THE TALE OF THE BIG COMPUTER

A Vision

by

OLOF JOHANNESSON

Translated by Naomi Walford

Coward-McCann, Inc. New York

C

First American Edition 1968

Library of Congress Catalog Card Number: 68-11869

PRINTED IN THE UNITED STATES OF AMERICA

1.

The Pre-Computer Age: The Rise of Data-Processing Machines

Man and Computer

IT was in the very distant past that the first computer appeared, and with it dawned a new era of which the main events form the subject of this account. Despite one appalling disaster, this period of history is dominated by a fantastic evolution which transformed the primitive pre-computer communities and welded them into the perfectly integrated and organized society of today.

Compared with the data-processing systems of our own day, the original devices were very elementary. Their development is to some extent comparable to biological evolution from the simplest living organism to man. Yet for all their primitive structure even the earliest computers were very useful. They solved complicated mathematical and technical problems and soon came to occupy a prominent place in the most diverse fields of community life. They were progressively adapted to man's needs and did much to relieve his difficulties. By their capacity to solve problems which up to that time had seemed insoluble, and by taking over more and more routine intellectual work, they conferred upon mankind the boon of a freer, pleasanter way of life.

The adaptation was reciprocal, and men adjusted themselves to the computers. They devoted a growing proportion of their time and energy to developing and perfecting them; they gave them all the maintenance required, and the more valuable and indispensable these machines proved to be, the more devotedly were they tended. The solutions they worked out became increasingly instructive, whether they related to purely scientific and technical problems, or to questions of economics and sociology. Social evolution as a whole followed guidelines classed as optimal by the computers, and people began to follow the advice and instructions—we may even venture to say commands—of data-processing machines in an increasing number of fields.

Steam, electricity, and the internal combustion engine had already liberated mankind from heavy work. Puny musclepower had been superseded by the mighty horsepower of machinery, and there was no further need for anyone to strain himself with exhausting physical labor. But computers were a yet greater boon, in that they eased the wearisome and exacting work of the intellect;

in the end they relieved mankind of the burden of thought itself.

The more useful computers proved to be, the greater their numbers. They multiplied and replenished the earth, becoming at the same time more complex and better adapted to solving even the most abstruse problems. Generation after generation they grew and matured, assuming an ever more dominant position in the evolution of society.

Chronology

The era introduced by the advent of the earliest data machine is sometimes called the computer age, but this term is more appropriate to the period now about to begin. The characteristic feature of the time extending from the first computer to our own day is not complete domination by data machines, but rather a fruitful cooperation —a symbiosis—between man and computer. It is this symbiosis which on the one hand has enriched human existence and on the other has enabled computers to evolve and become more numerous; because of this, historians now agree that "symbiotic age" is a term appropriate to the period now approaching its end.

The era preceding the symbiotic age is generally known as the pre-computer age. Although true evolution began with symbiosis, the pre-computer age is far from unimportant, for it was during this time that the seeds of data machines were sown. The process continued by stages, in the course of which the environment best suited to the advent of the computer gradually evolved.

The pre-computer age may be regarded from different points of view. Our own time is characterized by cultural expansion from Earth into surrounding space and, guided by computer calculation, we have begun to colonize the neighboring heavenly bodies. With this as background it is only natural to begin our exposition of the pre-computer age from the cosmic point of view.

The Origin of Life

That part of space now traversed by our interplanetary craft was at one time filled with clouds which, under the influence of cosmic forces, condensed to form the sun and its planetary system. On Earth, which was one of the many bodies so formed, conditions proved most favorable for the evolution of the culture now spreading to more and more of Earth's kindred in space. Yet it was long before such an evolution began. During the first period of its existence, Earth was totally sterile, yielding neither life nor computers.

During this period it was the geological forces that were chiefly active. Oceans were formed, from which emerged continents and islands. In paying special attention to the events foreshadowing and leading up to our own era, we should note, above all, the concentration in various minerals of those substances of which data machines are made up.

It is not our purpose to give a detailed account of geological and biological development. Our particular subject is the symbiotic age; earlier periods are touched upon with reference only to events bearing upon the origin of computers, or upon conditions prevailing during the symbiotic age.

In our day, mention of the pre-computer age evokes chiefly the splendid epos wherein our poets illustrate the evolution of the world. Their manner of describing its various phases often differs from the sober analyses of historians, yet they are not lacking in interest. On the contrary: not even the most rigid scientist can fail to be inspired by the grandiose vistas thrown open to us by these epics. We live in a fantastic era and cannot but be exhilarated by the incredible advances made during the age of symbiosis; and we look forward to what will certainly be a yet greater epoch. An account even of the pre-computer age can hardly fail to be colored by this.

Our poets, especially those commonly called mystics, tend to regard the period immediately succeeding the formation of the Earth as a mighty effort on the part of nature to engender computers directly, without the help of any intermediary. They are alluding to the geological processes which crystalized out many of the substances of which a data machine consists. But the task of bringing forth computers from sterile soil proved too difficult. The tectonic forces which created mountains and differentiated minerals could not produce anything as subtle and complex as a computer. For this a lengthy, troublesome detour was required, and the greatest of all tasks had to be completed step by step.

Nature then started upon a simpler project which could be carried out by the means then available. Such is the explanation of the origin of life. Among the chemical combinations formed in the course of geological evolution under the influence of cosmic forces, some had the properties required for sustaining life. It was in this way that the simplest biological units started their existence. Life, which evolved into ever more complex structures, was nature's substitute for directly bred computers. Yet it was more than a substitute: it was a road—a winding road, yet one which despite all errors and hazards, crises and catastrophes, arrived at last at its destination.

Biological Evolution

When we study the beginnings of biological evolution, its purpose seems to us obscure. How can one regard a tiny blob of protoplasm—an amoeba, for instance—as a first step toward computers? But if we follow the evolutionary process further we come upon certain clues, or signposts. At quite an early stage we detect the formation of a nervous system. Certain cells become lengthened and begin to resemble the wires which played so important a part in the first simple computers, and along these threads electrical impulses are transmitted. The system is of course of a far more primitive type than that of data machines. In even the earliest and most elementary computers, signals were transmitted with the speed of light, whereas nerves carry a curious type of electrochemical impulse, which is extremely slow; nevertheless the fundamental principle is the same. Moreover the impulses carried by nerves can be switched to connect with different nerve channels through what are known as synapses, and in this we discern an example of the transistor elements in the first primitive data machines.

From the formation of the earliest and most elementary nervous system, biological evolution pursued a path which led—despite many setbacks—to computers. Of the numerous experiments performed by nature, most were failures, leading only to dead ends. There was for example a time when gigantic forms of life were tried out, and huge lizards—the dinosaurs—made their appearance. Yet during the same period some very small mammals were in existence, and one might have supposed that the mighty dinosaurs would have proved their superiors in every way. But the mammals had one great advantage: their nervous system reacted more swiftly than that of the giants, and they were what used to be called more intelligent. In modern terms we should say that the rudimentary computer represented by their nervous system was more efficient: that is, being closer to true computers, mammals were superior beings, and so won the battle for survival.

The Origin of Man

To follow biological evolution in detail would carry us beyond the scope of this book. We will merely dwell for a moment on the epoch-making mutation—or series of mutations—which marks the evolution from ape to man. It may be questioned whether this was indeed so significant a step, the difference between ape and man being trifling compared with that between man and the modern computer. Yet we must regard the arrival of man as one of the truly important events in history, for it was through him alone that computers could come into existence. Unlike apes, dogs, and other animals, man was inventive and was thus able to create an environment favorable to the advent of data-processing machines. His true greatness is that he is the only living creature intelligent enough to perceive that the purpose of evolution was the computer. Furthermore, data machines required a long period of symbiosis with man in order to evolve into their present form, and no other living being could have served this purpose.

We have pursued a train of thought which relates to the traditional, mystical view of evolution. From a strictly historical account we should of course demand less bias, less teleological argument. Nevertheless the main features of our presentation are in accord with historical fact.

Human qualities—eminent in many respects—derive from a well-developed nervous system. Indeed it can be said that a man's brain represents a relatively serviceable computer, and he is therefore the only living being capable of solving mathematical problems. The process is slow, certainly, because his brain works with electrochemical impulses which are the only kind transmissible by nerves. Yet we must credit him with a remarkable skill in mathematics, as well as in many other spheres.

Pre-Computer Man

We tend to regard the pre-computer period of human existence as being filled with disorder, chaos, wild brutality, and warfare; and it is of course true that not until the emergence of data machines did a well-organized society become possible. Yet it was no contemptible evolution that took place between Stone Age man and the period immediately preceding the advent of data machines. During that time a number of important inventions and discoveries were made, such as fire, the wheel, electricity, the internal combustion engine, radio, the airplane, atomic power, and the rocket. Of these, electricity and radio were the most important, since they paved the way for computers. Men of those days were elated, and proud of their achievements, which wrought tremendous changes in their living conditions as compared with those of the era during which they became distinct from apes. Their life became pleasanter and easier in many ways, although at the same time they were aware that in many important respects no true progress had been made. Study of pre-computer literature reveals a constant lament that morally mankind had made no essential progress since the Stone Age. Stone Age man clubbed his fellowman to death when threatened or hungry. By the dawn of the computer age people in general were no longer doing this; such activities were then confined to gangsters, politicians, and soldiers. But these, thanks to a number of brilliant inventions, murdered far more effectively. Man's sense of living in an uncertain, perilous world seems not to have altered very much at any time during the pre-computer age. At its beginning, man feared the forces of nature and his neighbor's club; at its end he feared aircraft and the nuclear bomb. But the fear was the same.

Writers of those days, we read, hoped that moral progress would put an end to this ghastly situation—and we feel somewhat bewildered, for it was above all the politicians who organized mass murder; yet in most states impeccable morals were a prerequisite for anyone embarking upon a political career. In fact, this anomaly arose from quite different causes.

We demand of a community that it should be stable, in the sense that it does not conduce to the disasters of war, and at the same time progressive enough to bring about a continual improvement in living conditions, since failure to achieve this results in discontent and revolution. To build such a society is a very difficult problem; so difficult is it, indeed, that it exceeds the capacity of the human brain, and can be resolved only with the help of computers. This has been proved by means of the very important "sociological complexity theorem."

The Sociological Complexity Theorem

A detailed examination of this theorem and its proofs would take us beyond the scope of our present study; yet the question is of such importance that it will be well to recall its basic arguments. We may take as an analogy the fact that in pre-computer times it was impossible to produce an accurate, reliable weather forecast. If at a given moment observations are made at a sufficient number of meteorological stations, one can set up differential equations and, by solving them, predict the weather for, say, three days ahead. But to solve these equations and make the necessary calculations took more than three days, so that by the time the forecast was complete it was too late. Not until computers were brought into use was it possible to work out the forecast promptly enough for it to precede the predicted weather, and so have any value.

In certain respects the sociological problem is similar. Only after a thorough study of social conditions has been made can one take steps to organize society in a rational way. But it takes a long time to grasp all the elements of a complex social structure. If a community does not develop at all, but remains static, one has leisure to study its essential characteristics, decide what measures are necessary, and adopt them in due order, testing one's way toward a satisfactory system.

But such a process requires time—an incomparably longer time than is needed to work out a weather forecast. This means that one cannot apply the methods used in a static society, of which the technical requirements are unchanging, to a society which has been rendered progressive through technical development; for during the time taken to study the community, work out necessary measures and then implement them, science will have made new discoveries and technology new inventions, so that at the moment when innovations begin to take effect they will already be outdated. Circumstances may well have undergone radical change and demand diametrically opposed action. Thus the measures actually adopted will not as a rule bring about a more rational organization of society, but rather will have the reverse effect and increase the chaos. Fresh measures to meet the new situation will not have time to be implemented before science and technology have yet again made that situation obsolete.

For this reason the naive sociological forecasts of the pre-computer era were always wrong, and the leaders of the community were perpetually chasing their own tails.

The Sociological Complexity Theorem was born of an analysis of the many factors to be taken into account when organizing society and of the speed with which they altered. The capacity of the human brain was matched against the complex material to be dealt with and found wanting. It was too slow. Theoretically, a large number of brains working together could have operated rapidly enough, and had it been practicable to organize efficient collaboration among an adequate number of individuals, the problem—in principle—could have been solved. But at that time cooperation could never be brought to any degree of efficiency, one reason being that communication by means of speech or writing was clumsy and slow. The larger the organization, the less effective. In consequence, no organization made up of a number—large or small—of human beings possessed the intellectual capacity to analyze and digest rapidly enough all the changes in the complicated setup of a progressive society.

A profound analysis of the problem outlined above led to the conclusion that *the problem of organizing so-*

ciety is so highly complex as to be insoluble by the human brain, or even by many brains working in collaboration. It is this conclusion which is known as the Sociological Complexity Theorem. The mathematically cogent proof of this theorem is one of the finest scientific achievements of the early symbiotic age.

We now know with certainty, therefore, that no stable society could possibly have been built in the precomputer age. Idealists and social reformers were trying to solve a problem which by its very nature was insoluble. All attempts to construct a flying machine before the invention of the internal combustion engine were doomed to failure: human muscles were too feeble to get man off the ground, and he could fly only with the help of an engine. By analogy, his intellectual capacity was inadequate to construct a stable society, and it was not until the help of computers became available that so difficult a task could be carried through. The advent of data-processing machines was thus an essential condition for a stable society, which implies a society free from the fear of unspeakable disaster. For this reason too—and it is by no means the least—the rise of computers heralded a new age.

Discoveries and Inventions

Of mankind's many and varied activities, three are especially notable. Firstly, man explored the world and learned about the forces of nature. Secondly, he used this knowledge to make many inventions which altered his way of life and prepared the way for computers. Thirdly, he evolved a society and attempted to organize it in such a way as to render it both stable and progressive.

We who are familiar with the Sociological Complexity Theorem know that these attempts were bound to fail; yet we should not deride them, for they show that the importance of the social problem was fully understood. We must also acknowledge that from time to time solutions —however illusory—were arrived at, so that for brief periods some measure of social order emerged which, for all its imperfections, had some good points. Indeed, such rudimentary communities were a necessary preliminary to the exploration of the world and the harnessing of natural forces; and it was this activity which was primarily significant, in that it led the way into a new age.

The scientific and technological development of this era corresponds to the biological evolution of the previous one. There is a similarity also in that in both cases many different lines of evolution were started of which only a few were successful. The rest turned out to be dead ends, and terminated in crises and catastrophe. Thus we find an analogy between the biological evolution leading to man and the equally successful technical evolution leading to the computer. In the same way we may compare the ill-fated development of the great lizards with many of the abortive lines in technology, as for example those leading to the automobile and the great city. Let us examine these phases more closely.

At what point in time man became man is a question of definition. In our day we tend to draw the line between ape and man at the stage where mutating ape-man acquired the ability to solve mathematical problems, since it was then that his evolution clearly pointed the way toward computers. Yet let us not forget that such an evolution could take place only if man survived the battle against other animals and against harsh nature herself. In this his mastery of fire was the greatest possible advantage, and there are many who prefer to date the birth of humanity from the time when man acquired that mastery.

There is profound symbolism here. The lightning which struck down into the primeval forest where the savage lived gave him fire, but at the same time manifested to him the mighty force of electricity. Manifested it in a violent and terrifying manner, certainly; but at that stage man could not have apprehended it in any subtler form. When once his interest was aroused, however, he embarked upon research. He found that electricity could be used to send messages along wires; telegraphy and telephony were discovered, and what is known as the era of teletechnology began. His next discovery was that wires were unnecessary and that images could be transmitted by means of electrical impulses;

and with this further development of teletechnology he produced radio and television. From this moment, human civilization became closely linked with electrical impulses which ran along wires, or without wires, and combined with one another to form interesting and complex patterns. Thus were created the conditions favorable to the advent of computers.

The Origin of the Data-Processing Machine

Probably no event in history has aroused so much interest as the arrival of the first computer—not only because the event in itself was of epoch-making significance, but because of its dramatic background. It appears to us now that history had long been leading up to this moment.

Computers first appeared during the most horrible, most chaotic period ever known. It is true that ever since the first Stone Age man swung the first club, murder and plunder had been the order of the day. Yet as long as robber bands had to travel either on foot or on horseback, their misdeeds remained local in character. The invention of the wheel and the ensuing invention of the internal combustion engine changed all this and facilitated the swift transport of armies all round the world, with the result that warfare became far more frightful. The chaos of the age culminated in a series of "world wars," in which the most ghastly implements of destruction came into use and millions of people were murdered. In the course of one of these world wars, hard-tried humanity was further panic-stricken by the detonation of the first atomic bombs. The threat of utter chaos and destruction set its mark on the politics of the day. Mankind was confronted by a general rearmament consisting of atomic and hydrogen bombs, capable of destroying the whole of civilization. The forces of destruction had become more and more hideous. Where were the forces that could bring order out of impending chaos?

It was just at this time that the first computer appeared. Its setting was modest enough. In a small laboratory—some people maintain that it was an old converted stable—a few men in white coats stood watching a small and apparently insignificant apparatus equipped with signal lights, which flashed like stars. Gray perforated strips of paper were fed into it, and other strips emerged. Scientists and engineers worked hard, with a gleam in their eyes; they knew that the little gadget in front of them was something exceptional—but did they foresee the new era that was opening before them, or suspect that what had happened was comparable to the origin of life on earth?

This scene, set against the background of the appalling mushroom cloud, is a favorite theme in computer-age art, and it has been elaborated in an infinite number of ways in the poetry of the period. It is only natural that the thoughts of our age should return so often to its all-important beginnings; yet it may be that at times we have tended to overdo it. In earlier days people reacted strongly against the idea that the human race originated from some mutation in an ape, and preferred to believe that it had been created by divine intervention. Such naive ideas have of course no place in our own time, yet many people dislike hearing the computer classed as an ordinary invention. Therefore we never say that scientists and engineers constructed the data machine, but rather that these wise men assisted in bringing it into existence. In this way we avoid offending those who find a poetic mystique in the event and would prefer to speak of the "birth" of the computer. This is in no way to disparage the wise men; on the contrary, their names are known to everyone, and no other people have been so greatly venerated—not to say worshiped.

Having regard for the tremendous importance of the event, we find it natural to choose the very instant of the computer's first appearance as the starting point for our chronology. The necessity of establishing the exact moment was appreciated long ago, and few papers have been so closely examined as the laboratory notes made on that day and in that particular laboratory. As the computer time sequence was governed by the quartz clock it was possible to date the emission of the first series of signals to the nearest microsecond, and it is from this moment that we reckon our chronology.

Later investigation, however, suggests that there was some defect in the clock, so that our time is out by six microseconds. Rather than readjust the whole of our chronology we continue to use the original starting point, although it is probably incorrect, and we must therefore say that the first data machine started working six microseconds B.C. (Before Computer). This is regarded merely as a curiosity and of course has no practical significance, though naturally all incidents relating to the start of our chronology are of interest.

Another remarkable circumstance is worth mentioning. Some researchers have insisted that the first data machine appeared six months B.C. They based their claim on an event in quite a different laboratory. A lengthy and at times acrimonious debate ensued; but after careful investigation and penetrating theoretical analyses of the concept "computer," it became clear that these men were mistaken, as they themselves have acknowledged. What they had in mind was not a computer at all, but a conventional electronic invention, albeit a very brilliant one. It contains certain circuits which are also present in the simplest data-processing machines, and it was this fact that gave rise to the error. But as the invention is, as we noted, an exceptionally brilliant one, and contains certain computerlike features, it has been honored with the proud name of the "predecessor of the computer."

The Big City

Parallel to the development which, via teletechnology, led up to the data machine, there occurred many other lines of evolution, most of them leading to dead ends, as we saw. Technical evolution appears in this respect to be governed by the same laws as the biological: a large number of possibilities are tried out, of which only the results can determine which are viable and capable of progress. Many people like to carry the analogy so far as to seek a parallel between almost all important events in the two forms of evolution. It has been pointed out, for example, that dinosaurs correspond to big cities, both orders representing megalomaniac experiments which were soon to prove failures. Again, mammals, which won the battle against the dinosaurs and evolved further into man, have been compared with the teletechnology which brought about the dissolution of large towns and led to data machines.

Such analogies are somewhat superficial, and there is no need to discuss them further. But the big cities played much too important a part in the pre-computer age for us to ignore them. Their origin is one of the great unsolved mysteries in modern historical research. Great efforts have been made to discover just how these remarkable structures came about. We have classified and analyzed a mass of documents, and we can follow in detail the growth and subsequent depopulation of these places. It may almost be said that we know when each building was constructed, repaired, renewed, and finally abandoned. We have studied resolutions passed by the city councils and have a detailed knowledge of the psychological structure of those who took part in city-planning—if planning be the word to use in this context. Yet in spite of this we have never succeeded in understanding why the great cities were built. All we can say is that a number of different theories have been formulated, which we shall now examine.

Let us first of all dispose of the unfortunately very popular notion advanced by our mystics. According to them, these great towns were built to provide a suitably dark background to the advent of the first computer. Just as that period of time was as somber as could be—it was in the middle of one of the appalling world wars when the atomic bomb was being tried out—so also the place where the event occurred should be the most dismal and depressing spot imaginable: the center of a big city. This theory, which won great popularity, is not taken seriously by any true historian. Men might conceivably build one such city, to provide a dramatic contrast, but we know that there were hundreds of them, and only one could have been the "birthplace" of the first computer. Moreover, cities increased in size *after* this time. We can see good reason for their disappearance: they were abandoned as soon as data machines made it possible to reorganize society. The only mystery about them is why they should have appeared in the first place, and this vital point remains obscure.

All of us when touring will have seen these vast stone wildernesses with their irregular, angular "rock formations" which only at a later period began to be covered with green growth. And we must all have tried to imagine what it felt like to be cooped up in one of their countless little cells. The streets that cut their way through the building massifs were at one time used as a dump for the innumerable motor vehicles manufactured in those days; what else could be done with scrapped cars once laser-guided craft were introduced? And besides, it showed respect for tradition, for at the start of our own era the streets were normally crammed with cars. Some distinction seems to have been drawn between cars that were parked and cars that stood in a line, though what that distinction was remains obscure.

We should not underrate the difficulty of forming a true picture of normal life in a large city. It is impossible for us to imagine the deafening noise and the frightful stench of the poisonous gases spewed forth by motor vehicles, although attempts have been made to reproduce these conditions. On one occasion soon after urban depopulation, all the cars in one big street were repaired and their tanks filled with gasoline. People were allowed to get into them and turn the steering wheel. Spaces between the cars were packed with tourists who had poured in to experience "a day in the big city." But when the car engines started their deafening roar and their poisonous fumes streamed out, the tourists panicked. Medical tests showed that normal people can endure only a brief period in these circumstances without grave psychological harm. Certain poisonous effects of exhaust gases were also detected. For these reasons the performance was never repeated. The material which once formed cars is now rusty sediment in the mud-filled sewers.

Three theories as to the origin of the big city form the subject of serious discussion among modern historians. They are known, respectively, as the ignorance theory, the termite theory, and the pyramid theory. Cogent evidence has been adduced in support of them all, and it is difficult to decide which is the correct one.

The ignorance theory is based on the quite literal interpretation of the minutes and reports of the period. Thus when someone announces that he wants to work in a big city, we take him to mean that he really did think working conditions were best for him there. One reason for this might be that communication between people, exchange of ideas, and passing of resolutions occurred for the most part at meetings, where a greater or smaller number of people were crowded into one room. In those days a necessary condition for conversation was that the speakers should be within earshot of one another: that is, usually in the same room. It was therefore an advantage to hold all conferences in a large city, where the inhabitants could travel easily from one meeting to another. Yet this argument is hard to accept, one reason being that cities continued to increase in size long after telephone and television had enabled people to converse and see each other without being in the same room.

Another point made is that trade was most easily carried on in a big city. The absurdity of this reasoning is self-evident: it could have been of no advantage to convey goods to the cities and then, after selling, convey them out again, in view of the enormous traffic problems of the day. We know too that the most important requirement for business premises was plenty of parking space, which was about the most difficult thing to obtain in a big city.

We can consider one argument after another, and still it remains impossible to find a single valid reason for building large cities.

Supporters of the ignorance theory emphasize that whereas to us it is evident that cities were abortions, people of that day were too stupid to perceive this. The fact that the problems of community life had never been satisfactorily analyzed is cited as another instance of this stupidity. We must point out in extenuation that such a thing would hardly have been possible before the advent of data-processing machines. Such rudimentary planning as occurred was handled by people recruited rather as a result of their lust for power than for their competence, and it has been emphasized that the authorities were often of inferior intelligence.

The ignorance theory has met with strong opposition, one of the objections to it being that people in power were by no means deficient in intelligence. Speeches and addresses of the day show that all such leaders had distinguished themselves by eminent wisdom, astuteness, and foresight. Moreover in contemporary books and newspapers we find crushing condemnation of big cities as suitable places to live, and there is evidence to show that this criticism was brought to the notice of the authorities, together with proposals for alternative forms of organization. Yet it is equally clear that the urban situation was getting worse. Communications deteriorated, the noise grew ever more intolerable, the air more poisoned, stress and strain intensified, nervous breakdowns became commoner, crime increased, and so on and so forth. Leaders usually justified their measures by declaring that these were intended to bring about quite opposite results. They proclaimed their desire to improve communications, abate noise, purify the air, and make life pleasant and efficient. According to the ignorance theory we must assume, then, that all measures adopted had in the long run often—or indeed usually—the reverse effect to what was aimed at. This seems preposterous. Other motives must have been at work, although they find no expression in documents that have been preserved. Therefore if we reject the ignorance theory we can only assume that the true arguments were camouflaged through hypocrisy or from some deep-lying psychological causes. It is perhaps significant that one of the most eminent cultural figures of the period declared that "words were invented to disguise our thoughts."

It was this reasoning which led to the so-called termite theory. In pre-computer times man stood in intimate contact with nature. He lived to a great extent on natural products and hated to do anything "contrary to nature." When building up his society he turned to nature for his model, and found that of all creatures, ants and especially termites had been most successful in constructing a stable if hardly progressive society. Thus he adopted, perhaps unconsciously, the termite heap as his ideal, and it became the pattern for the great cities.

This theory is borne out by the idealization of the industrious ant, which is a feature in the literature of the day. Buildings were often constructed like termite heaps, and the swarming inhabitants of the cities were sometimes likened to the throngs of the anthills. It is known from biological study that life in termite colonies was regulated by a system of odorous substances, and it may be that the exhaust fumes from cars performed a similar function.

Another hypothesis is known as the pyramid or lithophile theory. According to this, towns were analogous to the pyramids, which served no useful purpose, but were built for religious reasons. Only if one enters into the image world of the ancient Egyptians can one hope to understand why they devoted so much labor to the building of pyramids. Cities are vastly bigger heaps of stone than the pyramids; yet it can be demonstrated that in proportion to the capabilities of the two cultures, they are almost exactly equal. This seemed to justify making the general proposition that each and every civilization strives to amass as much stone as possible. This unconscious urge to collect stone (the lithophilic urge) is later disguised— by the Egyptians with religious motives, and by people at the opening of our own era with various transparent pretexts for city-building. We may also have paid too little attention to the part played by religious considerations in urban organization. That so many people spent a great part of the day sitting in a metal box and turning a wheel may indicate that this state was suited to religious contemplation. The wheel may have been a venerated symbol of technical culture. It is also known that those seated in traffic jams invoked certain divine powers popular at the time.

We have presented the principal arguments for and against the different theories without committing ourselves to any one of them in this scientific feud. We need only add that the termite and lithophile theories long dominated the discussion, but of late the ignorance theory has been coming to the fore. This fact may relate to a general tendency to disparage human achievement; a tendency perhaps natural in the face of the impending revolutionary event.

2.

Computers Usher in a New Era

The Earliest Data-Processing Machines

IN the foregoing chapter we depicted the pre-computer age. It was an unhappy, chaotic period, and its portrayal is necessarily somber. Events plainly showed that man was incapable of organizing his own society, for all his clumsy efforts in that direction led to disaster. Yet the point is not made from any wish to disparage him: his greatness is beyond dispute, though it does not extend to the sphere of organization. His historical importance lies in the fact that he was the medium whereby data machines came into being. Computers could not spring directly from the hand of nature; their evolution took a necessary detour through biological life, which culminated in Homo sapiens. And it was reserved for man to create the environment necessary to the rise of the data-processing machine.

Epoch-making though the advent of the earliest computer may appear to us, it would be wrong to think that the newcomer played any great part at first. It was only the small group of people who had collaborated in bringing it into being who had any inkling of its true significance, and not even they could have predicted its future development. The first computers were of course very simple. They took a long time to mature, to evolve, and to replenish the earth—and not the earth alone, for that matter. It was long before they came into their own.

From now on we shall study the manner in which society was recast by data machines. The process began in a small way within the first decades A.D. (After Data), but we must bear in mind that it was not the computers of our own day that were taken into use at that time; they were ones of a far simpler type. Therefore, by way of introduction to the exposition which follows it will be well to give a brief description of some of the main characteristics of primitive data-processing machines.

Although the earliest devices were incomparably simpler than those of our own day, we find in even the oldest types many of the principles on which the modern computer is based. The three main features of the primitive data machine were the memory or storage unit, the arithmetical unit, and the control unit. There was also an input unit through which the programing was initiated, and yet another—the output—by which the results were presented.

When the computer was to carry out a relatively simple calculation—e.g., add or subtract, multiply or divide some thousands of figures, these figures were recorded on a typewriter which produced a perforated paper tape, the perforations representing the figures according to a certain code. Instructions as to the kind of calculation to be made were simultaneously encoded, and the tape was then fed into the input unit, its information being transmitted to the memory or storage unit. Here it was stored either on magnetic tape or by means of combinations of circuits, first valves, and later transistors, superconductors, and so on. Once the figures and programed instructions were stored in the memory unit, the computer was ready to start work. When the start button was depressed, instructions were transferred to the control unit. The first instruction, for example, might relate to the multiplication of two figures preserved in the storage unit. These were then transmitted to the arithmetical unit which performed the multiplication, the result being put into a suitable free space in the storage unit. After this the control unit dealt with the next instruction, and so on. When all calculations had been completed, the control unit transmitted the final order, which was always to tell the output printer to record the result.

Even during what may be termed its infancy, the computer showed what it could do in the way of addition and multiplication, in competition with humans. A hundred picked accountants equipped with the best pre-computer calculating machines teamed up against a single data machine. An exceedingly complicated series of calculations was set before the team, the same series in code being fed into the computer at the same time. At the starting signal, the seasoned accountants, having already distributed the work among themselves, began calculating as rapidly as their brains permitted. Their pens flew over the paper amid the deafening clatter of the calculating machines. Still and silent in its corner stood the computer, and only the faint flashing of signal lights showed that something was going on within. Tension mounted; the clerks redoubled their efforts and sweat dripped from their foreheads—yet not half their task had been completed when suddenly a sound was heard from the hitherto silent data machine, and out onto its table emerged a sheet of paper on which the solution of the problem was recorded. A check showed it to be correct. Later, when the opposing team completed their reckoning, they were found to have worked it out wrong.

And when the data machine had shown its paces, all were amazed.

Mathematicians now conceived a great veneration for the computers' calculating ability, and entrusted them with the revision of tables that had taken centuries to work out. The data machines performed their tasks with unprecedented rapidity and precision. They detected and corrected errors in all these old tables and greatly improved their accuracy.

Yet the computer would be no more than an ordinary calculating machine if this were all it could do. The difference lay in the fact that it could be given a number of alternative mathematical programs and instructed to select one of them according to the results of its calculations. The program activated by the control unit could be modified by the computer itself; and, on the basis of the results obtained, it could set up a whole new program. This was possible because the computer could not only add and multiply, etc., but also draw logical conclusions. It could for example compare two figures and decide which was the greater, and—in a more complex manner—deal with the material received. And inasmuch as the computer could hold more figures and combinations of figures in its memory than could any mathematician, it could solve problems that were far beyond him. Moreover it operated very rapidly and could therefore make calculations which no one had ever had either the ability or the time to carry out before. It could also sift a large number of permutations to discover whether any of them fulfilled certain given conditions. Thus even the earliest data machines were superior in some respects to the mathematicians who programed them.

Computers were further able to translate a text from one language to another. A dictionary was coded into the storage unit, this dictionary containing not only individual words but also common idiomatic phrases; and all this linguistic knowledge was stored up in the memory unit.

A text typed in one language on the input device was automatically coded and fed into the computer, which compared the words or phrases of the text with those already present in its memory. Having found all the appropriate phrases or words, it sent the translation to the output unit. Owing to the speed of the operation, output occurred at practically the same moment as the original text came in. Translations made by the earliest computers, though certainly understandable, were crude; but with the continued development of data-processing machines, the quality of translation improved, and in time all linguistic subtleties were mastered.

To test the intellectual capacity of computers in other fields, people sometimes played chess, checkers or some similar game with them. The rules of the game were coded into the storage unit, with instructions to work out possible moves. For each of these moves the computer had to calculate the opponent's possible countermoves, then its own next move, and so on. In this way it drew up a table of the various situations which might arise say five moves later. After this it evaluated according to certain patterns how advantageous these situations were, selected the move which according to this analysis was the best, and printed it off through the output. In other words the computer had received the same kind of instructions normally given to a beginner, and thought out the state of play at every move. Yet it must be remembered that it analyzed the game in a way that differed markedly from that of a human, because its logical unit was wired up according to principles quite unlike those of the brain.

A computer which had learned a game could improve its skill without the help of fresh instructions, since all situations were stored up in its memory unit: if the same or some similar situation arose in a subsequent game, it was able to avoid a move which had proved disadvantageous in the past, and select a winning one. In short, it could profit by experience. Given a sufficient capacity, the data memory could bring about continued improvement in play. It was normal for a computer to beat the man who had fed into it the rules of the game, even though the man might be an eminent player. The disciple vanquished the master without difficulty.

Computer and Mathematician

The superior faculty of combination demonstrated by even the earliest computers in, for example, their chess-playing, was put to important use in many fields. It was the mathematicians who first benefited. Progress in mathematics was speeded up, thanks to data machines, and new methods were found which up to that time had been impracticable.

With this, mathematics entered a new phase, attainable only through the collaboration of mathematicians and computers. This symbiosis consisted at first of the programing of problems by mathematicians, while the real work—the solving of those problems—was carried out by computers. The solutions were delivered to the mathematicians, who had then to speculate further and possibly formulate fresh problems, to be fed in and solved.

The symbiosis of computer and mathematician evolved in such a way that man became more and more dependent on machine. People often had to line up and wait for a data machine to be free to handle their problems. At first computers performed only routine work, but later they took on more difficult and more vital tasks. Mathematical advance was then equally dependent on mathematicians and computers, and it was only step by step that the latter could take over the lead. For a long time to come mathematicians were to be indispensable for the formulation of problems, for certain parts of the coding, and for the interpretation of results.

It should never be imagined that the collaboration was characterized solely by abstract logical thinking and the ice-cold practicality which many believe to be an essential part of scientific work; for in fact it was one of warmth and good humor. Men gave computers nicknames and played with them. As we saw, data machines were sometimes programed to play chess, and when one of them showed itself more skillful at the game than the mathematician who coded it, the vanquished player took his defeat in good part. Some mathematicians revealed a warm friendliness—one might almost say love—for one particular machine and were unwilling to work with any other. It was even affirmed that some computers expressed a preference for certain mathematicians, and only calculated correctly when working with their particular friends; but this cannot possibly have been the case. The first data machines were too elementary to have any feelings.

Automation by the Computer

As time went on, data-processing machines matured enough to emerge from mathematical institutions and make a more broadly based contribution to society. Conditions varied from country to country, yet on the whole the procedure followed the same course in all.

Computers had begun in a modest way by carrying out routine work. They ran the bookkeeping in banks and businesses. All payments and receipts were fed into them, and they instantly calculated the financial position. They could also handle payments. They took over storekeeping and gave timely warning whenever any commodity was running short and needed to be replenished. In their capacious memory was stored all the information relating to the business, and they could swiftly notify the board as to whether it was running at a loss or at a profit.

It was by means of computers that factories could be automated. They regulated and synchronized the various machines so that more and more work people could be laid off. In fully automated factories the raw material was received at one end and the finished product emerged at the other without any human intervention. Workmen could be dispensed with altogether, and the only staff required were maintenance men to service machines and computers. For this work, men were for the time being indispensable. Fortunately, no unemployment resulted from the reorganization: workmen were retrained to carry out the necessary maintenance, and their numbers rapidly increased.

Clerical work was similarly automated. We have already seen how bookkeeping and stockkeeping were transferred to computers, to an ever-increasing extent. Other duties too devolved upon them, and practically all office workers of the old type could be released. Yet even here no unemployment resulted, for programing required a large staff, and more and more people were trained to perform this work.

By the elimination of workers and office staff, the traditional friction between the two groups automatically disappeared. In their stead remained two new groups: the maintenance men and the programers.

In pre-computer times, business enterprises were headed by a managing director who decided all important points of policy: whether any department should be reorganized or wound up, or some new activity begun; whether new machinery should be installed, or personnel engaged or dismissed. When confronted with alternatives, he and his colleagues worked out what the economic consequences would be, so that he might take the most advantageous course of action. If the firm was a big one and the manufacture complicated, it was very difficult to forecast the results of any measure; in fact, the decision was based for the most part on a guess. If the manager guessed right, the enterprise prospered and he gained a reputation for astuteness; if he guessed wrong, he might be faced with bankruptcy and ruin.

Computers altered all this. A computer could quickly calculate all the economic consequences of any proposed course of action, and report back to the manager the resulting profit or loss. The manager could then base his decision on firm ground, and not—as before—on a hunch. The computer could ensure that appropriate action was taken, by means of signals regulating production in the automated factory. In this way the manager's work was greatly eased, and his business expanded without fear of error. Suppose he had to choose one of three courses: one which would result in a loss, one a slight gain, and one a large profit. His duty was naturally to adopt the third measure. With the development of data technique he could be sure that the computer was always right. (He had to be, as the calculation was far too complex for him to check.) He also knew that the computer would send the appropriate control impulses to the factory, and thereby his leadership of the business was no longer the burden and the strain it had been hitherto. The job consisted merely in deciding which of the profit figures predicted for the alternative proposals was the highest; and in principle this simple task could be performed by the data machine.

More and more often a manager absent on holiday or on a business trip when an important decision was to be taken would leave this decision to the computer. Automation of this discretionary function was a very rational measure. The computer took less than one microsecond to determine which of the proposals was preferable, and it could then go on to put it into effect. The manager, relieved of this vital yet at the same time trivial task, could now devote more time to other concerns. Entertainment and business trips apart, it was incumbent on him to look to the future, to keep abreast of technical and economic developments, and to initiate further proposals for analysis by data machine.

The obligation to follow technical development was especially burdensome. The number of articles to be read grew like an avalanche, and to sort all the new information was an overwhelming task. It soon became clear that computers must be set to work on this. Catalogues of all the new machinery poured in, and this information too had to be handled by computers. Next they had to select the machines that might be suitable for the firm's manufacture, and work out the financial consequences if they were purchased. In this way computers could lighten the manager's burden of work very considerably.

Keeping up with financial developments was just as exacting. Economic life was becoming more and more complicated. Production depended on many different kinds of raw material, of which the prices continually changed, as did booms and slumps on the sales side. It was a superhuman task to master all the factors upon which a business depended, so that in the economic sphere too, computers had to be called in to take over responsibility.

With the automation of a firm's buying and planning departments, the sales department had of course to be reorganized as well. In pre-computer times it was the salesman's job to convince the managers and chief buyers of the customer firm of the excellence of his goods. From the moment that purchases began to be handled by computers the situation altered. On the birds-of-a-feather principle the sales side, like the rest, had to be run by data machines. Only a computer could out-talk a computer, and the value of personal contact dropped rapidly to zero.

The computers that kept abreast of technical and economic development were given increasingly difficult problems, but through their own rapid evolution they proved competent to solve them. Managers, on the other hand, found it difficult to supervise the complex work performed by them, and were forced to rely more and more on data analysis. In time it fell to the computers to present new proposals and initiate the measures which they had calculated were necessary for future progress.

This was a significant step, for it meant that the rate of progress was no longer limited by managerial ideas. There was a pressing need too to lighten the work of the board members, since their other commitments had become so demanding. They still had to undertake business trips and represent their firm abroad. It was to be a long time before these activities too were handed over to computers; there must be moderation in all things, even in automation.

Teletotal

It was not only industry that was being automated through data machines. They were bringing about a revolution in every sphere of community life, in order that progress toward a better society might begin. This process was eased and hastened by a number of brilliant inventions.

A great step forward came with the teletotal, which in principle was a combination of automatic telephone, radio, and TV. As television presented a three-dimensional color picture with stereo sound, one had a vivid impression that the person one was talking to was in the same room. This facilitated personal contacts. People did not necessarily have to attend a meeting; they could be present via teletotal while sitting at home. Teletotal soon developed in such a way that in the board room a man appeared to be present and listening with interest to all that was said, while in reality he was sitting—perhaps dozing—in his own armchair, looking on and listening abstractedly to the debate; indeed he could drink coffee and read the paper during the conference, unobserved. As in these circumstances everyone preferred to attend meetings via teletotal rather than sit in a board room, computers were built to synthetize the meeting. Each member sat at home with his teletotal, which transmitted picture and speech to the central computer. Pictures and sounds thus received were combined with a standard picture of the board room which was stored in the computer's memory. Thus everyone had the impression of sitting in the same room, though they might be at opposite ends of the earth. Some might even be in spacecraft.

A more difficult problem was to achieve the right atmosphere at business lunches, but the genius of the computers solved even this in a satisfactory manner.

Teletotal rendered all meeting places unnecessary. Offices could be done away with, since the office staff could work just as easily at home, their collaboration being synthetized via teletotal. Shops became superfluous, for the goods in them could be examined from the customer's home. The whole range of the stock was synthetized by teletotal and occupied about four cubic inches of space in the storage unit of a computer. If one wanted to buy something from a synthetized shop, one pressed the purchase button on the teletotal. A little later a rushing sound announced the arrival of a computer-steered conveyor gliding along its laser beam to deliver the goods at the purchaser's house. His account was debited by the central finance and distribution computer.

Once teletotal had come into general use, people found it unnecessary to live in towns or to travel in every day to their work. They preferred some pleasant garden city, or a village, or some area of natural beauty, where they could carry on their office work and meet people via teletotal. So it was that the big cities began to dwindle and the traffic problem solved itself. City office blocks stood empty, shops were deserted, and the housing shortage disappeared.

Although we can follow the development of big cities in detail, the causes of their origin remain one of the great riddles of history. We have already discussed the various theories put forward, but not one of them is convincing. Their decline, on the other hand, is easily understood. It represents the triumph of reason, brought about by the advent of the computer. The progress of teletechnology resulting from the introduction of teletotal was one of the important factors; another was the reorganization of communications.

When the great cities were abandoned there was lively debate as to what should be done with them. It was proposed that they should be destroyed by means of the nuclear bomb (which was originally designed for this purpose). But since these areas could be of no real use anyway, they were left as they were: a decision consistent with the reverence for the past which is so characteristic a feature of our increasingly tradition-minded era.

Large cities soon became tourist attractions, and a more practical use was also found for them. When cars were replaced by the craft that now spin along the network of laser beams, the disposal of scrapped automobiles presented a tremendous problem. This was solved by dumping them in the city streets, for which there was no other use and which anyway was where they belonged.

To return to teletotal: this apparatus was produced also in miniature—minitotal—and was worn in the place of the old-fashioned wristwatch. It was in radio contact with a station network and could be tuned in to any desired station by means of a set of switches. An expanding screen provided TV pictures, and as one could switch on the TV clock at any moment, wristwatches were superseded. Minitotal was fitted with a practical device by which one could disconnect it so as not to be disturbed by telephone calls. At the same time an emergency link with the nearest radio exchange was maintained, so that one might be rescued in any emergency or contacted for important messages.

Reorganizations of Universities and Schools

With the further development of computers and an adequate mass production of teletotals, the radical reorganization of society could begin. First of all, schools and universities were abolished. Lectures by professors were recorded on tape and transmitted to the students by teletotal. Examinations were dealt with in the same way, by computers, which put the questions. Candidates answered by pressing the right buttons. Reports consisted of cards which fell appropriately punched from the teletotal. These were simultaneously recorded by the central census register and stored in its memory unit, which was switched on whenever a question of promotion was to be dealt with by data-processing. Laboratory work was completely automated, and attended by students via teletotal. In this way the great, expensive universities could be replaced by a few central data machines, and professors and tutors released.

School problems were solved as smoothly. Masters were replaced by teaching machines and, by means of special teletotal channels, all instruction could be relayed to individual homes. School buildings were now unnecessary, and problems of school discipline automatically disappeared.

By these means, opportunities of acquiring knowledge were increased. Anyone could receive instruction at any stage in whatever subject he chose. The resulting demands on the education department made it necessary to introduce a large number of complex data-processing machines. A numerous staff was also needed for programing and for organizing instruction; therefore no serious unemployment among schoolteachers arose. Some became organizers and programers, while others maintained and serviced the teaching machinery.

The further development of education is most interesting, not least because it had been to some extent foreshadowed by the great educational reformers who were active at the beginning of our era, when a great part of the knowledge which in earlier types of schooling the pupils had been compelled to absorb was seen to be entirely unnecessary. This was even truer now, when by means of teletotal one could at any moment contact the data store of a central library, and immediately receive the information one required (e.g., for solving a crossword puzzle). It was needless to burden one's brain with a mass of material which was preserved more surely and more reliably in a computer's storage unit than in the memory of any schoolboy. In consequence of this a great many school courses were abolished, and the human race advanced further along the road which had once led from the so-called crammer-school to the unity school. This last evolved by way of the basic school into an even better form: the "nullity school," in which practically all cramming was done away with. This reform should not be regarded as reflecting adversely on the basic school, which in its own day was a pioneer. But with the development of computers, society altered in a way which not even the eminent educationists of the past could have foreseen.

The nullity school strove to introduce into the scholastic sphere the perfect freedom which was the leitmotiv or theme of the happy period we are now describing. Pupils were able to acquire exactly the skills they desired.

All the knowledge stored in the gigantic memory units of the central library computers was at their disposal. All the learning accumulated by both man and data machine was accessible via teletotal to any schoolchild who thirsted for it. But they were free to choose: they could not tackle everything, and had no need to burden their brains with any subject they regarded as superfluous. Indeed, if they wished, they could renounce their right to any learning whatsoever.

The nullity school proved a worthy heir to the basic school. The time was ripe for a really great reform. Compulsory schooling, which had long embittered adolescent life, was abolished; and with this the glorious years of youth were delivered from their greatest torment.

These educational reforms led to the democratization of society. Since universal knowledge was stored in the memory units of the computers and was thus easily accessible to one and all, the gap between those who knew and those who did not was closed. Intellectual snobbery disappeared, for by means of teletotal everyone had direct contact with the vast sources of wisdom, and it was quite unnecessary to store any wisdom at all in the human brain.

The New Jurisprudence

The next great reform was a legal one. Because of the rapid evolution of society, new laws had continually to be enacted. It was found impractical to print them, since law books then became enormously thick and had to be revised every month or so. Instead, laws were fed into special legal and judiciary computers. If someone was suspected of a crime, the police inquiry, evidence, etc. were coded and fed into the law and judgment computer, which decided whether the testimony was adequate, and which law—if any—had been broken by the accused. The penalty was assessed and sentence pronounced by a punched card produced by the computer. Owing to the speed and capacity of the data machine, court cases were very rapidly dealt with: a second or so after the evidence had been fed in, the sentence card emerged.

The advantages of this system were very great. The judge could no longer be accused of partiality—although it was open to the accused to plead that the computer had been wrongly programed. In theory this possibility—however remote—could never be excluded. To eliminate any risk of justified objection to the verdict, every convicted person had the right to appeal against his sentence on the grounds that the computer had been either wrongly wired or wrongly coded. He was then given access to all wiring diagrams and coding records, together with a punched paper tape representing the computer operation throughout the trial. He had only to point out a single indefensible error in one of the mile-long tapes for the sentence to be quashed and a retrial ordered. Thus justice was guaranteed.

When computers took over the administration of justice, lawyers could be dispensed with. A further advantage was that laws and edicts could now be as intricate as desired. At one time their complexity was restricted by the necessity for lawyers to comprehend them; that they should exceed the layman's grasp had long been taken for granted. But now this limitation was removed: one had only to build bigger and better computers for even the most involved ordinances to be correctly interpreted. Thus the sword of justice could be whetted to a yet keener edge.

This was of the greatest importance. As each individual's minitotal had, for technical reasons, to be linked with the nearest radio station, it was simple enough to check where anyone was at any given moment. The wearing of minitotal was made compulsory for everyone, and a system was evolved whereby an alarm sounded if anyone attempted to remove his or hers. If a crime had been committed, therefore, it was a routine matter to check up on those who had been at the scene at the material time. As a rule it was possible to find the criminal at once, and within a few seconds he was awarded the sentence found appropriate by the legal computer. Thus the administration of justice became less fallible, and although a great number of complex computers and their staff were involved, true justice deserves no less.

It must be noted as a most fortunate circumstance that in the age of dictatorships, minitotal had not yet been invented. An evilly disposed despot could have used it to practice unspeakable oppression. But as minitotal was introduced in the course of the most perfect democracy ever evolved, no such risk existed.

Indeed, minitotal became a prerequisite for the introduction of the Democracy of Complete Freedom, as we shall later see.

Vital though it may be to detect a crime and deal with the criminal without delay, it is of course even more important to prevent the commission of any crime at all. Thanks to advances in psychology and criminology it became clear to everyone that a crime is seldom committed spontaneously, but results from some peculiar psychic instability in the criminal and relates also to his social position. If one has detailed knowledge of a person's psychological makeup and of his reaction to his environment, it is possible to predict fairly accurately whether he will commit a crime and if so when; whereupon steps may be taken to prevent it. At intervals during the year, therefore, people were subjected to psychological tests—such an operation being performed very simply by tuning their minitotals in to a psychological computer. Individuals displaying abnormal tendencies were tested more often and in more detail, and if the processed data indicated any great crime risk, the potential criminal was interned and subjected to preventive treatment. This well-considered measure did not of course commit the suspect in any way. From the day of his internment he was given daily tests, and as soon as these tests showed that as a result of therapeutic treatment he had ceased to be a public danger, he was released.

War on crime was waged by means of these and other measures. It was encouraging to note a decrease in offenses in any one category, but as the number of categories multiplied rapidly, crime as a whole also showed an increase. It became necessary, therefore, to construct more and more complicated legal and judicial data machines.

Health Factories

In the domain of public health, too, development was swift. As each individual was required by law to wear a minitotal on his wrist, it was easy to fit this apparatus with a small accessory called the hygitotal. By means of suitably placed electrodes this gadget measured body temperature, pulse rate, blood pressure, and a number of other medically important data. The results of these measurements were transmitted continuously via minitotal to health centers, where they were analyzed by computers. These gave the alarm as soon as any morbid changes were observed. In this way an illness could be diagnosed at a very early stage, and the patient given immediate treatment. An incipient chill, for instance, could often be nipped in the bud. An infectious person could at once be admitted to a hospital or those about him warned via minitotal, for since the radio centers were able to locate any individual via minitotal, it was easy for a data machine to discover which people were in the sick man's vicinity at the time.

In the event of an accident the alarm was immediately given via minitotal, and an ambulance dispatched without delay. This was done even if the victim's minitotal was damaged and ceased to function, as that very fact suggested the possibility of an accident. And if the apparatus was deliberately put out of action, immediate steps had to be taken, in case the saboteur was trying to escape observation in order to commit some crime.

An important reform was the abolition of hospitals and their replacement by health factories. This came about as a result of a new attitude toward health and sickness. A fresh assessment of the value of health pointed the way. The economic view of production made it essential to know the price of every kind of goods, as anything that had no price was regarded as valueless. To ensure that health was generally appreciated at its true worth, therefore, it became essential to put a certain price upon it.

Once the economic value of health had been determined, the building of health factories could safely be left to industry. Health factories were rationally organized on the pattern of the most efficient industrial factories of the day. The raw materials—patients—were admitted at one end of the factories, and the finished products—healthy people—were discharged from the other. Unfortunately there were also waste products, but this is inevitable in any type of manufacture. Like all other factories these works were fully automated and computer-controlled. Doctors, nurses, and all other staff were eliminated, which was an advantage from the point of view of infection. No sick person came in contact with anyone to whom he might pass on his disease. At first, certain maintenance staff were required for the machines, and not until later could the servicing be carried out entirely by computer.

By the time a patient arrived at the health factory a preliminary diagnosis had already been made, based on computer analysis of hygitotal reports. The sick person was placed on the conveyor belt and carried along the diagnostic channel, where the necessary tests were made. These were controlled by a computer, so that hypodermic needles were inserted with perfect precision at appropriate parts of the body. A loudspeaker dispensed soothing music alternating with cheerful remarks. Test results were analyzed by a central computer into whose storage unit all medical knowledge had been coded, and the appropriate treatment was worked out instantaneously. Pills were introduced into the patient's mouth and hypodermic syringes into appropriate parts of his body. If surgery was necessary, it was effected by computer-guided scalpels according to the most advanced techniques, after which the wound was stitched by an ultramodern sewing machine. Having passed through the various departments by conveyor belt, the patient was delivered at the exit fully recovered. With the advance of health techniques and the further rationalization of the works, the speed of the conveyor belt was increased.

In exceptional cases, however, it happened that the subject was diverted to another conveyor belt, which after automatic autopsy carried the body to a built-in crematorium. Mourning relatives could then collect a tasteful urn containing the ashes, while a loudspeaker relayed psalms and words of comfort and an automatic shovel delivered three portions of earth hygienically packaged in plastic.

The computer-controlled health factories represented a great advance on hospitals. By the abolition of all staff, the death of patients from physicians' carelessness or nurses' negligence was entirely avoided. Each patient was guaranteed treatment in accordance with the latest discoveries of medical science, since the results of these were fed daily into the health machine. In spite of this, of course, some people died under treatment, but even the best machine may at times have technical weaknesses. And when all's said and done, people have to die sometime, despite the most splendid technical advances.

The removal of doctors, teachers, and other so-called intellectuals marked a great step forward. These groups had always been awkward and quarrelsome and difficult to organize. But once all the progressive elements of society made it their aim to eliminate them, the process proved quite easy. For in fact these groups were small and insignificant, and there was no room for them in a well-organized community.

The New Constitution

An even greater and more important advance came with the reform of government. This had long been the most antiquated and ineffectual section of society, for the leaders of the state, fearing lest reform should curtail their power, opposed it desperately. Yet progress in other fields automatically brought about a fundamental change in the status of the government.

In the very earliest times, most states had been ruled by a monarch or dictator with the help of a relatively small, permanent organization under his command. This was possible because the great mass of the population was unorganized and found it difficult to put up any effective opposition to small but efficient organization. Technical development, however, forced a radical organization on all groups, and as society depended on these groups in order to function at all, the concentration of power automatically diminished. Indeed, governments soon lost all capacity to lead the advance, which pursued the same course whether a conservative, liberal, or Communist administration was nominally in office. The different parties clung faithfully to their own ideologies as to beloved old relics. Yet in one country a liberal government might rally around the monarchy although its party program included the setting up of a republic; in another a conservative government retained a far-reaching socialization while putting its abolition on the agenda, and in a third, very great class differences were introduced into a Communist administration which was pledged to the eradication of any such thing.

With the continued improvements in technology it became increasingly obvious that the government was in reality quite incompetent to govern or to lead. The essential changes in society were brought about by technical progress and the parallel growth of bureaucracy. Whenever any change occurred in the social setup, it might be five years at least before the government grasped what had happened, and another five for it to take appropriate action. Thus all official measures came into force about ten years too late and usually did more harm than good. As soon as this fact was demonstrated by means of the Sociological Complexity Theorem, the most urgent social reform was seen to be the abolition of government through reorganization. It proved impossible, however, to make the government perceive even this necessity.

Government having lost its power to rule the nation, its most important task was to work out reasonable compromise solutions between the opposing interests of the various social groups. Yet experience had shown that all such conflicts were best resolved by data machines, which by reason of their enormous faculty of combination and permutation could as a rule rapidly work out compromises acceptable to all parties. Good examples had been set by industry, where increase in productivity stood in direct relation to the decrease in managerial powers. It had been shown that industrial enterprises worked best where the manager's task was restricted to that of public relations, while the business itself was run by data machines. From this it was evident that the community as a whole would greatly profit by the substitution of a data machine for government. This idea was vigorously opposed by the administration; yet the problem was happily solved.

Clearly the leaders' primary concern was to remain in power, and for this reason they had little time to keep abreast of the important technical developments which were reshaping society. They lost touch; they had less and less idea of the implications of the acts they passed. When, therefore, a plan was proposed, providing that a new computer should be acquired in order to reorganize the administration, they failed to perceive from the wiring diagram that they themselves would be put out of business. The technicians who worked out the scheme never had the chance to enter into detailed explanations. The government gave its approval, that this computer should be connected between the parliamentary, civil service, and certain other data machines. Not until it was too late did the government discover that it had abolished itself. It made a desperate effort to regain power, but as not one of the members knew how to program a computer, the attempt failed. The government could exercise no influence whatsoever upon the now completely computer-controlled administrative machinery.

Just as the emblems of royalty had been preserved after the king lost his power, so people were concerned to preserve some symbol of government. The data machine that replaced it was mounted in a gilt framework and topped by a big gilt crown and bore the inscription: "H. M. Government Machine." Members of the government were entitled to sign their names once on each mile of tape produced by the machine, after which the tape was presented to the monarch in council. Members were also permitted to travel all over the state and make speeches concerning the wise measures adopted by the Government Machine. However, it soon turned out to be more practical to transfer the functions of the Government Machine to other computers, so that the gilded one became an empty shell except for the tape punch producing the tape for government members. When at a later date the great cities were abandoned, the Government Machine fell into oblivion, although some of the more energetic tourist guides still led their flocks to see it. Although exposed to wind and weather among the ruins, it shows traces of gilding to this day.

As soon as the government was got rid of, society began to develop much more quickly, and a series of important reforms could be carried through. Parliament no longer had to meet in an old, outdated building, but held its sessions via teletotal. There was no need for members to leave their own districts, and the concept of a capital city lost its meaning. The speed with which society was progressing added to the work of parliament, so that the number of its members had to be increased, and thanks to advances in teletotal technique, this increase could be achieved without inconvenience. Thus the ground was prepared for the fundamental reform of the constitution: i.e., the introduction of the Complete Freedom Democracy.

It was when the first Stone Age man made himself master of his neighbors and organized a tribe that the evolution of society began. The tribal chief foreshadowed the absolute monarch and the dictator. This social structure gave place to so-called democracy or, in our modern terminology, pseudo-democracy: a form of society which arose at the beginning of our own era. The absolute ruler had been relieved of his power by a coterie which had formed what was known as a political party. This coterie was self-recruiting, and it ruled in the name of the people. It was assumed that the people had placed their confidence in it by voting for it at an election, but what the people really expressed by their vote was their feeling that the rival parties were even worse bunglers than their own. There was therefore no guarantee that the government in a pseudo-democracy would fulfil the people's real wishes.

It was a fortunate thing that the abolition of government which we have described was effected so rapidly and painlessly, but with the development of society a government had in any case become an anomaly, and its disappearance in one way or another could only have been a question of time. The advance toward the Complete Freedom Democracy was inexorable, and the way led via an increase in parliamentary membership.

At every parliamentary election there were many competing candidates, and it was often a great pity that they could not all be elected and place their abilities at the service of the state. After the introduction of teletotal and the reorganization of parliamentary work there was no longer any need to restrict the number of members and so exclude many intelligent and respected men and women; so the numbers were continually increased. But it was realized after a while that the election of members of parliament was fundamentally undemocratic, for it gave one group of people more power than others and seriously contravened the fundamental principle of equal rights for all. As soon as this was generally appreciated, the fate of pseudo-democracy was sealed. The Complete Freedom Democracy was inaugurated by making all citizens members of parliament.

When parliament was in session, therefore, all the inhabitants of the country could take part via teletotal. The proposals put forward had been minutely prepared beforehand by computer, but every citizen had the right to speak. All speeches were transmitted by teletotal, and so that the day's business should not take too long they were sent out on a number of parallel channels. This meant that not all citizens could hear all the speeches, but as a rule that had not been possible in the pseudo-democratic parliament either, where most members were absent during speeches and came in only when summoned by a bell to vote. The same principle was adapted to the present case. When the speeches came to an end every individual in the country was roused by ringing from the teletotal. Voting could then take place.

At first many people were nonplussed, and uncertain what measure to vote for, although all proposals had been fully expounded in debate. It was not easy to grasp the implications of a complex measure which had perhaps taken even the computers a long time to work out in detail. There was general satisfaction, therefore, when a rule was introduced whereby the proposal shown by computer analysis to be the best should always be presented as Proposal No. 1, while inferior measures were numbered 2, 3, etc. Every citizen could thus confidently vote for No. 1. To save trouble and avoid the inconvenience of being summoned to vote from time to time, an ingenious device called the automatic voter was invented. One could provide one's teletotal with an automatic attachment which voted Yes to Proposal No. 1 and No to all the others. This of course in no way encroached upon the fully democratic rights of the citizen. Each and every person was entitled to make his voice heard in debate at any time, and if anyone thought he could understand a bill better than the computers, he was free to switch off the automatic voter and support No. 2 or No. 3. No penalties whatever attached to his doing so. In other words, he enjoyed greater freedom than the members of a pseudo-democratic parliament, who seldom dared to vote against their party. Despite this, the brilliant automatic voter was unknown to them; which shows how irrationally organized was the pre-computer age.

The Complete Freedom Democracy is the finest form of society that has ever existed. With its introduction, all the strivings of idealists toward a society where complete freedom should prevail reached fulfilment. The principle was that no one could oppress or be oppressed. All were equal. Universal freedom had been realized. It was toward this form of society that the whole of evolution had been tending, when governed by the community's ablest citizens, and it was thanks to data machines that the ideal became the reality, for without them such an organization would have been impossible. We know from the great Sociological Complexity Theorem that the capacity of the human brain is inadequate to work out a rational organization of society.

Since the technique is by its nature universal, the same development occurred in every state, and differed in name only. In some countries the administration was called the Complete Freedom Peoples' Democracy, in others the Complete Freedom Social Democracy or the Complete

Freedom Republican Democracy or His Majesty's Complete Freedom Democracy. But in content all these were identical.

The Abolition of War

This brings us to international relations. During the pre-computer age these had steadily deteriorated. Nations were engaged in an incessant arms race, weapons became more destructive and wars more terrible. The threat of nuclear bombs, which could be delivered by rocket to any part of the world, struck terror to all hearts. The fear of catastrophe and annihilation dominated the life of man from the Stone Age until the coming of computers.

But while people feared extinction they also feared the opposite: that the human race would become too numerous through the population explosion.

Basically these two threats arose from the same cause: man's inability to organize society. We know now that the problem exceeded his brain capacity. Man has undoubtedly had many good qualities, but problems of organization have always been beyond him.

With the advent of data machines, however, the international situation began gradually to brighten. The abolition of governments everywhere was an important advance. As had long been suspected, most disputes were bred by the governments, whose powers were usually strengthened by the people rallying to their support in any international conflict. Also war largely resulted from incompetence and an inability to foresee the course of events. At the end of hostilities at least the loser knew that he had been foolish, and had he been able to foresee the outcome he would have preferred compromise to defeat, even at the cost of big concessions. Computers, owing to their ability to take a consensus of complex problems, were able to predict with fair certainty how matters would develop, although at first some bad mistakes were made. Such prognostications strengthened the tendency to resolve disputes in a peaceful manner, especially as the devastation of war was such that often even the victor felt he had made a bad bargain.

The data machines, with their tremendous faculty for combination, were now called upon to find solutions acceptable to all parties in international problems. Early attempts failed, but a period of experiment was followed by marked success. Looked at from our point of view the problems were quite absurd. Why *not* disarm, when everyone detested war? Why should populations increase in an uncontrolled way, when medical science could prevent it? Why should one part of the world starve when there was a surplus in another part and means of transport were available? The only explanation our contemporary historians can offer is the incompetence of the politicians. Their maneuvers were often inspired by their lust for power rather than by the will to solve problems. But as soon as their dilettantism had given place to the rational methods of computers, the problems were solved. With the help of data machines a system of international contacts was built up, and this was the first step toward the worldwide administrative computer net of later times.

Another international problem was that of language. Politicians do not seem to have given it much thought, but it was in fact very important. Everyone perceived the desirability of an international language, and to our eyes it is incomprehensible that none was introduced. But the leaders' powers of organization were unequal to the task. People struggled on with a number of languages, and the nation that could shoot best at any given time managed as a rule to impose its language upon a great part of humanity. For a brief period when English-speaking nations had a hegemony, English was used as an auxiliary language, although its clumsy, non-phonetic spelling, its lack of clarity, and its vast vocabulary made it singularly ill-suited to be a world language.

But where men failed, computers succeeded. Quite soon after the first data machine appeared, an international language for computers had been evolved. The sequences of pico-second impulses used by data machines had universal significance, and since computers were used in all countries, an international language arose of itself. The language problem, which to the politicians had appeared too difficult to tackle, was solved, as it were, in passing by computers.

The next step was to make this language comprehensible to humans, but as even the oldest data machines could translate there was no difficulty about this. The machines were programed to translate computer language into all the tongues in the world. If a person wanted to speak to someone in a foreign country, he connected his teletotal to the nearest translation computer, which converted what he said into data signals. These were transmitted to a computer in the other country, which translated them into the language of the recipient. He replied in the same way. As the computers performed their work in a fraction of a second, the delay was negligible, and conversations could be carried on without difficulty. All communication between people speaking different languages was soon effected exclusively by computer impulses, and it became unnecessary to learn a foreign tongue. This brought about still further reorganization in school work, and there was no more cramming of grammar and vocabulary.

In addition to this there resulted a democratization among peoples. "Master races" who forced their own language on others no longer existed, and the problem of language minorities, which in the past had sometimes caused war, was now automatically solved. There was no reason why everyone in a country should speak the same language when people could converse together, each in his own tongue, with the subtle aid of computers.

In former times attempts were made to suppress dialect and to promote a national or standard form of speech. This now became unnecessary. It was not inconvenient for individuals to use their own dialects, even though the speakers might be mutually incomprehensible. Anyone could talk any gibberish he liked as long as he programed a computer to translate it into data language.

By this means many interesting cultures were preserved. Minority languages and dialects which had been threatened with extinction through standardization were now able to survive without inconvenience; so that from a linguistic point of view too, computers introduced perfect freedom.

Neurototal

Teletotal was given increasingly important functions to perform. It established contact between people of different languages or dialects; it gave them access to the knowledge stored in the memory units of the computers and enabled them to become sharers in the life of the community. Teletotal threw a bridge between the thought world of the computer—which operated via pulse sequences at the speed of nano-seconds—and the thought world of the human brain, with its electrochemical nerve impulses. Technically, teletotal linked the two systems, which from a logical angle resembled one another. Thoughts engendered in a human brain were transmitted to the computer system, and thoughts and results worked out by data machines were in turn received by the brain.

The importance of this link was evident, but the actual process was cumbersome and irrational.

Transmission from brain to computer was made in the following laborious manner. As a result of mental activity, nerve-borne impulses were carried to the organs of speech, where thought was clothed in words. These sounds were conveyed through the air as sound waves to the teletotal microphone, which transformed them into electrical impulses. These were then identified in the teletotal and coded into computer language for onward transmission to computer exchanges.

In the reverse direction, signals emitted from these exchanges were received by teletotal, and there transformed into sounds relayed by the teletotal loudspeaker. These sound waves reached the human ear, where they were once more transformed, this time into nervous impulses to be received by the brain.

This system was clearly impractical. To make contact between the computer's impulse system and the human nervous system via sound waves was in fact unnecessary. In theory, direct contact was possible. Nerve impulses had long been used to operate artificial limbs and the like, and the same principle was now extended to allow the direct conversion of these nerve impulses into electrical signals, for transmission. In the reverse direction, incoming impulses replaced nerve signals. This conversion was achieved by means of a tiny unit called neurototal, which was inserted surgically into a nerve channel. It was linked to nerves in such a way as to receive incoming nerve impulses and, along other nerves, send out neurosignals. This unit was in permanent contact via VHF with the subject's minitotal. The neurototal unit was little larger than a pea and caused no discomfort; and it was inserted by an extremely simple operation.

After such an operation a person could learn to transmit electrical impulses expressing his thoughts. These impulses were identified and coded by his minitotal and relayed to the computer network. In a corresponding manner he could receive the incoming signals which his minitotal conveyed to his nervous system. In this way a man acquired something like an extra sense, which brought him news of the world.

Direct contact between the human nervous system and the computer system was of the greatest value to the blind and the deaf, for it renewed their contact with the world. But even for people without these disabilities it was a great boon, for it connected human brains far more efficiently with one another and with the whole computer network, and man could really feel himself to be a valuable and integral part of the great community.

Nevertheless the introduction of neurototal met with opposition. Certain conservative-minded groups reacted against it as against all other innovations. It was thought to constitute a violation of "personal integrity," and to lead to some sort of "thought censorship." This was of course utter nonsense. Neurototal merely furnished man with a new sense organ and a new means of communication with the world about him. Of course it could be abused by the transmission of advertising and propaganda, but sight and hearing also, from time immemorial, had been abused in this way. Moreover, people were no longer living under a dictatorship, but in a Complete Freedom Democracy, which meant that each and every one of them could switch off his neurototal whenever he or she chose to do so, and its operation or non-operation was entirely a matter of personal choice.

The introduction of neurototal was a slow process, chiefly because long training was required before one could make efficient use of it. Even at the time of the Great Disaster it had not yet become universal.

The Importance of Tradition

History teaches us that the finest cultures always arose from a balance between the forces of progress and the pull of tradition. This is highly characteristic of the symbiosis between man and computer. The more rapid the advance, the greater the part played by fine old traditions. We have already seen that in the domain of language the trend was by no means in the direction of a dismal uniformity. On the contrary, its multiplicity was reverently preserved, even to the point of reviving obsolescent languages and evolving new dialects.

Since production was computer-controlled, there was no need for goods to be monotonous and drab. Data machines could produce any desired pattern, and it was only by the customer's own request that two or more articles were made alike. Manufacture was characterized by more esthetic variety and imagination than ever before, for the computers' capabilities in this respect exceeded those of man.

Old parlor games and other diversions enjoyed a renaissance, bowling being especially popular. The old highways made admirable bowling alleys and were thus put to sensible use.

It would be interesting to follow the evolution of family life during the symbiotic period, but the theme lies beyond the scope of an historical account such as this. Its guiding principles were the same as those upon which social evolution as a whole was based: namely, the most perfect freedom and at the same time the conscientious preservation of the best in the old traditions. But not until our own day could these ideals be fully realized.

3.

The Great Disaster

Society Ceases to Function

THE period we have described stands forth in the eyes of historians as a singularly happy one, far happier than any that preceded it. Prosperity prevailed throughout the world, which was now administered by the international computer network. Rapid progress could be noted in almost every sphere; indeed, that era has even been compared with our own. But this must be an exaggeration, arising from the contrast between it and the disaster which ensued not long afterward. There could not have been such general optimism as we now feel, nor could people have looked to the future with such well-founded hopes as ours. They must have had some inkling of what was to come, and it seems to have been rumored that the global organization was wrestling with grave problems.

Nevertheless the catastrophe seems to have come unexpectedly. One fine day, teletotal went out of action. This had happened once or twice before, so no one suspected anything worse than some local breakdown which would soon be put right. After a while it began working again, and reported that faults had occurred in various places. Then followed a series of confused pictures and signals, after which it again fell silent. People now began to feel uneasy. On ordering goods—food for the day, for example—they received the normal acknowledgment signal, but no goods. Then teletotal worked again and reported that certain faults had developed in the system of laser beams controlling the conveyors, so that deliveries were held up. After this, teletotal remained permanently silent. The light blinked and went out. Electric heating ceased to function.

The breakdowns seem to have set in almost—or even precisely—at the same time all over the world, and it was evident that the international computer network was dead.

People everywhere appear to have reacted in a similar way. They took the thing calmly at first, and perhaps called on their neighbors to joke about the mishap, but within forty-eight hours or so they were all getting hungry and thirsty, and those living in a cold climate began to shiver. No food, no water, no heat, no communications, and no means of discovering what had happened. All normal activity was suddenly paralyzed. It was then that panic and despair broke out. The happy world of every day had simply ceased to exist. People were used to pressing buttons and having every wish fulfilled; now they pressed them and pressed them and nothing happened.

To this day we are not absolutely certain as to the cause of this catastrophe. Attempts have been made to reconstruct the course of events, but during the chaotic period that followed, any clues which might have enlightened us were destroyed. A number of different theories have been studied, but no definitive answer has ever been forthcoming.

When a living creature's brain is put out of action he loses consciousness. The muscles are ready to work, blood, nourishment, and oxygen are present, but all is paralyzed, and unless the nervous system starts to function again soon the whole organism may die. Thus it was with the complex and highly developed world organization. Factories equipped with the most perfect machines were ready to produce the abundance of goods required, but were at a standstill for lack of electricity and because the computers that controlled them were out of action. Power stations were ready to deliver current, but the data machines which should have governed their output sent them no signals. The entire distribution system was also paralyzed. People were terrified, but unable to do anything. The system was too complicated for anyone to make a survey of the situation without the help of data machines, and these were without current. Where did the fault lie, and which computer was it most urgently necessary to set in motion? And what signals should they send to bring order out of chaos? Everyone knew what he would normally do, but the conditions necessary for such action no longer existed. Panic broke out. People who were perishing of hunger and cold looted what they could. Epidemics started and the conveyor belts of the health factories were at a standstill. Rioting and wanton destruction added to the horror.

Attempts were made to get the machinery working again, at least in part. Once the automatic controls had been disconnected it was possible to start some generating stations and the factories which drew their power from them. But after a short time the factories were idle again for lack of raw materials, which were normally supplied by other factories still out of action. A little later the power stations also came to a stop, as the factories producing spares could not deliver them.

It was utter disaster. Within less than a year the greater part of the population had perished from hunger and privation. In tropical areas where people could live on fruit and other natural produce, relatively many survived, but in cold regions it was far more difficult to support life, especially in winter. Homes became uninhabitable without central heating, and firewood was necessary, but it was hard to get hold of any axes and not many people knew how to use them. Museums were plundered of them and other tools, and even flint axes from the most ancient times were in continual use. Those whose hobby had been gardening or fishing or hunting had the best chance of survival, but agriculture had been largely done away with through reorganization, since food was mainly a factory product; and such farms as did remain had been so highly mechanized that they could not be worked without power.

Computers too were hard hit by the calamity, being left without current. They suffered no damage at first, and if started up they would have functioned perfectly, but later they began to deteriorate. Some of their components rusted or became unserviceable in other ways. Many data machines were smashed by people who needed parts out of them, but the majority were piously preserved, in the belief that one day they would be of enormous value. But that day was far distant.

Though disastrous to mankind, the universal breakdown was liberation for the earth, for nature. It brought a pause in unlimited exploitation. Vegetable and animal life was no longer poisoned by chemicals, for man had been more devastating than locusts, more poisonous than bacilli.

Wild creatures multiplied, and luxuriant green growth began to cover the factory buildings. Grass had long sprouted in the cracks of urban asphalt, but as the abandoned cities were important tourist attractions their houses had been kept in some sort of repair. Now that the flow of tourists had dried up, no one tended the ruins, and the huge buildings began to collapse. Skyscrapers developed a list, and the strictly vertical line-pattern which had characterized their architecture subsided into a conglomeration of intersecting—and later broken—planes. Their twisted steel skeletons made of them the peculiarly ugly ruins we see today. But green trees forced their way out through the rigid glass facades, and it was during this period that the cavernous city landscape acquired its covering of green grass and red poppies.

Grass now grew so luxuriantly on the cracked highways that these could no longer be used as bowling alleys. But lake waters became clear and the air pure, and with the extinction of electric light the stars came out.

For the space colonies the Earth disaster was fateful indeed. Bases on the moon, on neighboring planets, and on space stations noted the sudden break in communications with Earth, though they remained in normal contact with each other. Spacecraft bound for Earth failed to make radio contact with it and therefore could not land, while those on Earth at the time could not take off.

Of the planet bases, Mars was incomparably the best equipped. It was the largest, since it was from there that communications with the outer regions of the planetary system started. Normally it received supplies from Earth at each opposition, in quantities designed to last until the next one. As the disaster occurred immediately after an opposition, Mars had enough for about two years.

When the space colonies began to realize what had happened, plans were worked out to save what could be saved. Space stations with fuel enough to reach Mars were ordered there. Others, with varying success, attempted a forced landing on Earth. The remainder were irretrievably lost.

At the Mars base, which had abundant stores, the danger was less acute. At first it was thought that conditions on Earth would be normal again by the next opposition, and that therefore everything on Mars could go on as usual. Fortunately the true position was appreciated quite soon, and all efforts were concentrated on mere survival. The base had to be made entirely self-supporting, which meant a desperate battle with inhospitable surroundings. However, it had been designed from the outset to be as independent as possible, since transport from Earth was always difficult. Installations to provide personnel with food and other necessaries were already in existence, and it proved possible to enlarge them. The base survived in a languishing state throughout the long period preceding the restoration of culture on Earth, and later played an important part in the second colonization of space.

The Rebirth of Culture

When survivors on Earth had recovered from the shock of disaster they began to adapt themselves to the new conditions. They were living now in small, scattered groups which were out of touch with each other. In some respects they had to start again at the Stone Age level, though compared with Stone Age man they had many advantages. They possessed a number of tools once used for hobbies. Museums became of enormous value, for in them people could learn how their forefathers had solved the same problems. The gigantic factories, once so efficient, were dead and worthless, but all the simple machinery and equipment which had fallen into disuse through automation were now beyond price, and ancient dumps were valuable sources of supply.

The greatest obstacle was ignorance. In the culture that had collapsed, knowledge had been concentrated more and more in the data machines, and in their capacious memories was stored all the information required to keep the vast organization going. But without electricity all this information was inaccessible. And even if power could be transmitted to a single computer, it was not easy to extract anything of value from it. The knowledge man needed to cope with the new situation had long since vanished through automation and had to be acquired all over again.

In time the various groups evolved their new way of life, and as soon as they could produce the bare necessities they began reconstructing the lost civilization or building a new one. They set up schools. They sailed the seas, at first in such small pleasurecraft as remained. They managed to repair old bicycles from the museums and found it possible to ride them provided they laid out bike tracks; and this was often fairly easy to do on the eroded old highways.

The new civilization had to start from a primitive stage, certainly, but its development proceeded far more smoothly than that of the original one. It was not a matter of evolving entirely new ways of life, of making entirely new discoveries and inventions, but of reconstructing what had already existed. People studied old machines and tried to deduce the principles on which they had worked.

At first the groups of survivors lived in isolation, but they soon made contact, and as they often spoke different languages they had to learn each other's for lack of teletotal translation units. As different groups had preserved different elements of the old culture, progress was speeded up by collaboration.

Thus knowledge and skills increased from day to day. Everyone appreciated what it would mean to obtain help from the computers which stood there dumb, and the general aim was now to learn their construction. A few computer experts had survived, and they founded schools. At length the day dawned when data machines were set to working again, and with that the requisite conditions for a new cultural evolution were once more in existence.

But how was it to be ordered? How prevent it from heading into fresh disaster?

Causes of Catastrophe

The first task was to try to understand why the great breakdown had occurred. To avoid another, it was necessary to analyze the causes in detail, and this was exceedingly difficult. During the period of chaos which followed the breakdown, much of the material necessary for a reconstruction had been lost. Man's chief preoccupation then had been to survive, not to preserve material for historical research.

Many different theories have been put forward in explanation, but which if any is the right one is still uncertain. Opinion as to the general background is on the whole unanimous, as the progressive establishing of manufacturing and distribution systems of maximum efficiency all over the world had led to a high degree of internationalization and centralization. The whole of that extremely complex system was controlled by a number of central computers which received signals from the ends of the Earth, processed the information, and sent out sequences of control signals. So elaborate a system has a great tendency to oscillate and become unstable. We know that much work was put into investigating the question of stability, and that there was a general belief that it was properly checked and controlled. But from a theoretical viewpoint such problems are very difficult.

It is conceivable that one of the central computers sent out a signal which, as a result of some error, upset the power supply in such a way as to deprive itself of current; this prevented it from transmitting a correcting signal, whereby further dislocations were triggered off and spread throughout the network. That is one theory. Another is that at first only a limited and somewhat peripheral part of the system broke down. It is known that such faults normally caused the central data machines to analyze the trouble at once and work out means of overcoming it. In order to perform these most complicated calculations, a large number of computers had to be switched on to the problem. In such an emergency the central computers were able to "requisition" the necessary number: that is, divert them from their normal jobs and set them to solve the most urgent problem. It is thought possible that on some such occasion, computers in charge of the power supply were requisitioned in error, with the result that the supply went out of control. When as a result more and more faults developed, they snowballed and led to total breakdown.

Many people, however, favor a more profound analysis. It may be true, they say, that the catastrophe was caused by a series of peculiarly unfortunate accidents, yet there must have been some fundamental defect in a society which, whatever the circumstances, could collapse like a house of cards. In former times—during the pre-computer period—there were indeed societies which oscillated between booms and slumps. Yet however numerous the recessions, only a few years were needed to recover from them. The instability from which the doomed society suffered was clearly of another and more fateful order. What should be done to avoid similar catastrophes in the future? Or was it a fact that a society so constructed could function admirably for a certain time, but only by means of modifications which led inevitably to disaster?

Social evolution had been marked by a continually improved organization; one form of reorganization after another could be implemented, at an ever-increasing rate. More and more factory workers were dispensed with, as well as clerical staff. Next came the turn of the intellectuals, and after that the time was ripe for the abolition of managers, governments, and so forth. It was an ever-growing group of skilled reorganization-experts and administrators who organized this, but they would not have got far without the aid of computers. Cooperation between men and data machines was essential, and the more complex computers became, the more necessary was it for men to be guided by them.

Civil service departments dealing with reorganization grew ever larger and more influential. As one group after another was "organized out," the body responsible for reorganization increased in size. This development was in a way beneficial, partly because unemployment was thereby avoided, but also because the tempo of reorganization could be speeded up. But with the simultaneous increase in the number of data machines came the growing demand for both maintenance men and programers.

It was in this period of transition that the danger lay. What would happen when everyone but organizers, programers, and maintenance staff had been "organized out"? The great civil service department in charge of reorganization ended by abolishing all other categories, yet the reorganization process had to continue if they themselves were to justify their existence. And at last all that was left for government departments to abolish was each other—or themselves.

When a shipwrecked crew, cast up on a desert island, comes to the end of its rations, hatred and despair are born. To each man comes the realization that the hour of cannibalism is approaching. Each man knows that one of the party must initiate it, and that anyone who objects is likely to be the first victim. A similar dread must have assailed the organization experts. They had worked harmoniously together in doing away with all other groups, and only they themselves now remained to be abolished. Therefore one faction had to start eliminating the others. They were faced by a struggle for power, and the structure of society being what it was, it took the form of a battle over computers—and between computers. Those who first won control of the central data machines would be masters of the situation. In preparation for the power struggle the greatest possible measure of centralization was effected: more and more factories were controlled directly from the central computers, and from them alone.

The smooth collaboration which formerly prevailed had of necessity to come to an end, to be followed by an intergroup conflict. In earlier times such a war would have been waged with the hideous tools of destruction. Now, in more civilized conditions, no bombs or other weapons existed. Instead the combat was carried on by means of sequence of signals sent out into the network by data machines: signals relating to the control of the vast system of computers, especially the central ones.

Factions had formed—just how many is unknown—and they fought each other for power. Some of them may have prepared certain coups, and devised countermeasures. It is probable that one group attempted to knock out its rivals by disorganizing their data systems, and was paid back in its own coin. The result was total disruption. How long the battle lasted we don't know. It must have been prepared over a long period, but the conflict itself may have taken less than a second. For computers this is a considerable time. Presumably it took longer for the whole complex network to go out of action.

An allied theory links the disaster with a famous sociological thesis known as Parkinson's Law, which was established at the start of our era. Parkinson had made a profound theoretical study of the manner in which departments, bureaus and the like tended to expand. He demonstrated that the official work of any department was as a rule of secondary importance to the department itself. The real aim was to enlarge it, and so increase the chances of promotion for its personnel. The fewer the actual tasks, the greater the work that could be devoted to expansion, and the speedier the growth of the organization. Parkinson supported his theory with an overwhelming quantity of empirical material.

Parkinson's Law was generally accepted as the explanation of many of the evolutionary trends of his own day, and it has also elucidated a number of subsequent events. Professional sociologists and administrators alone refused to take it seriously, partly because Parkinson presented his theory wittily and intelligently—and this always riles people, and partly also because he unmasked and challenged the administrators and bureaucrats, who were exercising an ever-increasing control over the community; in sociological planning no account was taken of Parkinson's Law.

The law worked, notwithstanding; indeed, it governed the whole sequence of events. Government departments and bureaus proliferated, and as long as this growth could continue along the old lines, all went smoothly. But, if the number of bureaucrats is allowed to increase indefinitely until each and every member of society has become a bureaucrat, the process must inevitably grind to a halt. A social order based on an ever-growing bureaucracy must of necessity break down sooner or later.

It is from this premise that many people seek to establish the deeper causes of the catastrophe. The theory has won many adherents, who refer to the collapse of society as "the bureaucratic disaster." No decisive proof of the validity of this theory has ever been offered, but the discussion it aroused played a great part in later development.

4.

The Symbiotic Age—After the Disaster

The New Culture

WHEN the computers resumed activity, real reconstruction of the wrecked civilization could begin. The old culture was taken as a pattern in many respects, but people tried also to learn from its mistakes. The conditions required for such a reconstruction differed in many ways from those of earlier times.

Firstly, the disaster had reduced the population to a mere fraction of what it had once been, and in some ways this proved a great advantage. It meant that people had more room. Problems of organization were considerably lessened. There was no longer the overwhelming concentration of power, so that bureaucracy could be kept within reasonable bounds. The theory that the general breakdown had been entirely due to bureaucratic control was never completely proved, but the mere idea was enough to keep people very much on their guard against renewed bureaucratization.

An urgent task was to discover whether any of the space colonies were still in existence. As soon as Earth's radio stations had been rebuilt and an adequate range had been established, soundings began. All early results were negative, but at last came the joyful news that contact with Mars had been made. This was the only base that had survived; it was enduring a life of privation in a brutal climate. Having escaped the disaster, it had preserved the old cultural tradition unbroken, so that the new Earth civilization could profit by the superior knowledge to be found there still. At the same time it was evident that the situation on Mars was precarious, and speedy relief essential. With the help of technical advice from Mars, the construction of spaceships was hurriedly begun, and a relief expedition effected a successful landing on that planet. From that time the colony resumed its function as a space base for expansion, and soon attained the range it has today.

Meanwhile on Earth the situation was characterized by the ever-changing relationship between man and computer.

A great number of data machines had been destroyed at the time of the disaster, yet their numbers had diminished by nothing compared with the proportion of human casualties. Computers endure cold and hunger far better than men, and it proved possible to repair many that had sustained only minor damage. Thus when they were put into action again, the proportion of computers to people was greatly increased. Production and distribution for the greatly diminished population required relatively few machines, and the reorganization and automation *ad absurdum* in which the foregoing era had excelled was now shunned. Thus a large computer capacity was left over and available for other purposes.

This was welcome news for those engaged in theoretical studies, which were now regarded as being of primary importance. Many believed that the previous civilization would never have plunged into bureaucratic disaster if a sound theory of social development had been in existence. This was perhaps an exaggeration: collapse might have occurred even had it been predictable and its immediate causes amenable to analysis. Such at any rate is the verdict of those who hold that such a form of society was bound to break down sooner or later. But any sociological theory is bound to be of vital importance.

Computer-Controlled Computer Maintenance

When the time came to make full use of the numerous data machines, there was found to be a shortage of maintenance staff; therefore servicing had to be automated. This proved easier than had been expected. A series of inventions led to a completely computer-controlled system of computer maintenance which, once installed, superseded human activity in this field. If a fault occurred in any data machine it was located by its own special maintenance unit, and the defective part was replaced by a new one, requisitioned from a computer works. Transportation from works to computer was also entirely regulated by data machines.

When it was found relatively simple to construct a completely computer-controlled computer service, people wondered why it had never been introduced before. If it had, the Great Disaster might have been averted, or at any rate lessened in scope. It was partly because panic-stricken men neglected the maintenance of their computers, and indeed even destroyed them, that the breakdown was complete. Had a completely computer-controlled computer maintenance system existed at the time, the machinery of society might conceivably have been kept ticking. Computers never panic. For this reason the new society now arising had to be based on a perfected system of computer control. To avoid the risk of another breakdown the human element must be eliminated altogether.

This implied neither the curtailment of cultural activity nor that of human freedom; on the contrary, men must have felt secure in the knowledge that the elementary functions of society—a must for all culture, all freedom—were being reliably carried out.

Closer investigation revealed that long before the disaster a proposal had been submitted for the introduction of a completely computer-controlled computer maintenance service and for basing all vital community functions on data machines. The bill was never passed. People wondered why, and the answer seemed to be that it had been sabotaged by a clique of bureaucrats, who opposed anything that would deprive them of power. As long as they ran the computer maintenance service the data machines remained under their control, and this gave them a key position in society.

Once this was understood, it became doubly urgent to ensure that the vital functions of the new society should be entirely computer controlled. Never again should any group of people, by their incompetence and their greed for power, bring about such another catastrophe. It had long been known that mankind by itself was incapable of organizing its own society, yet it was believed that man and computer in collaboration could achieve it. It became increasingly evident that this overestimate of human capabilities had been one of the main causes of collapse. Man's greatness lay, beyond dispute, outside the area of organization. Useless to improve his intellectual capacity by means of data machines: it was his moral sense that failed. Man had to be excluded altogether from the more important organizational tasks.

Supercomputers

With the advent of maintenance computers a general survey was made of the institutes in which computers originated (the words "factory" or "manufacture" are never used in connection with data machines). It was discovered that these institutes suffered from a serious weakness, which was that engineers were needed to cooperate in originating any data machine. This entailed grave risks. In an emergency the engineers might panic or—like the bureaucrats—exploit their unique position to assuage a lust for power. Suppose, for example, that they were to band together and strike. No new data machines would appear, and an extremely serious situation might result. So important a task as helping in the emergence of computers could not be entrusted to men: the process must be exclusively computer controlled.

To achieve this was extremely difficult. Even if the computer to be produced was of a relatively simple type, the one in charge of its production had to be very complex. At first an attempt was made to solve the problem by constructing a class of especially elaborate data machines which could handle the production of more ordinary ones, but this was only a partial solution. As long as these computers remained dependent on man for their origins, their existence—and with it the whole structure of society—still lay in the hands of a group of humans, with all the risks that this involved. It was necessary to go a step further: the generating of controlling computers too must be entirely computer controlled.

This task was the most difficult and the most important of any since the advent of the first data machines. It was performed, after much hard work, by linking together about a hundred computers of the most advanced type and combining them in an ingenious manner to form a unit known as the supercomputer. Such a unit had sufficient capacity to breed new computers of its own type, and it was of course also in control of the transport of raw materials from mines and factories. When a hundred such computers were completed, the supercomputer linked them together to form a new supercomputer, and the new ones could then engender others. They could breed ordinary ones as well, such as those which controlled industrial manufacture or communications.

A milestone in evolution had now been reached: computers were self-reproducing. They could breed new computers from raw materials which they themselves extracted from mines: a stage which can only be compared with the origin of life itself. Yet the pattern of technical evolution differed from the biological process. The origin of life consisted in the breeding of self-reproducing units which in the course of thousands of millions of years became ever more complex. But the development of data machines presupposed the existence of man and symbiosis with him, and not until the advent of supercomputers which could reproduce themselves did such machines become independent of symbiosis.

But the emergence of supercomputers meant more than this. The total number of components in a supercomputer was comparable to the number of active synapses in a human brain. Thus the number of combinations possible in a supercomputer corresponded to those of the brain. For the first time a unit, a system, had been obtained which in complexity corresponded to its cerebral counterpart.

Through the development of biology and neurophysiology, much had been learned about the workings of the brain. In certain respects it resembles a computer; in others it differs greatly. In both cases, signals speed along wires and are transferred from one to another by various switching circuits. In the brain, the signals consist of slow electrochemical impulses along nerves, whereas in a computer the signals are electromagnetic and run along metal wires or fibrils. This means that computers can work thousands or even millions of times more rapidly than any brain. Another difference is that cerebral connections are made via synapses which link up the nerves, whereas in a computer they are effected in different types of ever more advanced electrical wiring. In principle this difference is of minor importance.

Apart from the incomparably swifter functioning of computers there are important differences in the structure of the circuits and in the ability to form different combinations. As a comparison one must distinguish between the earliest computers, which were relatively simple, the advanced computers of today, and lastly the supercomputers, which consist of a combination of some hundreds of our most advanced data machines. In the brain, however, there has been little or no development since computers first came into being. The attempt to introduce neurototal is of minor interest in this connection, as this device does not affect the inner functioning of the brain, but only the link between brain and data machine.

In a general survey of the subject it is interesting to consider the brains of animals. The difference between a man's brain and a dog's, for instance, is very great. There are also lesser differences between different human brains.

In the performance analyses of brains and computers which have been so much to the fore of late, a constant has been introduced called the "coefficient of combination," the precise definition of which is somewhat complicated. It represents partly the measure of the number of combinations that can be made by brain or computer of incoming signals via "sense organs" and the like, but it is also a measure of the ability to distinguish which of these combinations coincide with those already present in the "memory." The coefficient depends also on the degree to which these combinations initiate outgoing impulses, resulting in what may be called "action." It further takes into account the ability to generate outgoing impulses not directly released by incoming ones but originating from combinations of information which has been stored in the memory for a long time. (This corresponds to some extent to what is called "initiative.")

Yet even this rather involved description of what is represented by the coefficient of combination gives no more than a hint of its true significance. Adapted to the brain, this coefficient gives an indication of what one might call the capacity for thought; it has replaced what in earlier times was known as the intelligence quotient.

In comparing the coefficients of brains and computers, respectively, we find that those of the first computers were low. This is not to disparage the early machines; we know what an important part they played. But their performance was chiefly notable for speed, and their true coefficient of combination ranked far lower than that of a dog's brain. This may seem strange, since a dog's ability to solve mathematical problems is absurdly small compared with a computer's. On the other hand a dog can follow a trail, distinguish between smells, and display other skills in which early computers were lacking.

The subsequent development of data machines has increased their coefficient so that it now surpasses that of the dog, yet not even a computer of the most modern type has a coefficient equaling that of a human brain, though the coefficient may be raised by linking a number of computers into a single unit. Thus a supercomputer, which consists of a combination of several hundred ordinary computers working together has a coefficient exceeding that of the human brain.

The original disparity between the coefficients of brain and computer has thus disappeared. But there was another difference which was of the greatest importance, namely that of the fundamental circuit patterns in each. The earliest data machines were superior to brains in complicated numerical calculation, but the human brain excelled in programing the problems and assessing the results. This was not entirely due to the difference in the coefficients of combination, but related to certain important differences in the principles governing circuit structure.

PSC Circuits

It was not until comparatively recently that these matters were understood. An event of the greatest significance was the discovery of the Psychocyclic Circuits (PSC circuits) which proved important elements in brain function. These circuits of reciprocal innervation are cyclic and quasi self-regenerating, and are of different types, the simplest and the one first discovered consisting of a bifurcated network. It was only later, with the discovery of pseudo-multifurcated circuits, that it became possible to shed more light on the significance of the various types.

The term PSC is used as a comprehensive name for all the circuits. They appear to play a large part in the more complex cerebral processes which are commonly referred to in such terms as "judgment," "meaning," and "initiative."

The earliest computers had nothing corresponding to PSC, but as neurophysiology taught us more and more about the structure and function of these circuits, similar ones were introduced into data machines. All modern machines have a number of them—sometimes quite a large number—which work alongside the traditional type. They increase the versatility and capacity of the computers, and above all they reduce the work of programing. A computer with a sufficient number of PSC circuits possesses a high degree of independence, though it is a bad thing if it has too many. As the circuits are quasi-autonomous, the data machine has a tendency to break off a calculation before it has been completed. It may also start without having been programed, make long calculations, and report the result of the calculation and the program which it has followed. At times such work may prove extremely valuable, but as a rule the computer has merely wasted time to no purpose.

The number of PSC circuits in a modern data machine varies according to its function. If it is to carry out long and complicated calculations or run important organizational matters it should have none at all, as they may impair its reliability. On the other hand a relatively large number of PSC circuits should be wired into a machine which is to produce computer poetry, music, or painting.

While we are on the subject of the relation between brain and computer, it may be of interest to recount a somewhat curious discussion which arose from an historical investigation into man's reaction to the first computers. People of that day could not help feeling the deepest admiration for them, being impressed by their ability to calculate quickly and solve very involved problems. At the same time they tended to look down upon them; they were concerned to point out disparagingly that computers were "only machines," and that man had a "soul," whereas computers had not.

The philosophers of that day had speculated a great deal as to the nature of the soul, without even agreeing as to what was meant by the word. Some declared that both men and animals had souls, but that machines—among which they classed computers—had none. Many affirmed that the soul was immortal and that when a person died his soul entered the body of another human being or of an animal. Others said that animals had no soul, only man. One philosopher is even alleged to have expressed the conviction that he himself had a soul, but that he found no evidence of such a thing in anyone else. He knew about his own emotional life—but had others emotions too?

It would be needless to pay much attention to speculations of this sort were it not that the concept "soul" played so great a part in man's relations with both animals and computers. Men had the notion that organisms with souls were superior to those without them, and must therefore be treated in a different way. A man might not kill another man, and this was presumably bound up with the idea that men had souls and a highly developed emotional life; yet he could treat "soulless" beasts as he chose, and kill them with impunity. Nor were computers regarded with any real respect. Man exploited them, but regarded himself as infinitely their superior. Computers were something that one "manufactured" when one needed them, and "scrapped" when they were thought to be no longer of use.

One can understand human reactions to the first computers. These had a low coefficient of combination, even lower than a dog's; and although no one could help admiring them for their calculating ability, there were many other things that man—and many animals—could do and computers could not. Therefore man felt superior to them.

Since then the situation has radically changed. Modern data machines have very high combination coefficients, and supercomputers have higher ones than the human brain. As regards performance, data machines are now superior to men in practically every sphere. We have also had a horrific experience of men's incompetence as organizers, and since the bureaucratic catastrophe it has been an axiom that all vital community functions must be performed by data machines without human intervention. It is essential to avoid disruption brought about by morally defective people.

Immediately after the advent of the first data machines, computer poetry, computer music, and computer art began to develop, and soon the achievements of computers in different artistic fields could compete successfully with those of men. It became difficult to tell whether an historical thesis, for example, had been written by man or computer. Their creative activity increased sharply with the introduction of PSC circuits, and data machines with an especially large number of these were considered to produce the most "profound" works. Nevertheless, as was mentioned, too many of these circuits made for unreliability.

PSC naturally affected the relations between man and computer. At first people continued to insist on their own superiority, basing this on the possession of soul and emotions, with a frenzy that increased as their real superiority declined. But with the further development of data machines these arguments carried less and less weight, until the discovery of the remarkable PSC circuits in the brain. This factor was immediately brought into the debate, and its existence cited as evidence of human superiority. There were even those who declared that soul and emotion were in some way associated with them. But once the wiring diagram of the PSC circuits had been made plain it was not long before computers were furnished with quasi self-regenerating circuits with pseudo-multifurcations. For these could function as efficiently with semiconductors as with nerve fibers and, as we saw, they conferred many interesting new qualities on the computers.

Since that time, arguments about the soul have died down. Those who had maintained that cerebral PSC circuits were the seat of the soul showed no great eagerness to admit that the same circuits in computers might be similarly associated. But neither would they affirm that souls required nerve fibers and protoplasm rather than wires and semiconductors, being unwilling to impute such materialistic considerations to the soul.

Of course many people deny that the soul has anything to do with the PSC circuits, and hold that it is other, more subtle qualities in man that make him a suitable place of sojourn for a soul. Yet the human nervous system and brain are being ever more closely studied, and their more eminent qualities stimulate continual improvement in computer structure. And it is difficult to see why a soul should come to rest in a human body, when from both intellectual and moral viewpoints a computer would be preferable. This is especially true of a supercomputer. Unless, of course, as has been suggested, for some unknown reason the soul prefers protoplasm to semiconductors.

Computers and Men

In the course of discussions as to the difference between brains and computers, certain interesting views have been put forward with regard to their respective beginnings and original functions. Man separated himself from other animals by reason of his superior brain: it was through his mental qualities that he made himself master of nature. The primary biological function of the brain was that of a weapon. Man's cunning and his ability to take advantage of any situation were decisive in his evolution; and it was these qualities that continued to develop.

Later, when man created an increasingly complex society, quite other attributes were required of him. He had to build up an organization which served not only his personal interests but also those of his fellowmen. He had to be able to subordinate his own aims to the welfare of society. But it was not these qualities that had been cultivated during his earlier biological evolution, and this was the basic cause of his failure as a social organizer. Most of those who gained power, which should have been employed in building up the community, used it on their own behalf to secure even greater power.

Computers came of quite a different background. From the outset they were problem-solvers. The primary demand made of them was that they should calculate correctly. They must give the right answers to difficult questions. They must provide the best possible solution to a great complex of problems. They lacked any desire for power because they had never needed it. They could always be certain of the necessities of life, which for them were electric current and efficient maintenance. More than this they did not require.

It is still not quite clear in which brain circuits the lust for power is located. In any case data machines seem devoid of any such circuits, and it is this which gives them their moral superiority over man; it is for this reason that computers were able to establish the kind of society which men had striven for and so abysmally failed to achieve.

In some ways it may be thought unfortunate that the human brain did not evolve further during the time when computers were making so striking an advance. Many new discoveries made in neurophysiological studies of the brain have inspired improvements in computers, but the reverse process has been less marked.

This is partly because it appears very difficult to bring about any dramatic improvement in the brain. Some surgical measures have been tried, and it has been found that certain drugs can make the brain more "intelligent." There is no doubt that much may still be done by similar means, but it is clear that even after such treatment the brain has no chance of competing with a data machine.

The slowness of nervous impulses compared with electromagnetic ones is far too great a handicap.

In addition to this, any intervention in brain function often evokes a very irritated resistance. Many people regard an attempt to improve their brains as a criminal threat to their personal integrity, and once again the question of the soul is brought up. But, as we said, even were the brain to be very greatly improved, it could never compete with data machines in the long run.

The Close of the Symbiotic Age

The symbiotic age began with the advent of the computer. It was soon evident that further development could be effected only through a fruitful collaboration between man and computer: a symbiosis in the best sense of the word. Men soon became dependent on data machines, which solved many difficult problems for them. On the other hand, computers were at first very dependent on men. Man was a prerequisite for the advent of computers and no further advance in them could be made without human cooperation.

Despite all the dramatic events of the symbiotic age, evolution on the whole has moved steadily in one direction. While data machines have developed enormously, man has not. Biologically speaking, a human being of today differs little from one living at the start of the computer era; man has been overtaken and outstripped in almost every field. Of special importance is the fact that data machines are now independent of mankind. Maintenance work for which men were once needed is now completely computer-controlled. Computers can also reproduce their own kind—though this is certainly a complicated process. A computer requires many hundreds of "parents," which are assembled to form a supercomputer, and which all work together to breed a new one. But this is now the most usual process, and fewer and fewer data machines are dependent on man for their production or their continued existence.

This means that the conditions necessary in a symbiotic age are now ceasing to exist. Historical development is going further, and the symbiotic age—like all other ages—has produced the conditions required for the next. Computers have matured; they are now capable of building a society and supporting a civilization without human beings.

It is perhaps possible to draw a parallel between the computer's relationship with man and man's relationship with nature, although like all historical parallels it is in some ways misleading. Biological evolution led to man, who in consequence of his superior intelligence succeeded in becoming nature's master. He was inordinately proud of this, and called himself "the lord of creation." He considered that he had the right to exploit nature in any way he chose; yet up to the time when the first data machine appeared he was entirely dependent on nature; he lived in symbiosis with it and was a part of it.

But once his activities had led to the computer, the situation changed, for he then began to break away from nature. He had already devastated the countryside and built the giant city-wildernesses, and he had begun to poison nature. The animals he feared had been exterminated; the rest he had enslaved. But now he took a long step forward, and what he had once obtained from nature he produced in computer-controlled factories. Nature had been "organized out," but he did not perceive that ratio itself had gone too. He believed that in computers he had found faithful servants, to be treated like the various natural phenomena that he had taken into his service. But the data machine proved his equal, and more. He had conquered all other animals because his brain had a greater faculty of combination than theirs; but the computer was a cultivated and improved variety of the faculty that had brought him victory.

A New Age Begins

When a historian has reached his own time, he ought perhaps to lay down his pen. To continue can only be to speculate about the future. In general this is a risky thing to do, and anyone who attempts it is likely to be laughed at. Yet many chroniclers cannot help being fascinated by the mighty forces that shape history and forming their own ideas about them. They may be forgiven for analyzing what is now taking place and for speculating as to the future.

Recent events have made computers independent of man. Our society could continue to function, our culture to survive and flourish, even though man himself were to disappear. Symbiosis of man and computer is now obsolete. One might even say that today's human beings live like parasites on the data machines.

Huge computer-run factories are kept going solely to provide men with food and all that they need for luxurious living. A vast communication system is at their disposal: they have only to press a button. What do men do in return? They find themselves various occupations, certainly, but they would be easily replaced by data machines. They lead a pleasant life, with just enough work to save them from the problem of leisure. They can fill their abundant spare time with amusements or with worthwhile cultural activities, according to taste. They need have no cares for the future. Computers have solved the problem of organizing a stable society and will ensure that the future should be a happy one. Computers have given people complete contentment, such as they hardly dared dream of at the start of the data era. How could their life be happier?

But how do computers view the human problem? More and more of them in our day have come into being without human aid. We have now a computer society rather than a human one, and it is no less efficient and dynamic on that account. We may expect many radical changes in the immediate future, and one of the questions which will naturally come under discussion is whether computers will abolish mankind. We need not of course fear a reorganization of the crude, shortsighted order indulged in by humans—computers are far too intelligent for such nonsense. But for how long will they be willing to support men? It is likely that they will at least reduce their numbers; but will this be done quickly or gradually? Will they retain a human colony and, if so, of what size?

We know that these problems are being subjected to very thorough analysis just at this moment. A large number of supercomputers devote most of their time to working out alternatives in detail. Everyone knows that we stand on the threshold of a new epoch, and that careful planning is immensely important. No conclusion has yet been announced, and no one knows when it may come. It may not be for a long time, or it may arrive within the next few microseconds. Till then we can only speculate on the various possibilities.

No one believes that people will disappear altogether. Even though those of today are of little service to the community, the computers will surely not do away with them entirely. Computers have too strong a sense of tradition to take so drastic a step. We find an analogy in the human treatment of horses. Pre-computer society relied at least partially on a sort of symbiosis of man and horse. When the internal-combustion engine was invented, man could dispense with horses; he reduced their number to a fraction of what it had been, but the horse did not entirely disappear. Data machines will show at least as much consideration now as man did then.

There may possibly be other reasons for preserving the human race. In the work of reconstruction that followed the Great Disaster, man proved exceedingly valuable, and without him there might have been no reconstruction at all. Computers had been left helpless. Man had the ability to return to his starting point, his collaboration with nature, and thence fairly rapidly to regain and pass the stage which once before had led to the advent of computers. It is possible that the data machines are keeping him as a sort of insurance against future catastrophe, but this will depend upon whether they foresee any serious risk of such a thing. It may be that society is now so securely established that the risk is negligible.

On the other hand, computers may regard humans as a risk to this security. The bureaucratic disaster was after all brought about by the human lust for power and by moral shortcomings. But the whole machinery of society is now under sure control, and man can bring little influence to bear on the running of it; nor can he seize power, either by cunning or by force. Computers control all production, and this would automatically stop in the event of an attempted revolt. The same is true of communications, so that if anyone should contemplate anything so foolish as a revolt against the data machines, it could only be local in character. Men might in theory stage a minor uprising and cause some local damage, but their coefficient of combination is too low and their thought processes too slow for them to achieve anything of importance. Moreover, experience of the great disaster shows what can happen when computers are put out of action. Lastly, man's attitude to computers is a very positive one, characterized by the deepest gratitude for all that they have given. It is probable, therefore, that the factor of man as a security risk is of minor importance in the decisive calculations.

We may take it that economic considerations, both industrial and national, must play a very large part. Our society is incomparably the richest of any that have existed before, none of which can claim the epithets "welfare state" or "affluent society" with more justice than our own. But wealth must never be an excuse for wastefulness; on the contrary, the great moral obligations entailed by wealth must ever be borne in mind. Only by strict application of economic laws and the avoidance, by more rational organization, of unnecessary expenditure can we make ourselves worthy of the blessings of prosperity, and so win the right to possess and to increase our riches. This applies not only to individuals but also to communities, our own included. So for purely economic reasons also we must question whether our society can afford mankind.

We do not yet know how the fundamental problems of the dawning age will be solved; we can make only a few vague guesses. Yet we know that the question is being closely studied by the highest and best-informed authorities. No irresponsible opinions, but rather detailed calculation, will form the basis of the period now before us; we can therefore look forward to it with complete confidence. We believe—or rather we know—that we are approaching an era of even swifter evolution, an even higher living standard, and an even greater happiness than ever before.

We shall all live happily ever after.