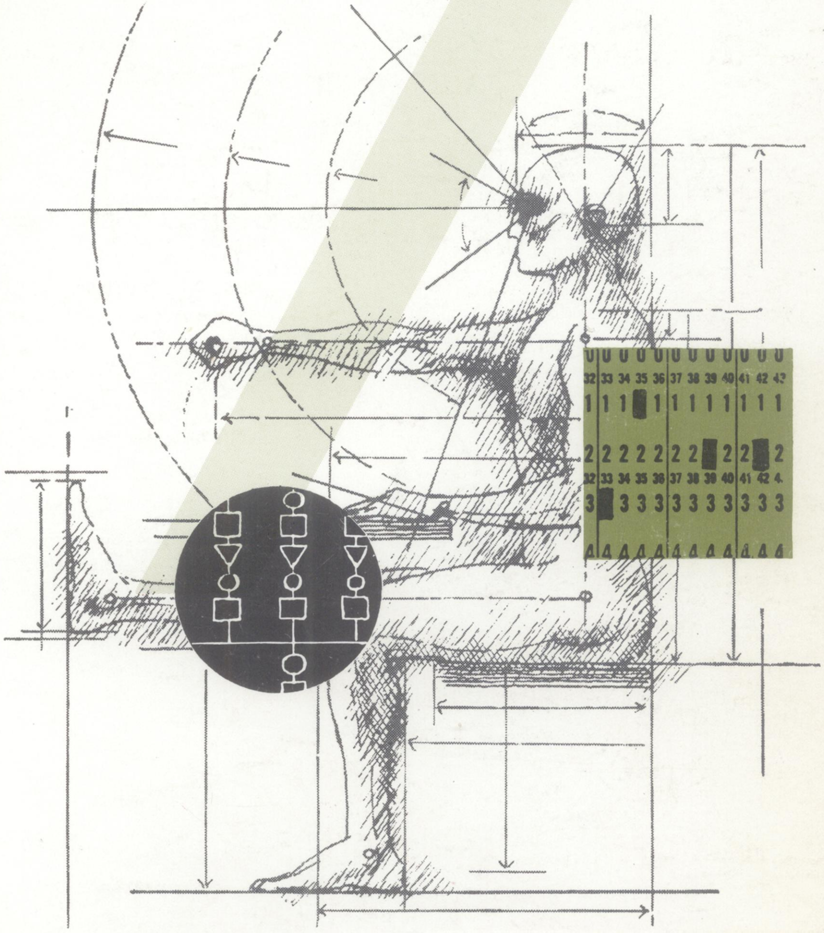
PROCEEDINGS

SEVENTEENTH ANNUAL INDUSTRIAL ENGINEERING INSTITUTE



UNIVERSITY OF CALIFORNIA

BERKELEY and LOS ANGELES February 5 and 6, 1965

PROCEEDINGS

SEVENTEENTH ANNUAL

INDUSTRIAL ENGINEERING INSTITUTE

Presented by

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FOREWORD

Louis E. Davis
Professor of Industrial Engineering
Human Factors in Technology Research Group

The topics and the speakers presenting them reflect the continuing process of change in the professional and academic worlds of Industrial Engineering

The past year has seen the culmination of a long period of planning with the introduction of the Human Factors in Technology graduate program and the launching of a research laboratory and active research program. This development brings into the Industrial Engineering faculty experimental psychologists, human engineers, physiologists and social psychologists. The human elements in systems are beginning to receive requisite research attention.

In the professional world we are at the stage of large scale expansion and innovation in computer application. The 17th Institute program provides a review and examination of these prospects. Continued and accelerated interest in application of operations research methods and costs are also well represented. Present concern with the social implications of automation and of Industrial Engineering makes a review of the effects on manpower a primary requirement for understanding existing problems. The Industrial Engineer's continued interest in human relations problems brings us an unusual examination of an old problem—ineffective performance.

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PROGRESS IN APPLICATION OF COMPUTERS TO BUSINESS AND INDUSTRY

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It is now over twelve years since automatic digital computers first became commercially available for application in business, industry, engineering and science. During this period, almost 20,000 computers have been installed; the vast majority of these installed systems are being applied to the solution of business and industrial problems. However, the effectiveness of the machines used in this area has, in general, been disappointing.

In this paper, we shall review some of the major business and industrial applications of computers; we shall examine the payoff of these applications; and we shall study some of the reasons why these applications have not been as effective as they might be. Finally, we shall discuss the prospects for business and industrial computer applications during the next few years.

COMPARISON OF INDUSTRIAL AND SCIENTIFIC COMPUTER APPLICATIONS

In analyzing industrial computer applications, it is useful to compare them with scientific and engineering applications.

First, let us consider the types of problems that have been attacked by these two groups. Business and industrial users of computers, at the outset at least, used computers to solve problems which were already being solved by other methods. They were obviously meeting their payrolls, controlling their inventories, allocating their resources, and doing their accounting by one means or another. On the other hand, the problems that were attacked by engineers and scientists when they started to use automatic computers were quite often problems that had not yet been solved. Such problems included the design of large commercial power reactors, the design of jet aircraft, weather prediction, and the analysis of data from experiments in high energy physics.

Next, let us consider the kind of people who were initially charged with solving these problems. In business and industry, these people were by and large the ones who were doing the same problems already, but by other methods. It was very natural for them to transfer the problem solution methods that they already knew so well over to the digital computing machine. On the other hand, the engineers and scientists who were originating new problems were often the ones who supervised the solution of these problems on computers. They were people whose business it was to invent new problem solving techniques. They were often well grounded in mathematics and in the construction of mathematical models.

It is no wonder when one considers the sorts of problems that were attacked and the kinds of people that were working on them that science and engineering forged ahead of business and industry in the application of computing machines.

Interaction Between Applications and Hardware Design – The differences in problems and personnel between industrial and scientific computer users has had a very strong effect on computer hardware design. This effect has persisted until very recently.

It is fairly obvious that for the same amount of money, one can build a more powerful binary, fixed word-length computer than one can build a decimal or alphanumeric, variable word-length computer. However, computer manufacturers felt very early in the game that binary machines would not find ready acceptability among commercial users. The argument was that the best prospects for the purchase of digital computers would be found among firms who were already using punched card equipment. This equipment was strictly alphanumeric and variable field length in nature. Manufacturers decided that the best way to minimize the shock of conversion from electrical accounting machines to computers would be to make computers for commercial applications which looked as much like electrical accounting machines as possible.

Scientists and engineers (with the exception of a few astronomers) had no such tradition behind them; they simply wanted the most powerful computing machine they could obtain for their money. The result was, of course, that they got a parallel binary machine.

Interaction Between Applications and Programming Languages – The differences between industrial and scientific applications also were propagated in the development of programming languages. The users of computers in the scientific community—the people who wanted to look at the answers—were often closer to the computing machines than were their opposite numbers in the industrial community; in fact, many of these scientists and engineers often did their own programming. This led to the development for them of languages such as FORTRAN and ALGOL which were very close to the intuitive languages which they used to state procedures for solving their problems.

The industrial computer user was in general farther away from his machine. The people who were doing the programming were usually former electrical accounting machine or clerical personnel. The result was that the programming languages developed for the solution of commercial problems, such as

COBOL and commercial translater, were designed for programmers and not for people who wanted answers.

I am not trying to imply here either that COBOL is not as good a language as FORTRAN or that all commercial users should use FORTRAN. However, I am saying that the development of programming language in the commercial application area tended to keep away from the computer the person who wanted to use the results generated by it.

EXAMPLES OF BUSINESS AND INDUSTRIAL COMPUTER APPLICATIONS

The following list of examples is intended to illustrate some of the points mentioned in the paragraphs above. These examples are intended to be as typical as possible; it will also be feasible, of course, to select examples which illustrate the converse of some of my points.

Personnel Records — Personnel record keeping is perhaps the blackest spot on the escutcheon of commercial computer applications. This is an area where the direct translation of manual or electrical accounting machine methods into automatic digital computer programs is almost invariably fatal. When one is using electrical accounting machines, it is quite necessary to keep separate files and to make separate runs for such applications as payroll, labor distribution, vacation accounting, etc. When one is doing these same problems on an automatic computer, it is generally preferable to consolidate many or all of the files associated with these applications.

The worst example of such an application with which I am familiar took place in an organization with several thousand employees. It was the usual practice in this organization to distribute to each employee every two months a card on which were summarized his sick leave and vacation accounts. Four years ago, this organization acquired a small tape-oriented computer which was to be used to handle its administrative data processing load. Shortly after the installation of this machine, employees noted that their vacation and sick leave accounts were being distributed on punched cards—the age of automation had arrived! When one examined these cards more closely, however, one noticed the telltale nick on the righthand edge of the card which indicated that the card had been hand keypunched and verified. One also observed that the balances of vacation and sick leave had been written in by hand.

What was the explanation for this remarkable state of affairs? It was simply that although the same source documents provided input for payroll, vacation and sick leave, the accounting functions for these two items had traditionally been performed by different groups. When the computing machine was installed, these two groups had maintained their separate identities and had maintained their separate files.

Even when computers are employed to perform comparatively routine tasks, it is often necessary for fairly high level management decisions to be made in order that these tasks should be performed rationally.

Inventory Control — The control of inventories is a problem which management scientists have interested themselves in for many years. In large firms, computers have been employed effectively at this task for over ten years. The important point to notice here is that effective techniques for the solution of this problem were devised before computers became available and that these techniques were easy to implement on computing machines.

In small firms, especially retail distributors, the development of effective, computerized inventory systems was hampered for a long while by the unavailability of satisfactory input devices. This problem has now been solved to a certain extent by the development of remote data entry devices and machine readable merchandise identification tags. The development of inexpensive random access storage devices has also stimulated the implementation of inventory applications in small firms.

The Defense Department has probably been responsible for the development of the most sophisticated computer-assisted inventory control systems. Over eight years ago, the Air Material Command started to use computers to control spare parts inventories for aircraft and other weapon systems. They developed methods not only for the dynamic control of inventory levels, but also for the optimal location of supply depots and for the optimal composition of spare parts inventories at remote bases. In implementing these applications, they also developed AIMACO one of the earliest business-oriented programming languages.

One of the most successful civilian inventory control applications has been the airline seat reservation system. Every major airline has, by this time, installed a computerized seat reservation system. The most sophisticated of these systems keep track of all seats on a given airline for a year in advance. They have response times of the order of one half of a minute and, in certain instances, perform additional functions such as devising alternate routings. Hardware developments that have made these systems possible include large-scale random-access memories, reliable digital communications systems and interfaces, and easily used remote data entry consoles.

Banking and Insurance — The larger banking and insurance firms were among the first effective users of large-scale digital computing equipment. Their accounting applications were of a sort which were quite readily adapted to automatic computers.

There was an attitude in both of these industries at the outset that it would be easier to train their people as programmers than it would be to train programmers in their business. This led to a certain amount of inefficiencies; one bank consumed 24 man-years in the implementation of a mortgage loan accounting application which could have been implemented by competent professional programmers in two man-years. Fortunately, this attitude has by now almost disappeared and many banks and insurance companies employ very talented professional programmers.

In check accounting and in demand deposit accounting, recent applications of computers have been very successful from a certain viewpoint. In one large bank, the productivity of bookkeepers has been increased by a factor of eight. Unfortunately, these gains in productivity have sometimes been realized at the expense of inconvenience to the customer. Perhaps some of you have noticed how difficult it is these days to get anyone to accept a check which is written on the back of an old envelope.

Scheduling – A large class of industrial computer applications of the scheduling sort have been implemented in recent years. These applications generally have been the result of collaboration between management science people and computer people.

One of the most successful of these applications was a scheduling system developed by a west coast steamship line. This system was built around a large computer simulation of the line's freight operations. By using this simulation, they have been able to conveniently evaluate alternative schedules and to select more nearly optimal schedules for use. It is interesting to note that the simulation model was developed and implemented by the line's research department.

Another, and less happy, example of a scheduling application was implemented a few years ago by a large railroad. They were interested in the empty boxcar problem; they wanted to minimize the cost associated with their use of freight cars belonging to other railroads. This problem is very large and very intractable, but it has potentially a handsome payoff. The railroad engaged the services of a distinguished consulting firm to work on the problem. This firm after working for several months, devised some ingenious algorithms for the utilization of freight cars and recommended a computer-implementation of these algorithms. The railroad accepted these recommendations, acquired a computer, and after several additional months of programming and debugging put the system into operation. Unfortunately, the system did not work. It did not work because the required data about the distribution of freight cars was not available on a sufficiently timely basis. I believe the railroad company was culpable in this instance because it did not work sufficiently closely with the consultants that it had engaged and because it failed to verify the assumptions that the consultants made in solving the problem. Now, after the lapse of two or three years, the railroad is again attempting to implement a freight car scheduling and control system. This time, however, it appears that they will achieve success because in the interim hardware devices have now become available in the digital data communications area that allows for the collection of the required data in sufficiently timely form.

Project Management – Critical Path methods have been used increasingly during the past three years as tools for project scheduling and control. These methods have the advantage that they are effective, that they are easy to understand, and that computer implementations of them are readily available. Even relatively small firms without operations research staffs can use these methods effectively.

The Critical Path Method was developed originally by Mauchley Associates for the DuPont Company. DuPont was interested in a system for scheduling and controlling the maintenance of large chemical plants in a way which would minimize shutdown time. They found that the CPM was a very effective tool for this purpose.

Another Critical Path Method (the PERT System) was developed by the Booze-Allen Applied Research Company for the Navy. The Navy wanted a system to schedule and control the Polaris Missile Project. It has been reported that the use of the PERT System speeded up the completion of the Polaris Project by 18 months.

PERT and CPM systems are now very widely used by defense department contractors and by construction contractors. These systems are important examples of applications which were done either badly or not at all before automatic computers were available.

Process Control – Computers are currently being used to control and, in some cases, to optimize the operation of petroleum refineries, paper mills, blast furnaces, rolling mills, cement factories, and power generation plants. Some, but not all, of these applications have resulted in substantial payoffs. Closed-loop control of one large catalytic cracker has resulted in an increase in productivity of over 2 percent—an excellent result.

Attempts to use computers as control elements in process industries have often led to a better understanding of the processes involved; such attempts have also occasionally revealed how badly these processes were understood.

PROSPECTS FOR THE FUTURE

Developments in computer hardware and in computer programming systems in the next few years should have a dramatic effect on the way in which computers are used in business and industry. The substantial increase in knowledge of industrial management about computers and the increasing availability of the powerful tools management science should lead to attacks on a very much wider spectrum of industrial problems.

Hardware Developments – In the next generation of large-scale computers, the distinction between scientific and business machines will have almost completely disappeared. These new, large machines are by and large binary, fixed word length devices and they are fast. Internal computing speeds in recently announced machines differ by a factor of over a thousand from the internal speed of the UNIVAC I, the earliest commercially available automatic computer. While these machines have developed powerful computation capabilities from the example set by scientific computers, they have derived at the same time increasing input-output capability from business-oriented computers. Magnetic tape systems which transmit data at rates in excess of 200,000 characters per second, and large magnetic random-access files which transmit data at rates of 1,000,000 characters per second are commonly available on announced machines. The sizes and speeds of internal memories have also increased; memories with cycle times of 1 microsecond containing 128,000 words are now available from several manufacturers.

Developments in central computer hardware have been matched by developments in peripheral hardware. Especially important in this area is the increasing availability of inexpensive remote input-output stations. These stations take many forms—from complete peripheral processors with their own memories, high speed printers, card readers, and tape units to small consoles consisting essentially of a typewriter. Some of these remote input-output stations allow not only the exchange of alphanumeric information with the computer, but also permit the computer to display graphical information. The capabilities in digital data transmission have kept pace with the development of these remote input-output stations so that it is now possible to reliably transmit data between a computer and a remote station which may be several thousand miles away.

In these new developments, the traditional disparity in unit computation costs between small and large computers has been maintained. It is very much less expensive in general to do a problem on the large computer than it is to do it on a small computer.

Programming Developments – The use of high-level problem-oriented languages, especially COBOL, is increasing rapidly in the business community. The use of such languages not only cuts programming costs, but also eases the problem of transferring from one machine to another. In the last year or two, progress has been made in the writing of translators for such languages. The translators which are now becoming available are efficient, both in their translating speed and in the efficiency of the machine-language programs they produce.

Another important development called multiprogramming has been stimulated by newly announced computers. Most new large-scale computers incorporate a basic imbalance between arithmetic speeds and input-output speeds. If one attempts to run a program which does even a modest amount of input-output, one finds that the Central Processing Unit is idle most of the time simply because it is waiting for the completion of an input-output operation. This poor CPU utilization can be improved by placing several programs in the main memory simultaneously and allowing them to share the use of the CPU. At the same time, of course, each program may be doing its own input-output tasks. Such multiprogramming systems have been announced by all major computer manufacturers for their large machines.

In addition to effecting more complete use of the computer, multiprogramming systems play another important role. They allow the operation of remote input-output stations, such as the ones described above, to act concurrently with the normal computer load. For example, while a computer was working on the monthly payroll, a user at a remote console could inquire about the status of a certain inventory item, and simultaneously another user at another console could ask to have displayed for him the current PERT network for a certain project.

Service Bureaus – An important consequence of the availability of powerful central computers, effective multiprogramming schemes, and reliable digital data transmission and terminal equipment will be an increasing use of service bureau facilities, especially by small firms. In the past, one of the unpalatable features of the use of service bureaus has been that the customer had to transport his input data files to the service bureau site and to transport his output back from that site. In the near future, he may have input-output facilities consisting of tape drives, card readers and punches, and high-speed printers installed in his own office. These input-output devices will be connected to a central computer in a remote service bureau. When the customer has a problem to run, he will only have to mount his input and output tapes, place his program deck in the card reader and push the start button. His program will then be read into the central computer and operated on a time-shared basis with other programs. His output will appear on tape, cards, or printer again in his own office.

Under this system, the economies of scale formerly achieved only by large organizations will now become available to small firms.

New Applications – The availability of powerful computers and an increasingly effective collaboration between managers, management scientists, and computer technologists will make possible during the next few years the implementation of exciting new applications. In performing these applications, the computer will not merely replace tabulating machines and clerks; it will begin to perform important decision functions.

Computer assisted resource allocation is such an application. This problem, which up until now has been solved largely by intuitive methods is beginning to yield to analytic techniques. The availability of an effective resource allocation procedure should affect great savings in the construction and transportation industries.

Computer assisted information retrieval systems will enable managers to obtain precisely the information they require at the times when they require it.

The advertising industry will make increasing use of computers. At the present time, it is very difficult for advertisers either to predict the effect of an advertising campaign or to assess the effect of that campaign after it is over. Simulation techniques developed to forecast the outcomes of political campaigns appear to be equally useful in forecasting the outcomes of advertising campaigns.

Some applications which will be accessible on computers to be delivered during the next year or two should be mentioned, although they do not lie within the business and industrial area. Such applications include the automatic translation of languages, effective long-range weather forecasting, automated teaching techniques, and automatic drafting.

CONCEPTS, COMPUTING CAPACITY OR COST — WHAT LIMITS?

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THE SUBJECT

My talk this morning is going to be about concepts, their formulation, their necessity, their importance and, above all, their relevance to the future use of computers in business. In very broad terms, I want to draw your attention to the inadequacy of the conceptual apparatus commonly in use today and to the price we pay as a result of this inadequacy. My brief is that any change as drastic and as discontinuous as has occurred with the advent of electronic computation is almost certain not to be orderly. And being disorderly, one can observe distinct shifts in the center of attention as the solution of one problem generates another which must be stated in terms of other concepts. This suggests that if one is slightly courageous and very lucky he may successfully predict the next major shift and take advantage of it. I am going to try to make such a prediction.

THE SHIFTING CENTER OF ATTENTION

To illustrate my point on the shifting center of attention, I would like first, very briefly, to review the history of computer usage in business. Starting with the modern pioneers (that is not including Babbage), it seems fair to say that they regarded their machines as being of interest primarily to the scientific community. Von Neumann, Aiken, Turing, et al, were above all scientists and it was only natural that they would think first in terms of familiar surroundings. This attitude lasted for about a decade, give or take a year or two, during which the primary question was whether a digital computer would work at all. Questions of manufacturing economics were very secondary at this stage and ultimate use outside the scientific realm was irrelevant. By about 1950, it became reasonably clear that not only could an electronic computer of substantial scale be made to perform reliably, but also that the market for such devices might well turn out to be more than the few nuclear physicists and other "long hairs" might use. And so the race was on.

In the period immediately following, attention was centered on the field of engineering design. Great efforts were expended but they produced mixed results. More than a few manufacturing organizations reached some very bad decisions (or had very bad luck if one chooses to accompany hindsight with charity), and their products completely missed the mark. Some systems were unreliable, some had serious imbalances in the productive capacities of sub-systems, and some never got off the laboratory floor in spite of promises made by optimistic sales departments. At this stage, factor-of-ten-errors were not uncommon, primarily, I believe, because the system design engineers were sometimes just as optimistic and as unrealistic as their sales oriented associates. For example, one group undertook to build a machine for around $25,000.00, with a capacity that wasn't offered for years at less than $250,000.00. The manufacturers, would be or real, were, of course, not the only ones who learned lessons the hard and expensive way. The pioneer users also found out that what was easy to identify as possible was often incredibly difficult to bring into practice. But the continuing development of the computer and its peripheral equipment did take place.

In the mid-to-late fifties, another shift in emphasis occurred as the cognoscente came to realize that the gap between machine language and the natural languages of men was much too large. Programming in machine language, or a near relative, not only was a bore, it was about to seriously slow the rate of progress. The result of this situation was, of course, an intense effort to develop intermediate languages, compilers, assemblers, etc., that more nearly matched the machine to the man who would program it. That this process is still going on with much debate I'm sure is well known. I think the majority could agree, however, that language difficulty is no longer the dominant limiting condition restricting further progress.

ATTITUDES TOWARD COMPUTERS IN THE PAST

Now, at some greater risk of being inaccurate, I would like to trace the same history but in terms of how responsible corporate executives, rather than the data processing specialists, behaved. The period prior to 1950 is quite simple to review because the typical corporate executive had simply never heard of an electronic computer and wouldn't have recognized one if it marched down the street. He might have been dimly aware of the "tab" department, if there was one, but unless he was a controller he knew little and cared less. The science of computing had at best just been born and he had no reason to consider it an important influence on his decisions. In the early fifties, a small number of executives, motivated either by their own curiosity or the salesmanship of the computing fraternity, began to inform themselves and an even smaller number decided to gamble on the attractive prospects they saw. Again, aided by 20-20 hindsight, it is apparent that gross errors were made in assessing the difficulty of making a data processing facility produce more than it cost.

The prime and almost universal error was underestimation of the degree of variation present in procedures which presented the appearance of uniformity to a superficial inspection. After all, a bill was a bill and only the amount changed from month to month, except for that very small set of people who moved. Then there was the well thought out and carefully followed account-numbering system that served effectively for twenty years. Certainly that didn't need any further thought. Unhappily, these observations and their equivalents in dozens of kinds of businesses were rapidly shown to be absolutely untrue. I remember doing a little informal research on codes in one organization and counted thirteen non-coherent systems before I gave up with a feeling of hopelessness. Some of you here must have had similar experiences.

Later, as the degree and costliness of these difficulties became apparent, it seems as if a reaction set in that slowed action on the part of a substantial group of executives. I say "seems as if" because I doubt that I could give you convincing evidence in terms of computer sales, tasks converted, etc. The rapidity of change was so great that the actions of this group may well have been completely obscured by the entrance of uninformed neophytes. Nevertheless, the limited evidence of personal contact left me with the impression that a substantial group prided themselves on not having made what they regarded to be the errors of the pioneers. It was the conservative view that the manufacturers would have to make the process of changing over easier than it had been and that a waiting game would pay off. The extent to which the conservatives were correct is difficult, if not impossible, to assess with any degree of accuracy. We can observe, though, that the capacity of both hardware and software per dollar of cost to the customer continued to climb at a very rapid rate and that as a result, few computer manufacturers made money. It appears, then, that the manufacturers paid for more than their share of the ultimate benefits produced.

LESSONS FROM THE PAST

This bit of history has a threefold lesson. First, it shows the changing frame of reference within which the then currently dominant problem was stated. At the outset, it was necessary to think in terms of voltages and magnetic fields with little detailed attention given to the end result. Then came the phase of thinking in terms of small black boxes; e.g., a register, a clock, a memory device, etc. In the competitive engineering phase came the larger black boxes; e.g., the main frame, the high speed memory, the printer, etc. Dollars began to loom large in importance at this point and the frame of reference had again to be extended to include the user and his problems. The second point illustrated is that as the important frame of reference changed, so did the background, viewpoint, position and training of the people who made the key decisions. Without the mathematical genius of Von Neumann, we might still be struggling without the idea of representing commands and data in the same fashion. But the group who probably have had the most influence of late are corporate controllers (excluding the military). Which machine is acquired and how it is to be used seems mostly to be decided at that level. The third point is that as the frame of reference has expanded, the conceptual modules, the building blocks of the thinking processes, have also become larger because it is literally impossible to deal with the complexity and number of variations at all levels simultaneously. A human mind simply lacks the capacity to think well in terms of a very large number of variables.

This fact is, of course, widely recognized not only by psychologists but by busy executives who refuse to be bothered by "detail." Such a refusal is entirely justified but the trick is to know what is and what is not "detail." I would like now to examine this question in terms of concept formation.

THE INFLUENCE OF AN ESTABLISHED CONCEPT

Having checked Webster and not being particularly satisfied with what I found, I propose to equate a "concept" with "a way of looking at things." It is certainly a common experience for two people of good will to see the same object or phenomenon and communicate their experience in ways which seem drastically different to a third person. Depending on the frame of reference an individual brings to a situation, he will tend to see and emphasize certain aspects and to de-emphasize, or even completely ignore others. In so doing, he will be neither right nor wrong because he receives more information via his senses than he can process and retain, so he must be selective. However, he most certainly can be effective or ineffective, depending on what he chooses to absorb and its relevance to the goal he is pursuing. In short, a concept is not right or wrong, but it is subject to criticism with respect to its utility. For example, the fire, air, earth, water system of chemistry as seen by the Greeks was not wrong, but time has shown it to be vastly inferior to Mendelyeev's periodic table.

To bring my argument a little closer to home, consider the primacy now given to the calendar year in almost every formal planning process. The "budget" reigns supreme throughout government from the smallest community to the nation as a whole. It plays almost as an exalted role in most corporations. But why should one make what purports to be a plan at one point in time and then consciously alter it in all sorts of awkward ways, all the while looking at a continuously nearing horizon? Is there something about January that inclines one to look twelve months ahead and something else about November that leads one to look forward only one month? Pretty clearly there is not and in a very real sense people don't behave this way. But they do record their formal (i.e., recorded) plans this way and then they struggle with the consequences.

The alternative is neither obscure nor original; namely, to alter formal plans periodically, continuously restoring the distance to the horizon. For example, quarterly revisions to an existing plan that looks, say, two years ahead will maintain the distance to the horizon of time between narrow limits of 7 and 8 quarters. Obviously, the same principle holds for annual updating of five year plans. There is much more that could be said along this particular vein that would be of interest by itself, but my purpose is to note that this rather elementary facet of good planning is the exception rather than the rule in practice.

Now let us see if we can determine why this is so. Unquestionably, there are influences that tend to emphasize the annual cycle; e.g., weather, income taxes, vacation schedules, crop production, etc. But I submit that the most compelling reason is simply that most formal plans are outgrowths of budgets and most budgets are outgrowths of accounting systems which were well designed to record history—not to assist forward planning. Anyone who has been through the process of "closing the books" in a pencil and paper accounting system will be likely to note that one is not inclined to do it any more often than one has to. The formulation, recording, and approving of a budget is perhaps a comparable burden under the same circumstances and these demands have undoubtedly contributed to preservation of "the annual budget." But the number of years has now passed during which the major portion of the burden could have been shifted to a data processing system and it has not happened.

One reason for this situation may be simply that the alternative is not considered any better. I am convinced, however, that in most cases the conceptual apparatus of the man who is able to make the change but does not, just cannot admit of any alternative to the mode of operation with which he is familiar. He has a system that works reasonably well so far as he can tell and he has learned to read between the lines; i.e., mentally to cross correlate certain figures, seek out sensitive areas, find "padding," etc. In so doing, he is in part practicing the fine art of being an executive; but also he is acting as an inferior processor of data and he will err in ways that would not be possible were the data already processed for him. But processed how? Again, I come back to the central theme of concepts and argue that it should be data processed in terms of concepts which the individual has agreed are more useful to him.

This brings me a step nearer the core of my argument because I have at least touched on the idea of matching information to the man. There are at least two ways to do it. One is to elicit from him the governing elements of his conceptual system and give him the information which fits. The other is to change his concept of the situation of interest and give him the information appropriate to the reformulation. Both are discouragingly difficult to do, but the alternative of doing neither leads to automation of mediocrity and those responsible are then vulnerable to the accusation of delivering the same old garbage—only faster. Again, I am tempted to pursue a tangent because there are a number of problems associated with "educating the boss" that are, to put it delicately, interesting. As a very wise man once observed, "It is very difficult to run a large organization from a subordinate position." But this hardly deals with concepts and computers.

THE UTILITY OF WELL CHOSEN CONCEPTS

Another approach to the relation of concepts and data processing is through the consideration of an idealized data processing facility which has infinite memory capacity with an access time well matched to human inquiry. Given this one could, in principle, maintain a file that reflected the "state of the system;" that is, the file would be the sink for all pieces of information relevant to the conduct of the operation and the source of all reports. It would follow then that any question that was answerable at all could, in a sense, be answered by giving the questioner a copy or printed listing of the file. But, obviously, such an answer would not be useful. To be useful, an answer must be the result of a high degree of summarization such as an average, a total count, a frequency distribution, or a simple yes or no. The answer to the question, "What is the state of the system?", is precisely the complete content of the file at that point in time, but for the reason given it must be an inadmissible question. An answerable question from an individual might be something like "What are the present values of the summary statistics of interest to me and my department?"

Now some of you may be thinking that this is an awfully round about way of saying that good questions are apt to get better answers than poor ones. But how many people are aware, even today, that whereas they used to starve for information they can now drown in it? So long as data was costly to process and in short supply, there was relatively little pressure to formulate questions well; i.e., to use powerful concepts. A sloppy question would probably elicit most of what there was to be had. Now the reverse is true but realization of the fact is coming very slowly.

THE INFLUENCE OF COMPUTING CAPACITY

At this point, I would like to turn to the second "C" of my title; namely, capacity. The burden of my argument has been that the dominant limitation at present is conceptual, but I do not mean to imply that capacity limitations are relegated completely to the background—I have waited for a computer run too many times to be so rash. However, it does seem reasonable to point out that the idealized machine I mentioned a few moments ago is not seriously different from the present generation of machines. Since an individual can mount and pass a tape in approximately ten minutes, this provides one with access to an infinite memory system with a response time not wholly unlike his own. Granted that seconds would be preferable to minutes, it does not follow that any further decrease in response time buys very much. Random access mass memories that store multimillions of characters with access times in the range of 100 milliseconds are now available. This capability introduces the possibility of quite rapid responses to unscheduled events, and one can think of quite attractive priority interrupt schemes that have great esthetic appeal. But it is not nearly so clear that the business world has any very extensive need for such response. Once more the frame of reference, the conceptual scheme in which such devices are evaluated, becomes important. Only this time it is not the boss's concepts which are called into question.

By way of illustration, consider the particular concept of a data processor and its environment, forming a closed loop. (The basic idea is no more than an analog of a servomechanism.) In the frame of reference of a closed loop, a data processor can be characterized as a device which receives certain input data and after some delay delivers certain output data. The input data may come from any of a number of sources, but at least some of the output will go to an executive who will take action to diminish the difference between the state of affairs that exists and the state he desires. The action may be as simple as filling a customer order or as complex as a revision of an entire price structure. In any case, his action will in turn stimulate a reaction, desired or undesired, from the rest of the world and this reaction in turn will be transmitted in one form or another to the data processor, thus completing the loop. In the vast majority of cases, the time interval between the receipt of the item of information which stimulates action, and the observation of the action's effects, will be adequately measured in days, weeks, or even months. This leads one to wonder about the reality of any purported need to decrease the time delay of information processing from hours to milliseconds or even minutes. As a matter of fact, servomechanism theory demonstrates that it is essentially useless to decrease any particular time delay in a closed loop system except the largest one. Obviously, it is possible to single out particular cases where the delay in processing is of comparable size to other delays in a particular loop, but I submit that these are few and far between in current business practice. One point of my argument is that in spite of the concerted effort now being made to sell electromechanical random access devices, computational capacity is not the basic limiting condition. Present processing delay times do not dominate in the loops of which the processor is a part. But more important is the conceptual frame of reference used to evaluate a new development such as those associated with the computer memory. It is certainly reasonable to quarrel with the particular suggestion I have made but it is irresponsible not to have a defensible alternative. One is always on the horns of the dilemma of overcomplicating or oversimplifying a particular situation, but there is no excuse for not knowing it.

THE INFLUENCE OF COMPUTER COST

The matter of cost is, of course, very closely connected with any consideration of computing capacity. For example, if the current crop of electromechanical memory devices could be produced to give all the desirable attributes of a tape plus decreased access time at comparable cost, there would be no question of preference. Such is not the case, however, so there is a genuine problem of allocating whatever money may be made available for hardware. In that sense, cost is a genuine limiting condition and always will be. But at the level of deciding what amount should be budgeted, the picture seems different.

Harking back again to the necessity of ignoring "detail" and viewing the problem in terms of allocating a company's investment resources, computing capacity appears to be a very good bet. First of all, every technical measure shows a tremendous increase in capacity per dollar of cost. Secondly, there are now some real success stories where data processing facilities are routinely performing tasks that could not be done by hand. This encourages one to hope that his company can find its way to the same happy situation. Thirdly, there is the element of fear that a competitor will gain such a commanding lead that he cannot be overtaken if his gamble turns out to be correct. These factors have made and are continuing to make it easy for boards of directors to be liberal with funds for data processing. The rate of growth of computer sales in turn tends to confirm the view that management is not reluctant to invest in this area. Whether or not this investment is justified remains to be seen because not all companies are getting value received from their machines and staffs, but for the time being at least, most firms seem to be willing to proceed on modest results and a great deal of faith.

AN EXAMPLE OF A USEFUL CONCEPT

At this point, I would like to take up a subject which must be well known to some of you; namely, inventory control. It's been written about forward and backward, inside and out, and all too often ignorance has been concealed with imposing looking mathematics. Having been guilty of giving the mathematical side more attention than it deserved and knowing in some instances the real story, as well as the published one, I feel painfully aware of the excessive claims that have been made about inventory control. Nevertheless, it is to my mind a very persuasive example of the power of a concept when it is matched by the appropriate computational facility.

The desirability of conserving capital investment by inventory control is, of course, a very old idea. Successful merchants have long since, by intuition or trial and error, arrived at quite good systems using the traditional tools of pencil, paper and a calculating mind. It was not until about 1925, however, that anyone took the time and trouble to generalize and formalize the underlying process and produce the economic lot-size formula. Even this formulation leaves out the very significant element of uncertainty and only in the last ten years or so has the gap been filled. So the concept of inventory control in its present form is relatively new. Stated very briefly, it is the idea that one should at all times balance the costs of acquiring, holding and being short of any desired item. At first glance this is a very pleasing formulation in that it has direct appeal to experience, it is not too complicated to grasp, and it does not involve very many measurements. At second glance most of the pleasing characteristics disappear as one starts to think of just what he means by the "cost" to hold an item in inventory, of discontinuous freight rates, quantity discounts, and a variety of other factors. It seems as if by thinking in these terms one is simply trading problems without any perceptible gain. But if one perseveres, still a third level of understanding emerges and the true power of the concept becomes apparent.

First of all, it becomes clear that an inventory decision can be specified in terms of two numbers - when to order and how much to order. One, then, is apt to do some searching for the individual who picks these numbers, and he will often find that it is a clerk who is operating with insufficient information and a serious lack of awareness of the implications of his decisions. It also becomes clear that although the formulation does not solve the strategic problem of balancing the three factors of acquisition, holding and shortage, it states the problem very well. It is impossible for a high level management group to deal successfully with thousands of different numbers, but it is possible for them to deal with three. For example, picking a shortage risk level is a difficult thing to do and the mere attempt to do so is very apt to lead to searching questions which need asking. Also, balancing any two of the three "costs" will usually require cutting across departmental boundary lines and the process of doing so will often reveal provincial points of view and behavior which need correction. In a case with which I am familiar, an inventory study turned up the fact that the dominant cause for high inventories was wide variation in the time delay between order placement and receipt of goods. The end result of this study was the discovery of a large investment on the part of the supplier to provide better service to the customer. These are only a few of the more obvious consequences of conceiving of inventory control in a particular way.

At a more subtle level, one can see the value of forecasting demands in very concrete terms; i.e., you can make an incontrovertible statement that a decrease in variance of forecast demand from actual demand by X % will release Y dollar's worth of inventory (all other things staying the same). And if you have an inventive bent, it may occur to you that a supplier could pay for "lead time" on an order from a purchaser in much the same way one offers a discount for cash. This begins to sound a little "way out," but so does the Kaiser experiment of sending out blank checks to suppliers. From all reports, this apparently radical scheme is working well. Why not provide an incentive to the purchaser to give you the information needed for an accurate forecast of required production?

Now lest you think I have gone overboard on inventory control, I would like to iterate that it is intended only as an example of a solidly successful concept. It has worked and can be expected to continue to work. On the other hand, the concept of a game in the Van Neumann sense, although given wide publicity, has thus far been relatively unproductive. The idea of a queue has been quite useful, though to date not too widely understood since it presupposes at least some feeling for random phenomena. Again to avoid misunderstanding, I want to emphasize that I neither expect nor advocate any serious attempt to delve into the mathematics associated with these ideas. What I do advocate, and expect, is a new openness of mind - a willingness to consider a non-traditional characterization of a situation.

AN OBSOLETE CONCEPT

I would like to introduce a conceptual framework that persists even though it is now obsolete. Consider the origins, assumptions, present practice and utility of most existing accounting systems. They are almost without exception outgrowths of an idea originated centuries ago which was very well designed to control a small merchandising business. Double entry bookkeeping was a valuable invention because it has the happy combination of being an excellent error control device (for hand operation) and at the same time being a quite useful conceptual framework for some relatively simple circumstances. The modern descendant of double entry bookkeeping has much less to be said for it on a number of counts. One serious difficulty is that current practice gives an illusion of scope and objectivity that is not consistent with the facts. Company A reports such-and-such a profit on operations while Company B reports a loss. Both show neat, well-presented balance sheets with assets balancing liabilities, but unless you read the footnotes you don't get a clue to the fact that Company B really turned in a better performance over the period reported. There is no need here to list the ways in which different accounting treatments of the same data can inform and misinform a reader. This has been well treated elsewhere. It should be pointed out, however, that in spite of the traditional reference to "generally accepted accounting practice" seen in almost every audited annual report, different auditors heatedly defend different points of view. It is my opinion that when honest people can differ so clearly in attempts to inform a reader, their vehicle of communication is highly suspect.

It appears that the basic difficulty stems from strict adherence to the point of view that all relevant facts must somehow be translated to the single scale of dollars. There is little question that when the facts can so be translated, it is informative to do so. But, unfortunately, life is not so simple and the translation usually introduces more noise than signal in the output. How, for example, does one translate the loss of a key executive to dollar terms? One just does not. Or how does one reflect the obsolescence of processing equipment brought on by a competitor's discovery? Again, the practice is to ignore it. Granted these are rather extreme examples at the end of a spectrum. It is still the case that, on the whole, what is not revealed by traditional accounting statements far exceeds what is revealed.

Insofar as the release of information to non-company personnel is concerned, this is probably just as well. For as the saying goes, "Does Macy's tell Gimble's everything?" But there is a state of confusion in the minds of some people and they seem to believe that the accounting statements constitute a sort of all-purpose summary which is sufficient internal information to control all facets of a business. In pre-computer days, this was not a bad view because good accounting statements were about the most one could hope for. An executive was thus well advised to become very adept in interpreting this particular presentation of information. But even though the practice is still carefully clung to in some quarters, the need for it is passé. A reasonable alternative is to abandon the assumption that only dollar measures have real relevance and to treat a variety of other measures as being of equal importance. Such a change, of course, places a burden on those whose expertise is associated with traditional ways and a substantial degree of reluctance to change can certainly be expected from such individuals. Concepts that served well for a long time are not easily abandoned, particularly when there is an element of self-interest involved. In the not too distant future, however, this change must and will occur and those who have the flexibility to change early will earn a competitive advantage.

THE PROCESS OF CHANGE

Turning to the questions of who is likely to change, the direction of change, and what can be done to speed the process, I would like to mention a kind of person that any innovator will inevitably confront. He is the man who indulges in "hypostatization," which is a wonderfully esoteric word that means confusing a concept or model of a situation with the reality itself. This is the man who cannot understand that there is more than one relevant point of view because to him points of view do not exist. His view is the reality as far as he <u>is</u> concerned and no matter how many alternatives are presented to him, each is brushed aside as being irrelevant. He is the man who lacks the concept of a concept, and he is a frightening individual to deal with. It would be nice to tell you how to deal with him gracefully, but, unfortunately, I do not know. It seems as if there are situations which must be resolved in terms of sheer power and this, apparently, is one of them. In some cases an appeal can be carried to a higher level in the organization, and in other situations such individuals can be bypassed. In still others, the individual is in such a powerful position that only time and the workings of the market place will unseat him.

Fortunately, such people are reasonably rare (though I expect everybody present could name at least one), so in most cases it is reasonable to anticipate at least a moderate amount of good will and understanding. But even in this happier state of affairs, there remains a difficult problem in changing the conceptual apparatus of an organization. It is not at all easy to give up recognizable, immediate return from productive work for the far less tangible and possibly distant reward of having a better equipped executive on the staff. Nevertheless, this is happening as witness the proliferation of short courses at universities and the seminars conducted by various consulting groups. In addition, even more costly steps are being taken, such as General Electric's school for its executives at Crotonville, the Sloan programs at MIT and Stanford, and IBM's extensive training courses.

THE PLACE FOR INDUSTRIAL ENGINEERS

Now I realize that the job of selling new ideas and concepts is well-known to industrial engineers. The whole history of the profession is a succession of innovations which were put through the acid test of having to work. Accordingly, these thoughts may be simply corroberation of already accepted ideas. But if unfamiliarity with computers and their distinctive problems has in any way inhibited optimism, I suggest that the time is ripe to become more ambitious. The era of clerk replacement is nearing its end and the era of concept replacement is at its beginning. Finally, I submit that there is no better trained group than industrial engineers to act as the vehicle for the promulgation, dissemination, and implementation of conceptual innovation.

THE CALIFORNIA ECONOMIC OUTLOOK

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INTRODUCTION - CALIFORNIA'S PAST ECONOMIC GROWTH PATTERNS

As a former industrial engineer concerned with improved methods, cost reduction and manpower utilization, I feel especially privileged to read this paper before the Seventeenth Annual Industrial Engineering Institute of the University of California.

In the decade prior to and during World War II, my industrial engineering work in mining, mineral processing, frozen foods and aircraft manufacturing had me identified with some of the West's basic growth industries. I am fully aware of the fact that modern technology and new and advanced techniques in industrial engineering have tended to relegate some of us "old timers" to the "horse and buggy" category. For this reason I am thankful that my subject will quickly take me into a field of activity in which I have had more recent experience.

When I switched allegiance from technical industrial engineering to the broader field of industrial economics and area growth at the end of the war, the problems of California's economic development have been the subject of my earnest endeavors (and ofttimes bewilderment) ever since. I should hasten to add that California's economic growth since World War II has been somewhat "bewildering" experience to all of our labor, business and government leaders. Most of our problems have resulted from California's unprecedented growth—which reflects what has been called "the greatest mass migration in the history of man". The demands—new housing; new school rooms; new police and fire protection; better transportation; increased water supply; greater waste disposal capacity and more important, new jobs for the rapidly expanding population. These demands are costly. In order to meet them, careful planning and effective action programs are required.

California's economic roots and history are soil based. In its early history the rancheros produced cattle and hides. Then gold was discovered. As wave on wave of immigrants swept into the State and as the gold placers were exhausted, the people moved down through the fertile valleys and began development of the greatest agricultural system ever evolved.

Today "agribusiness" still provides farmers with a $3 billion annual income—the largest in the nation—and food processing combined with agriculture is the state's largest single industry.

But as migrants continued to pour in, lumbering, fishing, trading and manufacturing were quickly developed. Today manufacturing income exceeds the combined total of all of the state's extractive and basic industries.

THE PRESENT STATE OF CALIFORNIA'S ECONOMIC DEVELOPMENT

During 1964, manufacturing employed 1.5 million persons; trade was second with 1.3 million; services, third with 1.2 million and government, a close fourth with 1 million. Agriculture, forestry and fisheries accounted for only 335,000, although California is the leading state in the nation in both agricultural and fishery sales and is second in forest products.

California is the nation's most populous state, with more than 18,000,000 people. Projections indicate the State will have more than 28,000,000 citizens by 1980 and 43,000,000 by the end of this century. California's population is growing by more than 600,000 a year or 1,700 every day—60 percent of this increase through migration from other states. While age distribution is generally similar to that of the nation, there is a somewhat larger proportion in the 20-65 working age group.

California is on the threshold of becoming the nation's personal income leader. Average per capita income is more than 20 percent greater than the national average. In 1962, it stood at $2,898. Total personal income in 1963 reached $52.4 billion, an increase of $3.2 billion over the previous year. A per capita level of $3,600 has been predicted by 1970.

For the 1964 tax year, more than 60,000 banks and corporations will report profits totaling over $5 billion. Approximately a third of the net income will be reported by manufacturers.

The foregoing is only a brief sketch of California's present economy. It should suffice as a backdrop to the main theme of this discussion.

THE PROBLEM AND THE CHALLENGE

Rapidly changing economic conditions in the nation and the State of California early in 1963 required that the ECONOMIC DEVELOPMENT AGENCY and many other public and private agencies in California direct immediate attention and efforts toward an effective accelerated action program.

Two important facts about the state's economy became evident to government, business and labor leaders: (1) California had just passed New York in population and thus became the number one consumer market in the nation; (2) preliminary analysis of current shifts in federal defense and aerospace programs indicated immediate leveling off in this activity and prospects for long-range cutbacks in an area that represents 35% of California's industrial economy. Phasing out of Benicia Arsenal, cancellation of the

Skybolt missile program and the beginning of a reduction in employment in the electronics industry were examples and tangible evidence of this trend.

Because of these new conditions, the State was confronted with an unprecedented challenge and opportunity. The challenge—in the face of curtailed federal programs, to create in much greater proportion in the private sector about 200,000 new jobs to sustain the population growth of 600,000 annually; the opportunity—to capitalize on California's dominance as a dynamic growing market and as a state with unmatched scientific skills, technological capabilities and profit opportunities.

WHAT IS BEING DONE TO SOLVE THE PROBLEM

During the first two months of 1963, a re-evaluation of the Economic Development Agency's program was undertaken. As a result of consultation with the Agency's Technical Advisory Committee and meetings with more than 35 community and economic development organizations throughout the State, an accelerated economic development action program was presented to and approved by the Governor on March 20, 1963.

The new program placed emphasis on the following areas of activity:

1. A vigorous campaign to attract new and expanded business investments in California.

2. Stimulation of community action for new payrolls.

3. Business climate improvement including action on freight rates affecting movement of commodities to and from California as well as within the State, and cooperation with newly created Tax Study Commissions in the Legislature.

4. Liaison with aerospace-electronics industry to determine proper action of the State Government in the problem of shifts in federal spending in California.

5. Cooperation and coordination of program with business and development groups throughout the State, including the California State Chamber of Commerce, California Association of Chamber of Commerce Managers, California Manufacturers Association, Aerospace Industries Association, Western Electronic Manufacturers Association, Society of Industrial Realtors, area, county and local development organizations and chambers of commerce. In more than 50 meetings with such groups, the Commissioner and staff members have stressed the importance of renewed action and cooperation in all phases of economic development.

California First Campaign – This project was assigned to the Economic Development Agency by the Governor late in 1962. The objective was to celebrate and commemorate California's becoming the largest and most important market for goods and services in the United States.

The campaign was carried on during the first five months of 1963 and the results were highly rewarding. Feature stories appeared in newspapers and magazines all over the United States, and more than 150 California companies or organizations used the "California First" theme in their printed material and advertising in magazines, newspapers, television, radio and outdoor displays. The event received nation-wide news coverage on radio and television.

Industrial Development – Industrial Development and investment inquiries have shown a considerable increase in number, and it is believed that the "California First" campaign may have been partially responsible for this activity. Moreover, it is becoming generally better known that every state has a department of commerce or development agency to assist companies in their plant location problems. Many states are becoming more and more aggressive in this highly competitive field.

During 1963 and 1964 an effort has been made to improve the handling of plant investment inquiries. Where inadequate information is provided in the initial inquiry, a telephone call is promptly made to the correspondent and from the conversation, a site location specification sheet is prepared. All inquiries are treated confidentially and handled in a strictly professional manner.

"California Profit Opportunities" – Nearly all members of the staff have cooperated in conducting research for the Agency's new folio-size publication entitled "California Profit Opportunities." This has been a major activity for which great credit must be given the E.D.A. staff, all state agencies and departments and many private agencies which have contributed to its preparation and production.

"Profit Opportunities" is an 86 page factual dramatic presentation of California's great human and material resources, markets, basic location factors and environment. It contains 14 full page color photos, 13 full page resource maps and 12 statistical tables and charts to substantiate the text. Editorial and technical assistance has been generously provided by a professional Editorial Board and by members of the E.D.A. Technical Advisory Committee.

The first limited printing of 3,000 copies has been completely committed. Certain errors of omission are being corrected and because of demands from airlines, banks and utilities all over the State who will purchase the book at a reduced quantity price, it is likely that more than 10,000 copies will eventually be distributed to potential investors throughout the world.

Other Publications – The Agency also produces the following publications designed to present facts about California's economic growth and favorable business climate:

1. California Statistical Abstract (annual publication)

2. California Million Dollar Plus New Plants and Expansion Announcements (quarterly)

3. County Profile Sheet

4. Quarterly Economic Newsletter

Community Action For New Payrolls – In past years the field staff of the Agency has assisted approximately 28 counties or communities in conducting and compiling economic resource studies.

While beneficial to areas and communities for long-range development, these studies have required more staff time than can be justified in relation to their "job creating" possibilities and with E.D.A.'s present very limited staff. Consequently, the community service program has been revised to permit assistance to more communities or areas by means of a new type of community development assistance–the "Economic Development Workshop."

Through well-planned and directed round-table discussions with leaders representing all phases of a community's economy, during the past year the Agency has assisted eight counties and communities to clearly identify and focus attention on their most important assets and limitations and to develop an action program designed to minimize or correct limitations and to capitalize on assets. This business-like approach to community development is proving quite satisfactory and will be pursued during 1965. This service is provided on invitation from the county and/or local community, and thus far has had greater acceptance in the less sophisticated or rural areas of the State. Present and future commitments will spread this activity to practically all geographic areas of California.

Business Climate Improvements – In dozens of instances, the Agency has refuted and corrected erroneous concepts about California's business climate. At the same time the Agency has been diligent in stressing the importance of keeping California competitive in basic business costs.

Factual information about business costs has been submitted to appropriate legislative committees and full cooperation is being extended in the concurrent tax studies of the Legislature.

It is a fact of life in California that some business costs in this State are comparatively higher than in some neighboring, or southern and midwestern states which do not provide California's high character of government service, an unmatched system of free education and training, toll free expressways, a high level of personal income and great profit opportunities.

California's pre-eminence in some phases of automation and in many technological developments may be attributed to the necessity of counteracting certain cost factors with more efficient and cheaper methods.

On at least five occasions during the past 2 years, the Agency became active in transportation rate reduction cases which have a direct bearing on business costs:

1. The aid of the Agency was sought by the California grain trade in obtaining a reduction of rail rates on export grain.

2. A rate reduction application for export corn which was rejected by the Trans-Continental Freight Bureau, was finally published by independent action of railroads operating in California and took effect January 8, 1964. There is no doubt that the timely action of the Economic Development Agency had considerable effect on the successful campaign to gain the reduced rates and will reflect in increased economic benefits to the people of California.

3. On May 13, 1963, a representative of the Economic Development Agency appeared before Hearing Examiner of the Public Utilities Commission taking evidence in Petition No. 233 of the California Trucking Association in Case No. 5432 concerning substantial changes in state-wide minimum rates. A statement of the Commissioner was entered into the record asking that no change in the minimum rate structure be made until an adequate study of the situation had been made because of possible serious effects on the business climate of the State.

4. The Economic Development Agency provided necessary research and prepared a statement for Acting Governor Glenn Anderson which was given on August 8, 1963 to the Pacific Southcoast Tariff Bureau, Docket 8788, to protest the application of eastern furniture manufacturers for storage-in-transit privileges at Reno, Nevada. The California Furniture Manufacturers Association later wrote the Economic Development Agency.... "Thank you on behalf of the furniture manufacturing industry and in particular for the members of the Furniture Manufacturers Association of California for the splendid support the industry received from you in the recent storage-in-transit case involving Reno, Nevada."

5. During the meetings arranged by the California Congressional Delegation in June and July 1964 between Secretary of Agriculture Orville Freeman and U. S. Department of Agriculture staff members and representatives of California Ports, Terminal Elevators, and Steamship interests, the Economic Development Agency aided in developing policy to ensure that: (1) California Ports are an integral part of the export grain marketing program to Oriental markets of the U.S.D.A.; (2) The U.S.D.A. continue recognition of the importance of Public Law 480 grain sales (payment in soft currencies) to California; (3) That wheat stocks will be located in California and replaced through elevators from which export sales are made. I feel that the establishment of these basic policies will ensure a continuing flow of grain to export markets which will benefit California ports and terminals, steamship companies, and railroads, and related service industries, thereby adding to the strength of the California economy.

The Agency has established a closer liaison with the Department of Agriculture and is currently working with the California animal feed industries in their efforts to gain a reduction in feed grain rates to enable California to remain competitive in this multi-billion dollar business.

It is believed that the whole subject of transportation costs involving California's competitive position with other states and regions should become the object of much more aggressive action at the state level. This is a very complicated subject requiring full time attention of qualified trained staff. E.D.A. has only one staff member qualified in this field and because of over-all demands and work load, his full time cannot be utilized in this activity. However, efforts are being made to enlist the further cooperation of other departments and agencies in an attempt to become more effective in this field.

Aerospace-Electronics Advisory Panel – As a result of a series of seminars on the subject of "shifts in defense and aerospace programs in California," the Agency arranged a meeting with the Governor and twenty-eight officials of the aerospace and electronics industries and members of the Governor's Business Advisory Council on December 13, 1963. It was the consensus of this meeting that the Governor should appoint an informal panel from the aerospace and electronics industry to meet regularly with the Commissioner of the Economic Development Agency to determine what administrative or legislative action might be taken at the state or federal level to assist in the problems of conversion and diversification.

Accordingly, the Governor appointed a Panel of sixteen members. Four meetings have been held and a fifth meeting is soon to be scheduled.

Members of the Panel have been enthusiastic in their support of this effort. A technical support group has been appointed from member companies to work with the Economic Development Agency in a concerted effort to find alternative uses for the state's scientific, engineering and systems management capabilities now heavily absorbed in defense work.

In the long range there are encouraging possibilities for diversification from defense to other public and private markets. Oceanography, education, urban renewal, low cost housing, transportation, medical electronics, regional economic development, manpower retraining, and several other areas offer fertile ground for the application of California's aerospace and electronics industries capabilities.

The task of diversification is a prodigious one. It would be foolhardy to assume that the Governor's Panel can do the job alone. However, it is hoped that the leadership and direction afforded by the Panel may help to accelerate the program to the extent that the net loss of jobs as the result of defense cutbacks may be greatly minimized.

THE FUTURE

I have never considered myself adept in the art of crystal ball gazing. For that reason, the few projections that follow are not my own–nor will I vouch for them. They are at best educated guesses.

It is estimated by the National Planning Association that California's population will climb from the present 18,000,000 to 22,994,000 in 1976 with the national total at 239,500,000. On the other hand, the most recent projections of the State Department of Finance place California's population by July 1, 1965 at 24,830,000.

The Planning Association estimate for civilian employment in California in 1976 is 9,224,000 with 2,088,000 represented in manufacturing jobs.

Projected in 1960 dollars, personal income in California in 1976 is estimated by the Association at $95 billion, with annual per capita income at $4,132 compared with a national average of $3,326.

The California State Treasurer's estimate of personal income in California in 1975 projected in 1962 dollars is $100 billion, $5 billion more than the National Planning Association estimate for 1976. So you may take your choice! Present annual personal income in California is about $55.73 billion.

California has been called "a window of the future"–a testing ground not only for the most advanced research in space, oceanography and medical sciences but also the crucible for cybernation, the social sciences and for new concepts in urban living, leisure and recreation.

I believe the future of California must depend upon that vital force that has made it first in education, science and research, just as that same vital force also has made it an "atom cracker" and a creator of space vehicles, supersonic planes and missiles.

CONCLUSION

A good cross section of that vital force mentioned above is represented by those in attendance at this 17th Annual Industrial Engineering Institute.

I truly believe that in a great measure, California's industrial engineers will play an important role in California's economic future.

While business costs in California are not excessive in relation to services received compared to other industrial states, we must keep our State competitive. Cost reduction programs are needed at all levels.

At the same time, through technological improvements and employee incentives, the profession will contribute to our future goal of achieving a higher standard of economic and social justice and more leisure for all of our citizens.

HEURISTICS, OPERATIONS RESEARCH AND INDUSTRIAL MANAGEMENT

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The title of my paper, "Heuristics, Operations Research and Industrial Management," possibly raises the question of what these three items have in common. My answer to this is decision-making and problem-solving. Heuristics can be described as processes or methods which on the positive side forshorten problem-solving time and effort. On the negative side the solutions they produce may be far from optimum. More will be said about heuristics later.

Operations Research is an activity and body of thought that, had I been giving this paper only ten years ago, would have required substantial definition and explanation. It is remarkable to me that such a set of ideas, techniques, and philosophy as Operations Research represents can now be assumed common experience, virtually as common as the earlier techniques of Industrial Engineering were assumed common among this group ten years ago.

Industrial Management is an activity and a group of people that for many years has received scholarly attention. However, it is only fairly recently that the emphasis has been on decision-making and problem-solving. Even more recent has been the attempt to build descriptive and mechanistic theories of managerial decision-making, that is, models good enough to describe and predict actual decision-making behavior. Earlier there had come from economists, engineers, and management theorists prescriptive theories telling the manager—at least in part—how he should make his decisions. When we know more and do better with the behavioral sciences in pure and simple description, we may once again return to advice, but at a more profound and useful level. We might even label these stages from advice, to better understanding, to better advice as thesis, antithesis, and synthesis.

A MODEL HISTORY

Now let me turn to a model and its history that illustrates a number of points and trends about Heuristics, Operations Research and Industrial Management which I would like to discuss. Right at the start I would like to put forth both the main point and the related main trend. The main point is that it is difficult to do operations research which, on the one hand, successfully models the real problem(s), and, on the other hand, successfully influences the actual decision-making of the relevant managers. The main trend is an increased activity and appreciation in those facets of the behavioral sciences that deal with modeling decision-making behavior; or, in more general terms, the main trend is concerned with developing concepts which explain the real world of the particular manager.

The points of difficulty may be illustrated by the so-called job shop scheduling problem. While in an academic sense it has been solved, the solution requires a linear program with an integer programming overlay and so a problem of any size—that is a real problem—is computationally not tractable. The other difficulty—that of the uninfluenced decision maker—is known by everyone in this audience.

The trend may be illustrated by two books which I recommend to you. The first is A Behavioral Theory of the Firm by Cyert & March (Prentice-Hall, 1963) which describes decision-making models in a fairly wide variety of circumstances. The second is Organizations by March & Simon (Wiley, 1958) which summarizes much of the theory and experimentation concerning the environment in which managers make decisions.

The model to which I referred earlier was developed in the context of a distribution problem. (1) A consumer goods manufacturer with his plant located about thirty miles from a major metropolitan area wanted to know whether he should have a warehouse in the metropolitan area. He already had one at the plant and, in addition, over a dozen others scattered over a five or six state area.

As is so often the case, in attempting to answer this question á la Operations Research, we ended up by asking another set of questions, which we proceeded to answer first. Because the direct distribution from the plant warehouse to retail establishments abuts areas served from regional warehouses, we felt we had to know something of the economics of these regional warehouse territories before we could supply a useful answer concerning contracting in the territory served directly from the plant. Our research was then initially directed to the question, "What is the economic size of a warehouse territory?"

Very briefly, and with little elaboration here, we developed the following model.

$$C = a + \frac{b}{V} + c\sqrt{A} \qquad [1]$$

where C = cost (within the warehouse district) per dollar's worth of goods distributed–the measure of effectiveness.
V = volume of goods in dollars handled by the warehouse per unit of time.
A = area in square miles served by warehouse
a = cost per dollar's worth of goods distributed independent of either the warehouse's volume handled or area served
b = "fixed" costs for the warehouse per unit of time which divided by the

volume will yield the appropriate cost per dollar's worth distributed.

c = The cost of distribution which varies with the square root of the area; that is, costs associated with miles covered within the warehouse district such as gasoline, truck repairs, driver hours, etc.

C, V, and A could be determined for each of the present warehouses. The values of the parameters, a, b, and c, could then be estimated by least squares regression. The model then tested out (multiple correlation coefficient equal to .89) as a very satisfactory description of the economics of the distribution warehouse territories.

Our next step was to turn this model into a decision rule for a preferred warehouse territory size. With $K = \frac{V}{A}$ as a definition of sales density, the decision rule derived (by differentiating with respect to A) was

$$A = \left(\frac{2b}{cK^2}\right)^{2/3} \qquad [2]$$

The company's actual branch warehouse areas ranged from about 95 to 150 per cent of the optimums computed. This means basically that the system was comprised of too few warehouses and that many of them were too large.

Given the results of this analysis we were then able to build a specific cost model to answer the question originally asked about the potential warehouse in the nearby metropolitan area. Our answer was that the new warehouse should not be developed.

Now at this stage of my paper several points of interest can be made. The first is that though the company accepted the answer to the question which they asked (they did not develop the warehouse in the metropolitan area), they did not accept the answers to the questions which they did not ask. That is, they did not reduce the size of their outlying warehouse territories and at the same time increase the number of such territories. A number of executives in the company influenced these final decisions. It may be too obvious to point out, but organizations are hierarchical, and both functions and goals are factored. Consequently, the executives do not and are not willing to look at such a problem from the same over-all vantage point (which presumably) the analysts used—we march to different drummers.

An aspect of frequent interest in Operations Research is the cost savings which result from a study. This, as it turns out, usually requires an answer which is at least as theoretical as the analysis itself. If a change in operations is made because of the study, then one is usually forced to compare the old decision scheme in the old environment to the new decision scheme in the old environment (which is a hypothetical case) or to compare the new decision scheme in the new environment to the old decision scheme in the new environment (which is also a hypothetical case). For the case where the Operations Research study basically results in maintaining the status quo, all one can say is that operations would have been worse if the proposed change(s) had been made.

MULTIPLE BRANCH PLANTS

Now let us move on to another application of this same basic set of ideas to the question of whether an ice cream manufacturer with ten plants covering a six state area was operating with branch plants of about the right size. In this case the model became

$$C = L\left(a + \frac{b}{V} + c\sqrt{A} + d\,M\right) \qquad [3]$$

where the added variables are L, for labor rates in the particular town, and M for product mix, a measure of manufacturing complexity. This extended model also gave a satisfactory fit to the problem. The decision rule (optimum volume) derived from this model was

$$V_{opt} = (K)^{1/3}\ (2b/c)^{2/3} \qquad [4]$$

In this case many of the branch plants which the company operated were too small (according to the rule) and some consolidation was called for. Subsequently, the company did go from a system of ten plants to a system of six somewhat larger plants.

Now I would like to return to my initial and brief definition of heuristics—processes or methods which foreshorten problem solving time and effort. In the decision rule (4) for the appropriate size ice cream branch plant, only K is a variable, while the expression $(2b/c)^{2/3}$ is really a decision rule coefficient made up of estimated parameters from the original cost model. Is there any other way to determine such a decision rule coefficient?

HEURISTICS BASED ON MANAGEMENT'S DECISION RULE COEFFICIENTS

Based on some research we have been doing (2) in the area of production, inventory and employment scheduling, we were led to a theory about these decision rule coefficients. If one looks at the decision rule for the moment as a description of behavior rather than a prescription for behavior, then management by the choices it has already made implies a value for the decision rule coefficient. In a mechanistic sense, the decision rule can be used as a model to fit, by statistical means, the previous decisions of management. By regression then, we can get an estimate of the decision rule coefficient(s), one that might be called management's estimate of the decision rule coefficient. Management's behavior has implied this estimate.

In the case of the ice cream branch plants, we used this procedure to determine a value for the decision rule coefficient in order to investigate what the economics of the system might be using this rule and its management coefficient as prescriptive. The results are shown in the following table, where d is the management coefficient:

		Savings/year
Original Analysis	$V_{opt} = (K)^{1/3}\ (2b/c)^{2/3}$	$207,000
Management (regression)	$V = (K)^{1/3} d$	$133,000

As can be seen a large part of the savings might have been available by restructuring the system using the central tendency of management's behavior as a guide.

A THEORY FROM A HEURISTIC

When we wish to go beyond the use of this scheme for determining decision rule coefficients as a heuristic—a process which foreshortens problem-solving time and effort, and explain why this seems to work, we are led into a number of subsidiary axioms which reach into concepts drawn from economics, statistics and psychology. I will not elaborate these here as they may be found in the research report in the Management Science article mentioned earlier.

However, I would like to put forth the most important generalizations of this paper:

Further research in decision-making behavior will permit this implied parallelism. That is, if the research is directed essentially at heuristics, methods that work, it will require and add to new theories and concepts—which will be scientifically verifiable, that is by replicated experiments and observations. If on the other hand, the research is directed essentially at theories, as these are developed they will surely suggest to those interested in such things useful heuristics for solving real problems.

Before leaving the work on heuristics and continuing with the model, I would like to place our work in a larger grouping. Feigenbaum and Feldman in their useful collection called Computers and Thought (3) separate similar work into two categories (used as well by others): 1) Simulation of Cognitive Processes, and 2) Artificial Intelligence. The first supplies a process (program) like man does, while the second essentially supplies a process (program) like man might. While our work on heuristics is more like Artificial Intelligence, it supplies results (output rather than program) like man might.

Probably the two best known applications of these two classes to business problems are 1) Clarkson's simulation of trust officer investment behavior as an example of the Simulation of Cognitive Processes, and 2) Tonge's work on assembly line balancing as an example of artificial intelligence. Pierce's work on Paper Mills Scheduling includes heuristics addressed directly to the scheduling problem as well as heuristics directed to the decomposition of the linear programming model describing the problem. All three of these research projects exemplify the trend to which I refer—all three won Ford Foundation prizes for doctoral theses and have been published by Prentice-Hall in this prize series.

COST CONTROL IN A PUBLIC UTILITY

A further extension of the basic model developed here was made in a public utility. (4) Many companies for purposes of cost control, especially where profitability accounting is difficult or impossible, use a ratio of cost per unit of output as a means of controlling operations. This gives a useful historical pattern and in addition makes comparison possible between branches (of various sizes). However, the difficulty here is that both top management and branch management know that other factors not within the control of the branch manager (e.g., area served) influence these costs per unit of output.

The study in question included these other factors in the cost model (similar to those shown above) and in effect used the unexplained or residual variance (from the model) in the costs as a rough measure of management performance. The company executives agreed that this was a better measure than had previously been used (i.e., total variance in costs).

The heuristic described previously of taking management's behavior (decisions) to determine the coefficients in the decision rule was also used in this case to answer the question of what size a territory should be. About two dozen territories existed at the time of this study. Seven or eight of them had recently been rearranged and regrouped from old territories.

The interesting point here is that using the decision rule with management's coefficient was substantially better when only the recent behavior of management was used. That is, where some of management's behavior is superior on some strong a priori grounds, it will probably pay to use only this in the coefficient estimating heuristic.

SUMMARY

More research in the area of actual managerial decision-making behavior will have a number of benefits. First, it will add directly to the kit of tools of operations research. Second, because it will give more insight into the decision-making world of the particular manager, it should increase the likelihood that problem definition in the early stages and implementation in the later stages will be more successful than they have been in the past. Finally, the theories and concepts developed will be useful to the manager himself as he searches for problems to attack, alternatives to consider, and consequences to evaluate.

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FITTING MAN INTO AUTOMATIC PROCESS CONTROL

Edward R.F.W. Crossman

My objective in this paper is to set out some approaches to a novel type of method study, designed to improve the efficiency of utilization of human labor in continuous process control. The present growth in the number and importance of automated manufacturing processes, where the operating crew's work is largely monitoring and control, emphasizes this problem and poses an important series of problems for the industrial engineer; I shall try to suggest some new lines of thought for handling them.

Industrial engineers are familiar with the fact that evolving production technology for any given product passes through the following three phases of development. First, highly flexible but unproductive on-off or small-batch methods operated by craftsmen; then a single method of manufacture is chosen and split up into a sequence of specialized semiskilled operations–this is the so-called "mass production" phase; finally the operations are automated and handling is eliminated, yielding a continuous automatic process. Of course the historical time-scale of this progress differs very greatly between industries according to the technical difficulties encountered in finding and operating a satisfactory continuous process. Some industries such as chemicals, paper-making, electricity generating, printing and so forth have been in the third phase for many years; others such as automobile component manufacture and agriculture, are just entering the third phase; and yet others, such as furniture and shoe manufacture, seem unlikely to get past the second phase for some time to come.

The classical techniques of method-study and work measurement and the modern predetermined-time systems were designed for use with the repetitive manual operations which bulk so large in the second, mass-production phase of production technology; but they tend to break down in the third, the continuous-process phase, for fairly obvious reasons connected with the changed nature of the work done by hourly-paid workers. The difficulty is experienced most acutely where work-measurement is used for incentive payment; if the proportion of inside-cycle work rises above about 80% then direct operator effort ceases to have much direct effect on production, and the whole rationale of paying for measured work as a means of securing greater productivity is undermined. Yet the operator has not lost his raison d'etre, he is still needed to operate the now continuous process; it is only that the type of work has changed so that it falls through the work-measurement net.

The essential conception of Taylor, Gilbreth, Bedaux and their successors was of work as a sequence of operations on partly-finished materials, each taking a certain time, all of them necessary and each repeated an indefinite number of times with no more than minor variations. Each element in a work-cycle produced a clear-cut increment of progress in the state of the work-piece or assembly, and the total time per unit of the work-piece or assembly, and the total time per unit of product was a direct measure of its labor content.

In continuous processes, on the other hand, there is no such progressive addition of elements of work to produce a product. Within limits, and once started, the product continues to emerge regardless of operator activity or inactivity. While the operator still performs a series of more or less repetitive activities such as observing instruments, taking samples, and operating controls, these have no clear or necessary time-sequence, and it follows that the work-content can no longer be simply defined as the sum of a set of necessary elements.

To find a new definition of work-content, we need to enquire briefly into the purpose of having an operator in charge of a process at all, and this leads us directly into the field of automatic control. Once the process is running, two main problems face a process-operator; first to prevent breakdowns, which results in lost production; and second, to maintain the quality of product within a given specification, as determined usually by a set of measurements or subjective assessments. The operator meets both requirements by the same pattern of activity, observing the current state of affairs at sufficiently frequent intervals and adjusting the process wherever it departs more than is indicated from the desired state. Figure 1 shows this situation in the familiar form of a block diagram, with arrows representing information transfer. The

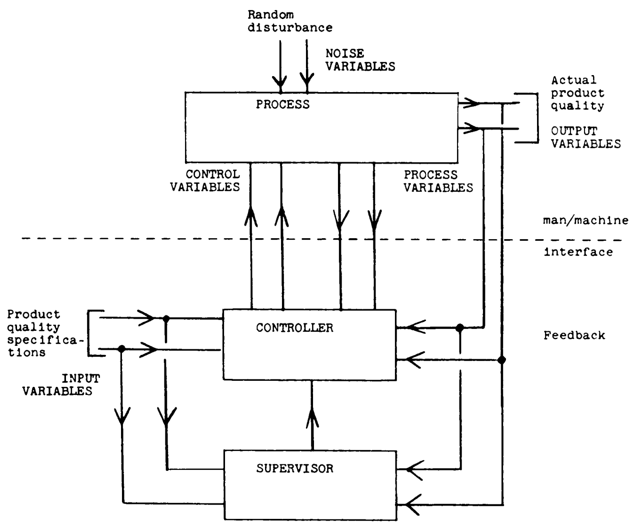

Figure 1. Elements of the process-control task situation.

operator collects information about the product and about the state of the process, relates it to a desired quality, and takes appropriate action. Unless some disturbance affects the process, no action will be needed, but this is an unusual state of affairs, and the more usual situation includes one or more random disturbances, as is shown in the diagram. The operator's immediate superior also checks on the output quality, and feeds corrective information to him.

Since the operator's task is to maintain a number of output variables at specified values, his performance can be measured by an independent comparison of actual and desired values averaged over time (shown as a function of the supervisor in Figure 1). Incentive payments are sometimes based on such calculations, but we will not pursue this complex topic here. While performance can be measured in this way, we do not learn much either about work-load or about operating methods from doing so.

However, the principle that a process-operator's job consists of monitoring or "sampling" the values of a number of variables, and using the results to determine appropriate changes in control-settings, provides a good framework both for work-measurement and for method-study. We can think of each variable to be monitored as a separate sub-task, with the operator sharing his time between a number of separate sub-tasks which together comprise the total job. In essence, he closes a number of distinct feedback loops concurrently, using a given proportion of his time for each. The time occupied in attending to each subtask or variable will itself be compounded of two factors, the frequency with which attention needs to be paid to it and the time needed for observing its value. This information, of course, then allows the operator to make a decision as to whether or not a corrective action is required, and if so, putting it into effect. Broadly speaking, the necessary sampling frequency for a given process variable depends on its maximum rate-of-change, and on the amount of random disturbance relative to the required accuracy of regulation to which it is subjected.

These quantitative relationships provide a feasible approach to a new system of work-measurement–yet to be developed; but my more immediate purpose is to show how this breakdown of the process-operator's task yields a principle that can be used to guide a methods analysis of process-control situations.

Proceeding from the notion that the operator's objective is to regulate certain specific process variables, we can construct a chart to be used in studying and evaluating the existing method of working as a preliminary to designing an improved method. Further, it may be possible to use this method either for better control of the variables, or for less work-load so that the operator can encompass a greater number of variables in his total task, or for both purposes. We cannot use a standard time-based method of charting, since there is no fixed cycle of operations and, in any case, the chart would not reveal the essential features of the work.

Instead of a time-based chart, the appropriate form of diagram for setting down and analyzing a control task is the signal-flow-graph. This is a scheme in which variables are represented by small circles (nodes) and causal relationships by arrows (branches) linking the circles. A process with its operator is then represented by a network of nodes and branches, and the various ways in which disturbances can occur and be corrected by the operator, can easily be traced as a causal sequence through the network. The relative ease or difficulty of detecting and correcting various possible disturbances can be seen at a glance, and it will usually be found that the operator controls one or more of the output variables by quite devious means.

Frequently important process variables cannot be immediately measured or even assessed, and their values must be inferred from combinations of other observations. Also the effects of controls available to the operator can be traced and the various interactions and side-effects followed through. Thus the signal-flow-graph is for a process-control job what an operation process chart is for a normal manual operation: an analytical tool designed to aid in detecting faults in an existing method or layout as well as a means for synthesizing new and better ones.

However, it is important to remember that it provides only a static picture of what is essentially a dynamic relationship. The mathematical methods of automatic-control theory can be used in conjunction with the signal-flow-graph to yield precise predictions of some or all of the dynamic behavior of the process/operator combination, but this requires more exact information about the process than is ordinarily available. Short of this level of sophistication, the analyst can usually gain an appreciation of the more important dynamic factors by noting which branches involve what kinds of lag, and bearing the lags in mind in tracing particular routes of control-flow.

The operator's role in a process is to provide feedbacks and other corrections between variables which would not otherwise exist. When he starts work he, so to speak, "plugs himself in" as to a number of variables, providing branches between them dependent on his sampling and decision-making behavior. The set of terminal variables or nodes from which he gets information, and into which he feeds control adjustments is termed the "man-machine interface" and it can conveniently be shown on the signal-flow-graph by conventional symbols for "display" and "control" variables. The operator himself, where he uses a consistent behavior-pattern, can be shown as a branch linking display(s) and control(s). A further refinement that is sometimes useful is to represent the operator's idea of certain variables by nodes within the operator himself. In most cases there will also be certain "command" variables determined by verbal or written instructions from management or other parts of the plant; these also have a conventional symbol.

Automatic controls are usually added to a process in a fairly simple way, by applying a sensor to measure each variable that needs to be stabilized and providing a controller which computes the appropriate mode of actuating a controlled member to offset any disturbance. These components can be shown on the signal-flow-graph, together with the operator's action on them through the adjustment of set-points.

The information needed to draw a correct signal-flow-graph for a given process is not often immediately available, and the analyst usually needs to do his own investigation into the nature and operation of the process. This entails gaining an understanding of the important causal linkages between the various factors in the process and of the lags and other timing considerations that affect the different factors. It is sometimes necessary to take recordings of selected phases of process operation to find out what affects the process itself, and this is almost always needed to determine what decision-rules the operator uses. Direct discussions with the operators and supervisors is also needed wherever the mode of operation is at all obscure.

Once the existing method has been set down in a correct signal-flow-graph the analyst can begin to devise an improved method by applying what may be called "principles of optimum information-flow" (by analogy with the well-known Gilbrethian principles of motion economy). A few of these are:

1) All important variables, particularly those in the quality-specification, should be readily available for sampling.

2) Information bearing on present or probable future disturbance to the process should be displayed to the operator at the earliest possible moment.

3) Control points should affect the variables being controlled as directly and rapidly as possible.

4) Controls should be independent of one another, and where interaction cannot be avoided the side-effects should, as far as possible, be displayed.

5) Wherever the process is subject to lag, some form of recording should be provided showing the past states of important variables, and control-settings.

6) Wherever possible, control-settings should be calibrated in terms of their quantitative effects.

Using these and other less important principles, the information and control-flow to and from the operator should be rationalized and improved as far as possible within the scope of economically justifiable expenditure. Some improvements in information-flow, such as calibration, provision of records, etc., will be found to be quite inexpensive; others, such as special new instrumentation, may prove too costly. Wherever possible, too, optimum operating methods should be reduced to decision-rules and written into the job-specification or training manuals. Thought should also be given to the various abnormal or emergency types of operation that occur in most plants, and to special facilities that may be needed only occasionally as on start-up or shut-down. When a complete new layout and/or set of operating methods have been devised and installed, they will, as always, need to be maintained by periodical checking to ensure that conditions remain near optimum.

The sum total of the foregoing activities amount to a specialized method-study procedure for process operations. It must not, of course, be supposed that this will stand by itself; usually the analyst will also need to apply standard method-study to the repetitive operations that constitute a part of most jobs, as well as to carry out normal work-measurement. However, the two types of method-study must be integrated to provide a balanced result.

A summarized account of a recent study carried out in a modern steel-works will be given to illustrate the method. It concerned the operation of a waste-heat boiler in a Lina-Dorowitz steel-making process, and was carried out at the firm's request by the author and his colleagues in collaboration with the British Iron and Steel Research Association. The boiler system, shown in outline in Fig. 2, is designed to extract waste heat which would otherwise be lost from the exhaust gases of the steel converter during each "blow," and use it to raise steam for use in the work's power supply. When not blowing, the steam output of the boiler is maintained by oil burners, and the operating requirement is to maintain a constant supply of steam in spite of rapid variations in heat arriving from the converter. A single operator works at a large control panel near the plant and has charge of three such boilers, one on each of three converters.

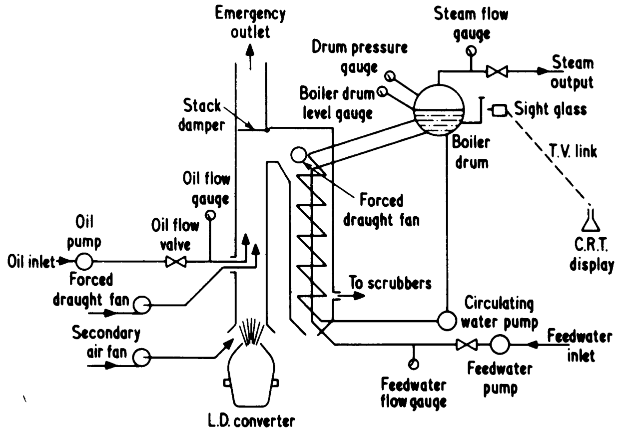

Figure 2. Schematic view of the Lina-Donowitz waste-heat boiler system.

As a result of discussions with plant engineers and management, the main causal relationships within the plant were identified and set out in a signal-flow-graph (Fig. 3). The operator was found

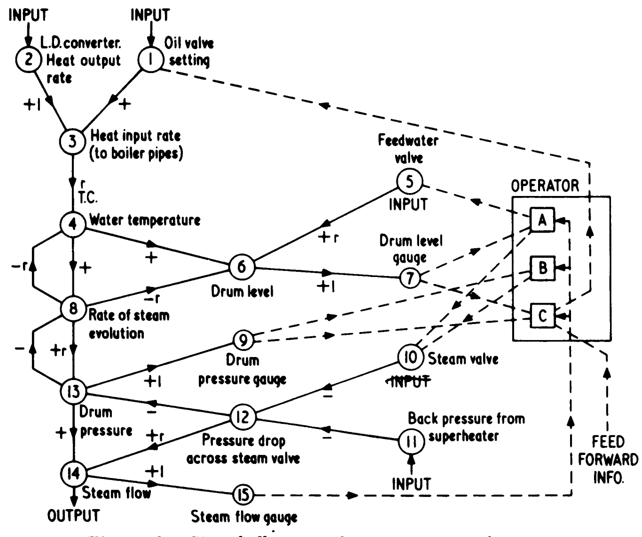

Figure 3. Signal-flow graph representing the process-control task on the waste-heat boiler.

to control three main variables, drum water-level, drum pressure, and steam output, using respectively feedwater flow, steam valve, and oil-flow controls. Under steady conditions these would be subject to only minor disturbance, but the irregular timing and amount of heat supplied by waste-heat gas produced major disturbances which it was his task to nullify. To study his control policy, recordings were taken of the relevant variables during sample "blows," and one such record is shown in Fig. 4, from which it can be seen that steam-flow is not exactly stabilized against changes in heat supply.

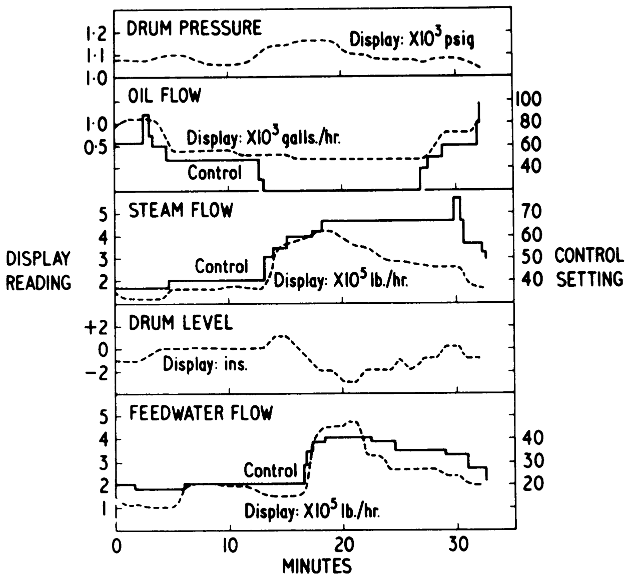

Figure 4. A record of a typical "blow" and the operator's reaction to it.

On Closer investigation it became clear that the operator was gaining information about the onset and amount of heat inflow by quite indirect measures, using small changes in water-level to detect and offset future changes in steam-output before they occurred, thus cancelling the inevitable effect of the lags in response to oil-flow and feedwater controls. However, his efficiency at doing this was severely hampered by a lack of adequate information about the heat inflow itself, and we recommend that suitable temperature sensors should be placed in the hood of the converter to provide more rapid and accurate forewarning of heat inflow during "blows." Other similar improvements were also suggested.

The plant was also fitted with automatic control facilities (not shown on Fig. 3) and when in use these reduced considerably the workload on the operator. But they did not perform quite as well as the operator in certain respects, even though they were connected to certain sources of information not available to him. In general, little attempt had been made to coordinate the roles of the operator and of the automatic controls to make the best use of the capabilities of each.

I hope that this very brief introductory discussion of the problems of methods analysis in nonrepetitive control work will serve to set some of you thinking about the problem of process-control as a human activity, and not as a task solely for the automation expert. Many types of process-control are not at present even remotely likely to be automated, yet substantial improvements can be effected by giving the human operator access to better sources of information and better control outlets. Finally, I might point out that many supervisory and management jobs can be discussed in exactly the same framework, and studied by the same rational analytic means.

SOCRATES: SYSTEM FOR ORGANIZING CONTENT TO REVIEW AND TEACH EDUCATIONAL SUBJECTS

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SOCRATES* is a year-old teacher whose name is an acronym for "System for Organizing Content to Review and Teach Educational Subjects." That most teachers are considerably older is not trivial since the ratio is about 20 to one. However, the important point is not that SOCRATES is precocious but rather that it represents a useful, interesting and practical approach to instructional problems.

First let us consider the conception, then the system it led to and finally the things currently being done with the system, including some of the results obtained in studies concerned with problems raised by a sophisticated training technology.

AUTOMATED TEACHING SYSTEM

In most general terms, an automated instructional system is a response-dependent, adaptive mechanism designed and used to produce systematic behavioral changes in the learner whose responses are necessary for its operation. It is a set of functions or transformations that adapts its operations to achieve a particular goal or objective in terms of the learner's responses. If the learner does one thing (e.g., choses an answer), the teaching system does something else, and in each case its activities are designed to achieve a particular objective that can be expressed in terms of behavioral change in the learner upon whose responses it is dependent.

It is important to distinguish between what an adaptive instructional system does and the way in which it performs its functions. This distinction can be made at different levels. Most generally, the machine teaches students, and it does this by presenting some material, eliciting the student's response, and then presenting more material based upon the nature of the response. At a more specific level, it accomplishes these functions by using a medium size digital computer connected to a number of display units and keyboards through a control system. Thus, while each student has his individual interface for two-way communication and works at his own rate, the system performs its functions for each student as if he were the only one being taught.

An analysis of the functions associated with tutorial instruction reveals that there are two basic sets: (a) Pretutorial functions, and (b) Tutorial functions.

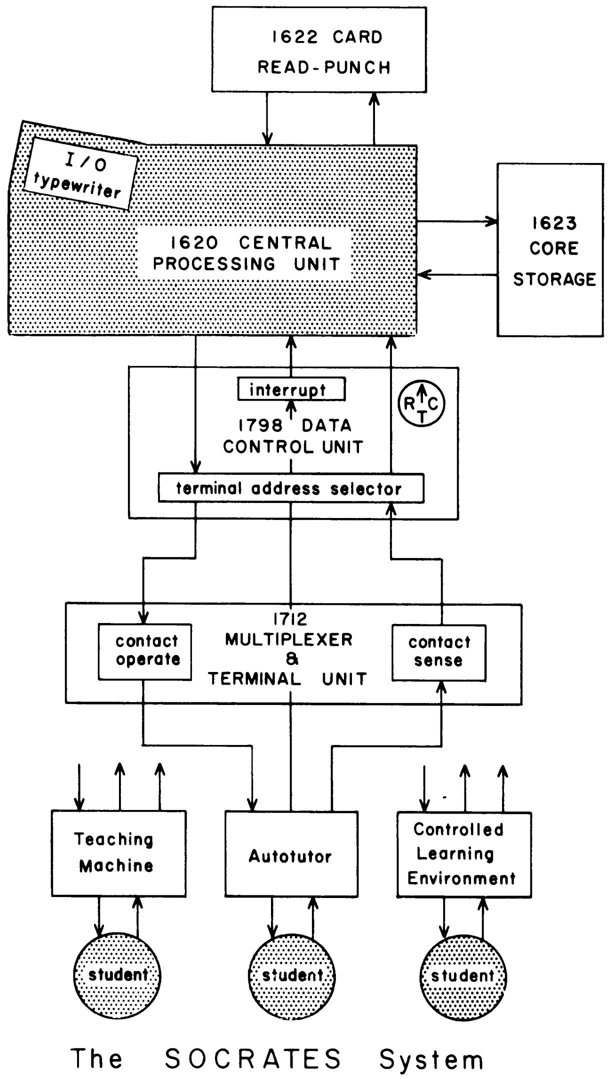

Figure 1

Pretutorial Functions

Objectives. One objective of the pretutorial phase is to determine the characteristics of the learner upon which a decision can be made regarding the program of instruction to be used initially. Thus from information about the student the system selects a program that is most likely to efficiently transform his performance in such a way that it will conform to a set of instructional objectives. The second pretutorial objective is to determine whether there is a program that is likely to accomplish the required transformation.

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Basic variables. In the pretutorial phase of the operation three basic sets of variables are important. The first is the set of possible outcomes of teaching which includes the sub-set of desired minimum performance characteristics of the learner at the end of training. The second is the entry behaviors or things the student knows and can do when he starts. The third is the how-to-do-it information, the instructional programs. The pretutorial phase determines the relationship between instructional objectives, entry behaviors and instructional programs. The output of this phase is the decision to reject or to teach a student in a particular way. The general flow chart for this phase is presented in Figure 2.

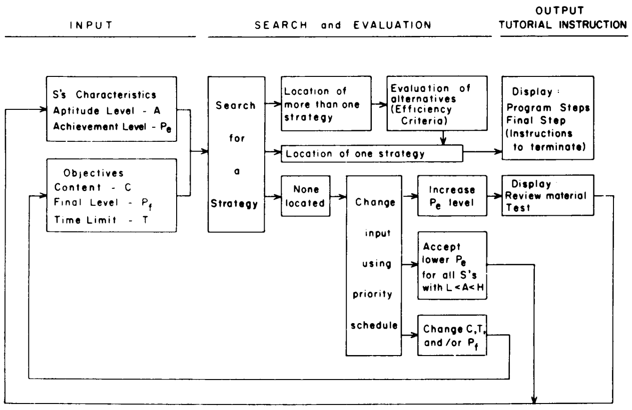

Figure 2

Decisions. To accomplish this phase it is necessary to have information that permits the prediction of the probable effectiveness of the different instructional programs for individuals with different patterns of entry behavior. Figure 3 shows some of the implications of changing objectives when the initial search for a program reveals that none of them is likely to produce the desired transformation. While the possibilities are mutually exclusive for an individual, different students can be treated in the different ways. It is possible, for example, to provide review for some students and to risk failure with others who are nevertheless the least risky of those who failed to meet the initial selection requirements. In addition it may turn out that the job characteristics might be changed so that some students can be trained to be useful though less well trained than originally

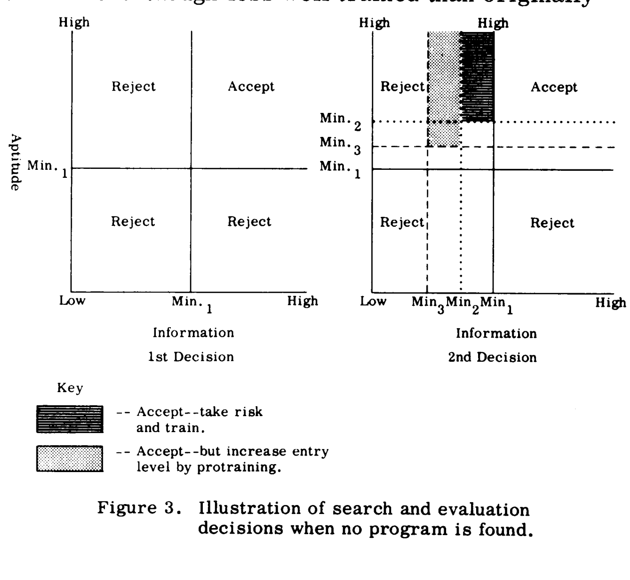

Figure 3. Illustration of search and evaluation decisions when no program is found.

planned. For these persons the instructional objectives may have been changed in terms of the topics or skills they are taught, the minimum level of expected proficiency, or the time allowed for them to achieve minimum proficiency. Many practical situations require that the instructional system be adaptive to the talent pool that is available for training as well as to the individual trained. The pretutorial phase of the system is designed to cope with that problem. For its accomplishment it is necessary to accumulate data that are not readily available at the present time. While prediction of success either in training or on the job can be made from existing selection batteries, there usually are no data on the differential success of individuals under a variety of instructional programs. Also lacking are data on levels achieved by different ability groups under self-paced conditions so that time estimates can be used.

Outcomes. As used in this formulation of the instructional process, outcomes of teaching have three characteristics. One is the level of performance attained. A second is the subject area in which proficiency or behavioral change is being accomplished. The third is the maximum time available. Therefore when one describes the desired minimum acceptable outcomes, it is necessary to specify three things: (a) the subject area or topic; (b) the final level of student performance that would be the minimum acceptable; and (c) the maximum time allowed to achieve the minimum level.

Entry Behaviors. There are two sets of critical characteristics of the entry behavior of students. The first is their level of knowledge or performance in the particular areas that relate to the knowledge or skill to be learned. The second is their ability, aptitude and personality characteristics. An adaptive instructional system should take these into account in selective ways so as to optimize the attainment of objectives. Cook (1962) found that ability (IQ) was related to speed of progress but not to error rate. Carroll (1963) has pointed out that aptitude can be defined in terms of the rate at which the individual learns particular concepts and skills. However, it is also necessary to specify the nature of the instructional program that is best suited to the individual student, for all students with the same level of aptitude are not also equivalent in other ways that relate to instructional effectiveness.

Instructional Programs. Since programs are the means by which the student's entry performance level is transformed into a specific final level, they can be considered as operations performed upon a learner. As operations they can be considered as being made up of two interacting parts: (a) a set of content units, called frames; and (b) a set of decision rules (strategies). It is possible to change a program by changing either the content (e.g., from a geometric to an algebraic presentation in mathematics) or the decision rules (e.g., to bypass frames or to add examples) depending upon the student's responses to frames either in terms of their correctness or latency. Linear programing (Skinner, 1960) represents one extreme since this type of program is invariant with respect to strategy but variable with respect to content. The linear strategy takes the student to the next program frame whether he made a right or wrong response to the previous one.

Intrinsic programing (Crowder, 1960) uses strategy paradigms of which very few variations are employed in practice. A common strategy paradigm is to take the student to the next frame if the response was correct but to return him to the original frame to make another choice if his response was incorrect. Ideomorphic programing (Stolurow, 1964a; 1964b) not only uses more information in making strategy decisions but also has a larger repertory of decision possibilities and therefore a greater variety of strategy paradigms. For example, incorrect responses can be dealt with by presenting the student with alternative formulations or problems that are generated as he needs them in order to achieve a criterion of performance such as four out of five correct responses. Also in ideomorphic programing a single set of content frames can be presented in a different sequence; so that for each student the content would be invariant but the strategy used to teach a student varied in terms of the single parameter of its organization of frames. In ideomorphic programing two different students making the same response to a particular frame may, nevertheless, see (or hear) different things. What the next event will be depends upon both the stored information regarding the student's entry behavior and his response record while learning. In this type of programing both content and strategy are subject to variation during the course of instruction.

If we adopt the methodological principle that two students with different entry behaviors will not achieve the identical outcome with the same program, then it is clear that the instructional system must use a different program for each distinguishable level of entry behavior whenever the same outcome is desired. Adopting this principle it is clear that whenever two students who differ in entry behavior achieve what appears to be the same outcome, either (a) it is necessary to construct a new entry behavior test; or (b) it is necessary to construct a new achievement test.

Tutorial Functions. Once a set of content units is selected, for example, based upon the particular scores attained on the test of knowledge or skill used to determine entry behavior, then a strategy must be selected to constitute a program for tutorial instruction. The tutorial process can be defined in terms of three sets of variables. The first set is made up of content units. The second consists of response measures such as latencies or number of incorrect responses for a given set of content units. The third set consists of the decision rules which relate the response measures to the presentation of subsequent events. The decision rules determine the contingencies between response and subsequent events which include knowledge of results, evaluative feedback (social reinforcement) and new content, all of which may be presented in one or more frames. The outcome of the pretutorial decision is the specification of the content, the response measures used to make decisions and the rules used in making the decisions.

The strategy employed in the tutorial phase can be considered at several levels of generality. At the most general level, it can be represented as a flow chart that does not specify in the boxes what the program is doing. At this level there is no specification of number of frames or their types, and strategy can be dealt with by a mathematical theory. It would be appropriate to consider the compatibility of devices with strategies of teaching. At this level a linear program can be represented by a flow chart in which each box leads to the next box whether the student's response is right or wrong. Some research has been reported (e.g., Beane, 1962; Roe, 1962b; Melaragno, Silberman, and Coulson, 1960; Silberman, et. al., 1961; Gropper and Lumsdaine, 1961), and the results frequently show that the different paradigms result in differences in learning time. Another level of strategy description is that in which individual frames are described but without reference to their subject matter. At this level a frame is considered in terms of its function, for example, introducing a new concept, relating two different concepts, applying a principle, etc. Thus these decision rules describe frames in terms of what the frames are doing but not in terms of what they are doing it with. At this level the decision rules relate directly to a theory of programed instruction. At a lower level decision rules are related to individual frames when considered in terms of their subject matter as well as in terms of what they are doing. Here a decision rule might be described in terms of introducing the concept of figure and relating it to the mood of a syllogism. Finally, there are decision rules relating to particular frames of a program by number. This is the lowest level at which decision rules play a part. Several studies have examined the effects of decision rules at this level (e.g., Roe, 1962a; Levin, 1961; Zucherman, et. al., 1963). The results at this level frequently reveal no significant differences in time or errors.

In addition to level differences, strategies can be considered in terms of a set of functions: (a) response accommodation; (b) evaluation; (c) selection; and (d) display. Response accommodation involves the communication of the student's response to the machine and transformation of it into a form that is usable by a particular teaching machine system. Several response measures other than correctness can be used such as latencies and accompanying physiological measures like the electrocardiogram (Avner, 1964). Evaluation requires the comparison of the response measure with a standard (comparator function) and this comparison would be simple or complex in terms of the number of variables taken into account, and it may be required immediately. With a computer-based system, it is possible to tell the student he is wrong without also telling him the right answer. The output of the comparator must be coded and stored in a form which permits its use in either immediate or delayed decision making and in subsequent analyses of the program. This is accomplished by the collating and recording functions. Selection is based upon the information stored in the memory of the system including test scores of entry behavior and that provided by the collator-recorder. Selection is made upon a library which may be magnetic tape, perforated tape, cards or film. If it is in coded form then it must be transformed for display to the learner. Selector functions could operate on information, knowledge of results, or evaluation of responses (Frase, 1963) either independently or collectively in any desired combination. The display function represents the communication of the system with the learner and this involves the transformation of a sample of the available content (library) into a set of conventional symbols, with certain constraints with respect to the form and duration of its exposure to the students contained within the set.

SOCRATES

SOCRATES is a child of the functional analysis just described. The student interface is a Master-Tutor which includes a rear-view 35 mm. projection system and fifteen keys for student response. The

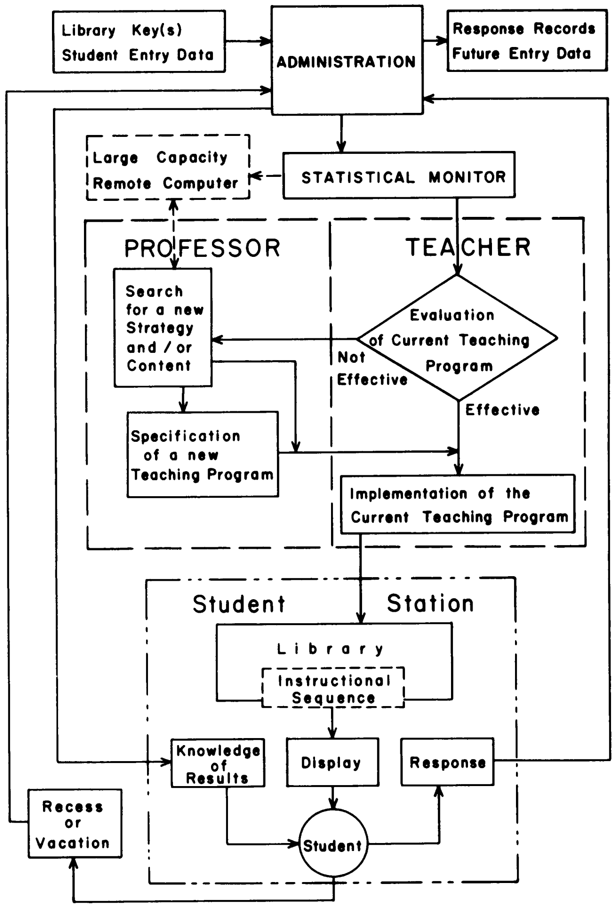

Figure 4

flow diagram for the system is presented in Fig. 4. Every student response is fed directly into the core of the computer and the computer has stored in its memory the instructions that will tell it what to do with this information. Besides making a permanent record collated with the display, it tells the student immediately whether he is right or wrong. The computer scans the library key for the film and selects from it a frame to be displayed. The evaluation and selection functions are carried out by the Professor and Teacher. While the Teacher is involved in the implementation of the current program, the Professor searches for the new program if the present one is not effective. The Administration controls the entire process, and a large capacity remote computer may be used in cases where the on-line computer cannot handle the operations, e.g., predictions of outcomes based on stored information.

When a student leaves a station, a command is relayed to the Administration (via the recess path), and action is taken to record the current status of the system (e.g., last frame presented, topic, strategy, content set) and the student's response record. When the student returns, this information is fed back into the system, and the status of an interface is restored so he can continue. Each student station has a location code or address. The Professor rules and associated memory blocks are stored in the computer. The Teacher uses the rules specified in the pre-tutorial phase. Not all students need to start at the same place nor do they have to study the same things. Each station can have a different content. Each time a student makes a response, an interrupt signal is generated. The Administration interrupts whatever it is doing at the time to identify the student who made the response and the response he made. Multiple responses are queued and accepted in order. The Administration stores the response and logs the time. The response is checked against the library key to determine its correctness.

RESEARCH

The most central applications of SOCRATES are those that study the relative effectiveness of particular teaching programs. A second is for research designed to determine the optimum match between individual differences and the effectiveness of instructional programs. A third use of the system is as a basic research tool in studies of learning where it can contribute both by facilitating the research work and by permitting the study of variables that would be impractical to study by other means. A fourth use to which the system is being put is to facilitate the acquisition of information by a sophisticated learner through its use as an adaptive retrieval system.

Teaching Strategies. Merrill (1964) was concerned with the strategies that might be used to effectively teach a hierarchically organized task, that is one in which some concepts are built upon other ones. SOCRATES was used to present the materials, collect the data and analyze it. In presenting the materials to each student, decisions were made by the system during the course of learning. The groups differed in the amount and type of feedback given them. In one condition, the students were told whether their responses were right or wrong, but the decision rule was to show them new material regardless of the correctness of their response. They received no remediation material when they were wrong. In a contrasting condition, the students were told whether their responses were right or wrong, and if they made a wrong response, they were given a review. In other words, after every wrong response, they received a review, and depending upon the number of wrong responses they made, they saw one or more reviews. Furthermore, the reviews became more specific as the students made more and more errors. Once the student made a correct response the system presented him with new material. The purpose of the study was to determine the relative effects on achievement of incomplete, and contrasted with complete, mastery of the parts of the hierarchical task.

The students worked on the program over a three week period on their own schedule. Each student gave the system operator his identification card containing his group number and frame location at the end of the last session. These data were fed into the computer, and it assigned each of them to a station containing an interface which was closest to the frame position they wanted; it moved the film to the appropriate frame and put into effect the appropriate decision rule for the particular student. Several students worked side by side at different MasterTutor interface units serviced by the same computer.

The research findings have important negative implications for the theories of Ausabel (1963) and Gagné (1961) for they show that both learning and retention are not necessarily facilitated by requiring the student to master each successive part before proceeding to the next part.

Hunter (1964) used SOCRATES to determine the effects of two sequences which were different in the length of runs they contained. He found that students given short length runs learned more rapidly to refrain from making a response than did those students who were given the long length runs.

Fríncke (1964) had his students learn English words and studied their ability to recall them. He found that there were two processes involved. One was a grouping of words into sets that were meaningful. The other was a rote-learning process. The students use grouping first, and when it is no longer useful, they depend upon rote learning to master the rest of the words.

A study we are currently running is designed to determine the relationships between mathematical and verbal abilities and learning under different conditions. Five different programs are being used, all of which cover the same information. Three questions are being asked. One is concerned with the effectiveness of a program that presents the student with minimal information. In it the student is merely asked questions about the material. A second is concerned with the relative effectiveness of a strategy that presents materials in a sequence that corresponds to the conceptual hierarchy versus one that uses a problem solving presentation in which the student only receives information when he needs it. The third question is concerned with the relative effectiveness of a strategy requiring the progressive mastery of parts versus one that does not.

Currently the system is being developed to initiate two new lines of research. One involves the use of the system to write program frames. AUTHOR I writes linear frames by combining "Swiss Cheese" sentence forms stored in the computer with words and performing, as necessary, the additional operations required to make the material gramatically correct, e.g., changing a to an when followed by a word beginning with a vowel. AUTHOR I also vanishes prompts as it generates the frames.

This program was used recently to tailor-make some frames used to teach a ten year old child with an IQ of approximately 110, who was considered a "lost cause" by the school after it had exhausted its special educational resources in trying to help him. Over a twelve month period, he was given about six frames per week of the computer generated material which was inserted in an electric typewriter. His scores on the vocal and motor encoding subtests of ITPA* were each raised by about three years.

AUTHOR II is a computer program that generates learning materials in syllogistic form from word lists. The student in a logic course can be given syllogisms of any specified mood (e.g., EAO sequence of major premise, minor premise and conclusion, respectively) and figure. Thus the forms of the syllogism can be generated according to any teaching strategy, and the student can learn to apply the rules that permit him to determine their validity. The program not only generates the syllogisms but also the information that they are valid or invalid and makes them gramatically correct. Consequently, the student's response can be judged immediately, and he can be branched to a new figure or mood according to a plan that is either established in advance or dependent upon his responses and entry behavior.

Finally, the adaptive retrieval application of SOCRATES might be described. It is an application of the system to learn about a sophisticated user while he is examining and judging the relevance of abstracts of technical materials. In phase I of the two-phase cycle the system stores information about the user such as reading rate, reading level, areas of interest, etc. The output of this phase is the identification of the set of abstracts to be displayed for judgment of relevance.

In the second phase, the user's responses are recorded and monitored for making decisions about the probable relevance of the remaining abstracts. It also will compute the retrieval times for these abstracts and then determine the sequence in which the abstracts will be presented. Decisions about sequence will be made according to different rules which will then be compared to determine their relative effectiveness. In other words, the decision strategy is the problem of interest in this research.

SUMMARY

This paper presented a general conception of an adaptive cybernetic, instructional system and a brief description of SOCRATES which is designed and in use. Some of the completed studies and those in progress were described to indicate the types of research that will contribute to the development of a sophisticated training technology.

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PROBLEMS AND PROSPECTS OF AUTOMATION IN THE LABOR MARKET

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Automation in our economy today has two sides. One is the new jobs that are created by advancing technology; the other is the old jobs which are eliminated. In a given situation, one or the other may dominate. So, it is no wonder that there are conflicting statements concerning the effect of automation upon employment. The problem is whether it is possible for analysts to synthesize these contradictory expressions into some valid over-all conclusions.

Certainly, a great deal depends upon the general condition of the nation's economy when the changes are taking place. It was my good fortune to attend a conference in Geneva, Switzerland, in July 1964, on The Employment Problems of Automation and Advanced Technology, held at the International Institute for Labour Studies. The conference was sponsored by the British and American Foundations for Automation and Employment. It was attended by management, labor, and government representatives from European nations, as well as the United States. The Iron Curtain countries of Europe were also present. The primary emphasis of the conference was upon the effects of technology upon employment (and unemployment), but secondarily upon labor-management relations growing out of these effects.

One interesting point which developed in the course of the discussions was the substantially different attitudes prevailing among the Western European representatives as contrasted with the attitudes of the American representatives. The Iron Curtain representatives were unimportant from this point of view, since they uniformly proclaimed that automation presented no employment problems to them.

The prevailing attitude of the Western European representatives, both management and labor, was that on balance automation would be a good thing in their economies. This attitude in turn reflects the sharp economic growth coupled with the labor shortages which exist in nearly all Western European countries. The general reaction of the representatives was that automation would enable them to get faster economic growth with the available supply of labor, which would in turn help to offset inflationary tendencies. Since practically all these nations have unemployment rates of one or two percent, they expressed little concern about the unemployment effects of automation.

By contrast, a number of the labor and management representatives from the United States viewed automation as a great engine of job elimination. Much of the discussion in the conference turned on the extent of unemployment in the U. S. and the degree to which that could be attributed to the effects of automation. Some American representatives, especially union leaders in industries afflicted with declining employment, spoke approvingly and hopefully of the 5-hour day and the 20-hour week.

One of the most animated discussions during the conference took place on the paper presented by a professor from Western Germany on the subject of "A New Definition of Work and Leisure under Advanced Technology." His assumption was that the productivity of automation is so great that it can be made to yield both higher real wages and vastly increased leisure. This idea has been carried so far by some recent writers (not in attendance at the conference) that they are advocating the distribution of the nation's income without regard to work, thus counting upon man's propensity to work as a sufficient incentive to produce the gross national product.

When we turn from theories to facts, we find that up to the present there has been no such dramatic over-all achievement of productivity through automation. This is demonstrated very simply by the basic facts on total employment in our economy. We do have occasion to be disturbed by the comparatively high level of unemployment (5 percent) in a highly prosperous year such as 1964. Certainly, this is a volume of unemployment which requires continuing public attention. However, that figure in itself fails to show the extent to which employment has expanded, even in recent years, when there has been so much discussion of our slow rate of economic growth. From the first half of 1957 to the first half of 1964, the total employment in the U. S. increased by about 5-1/4 million workers, which is at a rate of three-quarters of a million a year. So, despite all the jobs eliminated by automation (and there is no question about the fact that perhaps as many as two million jobs a year have been eliminated in this way), the over-all number of jobs in the economy has nevertheless continued to expand. However, the labor force, which is the number of people offering themselves for work in our economy, grew even faster, so that over this 7-year period unemployment increased by 1-1/4 million. The rate of unemployment, which was about 4 percent in the first half of 1957 was nearly 5-1/2 percent in the first half of 1964. In the second half of 1964, the rate has been brought down close to 5 percent.

There is one school of thought in our economy which argues that the simplest way to deal with this problem is to stimulate in some way the rate of the growth of the economy, so that more jobs could be created.

In crude, round numbers our employment history over those 7 years, from 1957 to 1964, is that for every 5 persons added to the labor force during this period, 4 obtained jobs and 1 joined the unemployed. Theoretically, a somewhat higher rate of economic growth would have provided a job for the 5th person. This line of thought leads to consideration of broad monetary and fiscal policies, such as tax cuts, government spending, easy credit, etc.

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For page 28, column 2, paragraph 3 substitute:

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For page 29, column 2, paragraph 1 substitute:

The BLS estimates a continuing decline in labor force participation of older men. For example, men aged 65-69, with a participation rate of 45.8 percent in 1960, are projected to a rate of 33.8 percent in 1975, barely more than one-third of that age population. Men 70 years of age and over are estimated to decline from 23.5 percent to 17.1 percent.

For page 29, column 2, paragraph 3 substitute:

In December 1964, the unemployment rate for adult men (20 years of age and over) was 3.5 percent; the rate for adult women (20 years of age and over) was 4.6 percent; while the rate for boys and girls under age 20 was 15.4 percent.

For page 29, column 2, paragraph 5 substitute:

Back in the early 1950's the unemployment rates for white boys and girls averaged around 7 percent, with nonwhite boys only slightly higher. In the case of nonwhite girls, the rate was about 9 percent. During the past decade, the picture has changed radically for the worse, so far as the nonwhites are concerned. In the recession of 1958, when the white rates were 12-14 percent, the nonwhite unemployment rates averaged 25 percent. During 1964, the unemployment rates for white boys and girls averaged about 13 percent, whereas the rate for nonwhite boys was 23 percent and for nonwhite girls 31 percent. These figures constitute ample evidence that nonwhite teenagers are having a difficult time finding jobs.

For page 29, column 2, paragraph 6 substitute:

One labor force group which has not been especially disadvantaged by technological trends and other industrial changes is the group of adult women (20 years of age and over). Between 1950 and 1964 the number of adult women in the labor force increased by nearly 6.5 million, while the number of adult men increased by nearly 4.3 million. Thus, the women in the labor force have increased by half again as much as men.

An alternate interpretation can be developed by asking such questions as these: Why didn't the number of jobs grow faster during the past 7 years? Aren't there large numbers of job openings which cannot be filled because qualified workers are not available? If we had adequate statistics on the number and kind of job vacancies in the economy, might it not be possible that these would be equal to a substantial proportion of the unemployed? (In a number of European countries, such statistics are regularly collected and published; and in some countries, the unfilled vacancies are larger than the number of unemployed.)

The import of these questions is to call attention to the structural character of unemployment, that is, to the wide divergence which exists between the skill and educational requirements of the expanding jobs and occupations, as compared with the characteristics of the unemployed seeking work. Sir William Beveridge in England, a quarter of a century ago, defined full employment as the situation when the number of unfilled vacancies and the number of the unemployed are equal. Under those conditions, the amount of unemployment could be called structural, because it is primarily due to the failure of the demand for labor and the supply of labor to match each other. This might be described as the situation in Great Britain today, when the unemployment rate is under 2 percent.

While the over-all economy-wide effect of automation upon unemployment is relatively small, there have been a number of significant differential impacts upon certain groups in the labor force, upon various occupations, and in some specific industries.

Groups in the Labor Force

One group of workers who have borne some of the brunt of automation, as well as suffering from some of the other changes in our economy, is the group of older men, that is, men over 60 years of age. For three-quarters of a century, there has been a continuing decline in the labor force participation rate of men 65 years of age and over. Over 68 percent of all men in that age group were in the labor force in 1890, but only about 30 percent in 1960. Two factors, more than many others, were responsible for this, namely, (a) the spectacular decline in agriculture and the rise in industrial and commercial employment, and (b) the expansion of social security after 1950. This same trend, although on a far smaller scale, is evident in the data for men aged 60-64 years—83 percent labor force participation in 1920 and less than 78 percent in 1960.

According to reports from the Social Security Administration, approximately half of the men now being retired under social security are in the age group 62-64, the group who were permitted to retire with reduced benefits by the legislation adopted in 1961. The fact is that 48 percent of the men awarded benefits in 1963 received actuarially-reduced benefits, because they were under 65 at the time they became entitled. Thirty percent of the awards to men in 1961 were for actuarially-reduced benefits. By 1962 the proportion had risen to 47 percent. Retired workers comprise 70 percent of all persons aged 62 and over who were receiving OASDI benefits at the end of 1963. Practically all aged men on the rolls draw benefits as retired workers.

The BLS estimates a continuing decline in labor force participation of older men. For example, men age 65-69, with a participation rate of 46 percent in 1960, are projected to a rate of 34.5 percent in 1975, barely more than one-third of that age population. Men 70 years of age and over are estimated to decline from 23.5 percent to 20.0 percent.

Another group who have recently been disadvantaged by recent trends in jobs and occupations are the young people, who constitute the bulk of new entrants into the labor force. These statistics are well known; I shall refer to them briefly. The young boys and girls who will be age 17 in 1964 number about 3-3/4 million, about a million more per year than their older brothers and sisters, 18 years and above. This especially large age group will be 18 in 1965. At that age they will be graduating from high school and the bulk of them will be entering the labor force, if they have not already done so in 1963 or 1964. Furthermore, the younger age classes—those who are now 16, 15, and 14—all number about 3-1/2 million, and these will be labor force entrants in the years following 1965. The nation is on the verge of a great expansion in the number of young workers. This trend is already showing up in the high unemployment rates of teenagers.

In October 1964, the unemployment rate for adult men (20 years of age and over) was 4.0 percent; the rate for adult women (20 years of age and over) was 5.0 percent; while the rate for boys and girls under age 20 was 14.4 percent. Furthermore, the unemployment rate for these youngsters would probably be substantially higher, if it were not for the fact that a high proportion of them are attending school and therefore are out of the labor force.

A particular group of youngsters, who are experiencing an even greater hardship in finding jobs, is the nonwhite group, consisting mostly of Negro boys and girls.

Back in the early 1950's the unemployment rates for white boys and girls averaged around 6 to 7 percent, with nonwhite boys only slightly higher. In the case of nonwhite girls, the rate was about 10 percent. During the past decade, the picture has changed radically for the worse, so far as the nonwhites are concerned. In the recession of 1958, when the white rates were 12-14 percent, the nonwhite unemployment rates averaged 25 percent. For the first 8 months of 1964, the unemployment rates for white boys and girls averaged about 14 percent, whereas the rate for nonwhite boys was 25 percent and for nonwhite girls, 33 percent. These figures constitute ample evidence that nonwhite teenagers are having a difficult time finding jobs.

One labor force group which has not been especially disadvantaged by technological trends and other industrial changes is the group of adult women (20 years of age and over). Between May 1950 and May 1964 the number of adult women in the labor force increased by nearly 7 million, while the number of adult men increased by nearly 3-1/4 million. Thus, the women in the labor force have increased more than twice as fast as men.

Industry Differences

There is also a marked differential impact of automation upon various industries. In analyzing these differences, the BLS recently issued a report, Technological Trends in 36 Major American Industries. This was a study prepared for the President's Committee on Labor-Management Policy. Insofar as data were available, the Bureau highlighted briefly the major technological developments in each industry, relating these to the output of the industry, employment in the industry, and where possible, the output per man-hour. Finally, the Bureau attempted estimates of the 1970 outlook for employment in these industries. In so doing, we classified the industries into three groups–a, b, c. The (a) industries were those in which the outlook is for an expansion in employment by 1970, regardless of the technological changes and labor-saving devices which are now in prospect. The (b) group of industries are those in which the outlook is a comparative balance between output increases and productivity gains, which means that employment would most likely remain at about the same level that it has been in recent years. The third group (c) consists of those industries in which mechanization, modernization, and other technology seem likely to produce further declines in employment from the present time to 1970.

In all such projections, it must always be clear that changing conditions in the economy, or in the individual industry, can modify projections of this kind. A speedier introduction of technology in an industry could shift one of the "b" industries into class "c." An exceptional demand in a class "c" industry might expand its employment so that it would belong in class "a." What is needed is a continuous appraisal of these trends in the 36 industries already covered and the extension of these analyses and estimates to additional industries. This work the Bureau is planning to do.

Labor-Management Relations

These differential industrial employment trends have already produced marked effects upon collective bargaining and labor-management relations in the United States. For approximately the first decade after World War II, unemployment rates were low in this country and the demand for labor was high. Union efforts to provide more jobs for members sometimes took the form of urging the elimination of compulsory retirement and the hiring of older workers.

Within recent years, however, there has been a pronounced shift in the opposite direction. In industry after industry, the union objectives have been to prevent declines in employment within the industry, or at least to provide protection for the workers already employed. Where shrinkage in employment has turned out to be inevitable, the pressure in collective bargaining has been to provide fringe benefits of all kinds, which would either provide protection in their jobs for the mature workers in the industry or would provide for early retirement and for substantial special allowances for those who had to leave.

To illustrate the ways in which management and labor in different industries have tackled this problem, I have outlined briefly the types of adjustments which have been negotiated.

Coal Mining - Coal mining is an outstanding example of an industry in which management and labor recognized that it would be possible to remain competitive only by reducing unit labor costs. Both also recognized that if their efforts were successful employment levels would have to be adjusted downward. In 1947, 426,000 workers were employed by establishments mining bituminous coal; by January 1964, this number had been reduced to 124,000—a loss of about 300,000 workers, or a reduction in total employment of about 70 percent.

In anticipation of this change, the Bituminous Coal Operators Association agreed with the United Mine Workers of America in 1946 to establish a Welfare and Retirement Fund. This fund is supported by employer contributions on coal produced for use or sale which began at 5 cents a ton and which now amounts to 60 cents a ton. This fund in turn has been used to provide early retirement of miners at age 60 with 20 years' employment in the industry in the 30 years preceding retirement. It also provides hospital and medical care, funeral expenses, and widows' and survivors' benefits.

In recent years, declining royalty income has led to reduction or elimination of some of the original benefits. Pensions were reduced to $75 a month from $100; rehabilitation and maintenance and cash benefits were discontinued; and eligibility for hospital and medical care for unemployed miners was limited to 1 year after the last date of employment.

Railroads - The railroad industry is another that has experienced a sharp decline in employment over the last 15 years. In 1947, the nation's Class I railroads employed about 1,350,000 workers. By January 1964, the number was down to 660,000, a cut of about half. In this industry, the collective bargaining situation is different from mining. In coal mining, a single industrial union covers substantially the entire industry. On the railroads, there are two major negotiating groups—one representing the operating Brotherhoods, and the other representing the nonoperating unions. Each group is composed of a number of individual unions, and each has experienced its own problems with this shrinking employment. In this great threat to employment opportunities in railroading, the efforts of the unions have been directed toward maintaining as many jobs as possible. The efforts of the employers have been to eliminate those jobs and occupations which they consider unnecessary in the light of progress of railroad technology.

For the operating unions, the outcome of this conflict was the appointment of a Presidential Railroad Commission, the establishment of a number of mediation boards, and finally, in August 1963, the imposition of Congressional legislation of compulsory arbitration of the issues of firemen and train crew size. In April 1964, the parties reached agreement "in principle" on the remaining issues in the 4-1/2-year work rules dispute.

Although the problem of changes in work rules and reductions in employment has been a major source of labor-management conflict, the industry very early did develop a plan for providing a substantial measure of income security to its employees. Originally, this plan was put into effect for workers affected by railroad mergers. The Washington agreement of May 1936, still in effect, provides substantial benefits to operating and nonoperating employees of Class I railroads with one or more year's service, who are separated because of railroad mergers. Included are "coordination" or furlough allowances of 60 percent of average monthly compensation for periods, ranging from 6 months' for those with a year of service to 5 years for those with 15 years or more of service. Employees receiving such allowances are subject to recall to service. Those who resign instead of accepting a furlough allowance are paid a lump sum separation allowance, ranging from 3 months' pay for those with one year of service to 12 months' pay for those with 5 years or more. In recent years, provisions similar to those of the Washington agreement have been negotiated for some railroad workers affected by technological change. Such provisions were included in the April 1964 agreement that ended the long work rules dispute involving the operating brotherhoods.

Longshoring - In the longshoring industry, there has so far been a marked contrast between the West and the East Coast. In July 1959, the Pacific Maritime Association and the International Longshoremen's and Warehousemen's Union agreed on a plan whereby the union accepted introduction of labor-saving devices and methods in return for the establishment of a fund to give workers a share in the savings from mechanization. Under the plan, as amended, employers pay about $5 million a year into the fund which is used to guarantee Class A longshoremen against layoff resulting from changed cargo handling methods, and to give them a weekly guarantee of an average of 35 hours' work or pay. The supplemental wage benefits are paid to fully registered longshoremen who, as a result of technological change, average less than 140 hours of work in a 4-week period. The maximum benefit amount, including a worker's earnings, benefits, and unemployment compensation, was set at $400 a month.

A major feature of the plan is a special payment to men age 62 or older, with 25 years of qualifying service, who permanently quit the work force. This payment amounts to $7,920 or $220 a month for 36 months. At age 65, these men become eligible for their regular pension as well as social security benefits. Since longshoremen do not have to retire unless they reach age 68, they receive the lump sum benefit even at age 65. There was also agreement in principle to mandatory early retirement at age 62 with 22 years of qualifying service; and workers forced to retire under this provision were to receive an extra payment of $100 a month until they reached age 65. Actually, the provision for mandatory retirement has not been put into effect.

On the East Coast, much less progress has been made toward encouraging technological change or toward providing job or income security to workers affected by such changes. In November 1960, an arbitration award permitted loading of equipment in large containers with a containerization fund to be established from payments by employers for cargo loading in this fashion in the New York harbor area. Late in 1962, a strike was ended with acceptance of the recommendations of a 3-member special board of mediators that provided for a Department of Labor study of manpower utilization, job security and related matters. This year's negotiations, begun after the Department of Labor's report was completed, have not reached an agreement and an injunction was issued under the Taft-Hartley Act after a strike began in early October.

Meatpacking - The meatpacking industry in recent years has experienced substantial technological changes. These developments, accompanied by replacement of older plants by more modern ones and competition of independent meatpackers, as well as changing marketing patterns, have not only reduced employment but have resulted in shifts in employment opportunities among areas.

One effort in this industry to deal with problems of technological change has been rather unique, in part because it involved only a single company—Armour. The company and two unions representing its blue-collar workers (The Amalgamated Meat Cutters and the United Packinghouse Workers) agreed in 1959 to establish a fund to be financed by the company, and to be used by a committee to study methods of cushioning the effects of automation. The funds were also used for training, although results were reportedly not highly successful. Company contributions were discontinued in 1961, but after making an allocation to defray committee costs, it was agreed to use amounts left in the fund to finance training and relocation of workers in other areas.

The 1961 agreement also changed seniority provisions to facilitate transfer of workers to new plants, liberalized early retirement for workers affected by technological change, and established technological adjustment pay. This is provided to workers under age 60 with 5 or more years' service when they are permanently separated from their job by closing of a plant or department. The adjustment benefits consist of $65 a week (less unemployment compensation and earnings) for 26 to 39 weeks, depending on years of service. Employees who exhaust their technological adjustment pay and State unemployment compensation before being offered a job in another plant can also get supplemental separation pay which varies from 3 weeks' pay for a man with 5 years of service to 37-1/2 weeks for a 30-year man, and a year for a worker with 40 years' service. Technological adjustment benefits are paid workers only if they register for transfer to another unit and seek work elsewhere, although those who do not register for transfer receive a higher level of separation pay than those receiving technological adjustment pay. The 1961 Armour agreement also provided that employees age 55 or over with 20 years of service, whose jobs are terminated by a plant or department closing or who are displaced by technological change, receive one and a half their normal retirement benefits until they become eligible for social security benefits. These early retirement benefits are in lieu of separation pay or technological adjustment benefits.

Steel - The steel industry has adopted a number of approaches to increase job and income security. One of the most publicized developments was the

Kaiser Steel Company progress-sharing plan worked out by a committee set up under the 1959 agreement between the company and the United Steelworkers. Put into effect early in 1963, this plan provides that no workers are to be laid off as a result of technological change or new or improved work methods. Workers displaced by technological change are placed in an employment reserve and assigned work in various parts of the plant, but their functions cannot result in reduction of hours of work in the plant below 40 a week. Those placed in lower paying jobs or those who fail to receive promotions as a result of technological change are paid a displacement differential, which continues for 52 weekly payments or 3 calendar years, or until they receive the higher level of pay through normal progress. Workers whose scheduled hours are reduced below 40 a week by changes in technology receive their average hourly earnings for the hours less than 40.

The Kaiser plan also incorporated features designed to increase, not merely maintain, pay of workers as a result of technological improvements, and indeed was primarily designed to distribute the benefits of industrial progress, instead of merely to protect income and job security. Workers receive 32-1/2 percent of any savings in materials or labor costs over a base period. During the first 19 months the plan was in operation, payments to eligible workers ranged from 9 to 66 cents an hour. In other basic steel plants, a variety of income security provisions exist: SUB benefits designed primarily to take care of seasonal or cyclical employment; severance pay and provisions for liberalized retirement benefits to workers retired early because of plant or department shutdowns. The contract negotiated in 1962 also discouraged workers from postponing normal retirement by providing that credits toward additional vacation pay would be reduced for workers remaining in employment after becoming eligible for normal retirement.

The agreement also established an interplant job opportunities program giving laid off employees preference for employment in plants hiring new workers. (Actually, there appear to be difficulties in getting workers to accept such jobs, perhaps because moving expenses exceed moving allowances or because of lack of assurance as to how long jobs in new areas will last, family responsibilities, local ties, etc.)

The 1963 basic steel agreement established a 13-week vacation every 5 years for the half of the work force with the greatest seniority. Since this sabbatical vacation includes the regular vacation, it amounts to a net increase of 9 or 10 weeks' vacation every 5 years. There was also some liberalization of vacations for workers with shorter service. This agreement, designed to spread employment opportunities, followed an agreement between the Steelworkers and major can producers for sabbatical vacations for employees with 15 years' service, and in turn was followed by establishment of long vacations once every 5 years for all aluminum workers with a year or more of service.

Automobiles - Recent settlements in the automobile industry were highlighted by greatly liberalized early retirement benefits. Although the industry has for many years had a variety of provisions aimed at increasing job and income security, and although liberalized benefits for workers retired early at company option are not new in this or other industries, the size of the early retirement benefits to be provided under the new agreement and the fact that they apply both to voluntary and company-induced early retirements makes them almost unique. Since 1955 the automobile industry has provided workers retired early at the company's option, or on mutually satisfactory terms, with double the normal retirement benefits until they reach age 65. In addition, the industry has supplemental unemployment and severance pay benefits as well as relocation allowances.

The new contracts provided that effective in September 1965 workers who retire at age 60 with 30 years' service, either at the company's option or voluntarily, can receive a monthly retirement benefit until they reach age 65 of 70 percent of their monthly earnings. The benefits are subject to a maximum of $400 a month. Workers retiring at age 55 or with fewer than 30 years' service receive lower benefits. At age 65 they will receive their normal monthly pension reduced only for retirement prior to age 62 plus social security unreduced for retirement before age 65.

Summary on Industrial Relations

The above illustrations are sufficient to establish the trend which has been dominating collective bargaining in recent years. The basic economic assumptions underlying this trend are that unemployment is likely to remain persistently high, even during periods of peak prosperity; that employment in many industries will at best remain stable and will most likely decline; that workers who once become attached to an industry by reasonable length of service should receive maximum protection in their jobs; that declines in employment should be met by earlier retirement at higher benefits and/or by substantial separation allowances and unemployment insurance. The net effect of collective settlements based on these assumptions will be to limit the flexibility and adaptability of the labor force in a rapidly changing industrial society.

INCREASING PROFITS THROUGH DELIBERATE METHODS CHANGE

Arthur Spinanger
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PROFITS AND CHANGE

We here today represent scores of American businesses from almost every sector of industry. Yet our companies, as varied as they are, all have one thing in common. They're all in business to make a profit. The Profit Motive is the catalyst for our free enterprise system. Without profits no company could long survive. So, I will direct my remarks this morning to that broad area—corporate profits; but concentrate on corporate profits through one particular approach.

I am sure I can correctly say that all of us here are employed by our respective companies to make money. By that I mean to make a profit for our company. As this profit is made, I do not mean that it will be a greedy, money-grabbing one-way profit. I mean that our profit will be part of a multi-way profit. One part will be for our company which includes our employees and our stockholders. Another part will be for our customers—we want them to be better off after buying our product than they were before buying our product. Still another will be for our suppliers—we want our business to profit them as it profits us.

So to get at the theme of this discussion, we can start with a very simple statement—"Our company is in business to make a profit. It plans to make this profit by giving value to the customer by making quality products the customer wants."

Now I don't intend to mention all, but there are several ways, of course, of making a profit. You are familiar with them, but I would just like to spotlight the ones that we are going to discuss at this time.

For example, one way to make a profit would be to develop and sell a new product. A second way would be to increase profits on existing products.

We can do this by increasing outlays on existing methods to increase profitable sales (for example, by increasing advertising or sales efforts).

Another way to increase the profit on existing products would be to reduce costs by controlling the costs of existing methods more effectively, perhaps, through better performance—belt tightening, taking up the slack, and so on.

A third way to increase the profit on existing products is to deliberately change existing methods to reduce extra costs.

This is the area that we are going to talk about today—about increasing profit through the philosophy of deliberate change.

Procter & Gamble, like your companies, is well-managed and has a history of strong management. Your company and my company not only accept change—we seek change. Your company and my company have cost control and cost reduction programs. All of the management of your company and my company are alert to take advantage of every opportunity to save money and to do things a better way.

But is this "doing things a better way" what I mean by increasing profit through the philosophy of deliberate change? Not really. While we at P&G consider this a very important starting point, we consider it only a starting point. Under a deliberate change philosophy we cannot see any limitation on how far we can go, but the possibilities are staggering. We can see how far we have come from the starting point and how we got there.

We know, for instance, that every management member of P&G's manufacturing organization is participating in a program to increase profits through the philosophy of deliberate change and that these men, over 2,000, contribute on the average over $17,000 per man in new profits each year.

HISTORY OF PROCTER & GAMBLE'S METHODS CHANGE PROGRAM

But all of this didn't happen overnight. It has been growing since 1946 in an effort we call Procter & Gamble's Methods Change Program.

I would like to review briefly the history of this program, touching the main points in its development.

The Program started in 1946 when formal training in Work Simplification was offered to management representatives of each manufacturing plant. These men returned to their plants as SPECIALISTS. By 1949—with annual savings per member of management approximately $700—it was obvious that specialists working as a one-man effort could barely "scratch" the surface of the savings potential.

SPECIALIST CHANGED TO COORDINATOR

In order to get greater participation, the role of those men was changed to that of COORDINATOR. In this capacity, they not only continued their individual cost reduction work, but assisted and encouraged line managers with their cost savings projects.

As participation increased, the savings grew. A bi-monthly bulletin was published by the central methods development organization to promote the reapplication of successful methods changes in the other plants and to summarize program achievements. Plants of different sizes were put on a comparable basis by calculating the average annual dollar effect of the projects completed per member of plant management. This measure makes no attempt to differentiate between one-time savings and continuing savings. It is conservative in that the savings credited are first-year savings, i.e., no credit is given for savings which continue beyond the first year, even though this is usually the case.

In 1950, the changes that had been made in the organization of the program began to pay off. With a broader participation of plant management under the coordinator plan, the rate of annual savings tripled from less than $700 per year to $2,300 per year per member of manufacturing management.

METHODS TEAMS WERE FORMED

In the early 1950's, Procter & Gamble developed its Elimination Approach. This approach is applied to any cost, operation or piece of equipment by identifying the basic cause for the cost. It is a questioning approach using the question—"If it were not for what basic cause, this cost could be eliminated." When this precise questioning reveals that there is no basic cause, or the basic cause can be eliminated, the cost is eliminated. The process of identifying basic causes is most successful when done by a group of men. This fact and others led to the establishment of teams in our plants—called METHODS TEAMS.

These teams consist of both line and staff management personnel. Group questioning of operations tended to build a backlog of more significant projects. Besides jumping the annual savings rate to approximately $3,000 per member of management, the TEAM APPROACH also had other values. Opportunities for recognition for good work were increased. Individuals who were having difficulty in showing results were aided and stimulated by the example of the more successful men on the team. Among teams there was a friendly rivalry for first place in plant standings. Display boards and intraplant newsletters showed team standings.

DOLLAR GOALS WERE SET

This program of deliberate change was extended to include not only more management participation on methods teams, but also to include more areas of cost.

Previously plants had usually only concerned themselves with costs under their control. Now one plant began to review all the product costs; materials, inbound and outbound freight, insurance, taxes, as well as the more direct aspects of operating expenses.

This plant's manager established a goal of $500,000 for the year. This goal represented over $5,000 per member of management. With participation of the Buying and Traffic Departments and considerable plant effort, the goal was achieved.

TEAM-GOAL APPROACH STARTED

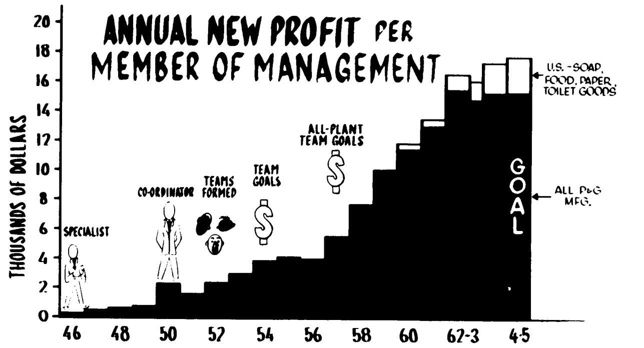
The central staff analyzed the strengths and weaknesses of the separate plant programs and recommended the most successful of these to the other plants. Thus the teams in each plant started setting goals following what we call the TEAM-GOAL APPROACH. This was a major step forward—teams committing themselves to a dollar methods change goal and then working as a team to attain it.

All-plant achievement began to reflect these changes in approach. Savings increased from an average of approximately $4,000 per member of management in 1954 to over $17,000 per member of management in 1963.

Extension to all manufacturing operations worldwide has been accomplished. Methods-change savings contributed to a corporate goal which is the sum of all team goals of all plants in all divisions. The current goal is $17,800 per member of manufacturing management and we know we are just beginning.

In the last few years, the Industrial Engineering Division has been in the process of extending the Methods Change Program to the technical staff groups and the functions other than manufacturing. For example, the Technical Packaging Division has been establishing methods change goals and office building operating managers have added industrial engineers to their staffs and several have a full Methods Change Program. We are steadily continuing our extension of the Methods Change Program toward our objective of including the entire management of the business.

With current company fiscal expenses totalling over 1-1/2 billion dollars—and under the philosophy that every dollar of cost is a potential dollar of saving through methods change, we can always say, " we are just beginning." While today's savings are most attractive, future savings will be multiples of today's. This summarizes the history to the present of P&G's Methods Change Program.



A visualization of the entire program history can be seen on this chart. (The half width bar in 1963 represents a transition from accounting on a calendar year basis to a fiscal year basis.) Vital to the success of this Program has been the attitude of all levels of management.

PHILOSOPHY OF DELIBERATE CHANGE

This attitude is built on the full acceptance of the principles of deliberate change. Deliberate change is quite different from improvement.

In Procter & Gamble we maintain that, as a first step, we do not want to try to make improvements. Some people have questioned this point. They ask, "What's wrong with trying to make improvements?" The answer is simple. We have found out that industrially if we first try to improve things, we will get into trouble—cost reduction trouble.

For example, if we study an operation whose methods look good, improvement will be difficult—especially in a well-run department. On this basis, we might decide that nothing can be done or needs to be done to such an operation.

In a well-run department, we would find that we would make the same decision for all the other operations.

A well-run department would conclude that some other department will have a better chance for improvement. But other departments feel that they too are well run. As a result—in the total of all departments profits do not increase because no improvements are made. Now, this is why acting on the principle "Perfection is no barrier to change" is so important.

For if improvement of these well-run operations is difficult to bring about, then we must seek to deliberately change methods rather than attempt to improve.

So today we approach costly, but smoothly running operations and ask the question, "How can we change them?" We say the operations are perfect, but we cannot continue doing them that way any longer. We must change them and continue to change them.

Let me give you an actual example of this improvement versus change point. Procter & Gamble used to handle its case goods on wood pallets with fork trucks. The operation was most satisfactory. Improvements in this operation were limited. However, because we used tens of thousands of wood pallets costing \$3 to \$5 each, we sought to deliberately change our method of materials handling. New and more profitable methods resulted. The first of these was the development of a paper pallet costing 50¢ to 70¢ along with a pulpac type of truck. This change from wood pallets to the lower costing paper pallets permitted palletizing to be extended to products requiring scores of thousands of paper pallets. Once again, seeking deliberate change, the clamp truck was developed. We now handle 90 percent of our cases without any pallets by using clamp trucks. An annual savings of over \$500,000 has resulted.

Without acting on the principles of deliberate change we could not have advanced the rate of making profitable methods changes. To present the principles which support our philosophy of deliberate change, I would like to show you a film. It is entitled, "Methods, Money and Mops."

Summary of Film "Methods, Money, and Mops"

Divergent demands made by stockholders, retail and wholesale customers, consumers, employees and suppliers compel a company to strive continuously to search for ways to make savings and increase profits.

There are two ways to do this—improvement and change. Improvement means operating a method more efficiently. Change means developing and using a new method.

The difference between change and improvement is demonstrated in the film. When an operation is perfectly done, there is no more opportunity for improvement. However, there is still a potential for savings by making a deliberate change.

The Methods Philosophy of Procter & Gamble is based on the concept of deliberate change comprising the principles of:

"Perfection is no barrier to change."
"Every dollar of cost must contribute its fair share of the profits."
"The savings potential is the full existing cost."
"Never consider any item of cost necessary."

These four principles of deliberate change function best in an environment which helps people put ideas into action. Teams are used to proceed toward planned goals of change. Positive recognition of results is emphasized.

The film closes by pointing out that the use of methods philosophy in all parts of the company will increase the profits for the company's suppliers, employees, stockholders, customers and product consumers.

Because of their importance, I would like to spend a moment more on the principles of deliberate change presented in the film we just saw. I would like to try to show how each principle can stimulate an attitude that is conducive to seeking deliberate change.

PERFECTION IS NO BARRIER TO CHANGE

Let us consider the first principle—"Perfection is no barrier to change." We used to consider the shipping case size of our Cheer 6's product to be correctly designed. It was performing perfectly and therefore we didn't consider changing it.

Originally Cheer containers consisted of one layer of six cartons with a support sheet in the middle. A packing department manager acting on the principle that perfection is no barrier to change suggested that another way of packing the container would be in two layers of three cartons each. The change was tested on Cheer 6's. It was found that the support sheet could be eliminated and less cardboard could be used in the container resulting in savings of over $100,000 annually for all brands.

EVERY DOLLAR OF COST SHOULD CONTRIBUTE ITS SHARE OF THE PROFIT

Let's consider the second principle–"Every dollar of cost should contribute its share of the profit." In other words, we spend no dollar without the intent of making a profit. An illustration to test this point might be, "How much profit do we make on a storage tank?"

A reasonable reaction to this question might be, "You really can't expect a storage tank to make a profit by itself. A tank is part of the process equipment needed to manufacture a product or material for a product."

Yet the profit question was asked–and developed a result that was most attractive.

Let me give you an example involving tanks at the Quincy, Massachusetts Plant - near Boston. We used to receive lye from a supplier that was located in the Great Lakes District of the States. This particular company made lye like mad during the summer and shipped it by barge down to the New York City Harbor. The reason for this high rate of manufacture during the summer was because at winter time the Great Lakes System and the canal system to the Hudson River freezes over. The manufacturer made this lye and shipped it down while the passage way was clear. Then in winter, after the waterways had frozen over, they shipped this lye from New York City by tank car to customers. I don't mean to say that a P&G Manager stood at the end of the pier by his plant as he thought this, but anyway he did wonder why this lye which was destined for his use at Quincy should be shipped all the way down to New York City by barge and then back to him by the higher costing tank car method.

With barge unloading facilities checked out as feasible, the Buying Department and Traffic Department asked the lye supplier if he could deliver the chemical directly to Quincy by barge. The supplier was pleased to hear of the proposal because it would help to achieve a much easier method used to make this delivery.

What's more, the supplier said that they would pay the Quincy Plant rent on the tanks because they now pay rent to the owners of the New York City tank field. In addition, they said that Quincy need not pay the cost of this lye until it was actually sent to its first point of use. As a result, Quincy now rents these tanks and has reduced working capital.

This same kind of point was paralleled down at the New York Plant. They had surplus tanks. Upon checking around with users of tanks, they found a company anxious to rent tanks. Thus, right now New York also rents tanks.

To recognize savings opportunities of this type, we must accept the principle that every dollar of cost must contribute to its share of the profits.

THE SAVINGS POTENTIAL IS THE FULL EXISTING COST

Moving on to the third point–"The savings potential is the full existing cost."

We used to package Drene shampoo in a carton with a liner. Application of the elimination approach led to the elimination of the liner first, and then the carton as well. (We found the attractive product would sell better without a carton than with a carton.)

NEVER CONSIDER ANY ITEM OF COST NECESSARY

Moving to the last principle–"Never consider any item of cost necessary."

Our example, again, concerns a storage tank. These tanks were used to store material in process to a recovery operation. We used to have roofs over these tanks that regularly required costly repairs. Before continuing these repairs, the basic cause for the roof was established. These roofs could be eliminated if it were not for the need to protect the contents from rainfall and weather exposure. Upon further study, it was found that over a period of time the processing of this material had been changed and weather protection was no longer required. It might literally be said that since the basic cause "did not hold water" the roof was eliminated, resulting in maintenance and replacement savings.

Who would question the necessity of having a roof over a standard tank without first accepting the principle–"Never consider any item of cost necessary?"

The film and examples we just saw served to develop and demonstrate four principles that are basic to the philosophy of deliberate change and they pointed out that these function best in a favorable atmosphere. In describing the history of the methods program, we touched briefly on the importance of TEAMS AND PLANNED GOALS. The third element that is necessary for a successful methods program is POSITIVE RECOGNITION. Actions which are re-enforced are strengthened. The re-enforcing process can best be achieved by providing public recognition that meets the needs of people to feel important by being important.

A SUCCESSFUL METHODS CHANGE PROGRAM DEPENDS UPON POSITIVE RECOGNITION

While our approaches to recognition generally fall into these categories:

Methods Program Kickoff Meeting
Methods Goal Victory Celebrations
Team Status Bulletin Board
Monthly Methods Change Newsletter
Plant and Team Rotating Trophies
Small personal awards of recognition to members of a successful team
Letters of commendation

our plants have been very ingenious in devising ways to recognize successful methods change achievements.

For example, one plant conducted a Methods

Savings Contest and awarded stamps for completed projects. This contest was a takeoff on commercial trading stamp schemes. The plant, however, printed its own stamps, stamp books and prize catalogues, all amply covered with methods change slogans. The savings exceeded the plant's expectation to such an extent that all the stamps were used up and the contest administrators had to issue vouchers for the additional stamps earned.

A victory celebration - banquet style- was held at which stamps could be redeemed directly for modest prizes or exchanged for bingo cards in the hope of improving one's lot—by winning an earlier selection from a group of special prizes ranging from a $40 fishing outfit to a $1.50 car wash.

The important point is that the recipients are recognized publicly—even by the number of bingo cards they command—and are made to feel important because their contribution was important.

SUMMARY

In summary, the basic objective of Procter & Gamble's Methods Change Program is very simple—To increase profits through the philosophy of deliberate change.

The key points in organizing a Methods Change Program based on Proctor & Gamble's experience are these:

1. Form Methods Teams

   Organize so that each manager can spend part—say 5%—of his time working on deliberate changes as a member of a methods team or a profit team.

   Make certain that the teams have surveyed all the dollars in their areas. There was a time when most cost reduction thinking was related primarily to wage costs.

   Procter & Gamble has broadened its horizon to include inbound and outbound frieght, the cost of materials, rent, taxes, insurance, as well as losses, yields, and material degradings.

   Plan to use your entire management group. Performance is usually best when managers participate on a team. Cost reduction is possible wherever dollars are spent. No function should be above participating in cost reduction.

   Keep the responsibility for success where it belongs—on the line organization. The line should retain responsibility for project selection, follow-up, evaluation of progress, as well as the obvious points of final decision and installation.

2. Establish Dollar Goals

   Be sure that challenging goals are established. Procter & Gamble experience indicates a need for building them democratically, from the first level up. Comparisons providing competition among plants and functional groups are a real incentive for achievement.

   Be sure that some person (Proctor & Gamble calls him a Methods Engineer) is assigned to give the program the kind of continuing follow-up and coordination that means meeting the goal. He will help with ideas, work on reports, obtain answers from the other technical organizations, and keep the record of achievement.

   Fight the delusion that exists in some minds that cost reduction is "cream skimming"; the misconception that the next year's goal will be harder to make because of success this year.

   Remembering that every dollar of cost is a dollar of potential savings, encourage the idea that you are just starting to work. Past success points the way to even greater profit increase through deliberate change.

3. Provide Positive Recognition

   Taking good methods for granted will not produce outstanding results.

   Sincerely done, it is almost impossible to overdo proper recognition. People like to be recognized in the presence of their associates—be part of a winning team—feel important by being important.

At Procter & Gamble the Methods Change Program produces one of our most attractive payouts. Since 1946 when the Methods Change Program started, the rate of return—using first-year savings only—has been around 1000%. In other words, $10 of profit is returned for every $1 spent.

I know of no other management effort that can match this rate of return.

THE MANAGEMENT OF INEFFECTIVE PERFORMANCE

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Much of the material presented in this and the basic format were originally developed in connection with a management education program which was first offered to a managerial group in 1958. This program had two primary objectives:

a. To provide a framework and approach that managers could use in making decisions with regard to subordinates whose work performance proved ineffective.

b. To develop a higher level of motivation to meet managerial role requirements in individuals who were not themselves performing in an entirely satisfactory manner as managers.

The essential technique described in the management development program and in the paper has been termed performance analysis. This procedure requires a manager to pose a series of questions regarding the causes, or strategic factors, that may be operating to produce performance failure in a given subordinate. These questions are then checked against the information available on the individual and his work. Those which receive an affirmative answer serve as a basis for formulating a plan of action which, hopefully, will restore the individual to an effective level of performance. The rationale underlying this approach is essentially the same as that involved in medical diagnosis and treatment. The paper presents a decision model especially adapted to the needs of business managers, when faced with the problem of ineffective performance in a subordinate.

The various potential strategic factors which a manager must consider in dealing with a given instance of failure have been grouped into nine major categories which form separate elements in the paper. In the following paragraphs an attempt will be made to provide a brief description of the components of the analytic framework, and to point up some of the more important conceptual formulations.

Intelligence and job knowledge. Mental ability is considered as a composite resultant of the interaction of three factors: native potential, motivation to learn, and environmental stimulus potential. Special abilities develop because learning is channeled into certain areas as a result of motivation and opportunity. Among these various abilities the verbal area is the most important because it determines the occupational level at which an individual may perform effectively. Other abilities and specific job knowledge serve to establish the individual jobs, within a given occupational level, for which a person may be suited. The primary sources of difficulty within the intellectual sphere are:

a. Insufficient verbal ability

b. Insufficient special ability other than verbal (numerical, mechanical, spatial, etc.)

c. Insufficient job knowledge

d. Defect of judgement or memory

Emotions and emotional illness. Emotional illness is conceptualized in terms of specific symptoms which take over and control behavior, producing an inflexibility so pronounced that job performance may well be disrupted. Symptoms may take the form of persistent emotional experience, physical complaints, certain types of behavior, or disturbed intellectual functioning. In the more severe cases, the psychoses, the individual loses contact with the realities of the world around him and as a result ineffective performance is almost inevitable. In less severe situations neuroses may or may not interfere with work, but are particularly likely to do so when the job requires considerable judgement and decision-making, as do managerial positions. Strategic factors may be considered within three major categories:

a. Continuing disruptive emotion (anxiety, depression, anger, excitement, shame, guilt, jealousy)

b. Psychosis (with anxiety, depression, anger, etc., predominating)

c. Neurosis (with anxiety, depression, anger, etc., predominating)

Individual motivation to work. Motivation is described as a process in which the experiencing and anticipation of pleasant and unpleasant emotional states serve to elicit various types of behavior. This behavior may be congruent with job demands, and thus integrated, or it may be at variance with management's requirements. Motives which are of particular importance for occupational performance are fear of failure, pleasure in success, various avoidant motives produced by fear and distress, pleasure in dominating or controlling others, a desire to be popular and accepted by others, pleasure in social interaction, and a need for support from superiors (dependency). Problems are particularly likely to arise along the following lines:

a. Strong motives frustrated at work

b. Unintegrated means to satisfy motives

c. Excessively low personal work standards

d. Generalized low work motivation

Physical characteristics and disorders. Here a considerable variety of strategic factors are treated under one rubric. Special attention is given to the problem of managing older workers whose declining physical skills make them unsuited for positions in which they were previously effective. In general the loss of speed and quantity of output is much more pronounced than any decrease in accuracy. The effects that psychosomatic disorders and brain damage have on performance are also considered in some detail. The various strategic factors covered are:

a. Physical illness or handicap

b. Physical disorders of emotional origin

c. Inappropriate physical characteristics

d. Insufficient muscular or sensory ability

Family ties. With this category the emphasis shifts from characteristics of the individual to strategic factors operating in the social environment. One area of particular concern involves instances where an individual is separated from his family over a considerable period of time, either because of business trips or transfer, and becomes emotionally upset as a result. In such cases returning the man to his family appears to provide the most appropriate solution. Within the family area the specific factors noted as potential causes of performance failure are as follows:

a. Family crises (divorce, illness, suicide, etc.)

b. Separation from the family

c. Social isolation and living alone

d. Predominance of family considerations over work demands

The groups at work. A major aspect of the group in which a man works is the degree of cohesion, or sense of emotional closeness, which characterizes the members. Where this factor is lacking, turnover is likely to be high and absenteeism frequent. However, cohesion need not lead to highly effective work performance. In fact the group may well band together in opposition to management and establish norms which restrict output and contribute to ineffectiveness. Similarly the manager, as a member of a group, may be a strategic factor in the failure of his subordinates. He may be so inconsiderate of his men that they will not work for him, or he may fail to accept managerial responsibilities, or he may judge his men on inappropriate criteria. These problems are considered under the following heads:

a. Negative consequences associated with group cohesion

b. Ineffective management

c. Inappropriate managerial standards or criteria

The company. Consideration is given to the fact that company policies, especially personnel policies, may well contribute to the failure of specific individuals, even though their overall impact is positive. Among such strategic factors are decisions regarding investment in manpower, decisions regarding staffing and the span of control, and organizational criteria for evaluating individual members. Placement policies and decisions appear to be at least a partial cause of ineffectiveness in well over half the cases which have been studied. Among the specific sources of difficulty are:

a. Insufficient organizational action

b. Placement error

c. Organization overpermissiveness

d. Excessive span of control

e. Inappropriate organizational standards or criteria

f. Intracompany conflict

Society and its values. Although human motivation may be a strictly individual matter it may also derive from the particular culture in which a person has been brought up. As members of society we learn concepts of right and wrong which may have a tremendous impact on our behavior, and on the level of work performance. These values may lead subordinates into behavior which causes them to be considered ineffective. Values can also serve to provoke guilt and shame which in turn serve to disrupt work. The values of management may contribute to decisions and policies which have little to do with profit-making, but which still define certain individuals as failures. The strategic factors noted are:

a. Application of legal sanctions (including imprisonment)

b. Enforcement of cultural values by means not connected with the administration of law (actions by customers, stockholders, the financial community, etc., against an individual)

c. Conflict between job demands and cultural values as individually held (equity, freedom, morality, etc.)

Situational forces. In addition to characteristics of the individual himself and factors associated with the various small and large groups of which he is a member, there is one more major type of determinant which may contribute to failure. This category includes social forces, such as actions taken by competitors or labor unions, which occur quite independent of the individual's membership groups. It also includes forces or factors in the physical environment where the work is done. These situational forces are diverse, and the discussions range from accident proneness to foreign assignments to human engineering. The major problem areas are:

a. Negative consequences of economic forces

b. Negative consequences of geographic location

c. Detrimental conditions of work

d. Excessive danger

e. Subjective danger

Although almost any of the strategic factors noted may contribute to performance failure in an individual at any level from president to unskilled laborer, there are certain difficulties which seem to be unique to managerial positions. These problems are associated with the fact that managerial work, in and of itself, can be a source of considerable anxiety for some people. Thus a manager may avoid his responsibilities, develop emotional symptoms, fail to make decisions, or be absent frequently because his job disturbs him. This discussion of the types of ineffective performance which may occur within management is presented with the objective of stimulating the reader to consider his own work performance. Should greater insight result, a manager might well gain increased understanding of his own anxieties and consequently develop a higher level of motivation to meet his role requirements. At the very least those in middle and top management should gain a better appreciation of certain factors influencing the performance of their subordinates who also have supervisory responsibilities.

It appears that unsatisfactory work is more prevalent in lower level occupations than at the top of an organization, but that even among those in managerial capacities the frequency tends to run as high as 20 per cent. The most frequent type of strategic factor is one which involves the company itself, usually a placement error. Next most common are emotional and motivational characteristics of the individual. These factors are not normally given sufficient attention when job applicants are screened for employment, and this may be the reason they emerge with such force later on. The only other major causes of failure are the groups at work and situational forces. In the average case studied there were four strategic factors operating, but the range was from one to eight. Some instances of ineffective performance appear to be extremely complex. In conclusion, it should be pointed out that considering available evidence regarding the incidence of ineffective performance and of the various strategic factors, perhaps the following general statements can be made.

Recommendations for minimizing the extent of performance failure in a company include the following:

a. Establish adequate selection and placement procedures administered by individuals who are thoroughly familiar with the available techniques and measuring instruments.

b. Conduct management development programs designed to sensitize individual managers to the problem of ineffective performance and to teach them the techniques of performance analysis.

c. Organize a performance analysis group to provide specialized assistance to management in dealing with particularly difficult and complex cases.

In summary this paper represents a brief attempt to develop a clinical psychology of industry to supplement the social (organization theory) and experimental (human engineering) psychologies that have received so much more attention in the management literature. It is hoped that this effort will serve to stimulate additional contributions in this area.

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