The Keynote Address

THE PROMISE AND CHALLENGE
OF THE COMPUTER

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California has always been synonymous in my mind with innovation and progress, and the past year has given me fresh reason to think so.

Seven months ago, at the NBC studios in Burbank, I had the pleasure of presiding at the inauguration of a new dimension in business communications. By means of two-way, closed-circuit color television, two large assemblies of RCA's shareholders—one in California and the other in New York—were brought into instant visual and verbal communication at our 45th Annual Meeting. Despite their continent-wide separation, the two groups were as effectively unified as though they were meeting under one roof.

Three months later, the sense of participation was almost as direct and immediate with the successful performance of Ranger VII. Again, this was an accomplishment that spanned the continent. RCA cameras and transmitters built in New Jersey, aboard a spacecraft built in California, completed their historic mission at a third point—the moon.

Today, I am glad to be in California and to experience again this sense of participation in progress. It is expressed this time in a gathering of more than 4,000 scientists and engineers from a new and dynamic industry that traces its line of descent directly to the beginning of the art and science of electronics. The modern electronic computer is the precocious offspring of wireless telegraphy and radio telephony, and it is creating a new dimension of progress through the high-speed handling of electronic signals.

Since the birth of RCA in 1919, our principal efforts have been concentrated on transmitting, receiving, and recording information by electronic means. It was natural, therefore, that our scientists and engineers were among the first to begin the study
of electronic computing techniques, and I believe their contributions to this new art have been significant.

Six years ago, when we entered the computer field commercially, it was the logical extension of everything we had been doing up to that point. We are making good progress—in technology, programming, service, sales, and revenue—and we will soon announce some significant new product developments which we believe will contribute to the industry’s future growth. Last month, we crossed over into the promised land of computer profits. While the trip was rugged, we found the new terrain to our liking, and we expect to stake out a permanent profit claim.

THE LESSON OF STANDARDS IN ELECTRONICS

During my 58 years in electronics, I have seen several dynamic industries emerge from conceptual beginnings in the laboratory. The most memorable were radio communications, radio broadcasting, sound-movies, black-and-white television, and color television. While their origins differed in detail, all shared a common experience that has a distinct parallel today in the rise of computers as another major member of the electronics family.

All were intensely competitive from the beginning and have remained so. But they began fulfilling their potential only after agreement had been achieved for technical standards prescribing the kind and quality of service to the public. A pattern for progress was thus fashioned without sacrificing the vital stimulus of competition in developing newer, better, and more economical equipment, and in furnishing more efficient service to the user.

I am convinced that this same process must occur in the computer industry. Even now, the computer is stirring a revolution of the brain just as steam power stirred a revolution of the muscle. The potential effects are almost incalculable—but their full realization calls for the same definition of ground rules that permitted the growth of the older electronics industries.

When sight was added to sound with black-and-white television, the need for technical standards as the basis for orderly growth was clearly recognized. The receiver in the home and the transmitter in the studio had to be built to operate on the same standards. A committee representing all major elements of the industry obtained practical unanimity on such standards as a precondition to the establishment of a public television service. It was on this foundation that black-and-white television grew so phenomenally in the post-war era.

Again, in the early 1950s, the industry underwent the long and difficult process of reaching agreement on a workable service to the public. This time the issue was color television, and two sharply different systems and standards were in dispute. One was based on a mechanical “color wheel” which could produce color images but whose transmissions could not be received by the black-and-white receivers in the nation’s homes. It was therefore incompatible with existing equipment. The other was an all-electronic compatible system which could be seen in black-and-white on any TV set in the home.
It was evident that, if the incompatible mechanical standards were to be adopted, the industry would be saddled with an inferior system and the public with an inferior, more costly product. To adapt the 10 million sets then in existence in order to receive a degraded picture in black-and-white would have cost the public approximately $500 million. Without an adaptor, the TV screen would simply go blank.

Clearly, there were many inherent advantages in adopting an electronic rather than a mechanical system of color television. For the industry, the basic issue came to this: should the millions of dollars already invested by television set owners be jeopardized by an incompatible color television system?

Once more, an industry group was formed to draft signal specifications and standards. The result, after 32 months of work, was a complete set of compatible color signal specifications closely following those that had been developed through long years of laboratory research and engineering. These ultimately became the basis for color television in the United States—a business that now stands with data processing in the forefront of the nation's industrial growth.

The industry committee did its work so thoroughly that every subsequent advance in the color television art has been put into service with no change whatever in the original standards.

THE NEED FOR STANDARDS IN COMPUTERS

The phenomenal rise of data processing bears certain resemblances to that of color television. It is confronted in similar fashion by a question of compatibility. The investment of the user is again a primary consideration. The issue becomes more acute as the growing computer industry intensifies its competitive drive for new and more ingenious ways to accommodate the user.

From the two-score or so machines in existence barely a dozen years ago, there are now some 17,000 general-purpose computers in the United States alone, and the number is increasing at a rate of more than 500 a month. Within the coming decade, the computer population can increase enormously.

Whether it realizes its full growth potential depends in very large degree, however, on the measures we undertake now to establish the basis for orderly development. The interests of the industry and the needs of the user demand a far greater measure of compatibility and standardization among the competing makes of computers and the means by which they receive and transmit information.

Neither the operators nor the machines we have built for the processing and transmission of information can yet speak to each other in a commonly understood and accepted language. The means of preparing data, of forwarding and entering data in the machine, and of instructing the machine in its use differ sufficiently from one make of equipment to the next so that none can readily accept the product of another.

We function today in a technological "Tower of Babel." There are, by conservative count, more than 1,000 programming
languages. And there are languages within languages—in one instance, 26 dialects, and in another, 35 dialects. There are eight computer word-lengths in use. There are hundreds of character codes in being, at a ratio of one code for every two machines marketed. Four magnetic tape sizes are employed with at least 50 different tape tracks and codes.

Standards have not been accepted even for commonly used symbols, instruction vocabulary, or program development procedures. Words which have currency throughout the industry assume different meanings, depending on whether a man has trained in Pasadena, Poughkeepsie, or Camden. We have yet to produce a universally accepted computer glossary.

No means have yet been perfected for a program in one basic language to be run efficiently into computers of different makes. The result has been needless duplication, delay, and waste—both to the manufacturer and to the user—in cost, in equipment, in operating efficiency, and in manpower and skills.

Incompatibility has compelled the manufacturer to build optional choices into peripheral equipment for the input and output of data. It has required him to maintain various types of the same equipment, or to build to a customer's specifications on each order. It has diverted needed engineering and programming talent from the vitally work of new product and systems development.

The burden of incompatibility has been even more onerous to the user. It has meant the extra cost of providing hardware and programs to handle the differences between incompatible systems, the cost of extra machine time to process data set for another computer, the cost of training people to do things differently, the cost of not being able to do the job immediately.

Last year, an estimated $2 billion was spent by American business and government for privately developed computer programs, representing thousands of man-years of effort. Yet, when a change to new equipment is made, portions of this effort must be thrown away because they have no validity to another make of machine, or they are retrievable only at further cost.

I have heard it said that even a degree of standardization and compatibility might inhibit the progress of the art. In my judgment, this argument is without substance. The nature of a computer is such that its operation is governed far less by its internal construction than by the program that is given to it.

The effort to bring order to the flow of computer intelligence need not affect competition either in creating programs or in seeking new generations of increasingly efficient machines. On the contrary, the result could be a greater concentration of effort toward this primary goal.

PRELIMINARY STEPS TOWARD INDUSTRY STANDARDS

During the past four years, certain essential preliminary steps have been taken toward industry standards and compatibility, largely under the aegis of the American Standards Association and the Business Equipment Manufacturers Association. Representatives of the industry, of users, and of technical groups have
proposed industry-wide standards in such areas as data transmission, information exchange, and character recognition.

Working with a committee of the International Standards Organization representing the computer interests of 13 foreign countries, they have recommended world-wide standards which would make it possible for a credit card or invoice produced in any country to be read by equipment anywhere in the world. Another recommendation, for information interchange, would make it possible for computers in all countries to talk to each other in a common language, when it is adopted and implemented by the manufacturers.

FURTHER ACTION ON STANDARDS IS ESSENTIAL

That phrase—when adopted and implemented by manufacturers—is central to the resolution of the problem. For in our country, at least, the action is voluntary, and until these and other standards are put into general use they remain little more than statements of hope.

Today, Western Europe is energetically seeking to close the computer gap and is moving toward the establishment of standards. During the next five years, the use of computers in European industry and government is expected to develop at an accelerating rate. Ten years from now, the foreign market might well equal that of the United States.

Unless we achieve some coherence in our own ranks, we may find ourselves following instead of initiating standards.

All of us, in computer manufacturing, in communications, and among the user groups—at the technical as well as the managerial level—share a common interest in the free interchange of information, and the media and equipment through which it flows.

This demands that we give compatibility the urgent consideration which it merits but which it has not yet received. It requires the wholehearted support by all of us of the standardization work that is now going forward, and implementation of the results with all deliberate speed. It will require that we submerge our differences, through fair and equitable compromise, to achieve greater ends.

I do not suggest that existing systems be discarded. That would be unrealistic as well as costly. Even today's computer has reached maturity in one basic respect: its average time between failures, measured in minutes only a decade ago, is now measured in months. This is a level of operating reliability far beyond that of either the automobile or the airplane.

But new generations of systems are coming, and the time to bring order into progress is now, before they have fully arrived. Standards can be established which, if planned with thought and foresight, can guide us in the future, linking our separate efforts and facilitating the common evolution of our industry. Such standards are indispensable to continued progress.

THE COMPUTER'S IMPACT ON THE FUTURE

As the shape of tomorrow's technology takes form, the
volume and accessibility of data stored in the computer will play a
decisive role. All information as to what to do, how to do it, and
what data to do it with, resides in the memory of the machine.
With larger and faster memories there are few limits to the tasks
that can be solved or the speed with which they are completed.

The time is soon coming when these memories will be capable
of storing up to 100 million bits of information, retrievable in
fractional millionths of a second. For external memories, the goal
is a trillion bits, possibly advancing later to capacities that are many
times greater. By these means we can hope to store all of the
information that is presently contained in all the world's libraries.

Tomorrow's standard computers and their peripheral equip­
ment will instantly recognize a handwritten note, a design or draw­
ing which they will store and instantly retrieve in original form.

The computer of the future will respond to commands from
human voices in different languages and with different vocal inflec­
tions.

Its vocabulary will extend to thousands of basic words in
the language of its country of residence, and machines will automatic­
ically translate the speech of one country into the spoken words
of another.

The computer itself will become the hub of a vast network
of remote data stations and information banks feeding into the
machine at transmission rates of a billion or more bits of informa­
tion a second.

Laser channels will vastly increase both data capacity and
the speeds with which it is transmitted.

Eventually, a global communications network handling voice,
data, and facsimile will instantly link man to machine—or machine
to machine—by land, air, underwater, and space circuits.

We will see computer switchboards in space, similar to those
presently in operation on the ground, routing in milliseconds any
communication to and from virtually any point in the world.

The interlocking world of information toward which our
technology leads us is now coming closer to realization. It will be
possible eventually for any individual sitting in his office, laborato­y, or home to query a computer on any available subject and within
seconds to receive an answer—by voice response, in hard copy or
photographic reproduction, or on a large display screen.

We will see the emergence of national and global information
processing utilities, serving tens of thousands of subscribers on a
time-sharing basis. These utilities will accommodate the specialized
needs of researchers and engineers, lawyers, medical men, sociolo­
gists, or the general needs of the public.

The ordinary citizen may well carry an individual credit card
for use anywhere to charge his bank account electronically over a
worldwide data communications network that would link up with
the telephone systems of all nations.

Such an arrangement could employ simple input units located
in all retail establishments—service stations, restaurants, hotels,
and other public facilities. These would be in direct and instanta­
neous communication with a system of banking computers to permit
the transfer of funds without the many duplicate bookkeeping and mailing steps that characterize the present credit card system.

A scientist will be able to discuss a problem by two-way television with a colleague anywhere on the globe, and both of them will be able to query a computer at another terminal point for assistance in finding the solution.

Private corporations, many of which will be international in ownership and operation, will have instant access to production and market information from data stations positioned around the globe.

Similar systems will operate on a vastly larger scale for government agencies—military, diplomatic, and economic.

The computer will evaluate and offer alternate courses of action, taking into account all the known and probable variables of a given situation.

This emerging pattern inevitably will set in motion forces of change within the social order, extending far beyond the present or presently predictable applications of the computer. It will affect man's ways of thinking, his means of education, his relationships to his physical and social environment, and it will alter his ways of living.

I believe, for example, that television in a vastly expanded form will become our major instrument for communicating general or specialized information. The same broadband channels that accommodate the TV picture signal can also transmit masses of computer data at ultrahigh speed for instant display.

One day, we will receive our newspapers and technical publications, photocomposed by a computer, by direct display on a wall screen in the home or office. If we wish to retain any part of them for further reading or reference, it can instantly be produced in electrophotographic copy.

As computers become amenable to simple commands, they will become as indispensable to education as the reference library. Indeed, they will become tomorrow's reference library, used by every student from the upper elementary levels through university.

Far from eliminating the need for intense intellectual effort, they will permit young people to undertake mental explorations far beyond the boundaries of the present classroom world.

The computer already is opening areas of knowledge long denied us by the sheer magnitude of the mathematics involved. The implications are no less fundamental for the social and life sciences than for the physical disciplines.

By correlating vast quantities of data and uncovering new relationships we can for the first time obtain significant information on social and human behavior—from the destructive tendencies of some to the learning power of all.

THE ULTIMATE CHALLENGE POSED BY THE COMPUTER

The ultimate implication of the computer is that it provides a means of releasing the productive powers of the human brain to an almost limitless degree. Yet the computer imposes as a precon-
dition the sternest discipline to which the mind has yet been subjected.

Even to use the machine, we must apply clear and precise logic to situations which heretofore were assumed to be beyond analysis. We must state precisely what we know or do not know, and what we wish to know.

If we are to develop the computer to its full potential as a reference storehouse of human knowledge, we face the immense intellectual challenge of researching every major field of human activity, of assembling, analyzing, and identifying its documents, and reducing the information to acceptable machine form.

Before the end of the century, I believe that these codification efforts will coalesce into what unquestionably will become the greatest adventure of the human mind. We shall achieve a far more comprehensive understanding than we have today of man and his environment. We shall do so through the orderly compilation of accumulated knowledge and wisdom, beginning with the days of clay tablets and papyrus scrolls. The human horizon will then encompass all that man has ever known, and all that his science will enable him to know.

But how swiftly we scale these heights depends upon the steps we take today to bring order and compatibility to our art. It is an urgent task to which all of us who bear the responsibility for leading this industry into the future must turn our efforts.

It was Socrates who said: "Let him who would move the world move himself." His words have particular pertinence at this time and in this place. For we of the computer industry must surmount today's challenge before we can advance to tomorrow's promise.

Let me conclude on a personal note. Whether your individual role is large or small, the significance and scope of this new science and industry are such that in a genuine sense you are making history. The impact of your knowledge and talents will echo down the corridors of time. The quality and content of life on this planet will be profoundly affected—indeed are already being affected—by your labors.

I am grateful for the opportunity to have shared a few thoughts with you.
LUNCHEON SPEAKER

The Conference Luncheon Speaker was Gerard Piel, Publisher of Scientific American. As publisher of a magazine with broad appeal to the scientific community, Mr. Piel has contributed to the difficult task of describing and interpreting the sometimes bewildering developments in the fields of science and engineering. He has chosen for the title of his subject, "The Computer as Sorcerer's Apprentice." Mr. Piel is a graduate of Harvard University (magna cum laude) and holds honorary doctorates from Lawrence College, Colby College, Rutgers University, Columbia University, Tuskegee Institute, and the University of Bridgeport. Prior to building the new Scientific American, he was for six years Science Editor of Life magazine.