Computers as Tools for Management

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It is a real pleasure to speak at this national meeting of electronic computer engineers. Each year your Joint Computer Conference has marked a new step forward. This year’s conference seems to me to have special significance in that you are here to assess the capabilities of digital computers for handling business computations. I say “special significance” because I believe that in this area, where the computer becomes a tool for management decisions, there is a great potential for the growth of a new major industry.

In these circumstances, it would seem necessary to look to the fundamentals right now, early in the growth period. Most of the business applications of the computer, which we have planned up to this point, have led in one direction: greater speed in the processing of business data. To achieve this goal, we have aimed at more and more complete office automation. Probably that was a sound choice of a starting point. For business became interested in the electronic computer when it was pointed out that the machine can effect great savings in the processing of data. Hence this application of the computer was the foot in the door needed to get this industry off to a sound start financially.

A number of effective applications of this kind are in sight, and the number of good applications will gradually increase. Although it seems over-optimistic to call office automation, to the degree that we currently foresee it, a “second industrial revolution,” nevertheless, it appears certain that an evolutionary process is under way. It will clearly take a number of years to exploit the various possibilities over a wide variety of types and sizes of business.

But in spite of the encouraging start that has been made, is the long run significance of electronic computers for business to be found principally in their ability to process data, however tremendous a speed they may achieve? I think not. Adding machines and accounting machines introduced less spectacular but highly significant improvements in their day. And I dare say, as the mushroom cloud of this electronic computer explosion settles down, the power of high speed and routine data processing will not exceed the all-over power of the simple adding machine in cutting the costs of business. The inventors of the steam engine and the automotive engine will in the day of atomic power still hold their positions in the history books.

Considered merely as a data-processing tool, the computer is only one more cost-cutting device—and not yet completely proved, at that. Much more significant is the use of the computer in solving management problems of a high order. For, when it is employed as a tool for management decision-making, the computer achieves much more than its negative role of cost-cutting. It can then play an important part in decisions that will increase the revenue of the business and maximize profits. It is this latter and broader application of the computer that I should like to discuss, for here, I believe, lies the best hope for the future of the industry.

Perhaps I should pause here a moment to explain my use of the term “the electronic computer industry.” At present you are faced, as electronic computer engineers, with a series of fascinating challenges. The challenge which you have clearly mastered is that of scientific and engineering computation. You are on the threshold of establishing some areas of effective business application. You are actively developing computers for control of military equipment and aircraft. You are groping toward use of computers in industrial process control.

With this variety of basically different and basically important applications, there is the prospect for emergence of electronic computers as a major industry. Although you are working in parent companies in the business machine field, the electronic and electrical machinery field, the aircraft field, and others, I do not think that you should any longer shy away from the term, the electronic computer industry. Of course, despite its rapid growth this is still an infant industry, not only in age, but in other important respects. Economically, as most of you no doubt know, it is largely a dependent of the parent companies which are creating it.

This year’s Joint Computer Conference is intended to bring computer designers together with management users of computers for business applications. This tempts me to suggest: Why not bring together, next year or sooner, management and computer engineers to consider the economic aspects of our infant industry? From management’s point of view I’m forced to ask: How long will we have the state of indecision as we go from vacuum tubes to germanium diodes, to transistors and bimags; is the end in sight in memory system progress from mercury delay lines, to electrostatic storage, to magnetic core memories before we operate as a true business? We are in the midst of a fabulous rate of technical development, but some degree of stability is necessary before electronic computers step out of the infant industry stage.

Alongside the need for establishing economic self-sufficiency, there is still the challenge of making computers truly useful on a widespread basis. At this meeting on use of computers for business applications, I think it is fair to say that although technical development of computers has gone far, the test of just how useful computers will be in business lies almost entirely ahead of us.

My purpose, then, is to examine with you the pros-

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pects for a broader use of computers as tools for management information and decision-making, for it seems to me that it is this concept which constitutes a major challenge to the industry. We cannot completely separate this concept from that of routine data-processing. When one deals with the use of computers for accounting, the question of reports for management and the possibilities of better control by management are always present. But I submit that this is just scratching the surface.

Management already has more reports than it can handle. What it needs is help in exploring all the alternative solutions to its problems, so that it is better prepared to choose the best one. For this task, the computer is an important instrument. Let me illustrate what I mean. It is useful, of course, for the general sales manager to know that sales in the North Central Region are below quota for the month. And the computer is an excellent instrument to use in preparing the sales data report which gives him this information. But far more useful—in fact, of first importance—is the ability to do something with this knowledge, which is in itself quite sterile. Hence, a far more profitable use of the computer is in the preparation of alternative solutions to the sales problem. When the sales manager can see what each of several decisions involves, then he can choose the most effective one. Used in this way, the computer is not just a mere by-product of office automation. Rather, it is a major objective. What I am proposing is not something new, of course. It is, however, a redirection of emphasis.

Already encouraging signs exist that the importance of this kind of application is being recognized. There is the growing partnership between management, scientific research, and mathematics which is usually referred to as operations research. A few examples where operations research, management problems, and the use of computers have come to a point of common focus include the use of linear programming, the Monte Carlo method, and the game theory for optimum strategy. Much has been written on these subjects and I shall pursue them no further. In fact, if I did you might question me about the details and our staff experts are too far away for consultation.

Other mathematical methods which require extensive computations are finding important uses by management. For example, in the Burroughs Corporation, recruitment of personnel now relies quite heavily on the results of an extensive program of correlation of work performance with psychological test scores. Computations to determine the significant correlations were carried out on the electronic computer at our Research Center. Without such a computing facility, our program along these lines might never have been carried through.

As another example from the experiences in my own firm, we have made good progress toward setting marketing targets for our various products on the basis of national figures on the levels of employment and income in the major areas of business where we find our customers. The computations required to determine quotas for each of our branches have been a stumbling block. This year a small scale electronic computer solved the problem. Broadly speaking, these examples indicate that computers are becoming a valuable tool for some of the recent developments in scientific management.

There is a quite different approach, in which, although computers would serve as a data processing tool, the key objective would be improvement in management controls rather than the automation of clerical operations. The objective of some firms which are interested in electronic computers is to use the computer to permit complete integration of their market forecasting and actual sales activities, with production and inventory control. This is a truly challenging prospect in those types of business in which a high proportion of the management functions must go into line activities involving production and inventory control on the basis of sales prospects and orders in hand.

An electronic computer for handling management control functions would provide a facility for storing records of sales forecasts, sales orders, production capabilities, and inventories, and converting this information to production and shipping orders. The computing machine would be able to apply the best available industrial engineering techniques such as well-known production log size formulas and newly developing production and inventory planning procedures to determine the best production plans. Success of such an approach will require not only the electronic computer and extensive research on the computing program, but also an effective system of rapid communication between sales order points, production facilities, and the computer. For this reason those companies which are striving for this goal of computer use have shown especially great interest in the development of integrated data processing in which all types of business records provide for coded output, such as punched tape, to facilitate long distance communication and input to computers.

A concept of this sort cannot, of course, be envisaged in all types of business, any more than the concept of office automation with high speed computers applies to the handling of all business records. The first prospect for use of computers along these lines would be in large scale manufacturing in which alternative product models, or a line of similar products, share the use of manpower, raw materials, and capital equipment. The automotive industry, producers of small machine parts such as screws, bearings, and gears, and the radio and television industry, are examples. Large scale retail trade offers similar possibilities, without the element of production control, but with tremendous problems of inventory control.

These applications have to do with system control rather than automatic data processing. And how much more it means to business than mere cost-cutting, important as that may be. Let's say that a company uses an electronic computer just for the sake of saving
money. We'll suppose that it uses the increased speed effectively and saves $200,000 a year. That is a sum none of us will look down our noses at. But let us say that this same company puts its computer to work at determining the number of salesmen necessary to cover a territory effectively. Or suppose that it uses the computer to arrive at a decision that a regional sales set-up is better than a national set-up with all control from the home office. It is not difficult to see that these latter two problems and their solutions are vastly more significant to that company than its economy measures. For these latter two affect the growth of the company, its revenues, its whole competitive position. Used in this way, the computer can help maximize profits and reduce expenses in a very basic manner. It could become part of the very lifeblood of the company, for lack of which a company could fail to survive.

A further indication of this fact is the manner in which operations research was born. In the Battle of Britain the military turned to science for help. Cost-cutting was of very minor significance at that time when the country was fighting for survival. This science was employed to arrive at the optimum use and distribution of men and material. And it was the outstanding success of this critical effort that led to the interest which business now has in operations research and its tool, the electronic computer.

It is interesting to note, incidentally, that the use to which the equipment is to be put must determine the type of equipment selected. Routine data processing and improved decision-making may be conflicting objectives if the same equipment is chosen for both purposes. This fact again indicates the importance of setting our aim on the proper target.

I have discussed two distinct concepts of an important role for electronic computers in management analysis and control: first, as an analytic tool based on operations research and other aspects of scientific management; second, as a system control tool bearing on production, inventory, and the related phases of industrial operations. Both approaches include large elements of speculation, but are based on significant trends and offer realistic challenges. The analytic concept suggests that electronic computers are linked with general developments toward scientific management, and that the time may come when at least the larger companies find it desirable to have a computer available for analytical computations on management problems in the same way as they are currently finding it desirable to acquire computers for engineering computations. The system control concept implies application only to certain types of business, but in those areas the computer may become an essential tool rather than merely a desirable one.

Before proceeding further with these ideas, it will be well to introduce a third line of evidence that computers are on the way to becoming tools of management—the various activities along these lines by government agencies, primarily by agencies of the Department of Defense. The problems of military logistics are by-and-large the equivalent to many of the problems of business management. Since the end of World War II each of the military services has been carrying on extensive programs of logistics research, in which electronic computers have served as a major tool.

The Navy has sponsored an active “Logistics Research Project” by contract with George Washington University in Washington, D.C. The Air Force has a Directorate of “Management Analysis Services” in the Pentagon for intimate contact with Air Force planning problems, and sponsors longer range logistic planning research by contract with the Rand Corporation, in California. The Army carries on logistics research through its operations research program under contract with Johns Hopkins University. In each of these logistics research programs an electronic digital computer is about the only major piece of research equipment. The Air Force has placed a digital computer in the very bowels of the Pentagon for planning calculations.

The logistics research programs are parallel to the prospective use of computers as a tool for general business planning and analysis based on developments in scientific management. At the same time the military services have been exploring the possibilities for use of computers in the day by day control over the operation of their supply systems, an approach which parallels the possibilities for business system controls over production and inventory. The Air Force has begun a careful program of trial and analysis of use of computers for control over movement of Air Force supplies, and the Navy and Army have similar programs.

The leadership being taken by the military departments in these developments is parallel to an earlier period, when ballistic calculations and other technical military problems paved the way for the initial development of electronic computers and paved the way to their widespread use in science and engineering. In the area of management computations, military research programs have again assumed leadership. The reason is clear: human lives may depend on it. We are reaching the point where we want to know whether corporate lives may also depend on it. There is little doubt that industry, like the defense agencies, will take steps to find out. At this stage it is the research spirit toward logistics by the defense agencies which has done most to pave the way to use of computers in management analysis and control. If industry develops similar research programs on a fairly widespread basis, we can hope for rapid progress.

If the problems to be solved were a relatively straightforward matter of further development, we could speak with greater confidence about the rate at which we can progress. At this stage it is most important that we recognize the underlying problems and foster the research to solve these problems. In the first place the complexity of business management makes careful research necessary in order to determine the proper scope of the targets for application of scientific methods and corresponding use of computers.

In management system controls the problems are more complex than in the more purely technical system
problems such as industrial process control. Management problems will require more extensive research to isolate the key factors, the interrelations, and techniques for obtaining good solutions from an environment of innumerable human factors and from broader management considerations which cannot be expected to fall within the scope of a scientific management approach.

An equally fundamental, but related issue lies in the uncertainties of making predictions which surround the problems of management. The very word management implies decisions which involve prediction of the outcome of alternative courses of action. I have recently seen the difference between human decision making and the choices made within mechanisms such as electronic computers nicely clarified by the statement that successful human decisions can be and generally are made without complete information, in fact, often with very scanty information. A machine, on the other hand, can make choices only on the basis of the information which it contains—it can only deduce consequences from whatever information has been fed into it.

This way of putting it seems to imply that the machine can only be a data processing tool. But, I am by no means detreating to that point of view. The machine can only be a tool, but a distinction should be made between a tool for clerical work, and a tool for management. The underlying question is whether a scientific rather than a rule-of-thumb approach can be found for some of the areas of management prediction. The approach cannot be a science involving certainties, such as is generally the case in the physical sciences. Instead, it must be a systematic method of determining possible outcomes, the relative probabilities of these outcomes, and methods for basing decisions on the probabilities.

Research on business prediction and on the evaluation of uncertainties has been going on in recent years. The results have provided some useful guidelines for management, but do not as yet provide a general approach to any one well-defined area of management. We can do a fairly scientific job of market sampling on particular products; we can assume, or hope, that forecasts of the levels of general economic activity made by government and industry economists are based on increasingly scientific methods; we may find linear programming or other results of operations research applicable on some production and inventory problems, but these are present isolated techniques, which, on the whole, deal with factors in management situations rather than the management situations as a whole.

Since any prospective science of business management will have to be a science for dealing with nothing but uncertainties, we have the further problem of determining whether any proposed scientific approach is actually superior to management decision on the basis of experience and intuition. We will perhaps have to go on a conviction rather than proof that the scientific approach is the desirable one, just as we go on conviction that the weather man is more often right than wrong.

That may be enough for us, but it may not be enough for the business man who is the prospective customer. He must be taught to have confidence in operations research and the part which the computer plays in it. He is from Missouri and he must be shown that the new science is superior to his intuition. May I suggest that in dealing with him, you be neither discouraged nor sarcastic. It is essential that management learn both to understand and trust your findings. The best way to bring this about would seem to be to explain what you are doing simply and in language he can understand. Of course, he need not understand the intimate details of either electronics or operations research any more than he needs to understand how the tax expert or controller arrived at his figures. But you must remember to go slowly with him, and to show that you are interested in his problems. If some areas of business decision can thus be brought into a scientific framework, then the prospects will be good for electronic computers to become important management tools.

These comments on the types of research which are going on and which lie ahead with regard to use of electronic computers as "management computers," have not brought us to any questions of computer system design. To some degree this is an expression of the widespread feeling that our ability to design electronic computers has run far ahead of our knowledge of how to use them.

Generally speaking operations research approaches a phase of management or a business system as though it could be analyzed by the same general methods as are used on engineering analysis of technical equipment. This suggests that the use of computers as management tools is likely to have a good deal of resemblance to their use as tools of engineering. If scientific methods for analysis of management problems make substantial headway, then computers will be important for solution of those management problems, just as they are for solution of engineering problems. If operating controls over certain phases of business by means of computers are based on technical analysis of business systems, that will be quite similar to engineering analysis of complex machinery in order to use computers in controlling technical processes.

In the important developments of scientific management undoubtedly computers have been an important stimulus. Technical methods may be as important in problems of management as they are in problems of engineering, but the problems in management are more complex. The possibilities of actually working out solutions became much more promising when electronic computers became available. Thus, electronic computers have helped pave the way to a new spirit of research on management, just as they have brought us into a period of research on methods of business data handling.

In my opinion the concept of "computers for management" is a challenge well worth considering. It is a large undertaking in which the computer industry can proceed only in partnership with management analysts and with management itself. If the computer industry provides leadership, I believe it will be taking a long step toward opening new markets for its products.
IN APPEARING before you to tell you of the trials and tribulations of the businessman who tries to use the equipment you are designing and building for basic business applications, I presume I should qualify myself as an electronics expert. A friend of mine, struggling to make one of the big machines work on a business problem, defined an electronics expert as "a man who hasn't yet received his computer." Under this definition I qualify fully because my company, the Consolidated Edison Company of New York, has not yet received the two Univacs and the one 70S it has on order. Next April after they are delivered I presume we shall appreciate to the utmost the point of his definition. Today, ignorance is bliss.

Since we are not yet in operation at Con Edison, my personal experience upon which these remarks are based only goes through the early study, decision, organization for programming and initial programming stages. The problems of operation are still ahead of us. Nevertheless, I believe I can show you enough about these initial problems to cause you to realize that problems do not stop with the design and construction of a computer but are just as severe and just as baffling in some cases on the application side of the picture as they are on yours.

Then I shall try to outline a few areas you might want to study from the business angle so that the equipment you produce may be of utmost value to the user. I believe that one of the greatest needs of the computer industry today is a closer liaison with the user, for you can only sell that which is of some benefit to him and to produce anything else is an economic waste.

THE BUSINESSMAN'S PROBLEMS

The electronic digital computer burst upon the business world some five or six years ago in a rash of articles in the magazines directed to business management. "Giant Brains" were the beginning of "Automation." "The Automatic Office" was certain to make people obsolete. The day of the millennium had come! These startling and breathtaking concepts, akin very much to the dreams of the future which appeared when the atom was first split, caused quite a stir and presented us with the first problem that every businessman faces when he begins to look at this field. He must find out what the shouting is all about.

Study and Training

The first step in this is education. He knows right at the start that someone must decide whether or not to proceed into office automation. Since the decision must be made with judgment, foresight, and care, the problem cannot be left entirely to junior members to study. Someone in a fairly high place in the organization and in whom the top management has confidence must take the time to acquaint himself with the problem and the equipment. In many companies this has taken the form of a committee, either of middle management personnel reporting to a top executive or of top executives guiding specially assigned middle management personnel. This latter is the approach used in Con Edison. Two of us spent a considerable part of our time for several years studying the field and reporting periodically to a committee of Vice-Presidents and associated executives.

This process of self education for the businessman starts with the reading and studying of everything he can find in print. He will then talk with the manufacturers' representatives at great length and perhaps visit actual installations. At this point he will probably feel that he still needs to know more about the detail if he is to be able to understand and evaluate not only the manufacturers' claims but also the problems his own staff will bring to him, for he soon will see the need for full time personnel in this field. He may want to enroll in the manufacturers' programming courses, especially the shorter ones, and thus gain at least a working knowledge of equipment and programming techniques. This knowledge will enable him to guide his staff with some degree of intelligence and will help him to listen more critically to the basic sales pitches of "fixed vs variable word lengths," "internal vs external checks," "plastic vs metallic tape," and so forth.

It must be obvious to you that this is a time-consuming task and that it is no small or insignificant problem the businessman faces when he approaches this field. Yet the pot of gold which seems to be at the foot of the computer rainbow appears to be so large that it cannot be neglected. He must take the time and make the effort to learn all this even though he may sometimes wonder privately whether it will be as big as he thinks when he reaches it.

Businessmen or Scientists

Early in the approach to the automation problem, the businessman is confronted with a jumble of technical terms more or less meaningless to him. "Bits," "binary adder," "flip flop," "minimum latency," and a host of others dance before his eyes and cause him to wonder whether this whole subject isn't just too technical for him to master and wouldn't he be wiser to retire gracefully and leave it all to the engineers. Most businessmen are not engineers and those of us who are, are of a vintage when Mark I was not even a gleam in

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