



NEW EQUATIONS FOR MANAGEMENT

Dr. J. E. Hobson
Director
Stanford Research Institute

Research produces needed facts. Men planning the course of today's industry need facts. They need dimensional facts from the laboratory and pilot plant; and they need facts on the human element in industry--the customer, the worker, and the executive.

A keen instinctive perception, an extensive background of personal experiences, and techniques acquired through trial and error guided the early leaders of industrial venture. In some instances these motivating factors still work adequately and effectively. But as the processes and operations of industry become increasingly complex and the requirements of management increasingly exact, such personalized decisions find greater difficulty in meeting the tests of competition.

The pencil must be sharpened, the blueprints for planning must be more exact in detail, and the platforms of management must be made more secure. Individual experiences and intuition are as important as ever--necessary but not always sufficient.

The words "new equations" when used with "management" suggest that there may be some new elements of equality or exactness in the function of management--or at least some new conditions, new factors, problems, or approaches in management's sphere of action. Certainly, the idea of change is implicit.

One of the definitions of the word management is "the skillful use of means to accomplish a purpose." "Skillful" and "means" indicate that the role of management groups in industry is to use in a scientific manner all available resources, methods, techniques, and facts to accomplish some purpose--usually that of company growth and development.

A concept of "equation" is "a correction or evaluation due to any varying source of error." In an industry setting, this implies that management must skillfully correct, evaluate, and appraise the factors and conditions at hand if it is to reduce errors to a minimum--errors or changes that arise from varying sources. If management is to correct and evaluate skillfully, adequate facts must be available on all of the major problem areas with which industrial management is confronted.

Presumably, this equating process has been the function of management since the days of the entrepreneur and the domestic system. However, the phrase "new equations" introduces the thought that there has been, or

soon will be, a change in the tools or means at hand--in the problems management must face--in the facts or methods available or needed--in the techniques through which it evaluates or corrects--in the relative preciseness of needed facts--or in the skill with which management can isolate and reduce the probability of error in its decisions.

If we scan the role of management as it has developed over the years, we see that important new conditions, new factors, new problems, and, in reality, new equations do appear from time to time in management. This review shows that new factors in the management equation are now emerging and that others will arise in the future.

In the days before the Industrial Revolution under the domestic system in Europe, the task of management was a rather simple one. An organizer or entrepreneur distributed raw materials to workers in their homes and collected the finished products. He owned the materials, paid or bartered for the work done, and took the risk of selling or trading the products in a local market. Foreign commerce was in the hands of a few merchants and mercantile groups. Transactions were of the simplest sort. There were no complications in organization procedure, little need for policies, little need for exactness, and little need for orderly management processes. There were, in reality, no significant factors in the management equation. A merchant or entrepreneur could operate his business successfully with only those facts he collected personally. This situation remained practically constant for about six centuries. The small changes in technology had practically no effect on the affairs of man. From the days of Homer down to the middle of the 18th century, only three small improvements were made in the method of making cloth. The rate of change in industrial affairs, as well as in technology, throughout this period was insignificant.

Suddenly, however, at least two new and important factors in the management equation came into being. One of these was capital accumulated over the years but for the most part lying idle in the hands of individuals. The other was a series of startling inventions which completely changed the existing methods of industry. The first came in 1763 when Hargreaves developed the spinning jenny. The steam engine appeared in 1782, the cotton gin in 1794, the process of making malleable iron castings in 1821, the Bessemer converter in 1855, and so on. Machinery was substituted for hand tools in production. The factory system replaced the domestic system. Large industrial organizations emerged. Although the change was more evolutionary than revolutionary, we have, since the days of Arnold Toynbee, known the period from around 1760 to about 1890 as the Industrial Revolution.

It was during this period that capital and technology were first brought together. Available capital made possible the formation of business and industrial organizations to exploit the potentials of an ever-increasing number of new inventions. It is significant, however, that prior to 1900 the major factor in the management equation had to

do with capital. Management was aware of the influence of technology, but the underlying philosophy within industry generally was to follow science, to promote the results achieved by the lone inventor, to capitalize on accidental or unexpected inventions, and certainly not to stimulate the discovery of new products, processes, and industries through organized research. Management was more concerned with the development of financial empires, with extending the boundaries of our geographical frontiers, and with company growth through various forms of financial transactions.

Throughout most of this period of industrial development, the mechanical factors of industry occupied the spotlight to the detriment (in many respects) of the human factor. The implications of this situation have indeed been far-reaching. The economic views of Marx and Engel and the early socialists have been attributed by some to the declining position of labor as one of the factors of production, and to the fact that the human element in the management equation failed to gain equal consideration to the machine in the workings and management of industry. Most of the great captains of industry during the 19th century achieved their prominence as eminent financiers, shrewd capitalists, or astute organizers. It is on historical fact that many of the great industrial decisions and managerial achievements during the latter half of the previous century were firmly rooted in capital transactions, and certainly not in the field of industrial relations, marketing, or even technology, except secondarily.

Late in the 19th century a relatively dormant factor in the management equation began to rise in importance. Management found its attention being turned quite forcibly to the human element--labor. The famous Pullman strike was a portent of the changing times. The American Federation of Labor was formed in 1886. The organization of labor increased during the following years as mass production industries came into being. However, it was not until the mid-1930's that the labor movement gained momentum with passage of the National Industrial Recovery Act and the National Labor Relations Act. The collective bargaining idea and the strength of organized labor were accelerated after World War II to the end that labor now has a major effect on the decisions of management. In fact, most industrialists today view the problems arising in the industrial relations fields as being among the more important and perhaps the more difficult with which they deal. Certainly, there is no question about industrial relations becoming one of the major problems areas of modern industry.

Almost simultaneously with the rise of labor as a human factor in the management equation, a transformation occurred in the role played by technology and research. Until about the end of the 19th century, invention remained for the most part an unorganized effort by individuals. Edison was one exception. Before most industrialists had given much thought to systematic efforts toward invention, Edison was keeping 75 men busy con-

ducting experiments and designing and building new electrical apparatus so that he could make the use of electricity practical. Edison was perhaps the originator of the idea that new discoveries could be the result of organized institutional research and experimentation, and that through this approach technology could be a powerful tool in the hands of industry. He believed that "genius is about 2% inspiration and 98% perspiration." It has been said that Edison in his drive to develop a storage battery conducted over ten thousand experiments. This approach--organized creative work toward a definite goal--signalled the entrance of an entirely new element in the management equation.

Industry in general did not at first appreciate the significance of this new set of conditions. For about twenty years, the concept of organized industrial research directed towards definite goals developed slowly. It started with establishment of an applied research laboratory by the General Electric Company in 1900. Fifteen years later there were only about 100 industrial research laboratories in the United States. However, by the end of the next fifteen-year period, i.e., by 1930, there were over 1,600 laboratories. Industry was then spending well over 150 million dollars per year in the search for new products and processes and other forms of applied research. In addition, the government was supporting research at the rate of at least 25 million dollars per year. By 1940, the national budget for research and development had increased to over 800 million dollars per year. Today, industry spends more than a billion dollars each year on research, and there are over 3,300 research laboratories in industry employing more than 165,000 people. The nation, industrial and government, is spending about \$3,000,000,000 annually on research this year.

The rise of industrial research during the past thirty years as a factor in the management equation was brought about, or at least was accelerated, by a number of well planned actions outside of industry itself. During the decade of the twenties, the National Research Council, through its Division of Engineering, conducted an organized promotional program designed to show industry why it should support applied research in its own interest. We are all familiar with the Council's Blue Book of industrial research laboratories which was started early in its program. Furthermore, the Department of Commerce, under Mr. Hoover's Secretaryship, began a long-term effort to encourage American industry to engage in and support applied research. One other major development should be mentioned. The first independent non-profit organization set up to provide research services to industry, the Mellon Research Foundation, came into being in 1915. It was followed by Battelle, Armour, Franklin, and Midwest, formed since World War II. The point has been reached where research and development now ranks along with the traditional fields of production, marketing, personnel, and finance as the major functional parts of a corporation--especially those in the technologically based industries. Industry in general no longer questions the need for organized research. Its big problem is to determine which of many promising research projects should be undertaken, and how to finance those projects--a problem of selecting

among alternatives--not one of deciding against the inevitable. This suggests that the facts management must evaluate in each case are not alone the facts of science, but rather a blending of both economic and technical facts.

While the labor and research factors in the management equation were assuming increasing importance during the first half of this century, the rate of change in the production factor was also accelerated. This change was most noticeable in the growth of mass production concepts and techniques. It was hastened by the work of such men as Frederick Taylor, the Gilbreths, and Gantt, who developed the concept of "scientific management," designed to provide management with facts it needed on complex production operations. The public marvelled at the idea of mass production and lower costs as Henry Ford began to turn out automobiles in a matter of hours instead of weeks. The use of automatic machinery resulted in tremendous increases in productivity per man. Special purpose production tools of all sorts gradually replaced general purpose equipment on the country's production lines. In reality, the economic concept for which America is best known throughout the world came into being--the idea of mass production, lower unit profits, lower prices, mass consumption, higher wages, and generally speaking, higher net profits. The trend still continues--and in fact may be entering a new stage with the wider use of automatic factory techniques, electronic instrumentation of many types, the use of nuclear energy for peacetime purposes, and various new production techniques. Advancing technology in many scientific fields has made production a highly technical endeavor. Indeed, many of today's production plants appear at first glance more like giant laboratories than mass producing units. Still another important transformation in the management equation began to develop during the past half century. This development is, in fact, still moving ahead with great force, and there are many who have called it a "revolution" to emphasize the significance and the rapidity of the changes that are coming. This factor in the management equation is the concept of marketing, or, as it is sometimes called, "complete distribution." As our nation's factories increased the flow of both producer and consumer goods, it became apparent that management's thinking on marketing had to be changed from one of "order taking" to one of aggressive selling to the mass market. Some of the great names in business over the last few decades are to be found there because of aggressiveness in the distribution field--men like F. W. Woolworth, the Hartfords of A & P, J. C. Penney, Patterson of National Cash Register, Rowe and Mills who developed the vending machine, Shields with his automats, Thomas J. Watson of IBM, and many others. The roles of advertising, public relations, and community relations all found their way quite naturally in the ever-increasing pressure for greater and more efficient distribution of industry's products. This marketing revolution brought with it a new need for an organized approach to fact-finding--economic and market research. The idea developed slowly--first in the eastern part of our country, then in the West. As industry has become more and more complex from a technological standpoint, the research functions in economics and in the physical sciences and engineering have inevitably been brought closer together. The resulting approach is now known in some quarters as "techno-economics."

Superimposed on all of these industrial developments over the last few decades in production, research, marketing, and human relations is another significant factor in the management equation--government. To a considerable extent our nation followed somewhat of a laissez-faire policy toward the business community until about the end of the Industrial Revolution. Shortly before the end of the last century, the Interstate Commerce Act and the Sherman Antitrust Act came into being and almost immediately had a major impact upon the deliberations of industrial management. Dissolution of the Standard Oil Trust, the Supreme Court's Rule of Reason, the Steel Decision, the Aluminum Company Case, price controls, wage stabilization, and the complex tax laws, to give only a few examples, bring to mind the disturbing conflict between government and business which must be encompassed by today's management. The legal questions mount as time goes on--presenting management with an ever-increasing mass of problems. Intermingled with these legal problems, brought on in large part by government, as a matter of economic policy, are those arising directly from questions of national security--defense production, amortization of facilities, allocation of materials, and restriction of output for civilian markets.

As these developments have occurred, management has been presented at each turn with new and extended equations through which it corrects and evaluates in order to produce those decisions upon which industrial progress is based. At the same time, a fundamental change has occurred in management itself. This change was first called to our attention about twenty-five years ago. As the size, complexity, and scope of industrial operations increased, there developed gradually a wholesale separation between management and ownership in much the same sense that labor and management divided at the beginning of the Industrial Revolution. Earlier in this century there were many large closed corporations presided over by men who not only held complete ownership, but who also in many cases had founded the original operation. With the ever-increasing demands for capital brought on by new technical developments, and with the rise of the investment banker, wide stock ownership began to replace private corporate holdings. The result was that management, instead of being the sole owner, became the servant of the corporate body; i.e., managers became professional administrators. Gone are the days when one man, such as the late Henry Ford, will personally hold the ownership over a vast industrial empire. We even hear now of the possibility that Ford Motor Company stock may before long be traded on the nation's stock exchanges. Perhaps, this separation of management and ownership has not presented a new factor for the management equation, but it certainly has brought about fundamental changes in the setting in which facts must be evaluated by management.

It would be difficult to attempt even a brief listing of all factors in the management equation. This would mean a recital of all the problem areas with which management is concerned. Even if such a listing were possible, it might be out-of-date when completed. Management in many ways is more concerned with the problems of tomorrow than it is with the problems of today. It must foresee the foreseeable, meet the un-

foreseeable with alternatives, lead not follow--and, in the final analysis, must steer the enterprise to further growth and development whatever the future may hold. The task is not an easy one. Industrial life in our country grows more intricate with each passing day. The intermingling of technology, economics, human motivations and incentives, and other factors in the management equation compound management's problem of evaluation, correction, and appraisal. It is more difficult to reduce or remove errors in decisions. The need for precision in the facts with which management deals is greater than ever before, and there is every reason to expect that this need will increase in the future.

Some of the new problems confronting management are intimately associated with science and engineering, but, as always, the decisions are founded on economics with adequate consideration for the human element. In manufacturing, we are experiencing a move to an advanced stage of mass production--the automatic factory. New types of instrumentation and devices of all sorts are being created to produce more complex products in greater quantities at lower cost. Electronic units with memory components are being adapted to the operation and control of machines both singly and in groups. Automatic process control is the order of the day. At every turn, management is seeking ways and means to reduce the human element in the production of goods and at the same time to perform production functions never before possible.

In research and development, the emphasis is on new and vastly superior products, on product diversification, on planning ahead to insure industry's future ten, twenty, or twenty-five years hence. The drive for technical supremacy within industry is accelerating, and the frontiers have never been so vast.

In marketing, management is seeking more than ever to anticipate the market, to know more about its customers' needs and motivations than they know themselves, to guide research and development to meet predetermined needs of the market, and to achieve complete distribution of an ever-increasing flow of new products. The economist, the marketing research specialist, and the statistician are teamed with engineers, scientists, and mathematicians to refine the marketing factor in the management equation to a more exact point. New tools are being developed to aid management in its evaluations. Some of these tools, such as input-output techniques and the application of high-speed electronic equipment to business operations, constitute almost a new approach to corporate economics.

In human relations, management is seeking new ways to appreciate, understand, and evaluate motivations, reactions, group dynamics, and human engineering problems, whether they involve workers, executives, customers, or the general public. The work of the psychologist, the sociologist, and the human engineering specialist is being recognized and used by industry. Applied research in the social sciences, long

far behind fundamental research in the nation's universities and research centers, is being extended throughout the business world. Management can never afford in the advance of technology to decrease its attention on the human factor--a criticism often levelled against the corporate entity as it progressed during the early stages of the Industrial Revolution.

The effectiveness of communication, the quality of leadership, the temper of employee morale, the adjustment of men to machines and of machines to men, and the significance of the working environment can be analyzed, interpreted, and predicted. General trends can be traced and reasons assigned; patterns of thought and action can be stated in figures; responses and preferences can be forecast.

The evidence that industrial operations are becoming more complex can be observed with relative ease. The important point, however, is that the rate of change is accelerating--a change brought on largely by technology. The increasingly dynamic nature of the management problem is in itself a new factor in the management equation. This trend brings an ever-widening and more urgent demand on the part of management for facts--economic facts about production costs and schedules, market potentials and requirements, inventories and prices; - technical facts about new products and processes; - and social science facts about people and their patterns of behavior.

It might be worthwhile to mention some of the actions management has taken over the years to adjust itself to changes which have occurred in the problems at hand. During the past few decades there have been a number of attempts by industry to meet some of its problems at the management level, either by centralizing or by decentralizing the responsibility for major decisions. It is curious that there seem to be several definite shifts in policy on this question. Events during the relative recent past illustrate the point. Before the last war, there was a tendency for large corporations to centralize authority and responsibility in a single top management group. Following the war, an underlying move existed toward decentralization of many top management functions--of moving the management function closer to the source of facts. In recent years there seems to be a shift toward greater centralization brought on in large part by the need for speed and unity of action dealing with government and labor, and in the need for concerted action on many technological and marketing problems. One evidence of this centralization movement is to be found in the increasing number of companies now organized into divisions as opposed to the wholly-owned subsidiary device. Changes of this sort have an obvious effect upon the flow of factual data up the channel of authority within a company. They also reflect management's attempts to deal with shifting problems.

The rise of the comptrollership function over the past few decades has been in response to management's increasing need for coordinated and analyzed facts on over-all operations of the enterprise. Some large

corporations now have sizeable groups devoted solely to the collection, analysis, and presentation of facts useful to management for control purposes.

Another adjustment in the organization of management is the increasing extent to which research and development occupies a position in the top councils of large corporations. Often now, the director of research of a large industrial organization is an officer of the corporation. This has given rise to the saying that "the research director of a company is the vice-president of the future." The cases are increasingly rare in which the research function of a corporation is subsidiary to one of the other functional elements, such as production. Simultaneous with emergence of the research viewpoint in management's thinking has come an increasing emphasis on the principle that scientific research must stand the tests of economics. Management is insisting, that "proposed research programs must first be pushed through the economic keyhole." The implication, so far as techno-economic facts are concerned, is obvious.

In attempting to achieve a more efficient operation to go along with the increasing complexity of industrial affairs, management has also given serious thought during recent years to the size and location of its organizational units. We hear more about the problem of size versus morale and efficiency. Some companies have taken the position that definite limits should be placed upon the size of a single operating group. Others are striving to place parts of their organization in suburban settings.

It is a curious fact that, while tremendous advances have been made within industry to increase the efficiency of operations in the major functional areas--production, research, marketing, etc.,--equivalent advances have not been made in the techniques for handling the routine facts of business operations. The volume of factual data mounts--the need for factual analysis grows greater--the demand for precision continues unabated. But, by and large, management has had to meet the problem with the same mechanical aids used by a growing army of administrative and clerical employees. The "clerical problem" is becoming a matter of great concern in industry. This situation gives a sense of urgency to the widening applications of high-speed electronic equipment on industry's data-handling problems and their information-processing systems. The possibilities appear to be tremendous--the results far-reaching. If the rate of progress continues for some time in the future as it has since World War II, it is conceivable that future business historians will know this period as the beginning of the "administrative revolution." If the trend continues, a new factor in the management equation will most certainly have been created.

There is one other important development which deserves some attention in reviewing management's attempts to improve upon the evaluation and correction process. Facts alone, no matter how great the volume or

how timely, are insufficient to meet the basic problems created for management by the accelerating change in industrial affairs. Even with greater precision in the accumulation of facts, the problem of analysis still remains. It is one thing to reduce errors in the facts received from varying sources -- and another thing, to reduce errors in evaluation and decision, wherever possible, to some calculated probability.

To meet this need, the technique of operations research is finding a practical application in business. Operations research has been defined as "application of the scientific method to the study of the operations of large complex organizations or activities in order to give executives a quantitative basis for decisions." Several words in this definition are significant to the theme, "new equations for management,"--scientific method, complex organizations, executives, quantitative basis, and decisions.

The very essence of operations research is a mathematical analysis of facts on complex operations. A mathematical concept employed frequently is the theory of probability. Many business operations are repetitive, but operational results may vary depending upon elements of chance. Often, it is essential to measure the extent of these variations and the probability that they will occur in the future. This is done by constructing a mathematical model for the problem being examined.

The particular advantage of an operations research approach, beyond the facts which it develops, is that the problem and its possible solutions are presented to the executive in a systematic way, so that he has the situation clearly and completely before him. He can select an optimum course depending upon the goal he wishes to achieve. At the same time, he may have some measure as to the probable correctness of his decision.

Perhaps a completely satisfactory answer to management's continuing need for a greater and greater volume of more accurate facts will never be achieved. However, we have learned much about techniques of collecting, analyzing, and presenting facts from experience to guide us in decisions affecting the future. We must search for still better techniques to provide management with the facts it needs when it needs them--and we must seek new methods of using empirical data as a basis for decisions by management. We must, in effect, defy Aristotle, of whom it is said:

"He could see no order in the chaotic appearance of experience. Facts (to him) occurred one by one in a seemingly unrelated fashion. Particular events . . . were an impregnable mass of occurrences without definite meaning. He did not understand what we call today . . . the theory of probabilities."

The really new factor in the management equation today is an increase in the rate of change toward greater complexity in industrial life. We must meet the challenge by giving management evaluated facts to overcome what might otherwise be "an impregnable mass of occurrences without definite meaning." Computing devices and information-processing systems have a major contribution to make in the gathering and evaluation of facts.

Applied research is directed to the production of facts for the management equation. The formulation of the equation, its expression, and its solution must remain with management itself.