research for developing new products, process research for developing new processes, metallurgical research for developing new metals etc. These, obviously entail very high initial costs and considerably long time before results can be achieved. The results achieved through these means are, however, very high and have no obvious limit. The means covered in items (*ii*) and (*iii*) entail organised studies involving systematic analysis and critical examination of facts. The group of techniques employed for these studies is termed " Work Study " and rightly so because here, we are mainly studying the work, that is the expenditure of energy, and the work generating sources. These studies entail little, and frequently no capital expenditure. The results are achieved almost as soon as the studies are completed, for the recommendations of such studies are easy to implement. This is mainly because the implementation of these recommendations is generally within the competence, authority and control of the local management and quite often of the lower levels of management. The extent of improvements effected by Work Study, although limited as compared to improvements due to Research, is more frequently of a very high, order. Basically, Work Study succeeds not because it is used by geniouses or is a miraculous or a magic technique but because there exists everywhere for various reasons, a considerable scope for effecting improvements. The main reasons are: (*i*) the non-recognition of the fact that work is an undesirable element in industry. (*ii*) the selection of work generating sources primarily on the basis of considerations other than those of work involvement. For instance, a particular product design may be selected on the basis of its functional efficiency or marketability alone, without giving due consideration to ease of manufacture or amount of work involved in manufacturing it. (*iii*) the motivation prevailing or the value of success: largely the motivation in industry is to accomplish a job, no matter how and at what cost it is accomplished so long as the product can be sold at that price. Success is judged mainly by the end-results and not the means. (*iv*) lack of appreciation of the ultimate objective: the final product is made of efforts of several people of various levels of intelligence, skill and competence under varying circumstances. Each of these people normally have different immediate objectives. These objectives are not blended in the right proportions to achieve the ultimate objective, as is usually the case, then the final outcome will obviously be far from the optimum. (*v*) lack of flexibility and sense of review: production in fact is a victory over many hurdles and problems. Each of these hurdles and problems are generally solved to the best of ability to suit the circumstances then existing or prevailing, restrictions and pressures. It is seldom realised that the *circumstances and conditions change with time,* with the result that solutions to problems which were once the best no longer remain so. *As time passes by, the old decisions become less and less efficient and productive.* If the facilities are not flexible and if the decisions, methods and systems are not reviewed periodically, inefficiencies creep in and amount day by day. Our *calf path* mentality comes in the way of achieving our productive possibilities.

Some Applications of Method Study

LR GOSAIN*

Method Study has been used for sometime now, in almost all industrially advanced countries, with greatly rewarding results towards increasing productivity. Its application in India, however, is still very limited and sceptics put forward more difficulties than results. The author, from his own practical experience, has given a balanced picture of difficulties experienced, ways and means of overcoming them, and by a few good illustrative case studies shown the actual results achieved and the potential of Method Study for increasing productivity.

IT WAS FIVE YEARS AGO, we (a young American methods engineer and myself) had just completed a visit of an American manufacturing plant. It buzzed with intense methodical activity and a small labour force produced a very large quantity of quality goods. The productivity of the plant was almost staggering in comparison to Indian standards. The young methods Engineer explained, "The plant production has almost been doubled during the last two years and the cost per unit reduced considerably." "How? by mechanisation? by automation?" I querried. "No. Mechanisation was undertaken several years ago. The results during the last two years have been entirely due to a new technique: Methods Study".

"Do you think, it would be equally applicable to my country or countries which are not so advanced technically." *"More, much more.* There may be some difficulties in the beginning in educating the staff and persuading them to accept the idea. But *once the idea is accepted, you are likely to achieve much greater productivity than we have."* During the course of years of application of Methods Study, the author has found this judgment to be wholly correct. Some case studies given here illustrate the different types of methods study and the results achieved.

Refining anti-friction metal

A foundry was engaged in refining anti-friction metals. A survey of the existing conditions revealed the following procedure of work. The old anti-friction metal was removed from scrap components by heating in a vat of 5 cwt capacity. When the vat was full, 4 cwt of metal was taken out and poured into ingots. These ingots were sent to the stores for safe custody, till required. The ingots were re-drawn from stores, re-melted and re-ingotted. The ingots were now given a heat number for identification. A sample was sent to the laboratory, which after analysis, suggested the addition of a certain amount of hardener per pound of metal, to bring

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the metal upto standard specifications. The ingots were then melted in a vat, requisite amount of hardener added, and the resulting metal ingotted as standard metal. A laboratory analysis of the sample was taken to confirm that the metal was Standard. Summarising, each batch of 4 cwt of old metal required three heats and two laboratory analyses, to bring the metal to standard specifications. After these facts had been noted, the methods study technique was applied and each operation was subjected to a close analysis. Why is the heat number not stamped straightaway, in the first heat, for identification? Why can some rough estimation of hardener required not be made, and addition made in the very first melt? Why not ingot all the metal melted in the pot? Why not use bigger vats?

The answers obtained from the supervisors and staff, who had been used to the method for a long time and were against any change, were something like this : "It has always been done like this. The rules require that the metal should be sent straightaway to Stores for proper accountal and to prevent pilferage. No rough estimation of the hardener required could be made, because analysis of each heat number varies." These answers were not, however, satisfactory and closer scrutiny and study revealed considerable scope for improvement. A study of about 100 samples was made and their analysis was found to be within close range of each other, and an average percentage of hardener required was determined. Experiments were made by adding the average percentage of hardener, determined as above, in the vat in the very first heat, and the subsequent analysis confirmed that the material was according to standard specifications in 99% of the cases.

The following revised procedure was, therefore, standardized : Remove the old metal from scrap components by heating, when the vat is full (cap. 5 cwt.) add hardener, and then ingot the resulting metal, stamping heat number. Send the sample to laboratory for analysis. In 99% of cases, metal was found upto standard and no other work was therefore required. Later on, it was decided to use bigger vats of 8 to 10 cwt capacity and thus reduce the number of heats. In other words, while previously 8 cwt of metal needed one transport between stores and foundry, six heats and four laboratory analyses; according to the revised procedure, one transport between stores and foundry was eliminated, the number of heats reduced from 6 to 1 and laboratory analyses from 4 to 1: an increase in productivity of about 500 to 600%.

The Case of Spring Washers

A blacksmith shop manufacturing a large variety of items was manufacturing spring washers. The output required was 10,000 per month and the same could not be met due to the number of operations involved, one of them being a slow hand operation and handlings in between operations.

A survey was made of the existing conditions. An analysis sheet giving full details of the operations involved was prepared and the operations were then subjected to a close study. Can scrap material or alternatively cheaper material be used? Yes—scrap could be used. Can any operations be eliminated? No? Combined? Yes—and efforts were made in this direction. Can any operations be speeded up? Supervisors and artisans, who had been working on the job for some years, were confident, at the start, that nothing better could be done. Could all operations be combined into one? "Oh no, impossible"—was the answer. The supervisors and tool makers were, however, asked to think over the problem, and suggest something. After a few weeks, *one of*

the men suggested a design of a tool which could combine operation 1 & 2. "Simple"—he said, "We have a similar design in so many other cases." The suggested tool was therefore manufactured, tried out and found surprisingly successful. Two operations had been combined into one, production increased, but the last operation—a hand operation still remained a bottleneck. Could it be done by machine? Could it be combined with operation 1 & 2? The negative attitude and the opposition to new suggestions had now softened down because of unqualified success of previous suggestions. The new attitude was something like this. "Success is doubtful but we will try. If all the operations are combined, the press is not likely to take it due to inadequate capacity; the tool is likely to break etc." A new design of the tool was, however, made and proved successful like the previous one. Finally, therefore, after all the suggestions had been implemented, new material had been replaced by scrap, the slow hand operation was eliminated, 3 heats were reduced to two, handling in between operations eliminated and *the output increased beyond all expectations*, and the cost per unit considerably reduced. Although these developments had taken place during the course of 6 months or so *its success had an electrifying effect on the staff* concerned with the operations. *Operators felt rightly encouraged to put forward their new ideas.* Supervisors began looking out for jobs which could be similarly improved.

The Axle Guard

The Axle guard is an important component of a railway wagon, and in service gets frequently worn, bent, twisted, cracked or broken. Its repair needs cutting of rivets, straightening under steam hammer, welding and building up of worn parts, drilling and re-rivetting. The repair of these components in a workshop repairing railway wagons was involving considerable movement, handling—which took time, caused a bottleneck and delayed repairs to the wagons. A methods study of the job was undertaken. Since the main item under study was movement it was decided to use a flow diagram or a string diagram.

The study of the existing conditions revealed that there was considerable movement to far flung shops. There was no special machinery required except a steam hammer in the black smithy shop. It was felt that there was justification to set up a welding booth, a drilling machine etc., all together in one straight line. Various alternative sites were considered and finally the one near the Wagon Shop was selected and approved. A string diagram of the revised set up was prepared to compare results. The results being satisfactory, the proposed layout was adopted, and gave the anticipated results.

The revised string diagram also indicated that the things could be improved further, if a steam hammer could also be located in the new set-up. It was not considered worthwhile to uproot the heavy foundation of an existing steam hammer, but it was considered economical to instal a new self-contained-electro-pneumatic hammer, if and when received by the Workshop. This *Method Study started a chain reaction* and led to a similar analysis of the movement and repair methods of a large number of other components, with corresponding beneficial results.

FIGURE 1. ROLE OF MANAGEMENT IN CO-ORDINATING THE RESOURCES OF AN ENTERPRISE

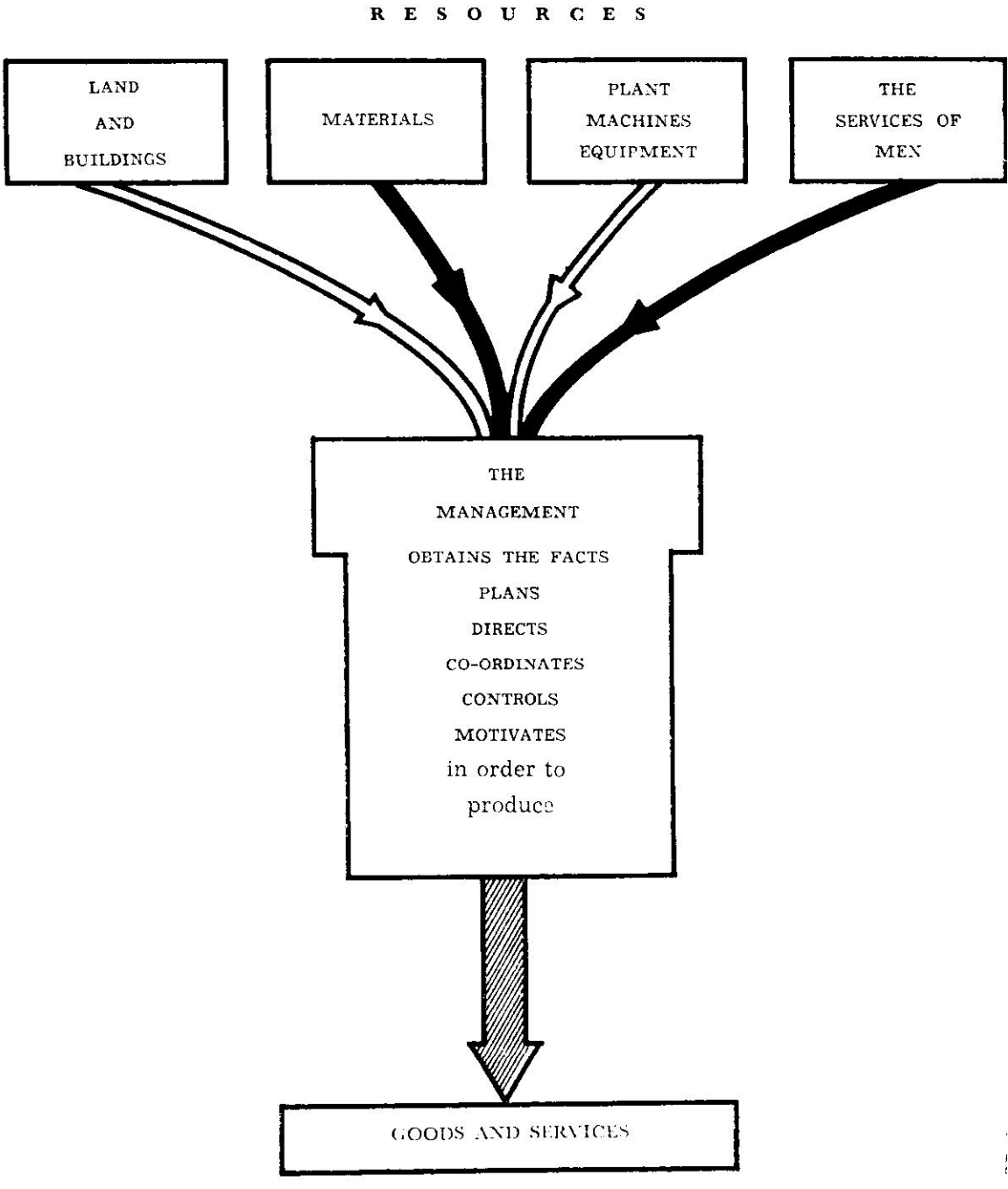


FIGURE 2. HOW MANUFACTURING TIME IS MADE UP

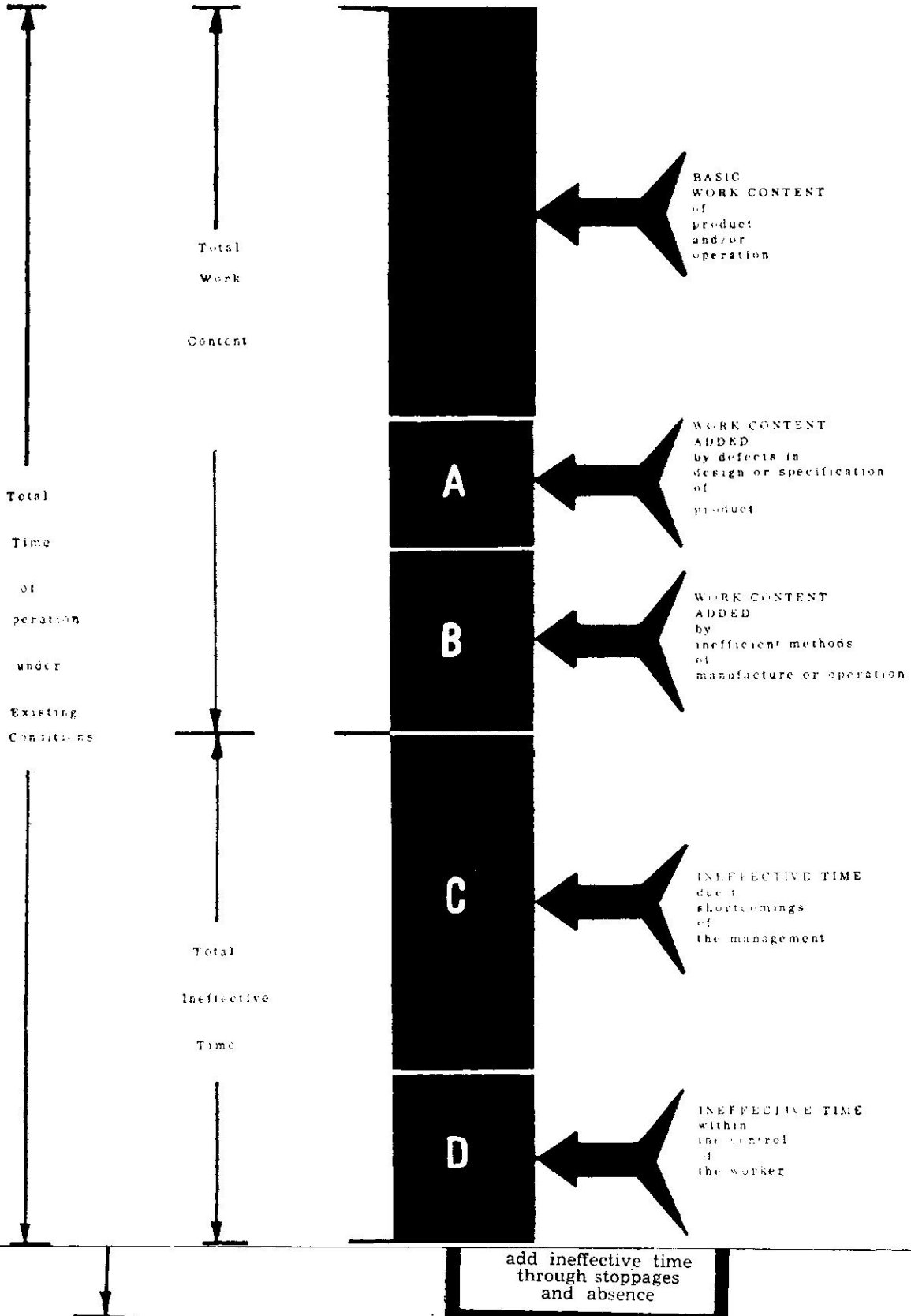
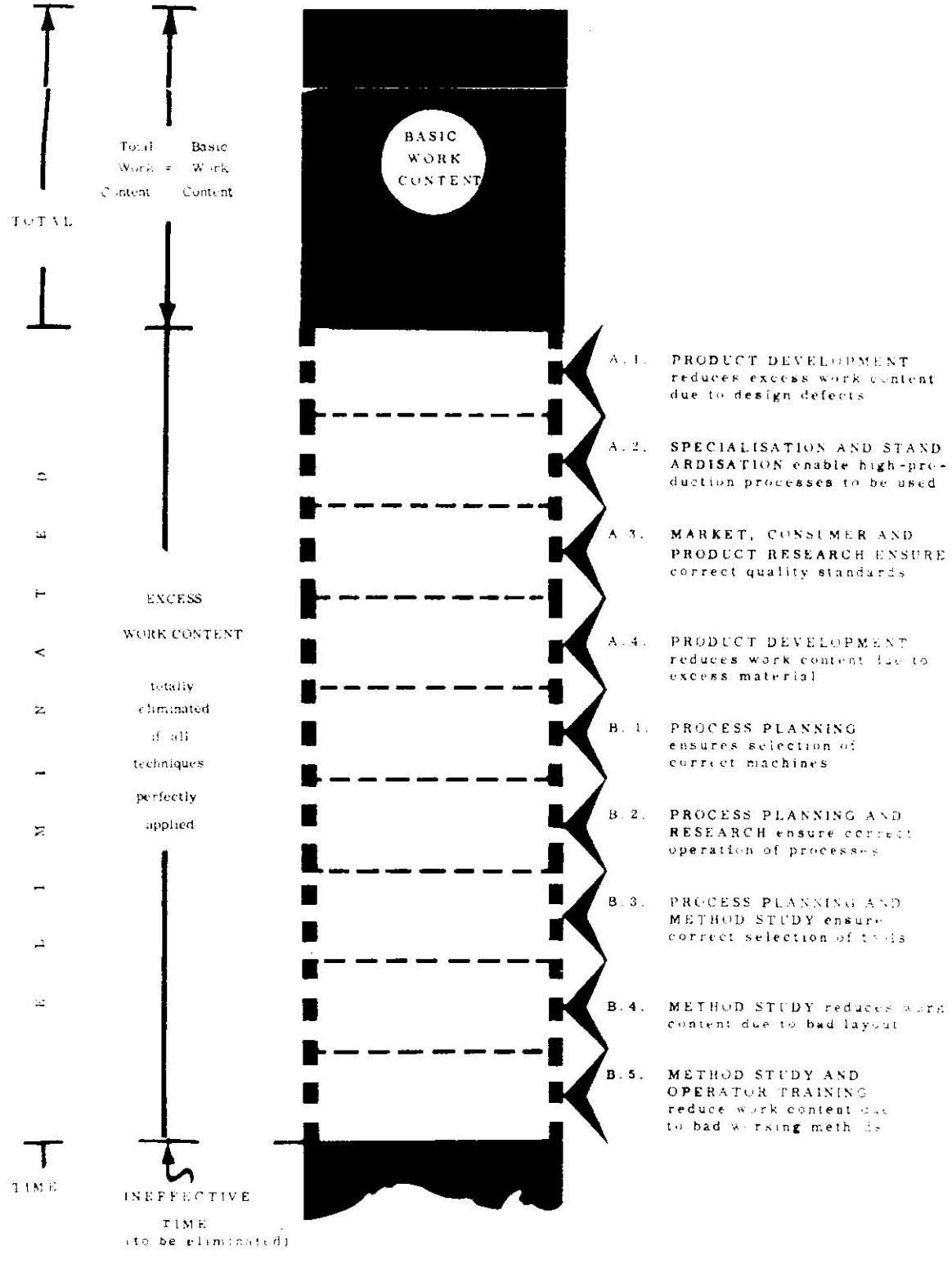


FIGURE 5.
HOW MANAGEMENT TECHNIQUES CAN REDUCE EXCESS WORK CONTENT



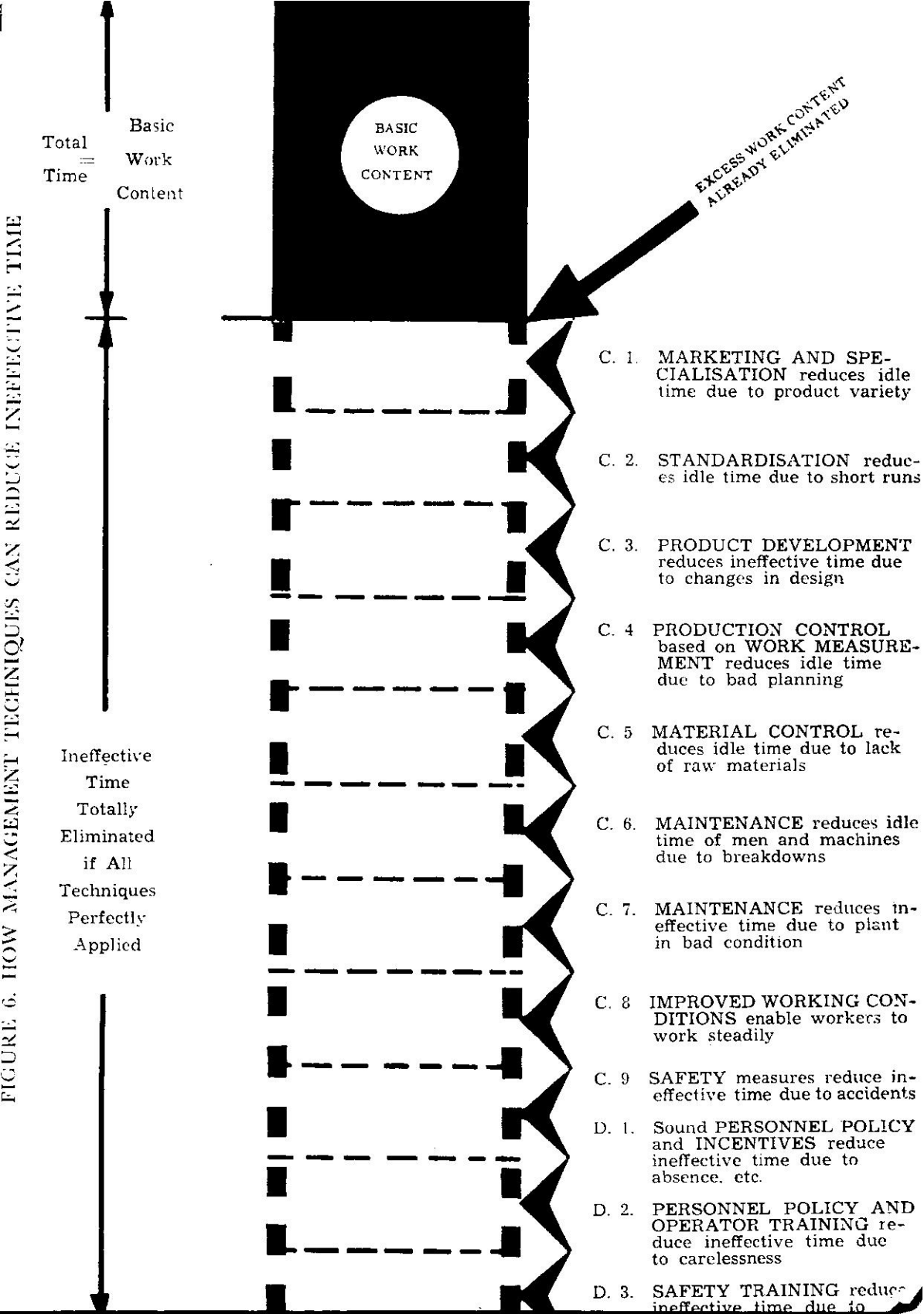


FIGURE 6. HOW MANAGEMENT TECHNIQUES CAN REDUCE INEFFECTIVE TIME

Taylor's Testimony Before the Special House Committee[1]

Thursday, January 25, 1912.

The committee met at 10.40 o'clock a. m., Hon. William B. Wilson (chairman) presiding.

TESTIMONY OF MR. FREDERICK WINSLOW TAYLOR

The witness was duly sworn by the chairman.

The Chairman. Will you please give your name and address to the stenographer, Mr. Taylor?

Mr. Taylor. Frederick Winslow Taylor, Highland Avenue, Chestnut Hill, Philadelphia, Pa.

The Chairman. Mr. Taylor, are you the author or compiler of the system of shop management generally known as the "Taylor system"?

Mr. Taylor. I have had a very great deal to do with the development of the system of management which has come to be called by certain people the "Taylor system," but I am only one of many men who have been instrumental in the development of this system. I wish to state, however, that at no time have I personally called the system the "Taylor system," nor have I ever advocated the desirability of calling it by that name. I have constantly protested against it being branded either with my name or the name of any other man, and I believe it has been a very great injury to the cause that it has been branded with any man's name... The next paper written by me on the subject was called Shop management, and in that paper *the task idea*—the idea of setting a measured standard of work for each man to do each day—was the most prominent feature... The word "task," however, had a severe sound and did not at all adequately represent the sentiment of the system; it sounded as though you were treating men severely, whereas the whole idea underlying our system is justice and not severity.

The most important fact which is connected with the working people of this country and which has been forced upon my attention possibly is the fact that the average workingman believes it to be for his interest and for the interest of his fellow workmen to go slow instead of going fast, to restrict output instead of turning out as large a day's work as is practicable... Now, I find that this fallacy is practically universal with workingmen, and in using the term *workingmen* I have in mind only that class of workmen who are engaged in what may be called cooperative industries, in which several men work together. To

1. Reprint of public document, *Hearings Before Special Committee of the House of Representatives to Investigate the Taylor and Other Systems of Tob Management Under Authority of H. Res.* 90; Vol. III, pp. 1377—1508.

illustrate, I have not in mind the coachman, the gardener, or the isolated workman of any kind...When you get almost any workingman to talking with you intimately and saying exactly what he believes and feels without reserve ; I mean when he speaks without feeling that he is going to meet with an antagonistic opinion not in sympathy with him ; to put this in still a third way, when you get that man to telling his real views, he will almost always state that he cannot see how it could be for the interest of his particular trade—that is, for the interest of those men associated with him, and with whose work he is familiar—to very greatly increase their output per day...The question the workman will ask you, if you have his confidence, is : "What would become of those of us in my particular trade who would be thrown out of work in case we were all to greatly increase our output each day?" Each such man in a particular working group feels that in his town or section or particular industry there is, in the coming year, only about so much work to be done. As far as he can see, if he were to double his output, and if the rest of the men were to double their output tomorrow or next week or next month or next year, he can see no other outcome except that one-half of the workmen engaged with him would be thrown out of work. That is the honest viewpoint of the average workman in practically all trades. And let me say here that this is a strictly honest view ; it is no fake view ; there is no hypocrisy about it. And as a result they almost all come to the conclusion that it would be humane, it would be a kindly thing, it would be acting merely in the best interests of their brothers, to restrict output rather than to materially increase their output...I think that is the view of the great majority of the workingmen of this country, and I do not blame them for it. I think I may say that for the almost universality with which this view is found among workingmen, and still more for the fact that this view is growing instead of diminishing, that the men who are not themselves working in cooperative industry and who belong, we will say, taking a single example, to *the literary classes, men who have the leisure time for study and investigation and the opportunity for knowing better, are mainly to blame*.....This view is directly the opposite of the truth. This view is false from beginning to end, and I say again that for this fallacy on the part of the working people the men who have the leisure and the opportunity to educate themselves, the men whose duty it is—or ought to be—to see that the community is properly educated and told the truth, are mainly to blame...I want to say right here, gentlemen, that while I shall have to say quite a little in the way of blame as to the views and acts of certain labor leaders during my talk, in the main I look upon them as strictly honest, upright, straightforward men. I think you will find as many good men among them as you will in any class, but you will also find many misguided men among them, men whose prejudices are carrying them away in the wrong direction, just as you will find with men of other classes. And please note here that I am using the words "class" or "classes" throughout in the sense of groups of men and women with somewhat similar aims in life, and not at all with the "upper and lower class" distinctions which are sometimes given to these words. So that when I say the labor leaders are misdirecting their followers, are giving them wrong views, are teaching wrong doctrines to their men, I say this with no idea of imputing wrong motives to labor leaders. *They themselves are as ignorant of the underlying truths of political economy as the workmen whom they are teaching*...I do not care what trade you go into, *get back to the basic facts, the fundamental truths connected with that trade*, and you will find that every time there has been an increased output per individual workman in that trade produced by any cause that *it has made more work* in the trade and has never diminished the number of workmen in the trade...And yet this is a fallacy, and a blighting fallacy, as far as the interests of the workingmen and the interests of the whole country are concerned...Let us examine the actual facts in one trade—the cotton trade, for instance. The power loom was invented some time between 1780 and 1790, I think it was. Somewhere about the year 1840—there were in round numbers 5,000 cotton weavers in Manchester, England. About that time these weavers became convinced that the power

tunities for advancement which will finally enable him to do the highest and most interesting and most profitable class of work for which his natural abilities fit him, and which are open to him in the particular company in which he is employed... The third of the principles of scientific management is the bringing of the science and the scientifically selected and trained workmen together. I say "bringing together" advisedly, because you may develop all the science that you please, and you may scientifically select and train workmen just as much as you please, but unless some man or some men bring the science and the workman together all your labour will be lost... *Nine-tenths of our trouble has been to "bring" those on the management's side to do their fair share of the work and only one-tenth of our trouble has come on the workman's side.*

The fourth of the principles of scientific management is perhaps the most difficult of all of the four principles of scientific management for the average man to understand. It consists of an almost equal division of the actual work of the establishment between the workmen, on the one hand, and the management, on the other hand. That is, the work which under the old type of management practically all was done by the workman, under the new is divided into two great divisions, and one of these divisions is deliberately handed over to those on the management's side. This new division of work, this new share of the work assumed by those on the management's side, is so great that you will, I think, be able to understand it better in a numerical way when I tell you that in a machine shop, which, for instance, is doing an intricate business—I do not refer to a manufacturing company, but, rather, to an engineering company ; that is, a machine shop which builds a variety of machines and is not engaged in manufacturing them, but, rather, in constructing them—will have *one man on the management's side to every three workmen* ; that is, this immense share of the work—one-third—has been deliberately taken out of the workman's hands and handed over to those on the management's side. And it is due to this actual sharing of the work between the two sides more than to any other one element that there has never (until this last summer) been a single strike under scientific management. In a machine shop, again, under this new type of management there is hardly a single act or piece of work done by any workman in the shop which is not preceded and followed by some act on the part of one of the men in the management. All day long every workman's acts are dovetailed in between corresponding acts of the management. First, the workman does something, and then a man on the management's side does something ; and then the workman does somthing ; and under this intimate, close, personal cooperation between the two sides it *becomes practically impossible to have a serious quarrel.*

You will see that the science of doing every little act that is done by every player on the baseball field has been developed. Every single element of the game of baseball has been the subject of the most intimate, the closest study of many men, and, finally, the best way of doing each act that takes place on the baseball field has been fairly well agreed upon and established as a standard throughout the country. The players have not only been told the best way of making each important motion or play, but they have been taught, coached, and trained to it through months of drilling. And I think that every man who has watched first-class play, or who knows anything of the management of the modern baseball team, realizes fully the utter impossibility of winning with the best team of individual players that was ever gotten together unless every man on the team obeys the signals or orders of the coach and obeys them at once when the coach gives those orders ; that is, without the intimate cooperation between all members of the team and the management, which is characteristic of scientific management.

We would see a first-class shoveler go from shoveling rice coal with a load of 3½ pounds to the shovel to handling ore from the Massaba Range, with 38 pou nds to the shovel. Now,

loom was going to win out, that the hand looms which they were operating were doomed. And they knew that the power loom would turn out per man about three times the output... They were certain, those men were honestly certain, and it was a natural conviction on their part, that nothing could happen through the introduction of this power loom except that after it was in, after it was fully installed and doing three times the work that the hand loom did, that instead of there being 5,000 weavers in Manchester they would be reduced to 1,500 or 2,000, and that 3,000 weavers would be thrown out of a job... They did in kind just what all of us would be apt to do in kind if we were convinced that three-fifths of our working body were to have our means of livelihood taken away from us... What the Manchester weavers did was to break into the establishments where these power looms were being installed. They smashed up the looms. They burned down the buildings in which they were being used. They beat up the scabs using them, and they did almost everything that was in their power to prevent the introduction of the power loom... Now, gentlemen, *the power loom came into use just as every labor-saving device that is a real labor-saving device is sure to come at all times*... In spite of any opposition that may come from any source whatever, I do not care what the source is, I do not care how great the opposition, or what it may be, any truly labor-saving device will win out. All that you have to do to find proof of this is to look at the history of the industrial world... And, gentlemen, scientific management is merely the equivalent of a labor-saving device ; that is all it is ; it is a means, and a very proper and right means, of making men more efficient than they now are, and without imposing materially greater burdens on them than they now have... In Manchester, England, today, the average weaver turns out, I am told, from 8 to 10 times the yardage of cotton cloth formerly turned out by the old hand weaver ; the man who does his work with this modern machinery turns out 8 to 10 times the yardage formerly turned out by the hand weaver. In Manchester, England, in 1840, there were 5,000 operatives, and in Manchester, today there are 265,000 operatives.

None of us probably appreciate now that in 1840 the ordinary cotton shirt or dress made, for example, from Manchester cottons was a luxury to be worn only by the middle classes, as the English describe it, and that cotton goods were worn by the poor people only as a rare luxury. Now the cotton shirt and the cotton dress, cotton goods generally, have become an absolute daily necessity of all classes of mankind all over the civilized world. And this magnificent result (more magnificent for the working people than for any other portion of the community) has been brought about solely by this great increase in output so stubbornly fought against by the cotton weavers in 1840. It is in those changes which directly affect the poor—which give them a higher standard of living and make from the luxuries of one generation the necessities of the next that we can best see the meaning of an increase in the wealth of the world. And the most important fact of this whole subject is that any association of men, whether it be a group of workmen or a group of capitalists or manufacturers, a manufacturers' association, or whatever it may be, any men who deliberately restrict the output in any industry are robbing the people... The fact is, that of the real wealth of the world, of the real necessities of life, of practically all the good things of this world, nineteen-twentieths are consumed and used by the working people, and only about one-twentieth by the rich people. Therefore that group of men who prevent wealth from coming into the world are robbing the working people of this nineteen-twentieths and the rich people of but one-twentieth. In fact I doubt if they are robbing the rich people at all.

I am now going to discuss the second great reason why workmen deliberately turn out a small instead of a large output. For this second cause I doubt whether either the manufacturer or the workman is directly to blame. I feel that any blame for this second cause should attach to the faulty system of management in general use ; certainly the work-

men cannot be blamed...Now, the foreman, acting on the orders of the board of directors, cuts the price per pen down until the workman finds himself turning out 20 pens a day where before he only turned out 10, and is receiving perhaps $2.50, or at most $2.75 or $3, when before he was receiving $2.50 a day...Now, gentlemen, *I have no sympathy whatever with the blackguarding that workmen are receiving from a good deal of the community.*

Scientific management is not any efficiency device, not a device of any kind for securing efficiency ; nor is it any bunch or group of efficiency devices. It is not a new system of figuring costs ; it is not a new scheme of paying men ; it is not a piecework system ; it is not a bonus system ; it is not a premium system ; it is no scheme for paying men ; it is not holding a stop watch on a man and writing things down about him ; it is not time study ; it is not motion study nor an analysis of the movements of men ; it is not the printing and ruling and unloading of a ton or two of blanks on a set of men and saying, " Here's your system ; go use it." It is not divided foremanship or functional foremanship ; * ....it does involve an immense change in the minds and attitude of both sides...The great revolution that takes place in the mental attitude of the two parties under scientific management is that both sides take their eyes off of the division of the surplus as the all-important matter, and together turn their attention toward increasing the size of the surplus until this surplus becomes so large that it is unnecessary to quarrel over how it shall be divided. They come to see that when they stop pulling against one another, and instead both turn and push shoulder to shoulder in the same direction, the size of the surplus created by their joint efforts is truly astounding...Both sides must recognize as essential the substitution of exact scientific investigation and knowledge for the old individual judgment or opinion, either of the workman or the boss, in all matters relating to the work done in the establishment. And this applies both as to the methods to be employed in doing the work and the time in which each job should be done...

The first duty taken over by the management is the deliberate gathering in on the part of those on the management's side of all of the great mass of traditional knowledge, which in the past has been in the heads of the workmen, and in the physical skill and knack of the workmen, which he has acquired through years of experience. The duty of gathering in of all this great mass of traditional knowledge and then recording it, tabulating it, and, in many cases, finally reducing it to laws, rules, and even to mathematical formulae, is voluntarily assumed by the scientific managers. And later, when these laws, rules, and formulae are applied to the everyday work of all the workmen of the establishment, through the intimate and hearty cooperation of those on the management's side, they invariably result, first, in producing a very much large output per man, as well as an output of a better and higher quality ; and, second, in enabling the company to pay much higher wages to their workmen ; and, third, in giving to the company a larger profit. The first of these principles, then, may be called the development of a science to replace the old rule-of-thumb knowledge of the workmen ; that is, the knowledge which the workmen had, and which was, in many cases, quite as exact as that which is finally obtained by the management, but which the workmen nevertheless in nine hundred and ninety-nine cases out of a thousand kept in their heads, and of which there was no permanent or complete record.

The second group of duties which are voluntarily assumed by those on the management's side, under scientific management, is the scientific selection and then the progressive development of the workmen. It becomes the duty of those on the management's side to deliberately study the character, the nature, and the performance of each workman with a view to finding out his limitations on the one hand, but even more important, his possibilities for development on the other hand ; and then, as deliberately and as systematically to train and help and teach this workman, giving him, wherever it is possible, those oppor-

is 3½ pounds the proper shovel load or is 38 pounds the proper shovel load ? They cannot both be right. Under scientific management the answer to this question is not a matter of anyone's opinion ; it is a question for accurate, careful, scientific investigation... Under the old system you would call in a first-rate shoveler and say, "See here, Pat, how much ought you to take on at one shovel load?" And if a couple of fellows agreed, you would say that's about the right load and let it go at that. But under scientific management absolutely every element in the work of every man in your establishment, sooner or later, becomes the subject of exact, precise, scientific investigation and knowledge to replace the old, "I believe so," and "I guess so." Every motion, every small fact becomes the subject of careful, scientific investigation... What we did was to call in a number of men to pick from, and from these we selected two first-class shovelers. Gentlemen, the words I used were "first-class shovelers." I want to emphasize that. Not poor shovelers. Not men unsuited to their work, but first-class shovelers. These men were then talked to in about this way, " See here, Pat and Mike, you fellows understand your job all right ; both of you fellows are first-class men ; you know what we think of you ; you are all right now ; but *we want to pay you fellows double wages.* We are going to ask you to do a lot of damn fool things, and when you are doing them there is going to be some one out alongside of you all the time, a young chap with a piece of paper and a stop watch and pencil, and all day long he will tell you to do these fool things, and he will be writing down what you are doing and snapping the watch on you and all that sort of business. Now, we just want to know whether you fellows want to go into that bargain or not ? If you want double wages while that is going on all right, we will pay you double ; if you don't all right, you needn't take the job unless you want to ; we just called you in to see whether you want to work this way or not.

Now, gentlemen, this teacher was no college professor... He was a teacher of shoveling ; he understood the science of shoveling; he was a good shoveler himself, and he knew how to teach other men to be good shovelers. The teacher comes, in every case, not to bulldoze the man, not to drive him to harder work than he can do, but to try in a friendly, brotherly way to help him... Now, gentlemen, I want you to see clearly that, because that is one of the characteristic features of scientific management; this is not nigger driving; this is kindness; this is teaching; this is doing what I would like mighty well to have done to me if I were a boy trying to learn how to do something. This is not a case of cracking a whip over a man and saying, "Damn you, get there." The old way of treating with workmen, on the other hand, even with a good foreman, would have been something like this : "See here, Pat, I have sent for you to come up here to the office to see me ; four or five times now you have not earned your 60 per cent increase in wages; you know that every workman in this place has got to earn 60 per cent more wages than they pay in any other place around here, but you're no good and that's all there is to it; now, get out of this." That's the old way. "You are no good; we have given you a fair chance; get out of this," and the workman is pretty lucky if it is not "get to hell out of this," instead of "get out of this." *The new way is to teach and help your men* as you would a brother; to try to teach him the best way and show him the easiest way to do his work. This is the new mental attitude of the management toward the men.

Now, all of this costs money. To pay the salaries of men who are studying the science of shoveling is an expensive thing. As I remember it there were two college men who studied this science of shoveling and also the science of doing many other kinds of labouring work during a period of about three years ; then there were a lot of men in the labour office whose wages had to be paid, men who were planning the work which each labourer was to do at least a day in advance ; clerks who worked all night so that each workman might know the next morning when he went to work just what he had accomplished and what

he had earned the day before ; men who wrote out the proper instructions for the day's work for each workman... All of this costs money... Under the old system the cost of handling a ton of materials had been running between 7 and 8 cents, and all you gentlemen familiar with railroad work know that this is a low figure for handling materials. Now, after paying for all the clerical work which was necessary under the new system for the time study and the teachers, for building and running the labour office and the implement room, for constructing a telephone system for moving men about the yard, for a great variety of duties not performed under the old system, after paying for all these things incident to the development of the science of shoveling and managing the men the new way, and including the wages of the workmen, the cost of handling a ton of material was brought down from between 7 and 8 cents to between 3 and 4 cents, the men who were on the labour gang received an average of sixty per cent more wages than their brothers got or could get anywhere around that part of the country. And none of them were overworked, for it is no part of scientific management ever to overwork any man ; one of the first requirements of scientific management is that no man shall ever be given a job which he cannot do and thrive under through a long term of years.

WHY NOT TRY THE PRODUCTIVE WAY

They tell you by implication that if you use a certain orange squeezer in your kitchen, you remain young, lovely and beautiful; if you wash with a certain soap you become rich; if you wear a certain type of underwear you inherit a large sum from a wealthy uncle and if you use only a special kind of tomato ketchup you learn foreign languages more easily. Of course, people are much too intelligent to believe such silly statements. But after all there may be something in it: why not try?

Taylor's Scientific Management

HARLOW S PERSON[1]

Frederick Winslow Taylor[2] was in temperament, training and experience an engineer executive, a doer. He was not interested in writing for its own sake, and, although he wrote painstakingly, he found the process laborious. Furthermore, he did not believe that management could be learned from reading or taught in the classroom; it had to be learned in the doing. Each of his expositions was the result of a challenge of circumstances. Viewed in present-day perspective it was not an adequate presentation of principles. On the one hand, Taylor's mind was pretty much the opposite of the academic type of mind that thinks in terms of generalizations; he was interested in action and its immediate measurable results. On the other hand, at the time "Principles" was prepared there had been no external force to extract from his what capacity for generalization he possessed. That external force presented itself during the winter months of 1911-12 at hearings before a special committee of the House of Representatives. The appointment of this special committee was inspired by organized labour, which by this time was showing concern over the effect on its organization and procedures of measured individual productivity in even the best examples of Scientific Management, and especially over the use of its mechanism (which Taylor said could be employed for good or bad) by unscrupulous employers and managers. Because Scientific Management had been developed in several arsenals of the army, labour asserted that the matter was one of Congressional concern, and the special committee was appointed. Its establishment was a public service insofar as its questioning inspired Taylor to utterances concerning philosophy, principles and technique that he would never have thought of writing into a professional paper. Some of them are eloquent as well as clarifying; for example, the famous passages concerning what Scientific Management is not.

IN THE COURSE OF HIS DAY-TO-DAY WORK Taylor developed and proved the value of that technique of management which he identified as the task system, which his associates termed the Taylor System, and everybody eventually designated as Scientific Management. The development of this technique came about in the following manner. When he was appointed gang boss he sought to increase the output by putting pressure on the men. A serious struggle

1 Formerly, President and Managing Director, Taylor Society, New York.

2 Frederick Winslow Taylor was born in 1856 in a cultured and well-to-do but not wealthy family in Philadelphia. His parents desired that he enter the law and sent him to Phillips-Exeter Academy to prepare for Harvard entrance examinations. Although not a brilliant student, by seriousness of purpose and hard study he led his class at the Academy. But he paid the price of serious impairment of vision because of too much study by kerosene light. The doctors advised against Harvard and any career involving close study. So young Taylor

between gang boss and workers ensued. Taylor finally won in the struggle, but the experience hurt him. He gave the matter thought and decided that the primary cause of conflicts is that management, without knowing what is a proper day's work, tries to secure output by pressure. If management knew what is a proper day's work, it could then get output by demonstration. He decided by experiment to discover what was a proper day's work for every operation in the shop. His experiments along this line continued throughout his service with the Midvale Steel Company, then at the Bethlehem Steel Company, and later in various types of enterprises as consultant. Within a few years he had developed a technique of managing that in its factual basis and scope was more effective both in productivity and in good worker relations than any management elsewhere.

This new technique of managing involved two major elements. First, discovery by experiment of the best way of performing and the proper time for every operation and every component unit of an operation: in the light of the state of the art, the best material, tool, machine, manipulation of tool or machine, and the best flow of work and sequence of unit operations. These data were classified, indexed and lodged in the data files for use as new orders came along. Second, a new division of labour as between management and workers: the assignment to management of the responsibility for discovering these best ways of performing units of operations, and the further responsibility of planning operations and actually making available at the proper time and place, and in the proper quantity, the materials, tools, instruction and other facilities required by the workers. The great gains in productivity accruing from this technique of management come not from greater exertion on the part of workers (it is generally simplified and reduced) but from elimination of wastes—waste of workers' time and machine time through delays of misapplied effort, of failure in coordination of quantities, and so forth.

Taylor became a member of ASME in 1885, attended its meetings and listened with great interest to discussions of management. But he became impatient of these discussions and of their controlling point of view. They were chiefly about premium and other differential wage systems, reflecting the point of view of what Taylor called the management of "initiative and incentive." In this type of management the manager tried through a premium or bonus to stimulate the workers' incentive to greater productivity by their own greater efforts. No thought here of what management itself could do to increase productivity and lighten labour's efforts.

In the course of his testimony before the House committee Taylor was asked

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returned to his parents' home uncertain as to his future activity. Energetic, conscientious and restless, he looked for a career that would not call for too much reading. Accordingly in 1874 he began an apprenticeship as a pattern-maker and as a machinist in a small shop in Philadelphia. In 1878 he had become a journeyman machinist and journeyman pattern-maker. Attracted by the reputation of William Sellers, president and general manager of Midvale Steel Company, he applied for and secured a job at the works of that company. However, this first job was neither as machinist nor pattern-maker, but as an ordinary labourer. His energy and genius are manifest in the following promotions: within a period of eight years he progressed through the stages of ordinary labourer, time keeper, machinist, gang boss, foreman and assistant engineer to chief engineer of the works. By night study in absentia his eyesight having improved he earned the M.E. degree at Stevens Institute.

how many concerns used his system in its entirety. His reply was: "In its entirety—none; not one." Then in response to another question he went on to say that a great many used it substantially, to a greater or less degree. Were Mr. Taylor alive to respond to the same question in 1962, his reply would have to be essentially the same. Yet there is a continuing demand for his papers; and American industry, and industry in parts of western Europe, has been profoundly influenced by Scientific Management and is densely spotted with fragments of it. Practically every manufacturing establishment of stability has a planning room. Time study technicians are employed by the thousands. The sales programmes, budgets and quotas of the best-managed marketing departments are in these devices utilizing the technique to a greater or less degree. General administrative schedules, budgets and standards have been inspired by Scientific Management. Modern cost accounting in terms of products, operations and processes would be impossible without it. Yet these are primarily mechanisms and they may carry with them in any particular organization little or none of the spirit of Scientific Management.

The most stirring part of Taylor's testimony before the House committee is that section in which he develops the thought that true Scientific Management requires a mental revolution on the parts both of management and of workers. They must accept the philosophy that, except for minor adjustments to keep different desirable products in balance, the interests of both and of society in the long run call for ever greater output of want-satisfying commodities. Output requires expenditure of human and material energies; therefore both workers and management should join in the search for discovery of the laws of least waste. They should join in these rearrangements which under division of labour are required to make these laws effective.

In the small plants with which Taylor was concerned in his active life these joint efforts came about informally; every worker was a participant observer in the development of standards. Taylor was never in a situation which called for consideration of formalized collective bargaining. Yet he did not disbelieve in collective bargaining as an institution, and since his day Scientific Management has in places been developed under collective bargaining auspices. While Taylor was not unsympathetic to bargaining whether the development of Scientific Management should be undertaken in an establishment, he was not tolerant of the concept that one might discover by bargaining a particular fact that lends itself rather to discovery by research and experiment. Recognition of the need of ever greater productivity, recognition of the necessity of discovering by scientific methods the laws governing the conservation of human and material energies in achieving the greater productivity, arrangement jointly by management and workers to give effect to these laws, and patience, and ever more patience—these were what Taylor considered the corner stones of true Scientific Management.

Therefore, true Scientific Management calls for a unifying point of view and a unity of interests and of efforts seldom present in a particular establishment. The directors must understand it in purpose and principle; that *it is a matter of development, not installation;* that it is in the nature of an investment the returns from which, though great, may be deferred; that the development takes time and patience. The active managers, all of them, must understand these things and have great skill in developing new standards to supersede obsolete standards, and in substituting the new for the old without interrupting

orderly processing. And especially must management be skilled in aiding workers to understand the purpose and meaning of Scientific Management and in maintaining their confidence in the purpose and in the management. Taylor said in his testimony that it takes two to five years—more frequently five years—to develop Scientific Management in an enterprise. It must be planted, and cultivated and fertilized, and pruned and shaped, like a shrub or tree. It is not something to be bought and installed like a boiler or a machine.

A REALLY PRODUCTIVE ECONOMY!

...If you are hungry, you go to the chemist's. A chemist's shop is called a drugstore in the United States; it is a national institution....In the larger drugstores you may be able to get drugs, too, but their main business consists in selling stationery, candy, toys, braces, belts, fountain pens, furniture and imitation jewellery. Every drugstore has a food counter with high stools in front of it and there they serve various juices, coffee, sundaes, ice cream, sandwiches, omelettes and other egg dishes. A friend of mine in Hollywood met Otto Hapsburg, the claimant to the Austrian-Hungarian throne, who—I understand—apart from his hobby of calling himself a king, is an extremely charming and cultured young man. My friend called on Otto one morning in his hotel. He was received by the aide-de-camp who declared ceremoniously: 'Seine Majestat nimmt sein Frahstack in der Apotheke' (His Majesty is having his breakfast in the pharmacy).

Frederick Winslow Taylor
The Engineer-Economist

HENRY R. TOWNE [1]

As a fellow-worker with Dr. Taylor, in the field of industrial management, I have followed the development of his work, almost from its commencement, with constantly increasing admiration for the exceptional talent which he has brought to this new field of investigation, and with constantly increasing realization of the fundamental importance of the methods which he had initiated. The substitution of machinery for unaided human labour was the great industrial achievement of the nineteenth century. The new achievement to which Dr. Taylor points the way consists in elevating human labour itself to a higher plane of efficiency and of earning power.

THE TRUE FUNCTION OF THE ENGINEER IS, OR SHOULD BE, not only to determine how physical problems may be solved, but also how they may be solved most economically. For example, a railroad may have to be carried over a gorge or arroyo. Obviously it does not need an engineer to point out that this may be done by filling the chasm with earth, but only a bridge engineer is competent to determine whether it is cheaper to do this or to bridge it, and to design the bridge which will safely and most cheaply serve, the cost of which should be compared with that of an earth fill. Therefore *the engineer is, by the nature of his vocation, an economist.* His function is not only to design, but also so to design as to ensure the best economical result. He who designs an unsafe structure or an inoperative machine is a bad engineer ; he who designs them so that they are safe and operative, but needlessly expensive, is a poor engineer, and, it may be remarked, usually earns poor pay ; he who designs good work, which can be executed at a fair cost, is a sound and usually a successful engineer ; he who does the best work at the lowest cost sooner or later stands at the top of his profession, and usually has the reward which this implies.

The conclusions embodied in Dr. Taylor's "Shop Management" constitute in effect the foundations for a new science—"The Science of Industrial Management." As in the case of constructive work the ideal engineer is he who does the best work at the lowest cost, so also, in the case of industrial operations, the best manager is he who so organizes the forces under his control that each individual shall work at his best efficiency and shall be compensated accordingly. Dr. Taylor has demonstrated conclusively that, to accomplish this, it is essential to segregate the *planning* of work from its *execution* ; to employ for the former trained experts possessing the right mental equipment, and for the latter men having the right physical equipment for their respective tasks and being receptive of expert

1 The author, President, sometime of the ASME (American Society of Mechanical Engineers) was a contemporary of Taylor, in whose presence, he read his famous paper on "*The Engineer as an Economist*" : a model of Taylor himself.

guidance in their performance. Under Dr. Taylor's leadership the combination of these elements has produced, in numberless cases, astonishing increments of output and of earnings per employee.

We are proud of the fact that the United States has led all other nations in the development of labour-saving machinery in almost every field of industry. Dr. Taylor has shown us methods whereby we can duplicate this achievement by vastly increasing the efficiency of human labour, and of accomplishing thereby a large increase in the wage-earning capacity of the workman, and a still larger decrease in the labour cost of his product.

It is great fun dying in the United States of America. It is great fun first of all for the undertakers who make a wonderful living out of it but also for the deceased who suddenly becomes the centre of attention and fuss. American newspapers are full of funeral advertisements: "Funeral Service that will leave your mind at ease for ever." Or 'A Funeral Service you will really enjoy.' Or 'Dignified funeral.' Or 'Comfortable funerals.' Or 'Funeral that will make your family happy for months' Or 'Unforgettable funerals as low as $150. The same with southern plants $200. The same with two palms $215.' Or 'Funerals with hidden neon lighting from Louis XIV rooms.' Or 'Come to us! We'll bury you better!'... And people go. They discuss their own funerals with gusto, choose the coffin (first their measurements are taken for this purpose), choose the decorations on it, the songs to be sung, the palms to be exhibited, how they are going to be embalmed. They pay in instalments and look forward to The Great Day.

Gilbreth
The Bricklayer

FREDERICK WINSLOW TAYLOR

In continuation of his marathan address to the Congressional Committee, Taylor illustrated "the application of scientific management to *a rather high class of work*: gentlemen, bricklaying, so far as I know, is one of the oldest of the trades, and it is a truly extraordinary fact that bricks are now laid just about as they were 2,000 years before Christ. In England they are laid almost exactly as they were then; in England the scaffold is still built with timbers lashed together—in many cases with the bark still on it—just as we see that the scaffolds were made in old stone-cut pictures of bricklaying before the Christian era. In this country we have gone beyond the lashed scaffold, and yet in most respects it is almost literally true that bricks are still laid as they were 4,000 years ago. Virtually the same trowel, virtually the same brick, virtually the same mortar, and from the way in which they were laid, according to one of my friends, who is a brickwork contractor and a student of the subject, who took the trouble to take down some bricks laid 4,000 years ago to study the way in which the mortar was spread etc., it appears that they even spread the mortar in the same way then as we do now. If, then, there is any trade in which one would say that the principles of scientific management would produce but small results, that the development of the science would do little good, it would be in a trade which thousands and thousands of men through successive generations had worked and had apparently reached, as far as methods and principles were concerned, the highest limit of efficiency 4,000 years ago. Therefore, viewed broadly, one would say that there was a smaller probability that the principles of scientific management could accomplish notable results in this trade than in almost any other." Taylor then proceeded to illustrate it from the life of Frank Gilbreth, how the latter through the techniques of Scientific Management, accomplished a revolution in bricklaying.

MR. FRANK GILBRETH IS A MAN WHO IN his youth worked as a bricklayer; he was an educated man and is now a very successful contractor. He said to me, some years ago, "Now, Taylor, I am a contractor, putting up all sorts of buildings, and if there is one thing I know it is bricklaying; I can go out right now, and I am not afraid to back myself, to beat any man I know of laying bricks for ten minutes, both as to speed and accuracy; you may think I am blowing, but that is one way I got up in the world. I cannot stand it now for more than ten minutes; I'm soft; my hands are tender, I haven't been handling bricks for years, but for ten minutes I will back myself against anyone. I want to ask you about this scientific management; do you think it can be applied to bricklaying? Do you believe that these things you have been shouting about (at that time it was called the 'task system'), do you believe these principles can be applied to bricklaying?" "Certainly," I said, "some day

some fellow will make the same kind of study about bricklaying that we have made of other things, and he will get the same results." "Well," he said, "if you really think so, I will just tell you who is going to do it, his name is Frank Gilbreth."

I think it was about three years later that he came to me and said: "Now, I'm going to show you something about bricklaying. I have spent three years making a motion and time study of bricklaying and not I alone did it; my wife has also spent almost the same amount of her time studying the problems of bricklaying, and I think she has made her full share of the progress which has been made in the science of bricklaying." Then he said, "I will show you just how we went to work at it. Let us assume that I am now standing on the scaffold in the position that the bricklayer occupies when he is ready to begin work. The wall is here on my left, the bricks are there in a pile on the scaffold to my right, and the mortar is here on the mortar-board alongside of the bricks. Now, I take my stand as a bricklayer and am ready to start to lay bricks, and I said to myself, 'What is the first movement that I make when I start to lay bricks?' I take a step to the right with the right foot. Well, is that movement necessary? It took me a year and a half to cut out that motion—that step to the right—and I will tell you later how I cut it out. Now, what motion do I make next? I stoop down to the floor to the pile of bricks and disentangle a brick from the pile and pick it up off the pile. 'My God,' I said, 'that is nothing short of barbarous.' Think of it! Here I am a man weighing over 250 pounds, and every time I stoop down to pick up a brick I lower 250 pounds of weight down two feet so as to pick up a brick weighing 4 pounds, and then raise my 250 pounds of weight up again, and all of this to lift up a brick weighing 4 pounds. Think of this waste of effort. It is monstrous. It took me—it may seem to you a pretty long while—but it took a year and a half of thought and work to cut out that motion; when I finally cut it out, however, it was done in such a simple way that anyone in looking at the method which I adopted would say, 'There is no invention in that, any fool could do that; why did you take a year and a half to do a little thing like that?' Well, all I did was to put a table on the scaffold right alongside of me here on my right side and put the bricks and mortar on it, so as to keep them at all times at the right height, thus making it unnecessary to stoop down in picking them up. This table was placed in the middle of the scaffold with the bricklayer on one side of it, and with a walkway on the other side along which the bricks were brought by wheelbarrow or by hod to be placed on the table without interfering with the bricklayer or even getting in his way." Then Mr. Gilbreth made his whole scaffold adjustable, and a labourer was detailed to keep all of the scaffolds at all times at such a height that as the wall goes up the bricks, the mortar, and the men will occupy that position in which the work can be done with the least effort.

Mr. Gilbreth has studied out the best position for each of the bricklayer's feet and for every type of bricklaying the exact position for the feet is fixed so that the man can do his work without unnecessary movements. As a result of further study both on the part of Mr. and Mrs. Gilbreth, after the bricks are unloaded from the cars and before bringing them to the bricklayer they are carefully sorted by a labourer and placed with their best edges up on a simple wooden frame, constructed so as to enable him to take hold of each brick in the quickest time and in the most advantageous position. In this way the bricklayer avoids either having to turn

the brick over or end for end to examine it before laying it, and he saves also the time taken in deciding which is the best edge and end to place on the outside of the wall. In most cases, also, he saves the time taken in disentangling the brick from a disorderly pile on the scaffold. This "pack of bricks," as Mr. Gilbreth calls his loaded wooden frames, is placed by the helper in its proper position on the adjustable scaffold close to the mortar box.

We have all been used to seeing bricklayers tap each brick after it is placed on its bed of mortar several times with the end of the handle of the trowel so as to secure the right thickness for the joint. Mr. Gilbreth found that by tempering the mortar just right the bricks could be readily bedded to the proper depth by a downward pressure of the hand which lays them. He insisted that the mortar mixers should give special attention to tempering the mortar and so save the time consumed in tapping the brick.

In addition to this he taught his bricklayers to make simple motions with both hands at the same time, where before they completed a motion with the right hand before they followed it later with one made by the left hand. For example, Mr. Gilbreth taught his bricklayers to pick up a brick in the left hand at the same time that he takes a trowel of mortar with the right hand. This work with two hands at the same time is, of course, made possible by substituting a deep mortar box for the old mortar-board, on which the mortar used to spread out so thin that a step or two had to be taken to reach it, and then placing the mortar box and the brick pile close together and at the proper height on his new scaffold.

Now, what was the practical outcome of all this study? To sum it up he finally succeeded in teaching his bricklayers, when working under the new method, to lay bricks with five motions per brick, while with the old method they used 18 motions per brick. And, in fact, in one exceedingly simple type of bricklaying he reduced the motions of his bricklayers from 18 to 2 motions per brick. But in the ordinary bricklaying he reduced the motions from 18 to 5. When he first came to me, after he had made this long and elaborate study of the motions of bricklayers, he had accomplished nothing in a practical way through this study, and he said, "You know, Fred, I have been showing all my friends these new methods of laying bricks and they say to me, 'Well, Frank, this is a beautiful thing to talk about, but what in the devil do you think it amounts to? You know perfectly well the unions have forbidden their members to lay more than so many bricks per day; you know they won't allow this thing to be carried out." But Gilbreth said, "Now, my dear boy, that doesn't make an iota of difference to me. I'm just going to see that the bricklayers do the right thing. I belong to the bricklayers' union in Boston, and the next job that I get in Boston this thing goes through. I'm not going to do it in any underhanded way. Everyone knows that I have always paid higher wages than the union scale in Boston. I've got a lot of friends at the head of the unions in Boston, and I'm not afraid of having any trouble."

He got his job near Boston, and he went to the leaders of the union and told them just what you can tell any set of sensible men. He said to them, "I want to tell you fellows some things that you ought to know. Most of my contracts around here used to be brick jobs; now, most of my work is in reinforced concrete or some other type of construction, but I am first and last a bricklayer; that is what I am interested in, and if you have any sense you will just keep your hands off and let me show you bricklayers how to compete

with the reinforced concrete men. I will handle the bricklayers myself. All I want of you leaders is to keep your hands off and I will show you how bricklayers can compete with reinforced concrete or any other type of construction that comes along."

Well, the leaders of the union thought that sounded all right, and then he went to the workmen and said to them, "No fellow can work for me for less than $6.50 a day—the union rate was $5 a day—but every man who gets on this job has got to lay bricks my way; I will put a teacher on the job to show you all my way of laying bricks and I will give every man plenty of time to learn, but after a bricklayer has had a sufficient trial at this thing, if he won't do my way or cannot do my way, he must get off the job." Any number of bricklayers were found to be only too glad to try the job, and I think he said that before the first story of the building was up he had the whole gang trained to work in the new way, and all getting their $6.50 a day when before they only received $5 per day; I believe those are the correct figures; I am not absolutely sure about that, but at least he paid them a very liberal premium above the average bricklayer's pay.

It is one of the principles of scientific management to ask men to do things in the right way, to learn something new, to change their ways in accordance with the science, and in return to receive an increase of from 30 to 100 per cent in pay. After Mr. Gilbreth had trained his complete force of bricklayers so that they were all working the new instead of the old way, a very great and immediate increase in the output per man occurred. These bricklayers averaged 350 bricks per man per hour, whereas the most rapid union rate up to that time had been 120 bricks per man per hour. And you will recognize, gentlemen, that this is due principally to the very great simplification of the work brought about through Mr. Gilbreth's three years' of analysis and study of the art of bricklaying, which enabled him to reduce the number of motions made by the workman in laying a brick from 18 per brick to 5 per brick.

The immense gain which had been made through this study will be realized when it is understood that in one city in England the union bricklayers on this type of work have limited their output to 275 bricks per day per man, when on municipal work, and 375 bricks per day per man when on private work.

I want to make it clear to you that this great increase in output on the part of Mr. Gilbreth's bricklayers could only be brought about, and was brought about, through the application of the principles of scientific management. In the first place, it is perfectly clear that unless Mr. Gilbreth had developed the science of bricklaying himself this could not have been done. In the second place, unless the management cooperated in the most hearty way in the scientific selection of the workmen, and then in their progressive development—that is, first choosing the workmen (picking out those men who were able and willing to adopt the new methods in bricklaying), and then teaching them the new movements—this result could not have been realized.

I have not the slightest doubt that during the last 4,000 years all the methods that Mr. Gilbreth developed have many, many times suggested themselves to the minds of bricklayers. I do not believe Mr. Gilbreth was the first man to invent those methods.