Their History, Present Applications, and Future

Computers

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Foreword

It is curious that historians will often spend much time and effort to record various battles, political, economic, and social events of our civilization, but very few if any care to examine and document the "computer revolution" which is so rapidly changing the structure and attitudes of our society. It is much easier to document the physical facts such as the number of computers in use, the number of persons engaged in using or manufacturing computers, the billions of dollars spent annually, etc., than it is to document the mental changes which will probably be far more important in the long history of man.

Many changes are occurring in our mental outlook due to the availability of large digital computers. Comparatively few years ago 90 percent of the experiments done at the Bell Telephone Laboratories were performed in actual laboratories, and only 10 percent were done on computers. Probably before 1970 the situation will be reversed. Clearly our attitude toward experimental science is rapidly changing in many areas. In the area of space science, for example, thousands of trial flights are made on a computer for every one actually attempted. The advantages of computer simulation include lower costs, greater speed in getting answers by programming rather than building experimental equipment, the ability to do "ideal experiments," and the general all around flexibility of computers in the preliminary exploration of a new idea.

Computers also greatly increase the precision of our thinking, since they expose areas of ignorance and sloppy thinking whenever we sit down to write an appropriate program of instructions for the machine. As Professor Alan Perlis has observed, computers are causing us to view the world with

eyes that search for algorithms to describe the processes we see rather than words to describe the facts we see. Thus the processes of precise thinking that are traditionally associated with mathematics are being used increasingly as the use of computers spreads.

I place such importance on the intellectual aspects of the Computer Revolution because I believe in the importance of ideas. We differ from the cave man not so much because we may or may not have better brains, but because we have discovered the social institution of organized thinking. It is this which, through the social institution of education, we pass on to the next generation; thus new ways of thinking are our most valuable possessions.

In a way it is not surprising that computers are closely associated with thinking. Man made the hammer to increase his muscle power, the microscope to increase the range of his vision, and the oscilloscope to give him a new sense. These are each tools for the body. But he also invented the natural languages we use to speak and write, the language of mathematics, as well as the modern electronic digital computer. Each of these is a tool for the mind. If one were asked to compare the importance of the invention of fire with the invention of language, most people would say that language was the more uniquely human. It is for these reasons that I do not feel apologetic for my enthusiasm for computers and for stressing the importance of the intellectual aspects of the Computer Revolution.

In this book you will find a careful, organized presentation of many facts about the Computer Revolution. Fortunately, the author does not confine herself to the current material facts, but discusses the past history as well as future possible developments. She is also well aware of the intellectual aspects of the changes that are occurring and mentions them when appropriate.

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Contents

1

The Computer

A "thinking revolution" has transpired within the last decade. This battle has been won solely because men have devised the most potent weapon of the era, the computer. With it, they have achieved not only a faster way of performing calculations, but have evolved a modern approach to the organization of thought.

The dramatic developments of atomic power and rocket power have altered the course of civilization—yet, even these inventions were aided by, and may well be dwarfed by, the magnitude of the computer's influence. One obvious reason for this is the universality of application. Whereas very few people have direct need for a nuclear reactor or a missile, the day can be foreseen when all businesses and most individuals will avail themselves of the help of computers.

Man is the best example of a general purpose computer. He has been "processing data," either consciously or automatically, since the Stone Age. His downfall almost came when the amount of data grew to such proportions that it swamped his ability to handle it. In the midst of this information explosion, the computer appeared to relieve him of mental drudgery. The computer is of major assistance in man's relentless assault on ignorance.

The invention of computers is a magnificent example of men rising to a challenge. First our nation was dominated by an agricultural economy. Then the industrial revolution changed our complexion. Within the last 25 years, the third major change has occurred; it is one in which science and technology have moved to a position of preeminence. The advancements in these areas of knowledge have added layers of complexity to every endeavor, and have expanded our

capability and knowledge in all fields by incredible factors. Thus, a need arose for means to cope with problems, data, and communication concurrent with these advancements.

There has been the increasing danger that we might be engulfed by the mountain of paperwork that has attended every activity. But where an army of clerks would have been utterly defeated, the computer has clicked through to victory.

Knowledge of all kinds has increased in staggering proportions, particularly in recent years. Today, boys in the sixth grade know as much (or more) about science as did the great scholars of ancient Greece, and freshman college students know more physics than did Galileo.

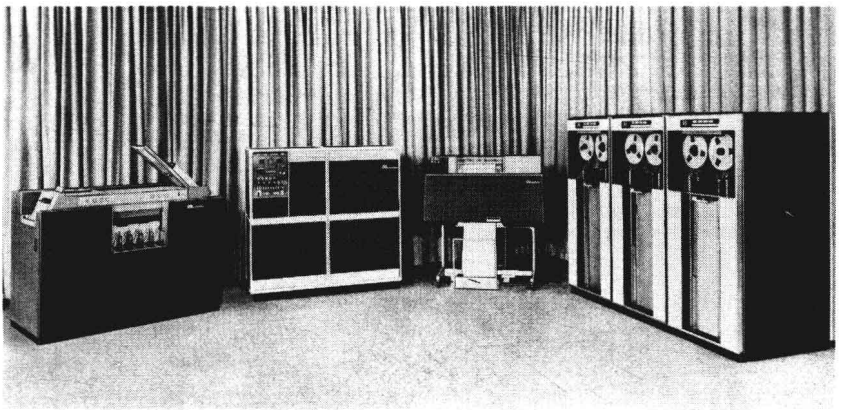
Computers have played a key role both in the acquisition of new knowledge and in its dissemination and storage for later recall.

Computers might be called the "brains" of automatic equipment—although the term induces certain fears. Whereas man never feared that an automobile would render his legs less effective, he has been overly sensitive that a computer might usurp the decision-making function of his mental powers. Luckily, that science-fiction fallacy is being thoroughly dispelled, and computers are being appraised in their true light—as tools men can use to extend their mental capabilities.

The computer is truly man's most remarkable tool. Just as engines allow him to press buttons and vastly increase *physical* power beyond the range of his muscles, computers tremendously increase the capability of *mental* processes. At present, the machines perform a great many of man's mental activities; but man still has a corner on creative thinking and imagination.

In this age of innovations, a certain blasé attitude has developed—one that works in favor of the computer evolution; it has become very difficult to astound people, and, therefore, has become very easy to bring about acceptance of complex concepts. Quickly, people incorporate advancements into the routine of living.

This acceptance also spells dependence. Should all of the functions and productivity of computers suddenly be with-



(International Business Machines Corp.)

Fig. 1-1. The components of this IBM-1401 are typical of many computer systems; (left to right) card read punch, central processor, printer, tape drives.

drawn from the world, utter and absolute chaos would inevitably result.

Some years ago our government began funding the development of computers for its own purposes, particularly in the area of defense. Subsequent applications have spun-off from this effort. Scientific application expanded into business utilization. Lately, the machines have been adapted to non-numerical applications—ones that involve thought concepts instead of numbers. No longer is the computer restricted to scientific computation or bookkeeping; it is used, also, in processing information in a logical sense. The machines can be made to solve almost any problem that can be expressed in symbols.

The development has taken giant forward steps that even those doing research in the field did not anticipate. The computer has proved to be the "dark horse" of the technological race, and has won the sweepstakes of the century. By 1970, it is estimated that computer-affiliated activities—designing, manufacturing, programming, and servicing—will constitute the *world's leading industrial occupation!*

2

Applications

Where and how are computers used?

The scope is so vast that the answer might almost be, "Everywhere." Recently, the magazine *Computers and Automation* compiled a list of 600 areas of application, and even this was by no means a complete tally. Any problem, process, or concept that can be represented mathematically (symbolically) can be solved, controlled, or investigated by a computer.

The uses that usually pop up in the news are the unusual and zany ones, and are no more than an amusing fringe to the real workload carried by the clicking boxes. For instance, at Arizona State University the students of the card stunt committee now have 46 extra hours a week to devote to study, simply because a GE-225 computer figures out the displays that take place during half-time at football games. (Stapled to the seats in the stadium are computer cards, giving detailed instructions for each stunt.)

Computers have vast numbers of applications in process quality control; they are now being used to control such widely divergent operations as those of oil refineries, rolling mills, power generation plants, and cement factories.

These electronic wizards are involved in food—right from the phase of agricultural research, through the production, processing, and distribution. In order to feed the population of this nation 50 years from now, twice as much food must be produced. Computers will play a vital role in the planning to meet this challenge. It is envisioned that farm systems will operate entirely under electronic control. For instance, sensors attached to animals can indicate their conditions to computers, and printed reports could keep the farmer advised.

Even the cake mixes that we now get from our grocery shelves have the help of computers. The Pillsbury Company uses electronic assistance to calculate the mixture that not only provides best nutritional values, but also permits taking advantage of fluctuations in cost of the ingredients. Whereas a dietitian formerly required 4 hours for this task, the computer now whizzes out the answers in 40 seconds.

The computer is a remarkable "toy" with which games may be played. This simulation may take such varied forms as war gaming, political gaming, or management gaming. "Game" gaming came into recent prominence when it was announced that, for the first time, the gambling casinos of Las Vegas had found it necessary to revise the rules under which the age-old game of Blackjack would be played. This was made necessary as a result of the computer-compounded theories of probability, as expressed by Dr. Edward O. Thorp, Associate Professor of Mathematics, New Mexico State University, in his book, *Beat the Dealer.* (Thorp contends that the casinos' rule change is futile—that his system still will work.)

A complex system to handle traffic flow has been effectively demonstrated in such cities as Toronto. This problem is one that requires extensive individual study. The Bureau of Standards devoted 3 years to a study of a 9-block length of 13th Street N.W. in Washington, D.C. San Francisco has undertaken a study to analyze the traffic flow across the 6 bridges that span its Bay.

The flow of railroad cars across the continent is also tallied by computer. In the past, keeping an accurate tab on the entire number has been a slow and formidable task. But, now, the Denver & Rio Grande Western Railroad can within 30 seconds locate a single car from among the thousands traversing 2300 miles of track.

Electronic data processing is becoming one of the primary tools of highway design by mathematical simulation. Engineers can ponder their initial designs, revise, alter—without ever moving a shovel-full of dirt. The many varying factors that are to be considered in laying out a highway can be evaluated effectively by computer, using the mathematical

tools of probability, statistical decision theory, and sensitivity analysis. Another advantage, not to be overlooked, is that a computer is devoid of political influences. It is not seeking votes when it makes a public works decision.

The secrecy born of competitiveness prevails over much of the computer utilization by the petroleum industry. However, a great deal is known about their extensive applications, ranging from tallying how many gallons of gasoline each customer buys each month on his credit card, to determining product mix for refineries. Analyses of aerial surveys, optimization of well-drilling programs, and the reduction of mass spectrometer data are also parts of the operation. A 1000-mile pipeline is controlled by one man at a computer in Texas. One company has tied its 30 computers, located in offices of many cities, to the large one at the corporate office; they chit-chat via direct line Telex.

When the computer's talent for composing music was disparaged, Paul Armer of The RAND Corporation became the electronic artist's champion by saying of the critics, ". . . they belittle efforts at musical composition by machine because the present output compares miserably with that of Mozart or Chopin. How many *men* can produce music that compares favorably?" [1]

This tolerant point of view should prevail when appraising the artistic output of A. B., Auto-Beatnik, a push-button poet created by R. M. Worthy of the Librascope Division of General Precision, Inc.:

Whales

The iron mother's bouquet did rudely call,
Yes, I am as fine as many murmuring crates.
People was braver than snowy hay.
It was dirtiest who bleeds behind the piano.

Though A.B. is not strong on grammar, "he" certainly conjures up a mood!

In utter contrast to this gimmick is the very serious use to which a computer has been put by the U.S. team negotiating

(MIT)

Fig. 2-1. At the Massachusetts Institute of Technology, Ercolino Ferretti is creating electronic music by computer.

tariffs in Geneva, Switzerland. Previously, it had required months to properly evaluate European proposals. By means of the "electronic diplomat," the forecast can be made in only hours.

Whereas the first utilization of computers was heavily oriented to science, this has tended to level off. There is now twice as much application in business, and it is steadily increasing. Businessmen are realizing that the computer is not a means of doing the same job with fewer employees, but that it actually embodies an entirely new approach. Those who do not appreciate this philosophy are likely not putting their equipment to completely efficient use.

There have been far too many instances of infatuation—of business leaders becoming enthused at this intriguing machine and installing it in their organization without justification. When the operation is simple, the computer may very well be too costly, both in investment and effort. As a dynamic computer expert at the Bureau of Standards so graphically phrases it, "It is very foolish to kill a flea with a cannon. Many people, ignorant of the wonderful possibilities of the

computer, use it for problems that could be better done with ordinary equipment."

But in the business applications where the computer has been judiciously applied, and where the full power of this tool has been felt, the results have been astounding. A Labor Department survey indicates that the largest classes of users are the automobile manufacturers, electrical industries, insurance companies, and financial organizations. Uses by these and other groups are enlarged upon in the remainder of this chapter.

Wall Street

In the years since World War II, this nation has undergone a drastic transformation in countless ways. One of the most striking of these is in the investment habits of the people. Between 1952 and 1959, the number of investors doubled. Today, more than 17 million people are shareholders in our private enterprises.

The Securities and Exchange Commission requires that all brokerage houses must figure and post every transaction of the day before they may open for business the following day. As growth rapidly expanded the operation, this became a frighteningly huge task on days of heavy buy- and sell-orders.

It became abundantly clear that conventional bookkeepers on high stools could not reasonably cope with such volume—even when armed with adding machines and desk calculators. Automation was needed in the houses that handle the bulk of the business.

Merrill Lynch, Pierce, Fenner and Smith, the nation's largest brokerage firm, now has half of the area in its main office packed with $4.5 million worth of computer equipment. The tasks these machines perform replace the efforts of a small army of people, yet the operations can hardly be considered fully automatic since over 200 persons are required. Machines provide not only the speed demanded for handling the company's half million accounts, but also they can achieve far greater accuracy than with the old method.

Francis I. duPont & Company was an early Wall Street user of computers; in the mid-1950's the company programmed (see *Glossary*) a machine to maintain the accounts of purchases on margin. The balance must be maintained daily on each account in this credit-type of buying, since the constantly fluctuating stock quotations determine the buyer's equity. DuPont now has 1 large and 4 smaller IBM computers that combine to process all daily records—including those of taxes and the thousands of commissions.

For every giant company that can readily bear the investment in either the purchase or rental of such equipment, there are many smaller firms that are also in need of improved data-handling facilities. To accommodate those companies that are not in a position to bear the heavy cost of installing their own facilities, RCA has established a multi-million dollar Systems Center on Wall Street.

This type of operation will most surely become a pattern in countless areas, since it reconciles the fact that many businesses need expensive equipment—but only for short periods of time.

The New York Stock Exchange itself has followed the lead of the houses; in the fall of 1962 an announcement was made of a contract to effect complete automation by 1965.

The computer-based IBM Teleprocessing system speeds trading information from the floor of the Exchange by means of 19 optical data "readers." These compact units, standing 40 inches high by 1 foot square, take only a little over a second to read ordinary pencil-marked cards that report sales and quotations. (This method is a striking advance over the prior method of transmitting the information by pneumatic tubes and voice.)

Then, in split seconds, the computer center in the Exchange will dispatch the information by printing the sales totals on the thousands of Exchange stock tickers through the nation (new models operate almost twice as fast as former ones). At the same time the "Voice Assembler" will respond to inquiries from subscribers to the Telephone Quotation Service. This remarkable unit composes its messages from 126 sounds—

words, syllables, digits, and letters—pre-recorded on tracks of a revolving magnetic drum. The sounds are played back in the proper sequence to compose responses to as many as 400,000 phone queries each day.

To close the loop of its operation, the computer center sends back constant reports on all of this information to the Exchange floor; this system has the capability to handle trading volume in excess of 16 million shares a day. Further, it can be programmed to perform other functions. As Mr. Keith Funston, President of the New York Stock Exchange, says: "We are providing here an electronic system to which extensions can be added in many directions in the future as conditions and scientific advance warrant."

Banking

All forms of finance are well-suited to computerized operations. In fact, this seems the only means by which the 15,000 banks of our nation could have surmounted the paper barrier. In 1940, we scribbled 3 billion checks; now we yearly exchange our money with about 20 billion checks! (And each one of these pieces of paper may go through as many as 20 operations.) Electronics can perform each step—such as sorting, reading, balancing—in a few millionths of a second.

Bank of America, the world's largest privately owned bank, pioneered computer applications. In 1950, the facilities were being strained by the explosive growth of California; needs were being created that were not being met by available business machines. So, S. Clark Beise (Bank President, now retired) presented the problems to Stanford Research Institute. The goal was a challenge, even to that capable group—to define an electronic system that would handle the many operations of commercial accounts, would prepare statements, yet would not change the style of checks that people were accustomed to using.

A means of reading the checks proved the most formidable of the research problems. Many methods were discarded before the one now known as MICR, Magnetic Ink Character