INTRODUCTION

Thank you, etc........

As with many emerging technologies, the arrival of microelectronics and computer technologies has been characterized by a lot of technological missionary zeal. The result is, of course, a great tendency towards fads and hoopla and misplaced belief by most in the imminent arrival of either the millennium or doomsday. My purpose today is to provide a bit of "historical perspective" in the hope of putting this matter of computers and their application into a frame of reference that offers a more realistic appraisal of where we are as well as where we may be within the coming decade.

Although people have always tended to ascribe human characteristics to inanimate objects and especially those which are the tools of their trade -- sailors are one of more familiar examples -- the computer industry seems dominated by
this anthropomorphic mind set. One can only marvel at the
wistful -- and at times even wishful -- thinking that
christened a device for recording the presence or absence of an
electromagnetic field as a "memory."

Somehow, though, the epitome of all these technological
malapropisms is the use of the word "generation" to describe
this year's computer model. As we gather here, then, we are
told that we enjoy the benefits of the fourth computer
generation and that the fifth is close upon us. Nonsense. It
is just once again a marvelous demonstration of the
technologist's capability for misusing language as well as
their apparent overweening reluctance to try to understand the
beings who speak it.

So today I am going to talk to you about the real generations
of computers. By so doing, I realize that perhaps I am
perpetrating the unfortunate practice I have just deplored.
But hopefully I can at least provide perspective rather than
promotion.

The supposed generations of computers, by the way, are: The
first, based on vacuum tube technology; the second, on discrete
solid state technology; the third, the integrated circuit; the
fourth, the LSI; and the fifth, a somehow mixed affair of
advanced circuitry and new architecture -- embodying
"artificial intelligence." Now all that is obviously a
technologist's view of the world.
A societal view would be a quite different one -- one in which a "generation" of computers is determined more by their role in society rather than by the technology of their innards. As we shall see, not surprisingly, the time span of such a computer generation is about 20-25 years.

What we'll do for the next few minutes is look at the arrival of computers in society in the late 1940s as another wave of immigrants similar to those human waves that arrived in the U.S. from Europe in the 1870s, 1890s, and the early part of the 20th century. The process of assimilating those human immigrants into American society parallels very closely the process by which computers are being integrated into our daily lives.

THE FIRST GENERATION

As with the great waves of human migration, the computer "immigrants" were preceded by early "explorers" -- the calculating devices of ancient history, the inventions of Charles Babbage, and so on. But the first wave of immigration, as so often happened with its human counterpart, came in the wake of great social upheaval -- namely World War II.
Out of turmoil of that conflict there arose a restlessness. First in a trickle and then in large numbers the computer immigrants came -- seeking change and opportunity. The typical computer immigrant arrived on the shores of society just as did its human counterpart -- a thing of basic skills and little sophistication with a tremendous language barrier between it and the society in which it chose to reside.

Society, on the other hand, busy with its many other preoccupations, mostly ignored the newcomer. In certain computer ghettos, however, such as California, there was growing concern as it proliferated. But in general, the new immigrant was tolerated -- the subject of ethnic type jokes dealing with its stupidity in handling customer complaints about bills or its obvious alien characteristics as in "I just heard the boss is planning to replace me but he's got to find a computer that knows how to grovel." Meanwhile, it was permitted to go about its cumbersome, sweatshop kind of work, stamping out payrolls and solving equations of fluid flow. Unable to communicate, it stayed tightly cloistered in ethnic neighborhoods -- called computer rooms.

Teaching this immigrant new skills was a slow and arduous task. By and large, it was so busy earning its keep that only in off hours -- after sometimes working 140-hour weeks, pausing only for brief health checks -- was there time to improve its
basic skills. Pidgin English dialects began to come into use. Although most were quite arcane and had strange names and sounds such as FORTRAN, COBOL, and ALGOL, some degree of communication with society began to be achieved. There was obviously still a lot of sign language required.

From shortly after World War II -- for 25 years this tide of immigration grew -- attracting new and more powerful fellow travelers.....all of them sensing opportunity.....seeking to make their mark. Many were quickly snuffed out in the accident-prone world of industrial America. Some survived and prospered. But all-in-all, these new immigrants were a rough hewn crew stumbling through society. Much as did the early human immigrants to the U.S., they increased the wealth of their industrial masters, and of the whole economy -- they were a new and vital source of energy and productivity. But the computers were also an alien lot, unintegrated and certainly incapable of serving any broad spectrum of societal need. These computer immigrants were, in short, the cheap manual laborers of the new information age.

For the last 10-15 years, the second computer generation has begun to arrive on the scene. The scenario follows that of its human counterpart -- the sons and daughters of first generation immigrants. The labors of the first generation have laid down a basic economic and intellectual foundation from which the
second can go on to greater achievement. This second generation is better educated. That is, its capabilities are drawn from a broader and deeper base of technologies. As a consequence, horizons in society for the second generation have broadened and a greater variety of opportunity is available across which to apply their skills. No longer are its members relegated to the sweatshops of numerical calculus and clerical processes. They've entered other occupations -- e.g. every police department includes them in its roster. Although hardly the equivalent of a good Irish cop on the beat, in their own way they make life safer for all of us. They perform routine chores for air travelers. And a few, following in the footsteps of Illinois pioneer Don Bitzer, have made it into the profession of teaching. Slowly, then, the offspring of our immigrants are making their way into society.

But not surprisingly that is mostly for the more adventuresome. As a whole, the second generation is somewhat torn -- clinging to its attachment to the old ways of the first generation, yet wanting to explore the new horizons now open to it. Language continues to be a problem -- although some can converse in the language of their adopted society, most are still far more comfortable with their native tongue. Some computers and their friends (programmers) still hanker for the ethnic cabals of old and decry the defection from the old ways. And if you will grant me just a bit more poetic license, members of the first generation just shake their disk heads in bewilderment over the doings of their offspring.
Society at large can no longer ignore the second generation's presence. They offer great promise and yet many of us -- such as a lot of educators -- are silently suspicious -- when our back are turned, will it do us in?

No one observing the introduction of word processing into the clerical function of an organization -- much less the agonizing forays of computer-based education or the feeble attempts of executive management in business to use this tool -- could conceivably use a term like "fourth generation" -- much less fifth -- to describe the current state of affairs. I saw an advertisement for a workstation the other day that speaks volumes as to where we really are. In full two-page glory stood a desk with a personal computer on top while down below the bold headline informed us that this was a "smart desk." You can literally see there the dotting, hard-working, first generation parent bragging about how smart the kid is.

And yet the pace of change is very great -- we are perhaps a bit more more than halfway through the second generation -- by the early '90s the third generation will be fully upon us.

THE THIRD GENERATION

To pursue my analogy, this third generation will be educated and knowledgeable, i.e. based on a spectrum of technology its "grandparents" couldn't imagine. It will be literate and
articulate and fully integrated with its human partners. It will be capable of taking its place in every arena of human endeavor -- not only accepted but sought after by society.

The point of all this is obvious. If the metaphor of generations is to be used at all, then it is more than simply misplaced to use it to describe the status of electrical circuits. For the "generations" of computers, in fact, are defined by the ways in which people can use them and, with that in mind, it should not be surprising that roughly 20 years -- not five years -- is the dividing line between the generations. Those are the generations of mankind, and the introduction of computers into society is faithfully following that generational pattern.

Well, with that much perspective, let me now explore the promise and pitfalls as we approach the end of the second and the beginning of the third generation of computing.

TOWARD THE YEAR 2000

First let me deal with the underlying technology. The current technological trends of our industry are easy enough to describe. First and most important is the increasing diversity of microelectronics technologies available. This includes not
only an increasing number of basic materials such as galium arsenide and silicon but a continuing increase in the configuration of those materials and the structure of the circuits constructed from them. The technological implication of this is greatly enhanced potential for effective application of microelectronics. But the economic and societal implication for most companies and countries is that technological cooperation is essential to survival. I'll come back to that point.

As far as computers are concerned, the third generation could easily be thought of as the generation of the individual workstation. The computing world of the '90s will be dominated by supercomputers and workstations. Communications is the third key element of the world of the coming decade. In the field of engineering and computer-aided design a harbinger of the future is the "domain" system produced by Apollo Computer Corporation. The architecture and software technologies which are of dominant importance are vector and parallel processing (and they will increasingly be found in combination), data base management, and closely related to it the emerging array of technologies loosely grouped together as "artificial intelligence." Finally, there are the technologies associated with man-machine interfaces. Although these technologies are all experiencing rapid change, that change will accelerate between now and the early 1990s. Essentially, one basic technological power in each of these areas by two orders of magnitude over the next 7-10 years.
It is important to keep in mind that being in the midst of the second generation of computing we are still dealing with an oddity -- a cultural oddity -- at one and the same time more and more visible and accepted and yet somehow still strange to us. The transition to a fully integrated third generation has profound implications -- more so than all computer history to date.

Perhaps more important, it makes possible a non-pathological solution to the state of "interdependent independence" in which society finds itself.

Interdependence. For nearly 50 years, from Wendell Wilkie's One World to Toffler's Third Wave, we have been reminded by writers of every ilk of the growing world-wide interdependence. For all our lives that force has been growing, pressing, and shaping the world around us. And inevitably, as it has grown, the counter-balancing force of individuality has also grown. Look around us. Take energy and food -- the very basics of existence: There is practically no nation on earth self-sufficient in both these necessities. Yet have we seen larger and larger conglomerations of people into nations? Quite the contrary. Fifty years ago there were 79 nations in the world -- today there are 170.
As trend-watcher John Naisbitt has pointed out, "An extraordinary thing happened in the late 1960s -- the U.S. gave up the myth of the melting pot. For years we [were] taught.....that America was a great melting pot, as if we were all put in a giant blender and homogenized into Americans. Now we have given up that myth and recognize that it is our ethnic diversity [our individuality] that has made us such a vital, creative country." So we must structure ourselves to deal with this "interdependent independence" that will be necessary for 21st century existence. Is it achievable? That cannot be said with certainty. But I have experienced examples of what can be achieved.

The technologies of computers and communications will provide us the opportunity to pursue individuality to a degree not possible today -- in education, for example. And at the same time they will provide the only analytical resource capable of dealing with the incredible interdependencies of our world.

Let's explore that for a moment. No topic is of greater interest or importance in late 20th century than that of job creation. Computers, or more generally microelectronics -- have a complex and seemingly paradoxical relationship to this issue of jobs. Microelectronics is the only salvation for manufacturing industries. But, at the same time
microelectronics will dramatically reduce the labor intensity of these industries. In effect, high technology preserves the economic benefit traditional of manufacturing industries while reducing their importance as a source of job creation.

Nor will the computer, microelectronic, and high technology industries generally in themselves create the necessary jobs for those displaced from older manufacturing industries. The main issue for high technology companies is already the reduction of labor intensive processes. This is much more than a matter of conventional thought regarding robots and automation. Likewise, it goes beyond the productivity that microcomputer-based workstations can bring to the engineer or marketing person. It is a matter of redesign or replacement of most of the products of these industries to accommodate to the changes brought about by microelectronics.

Yet appropriate application of new technologies, including computers, will allow us to attack major unmet societal needs such as high quality, more available, more affordable education and training; better and more affordable healthcare; the morass of the agricultural sector; decaying urban areas; overcrowded prisons; and energy. And in so doing we can create the jobs we need. So again, the appropriate perspective -- a third generation perspective -- is one that concentrates on the application of the tool -- rather than a fascination with the foibles of the tool itself.
For example, Control Data is using computer technology to deliver training, education, job skills, and other information to small business entrepreneurs and inner city and rural community residents. The results are dramatic.

We've started 15 Business and Technology Centers that provide office space and office services to help newly starting small businesses grow and prosper. These centers are the cornerstones of job creation networks in the cities where they are located. Through computers at these centers, entrepreneurs can take courses in management skills and gain access to important marketing information. In other words, by means of computers, people can have greater independence -- i.e. their own company -- while having the knowledge access to deal with interdependence -- i.e. market knowledge, and so on.

Control Data also is involved in delivering computer services to farmers through the establishment of independent, locally-owned, computer service businesses in rural communities. They provide farmers with data to make better business decisions and help them better manage their operations. Because the services are offered through local dealers, new businesses are created in these small towns. Again, you can see that appropriate application of computers can yield greater potential to pursue one's individuality in a world of increasing interdependence.
Let me move on now to a more close-up view of this third generation computer (and its human companion) at work. A few brief scenes will serve to illustrate the powerful and integrated systems of endeavor which are possible as these more capable grandchildren come into the workforce.

Take, for illustration, the matter of computer-aided design to which I have referred. As you know, this technology has rapidly grown to be a matter of survival for American industry in the face of growing world-wide competition. Extending its usefulness almost daily, CAD-CAM is surely one major key to our success against the combination of cheap labor and sophisticated manufacturing technology that faces us.....not just from Japan, but from places like Brazil, Malaysia, and Taiwan. And I want to come back to that in a moment.

The second generation's role in attempts to modernize industry is one of monitor or scorekeeper. Through its efforts, we gain precise information to help us pinpoint inefficiency and waste. Those computers keep our records, issue our checks, and some of them keep watch on the quality of our products.

But all this scorekeeping does little to expand the basic capabilities of the key person in the most important place -- the engineer working on the product. As the third generation
has dawned, that is changing, partially because of improved technological capability, but much more because of a changed perspective -- a more complete understanding of the man-machine team and how it can function.

That understanding will significantly change the way we work and live. But let's investigate just one aspect of this phenomenon and what it means to engineering design process.

The scene opens with the animation -- using computer-generated graphics -- of the aerodynamics of an aircraft wing. You, the engineer, now begin the design modification, with the computer guiding and prompting you on the process.

Do you want to examine a library of standard designs? Do you want to run additional tests? Each step is checked against design rules and you are informed of errors or deviations along with suggested corrections.

Once the design modification is complete you can "see" the performance in a simulated wind tunnel.

This type of expert system will not only improve the learning process, but will be applied by industry to improve quality and shorten the design cycle.
Now let's eavesdrop on some engineers at a Westinghouse lab. One says to the other, "Double up on the current. Let's see if she can take it." The circuit breaker shudders and snaps. The trip bar had shattered. High voltage was all over the place. The engineer merely shrugs and says, "Let's roll it back to the trip point, thicken up on that pivot, and run it again."

A few keystrokes made the change -- because, again, the design was being simulated in a computer. Product testing takes place on the spot. Results of an experiment, stored in the computer's memory, can be replayed again and again until you, the engineer, are satisfied. Stress analysis is easier and less expensive. A product is created, or improved, in much less time -- at much less cost.

Realizing the potential of the third generation will not be automatic. It depends mainly on the policies and attitudes -- the approach -- society at large takes. In this regard, too, we have a direct analogy to the waves of human immigrants who reached America's shores.

And as with all potential for advancement, there is the contrary potential for human exploitation and suffering as well. This is not the place for a digression into the perils of computer fraud, privacy invasion, and human manipulation
which are possible as a result of a fully computer-integrated society. I do, however, need to spend a little time describing some of the policies and practices we humans -- society -- must take if we are to best utilize the capabilities of our third generation friends.

At the top of the list is a greatly increased level of cooperative effort -- the only way in which the necessary resources can be marshalled to solve pressing problems. In industry, cooperation must be at the level of basic and applied technology. Over the last dozen years, there has been growing concern among thoughtful Americans about the decline of the U.S. position in a number of important and visible world markets. This concern has not been misplaced. The U.S. position of leadership in many fields and markets has increasingly been challenged, often successfully, by other nations.

On balance for perhaps 20 years or so following the end of World War II, the U.S. benefited dramatically from its international science and technology transfer activities. It could probably have continued to enjoy this situation but for two policy "failures" -- public and private. First, the U.S. was increasingly wasting the resources necessary for research and development through continued duplication of effort with
regard to basic and applied research. Both public and private attitude and policy contributed to this waste -- as it still does. Second, U.S. firms failed to acquire the rights to the technologies and techniques developed overseas on the basis of U.S. science.

These failures have been compounded by the fact that overseas competitors profit from massive government, legal, and financial support, and from government-encouraged intercompany cooperation. The deep pockets of these firms and their governments can buy both new technology and market share. American firms are at best ill-equipped to counter such efforts individually. As a result, there is a growing interest in cooperative research ventures.

Properly constituted, such ventures are joint activities that allow firms to share research results which they can then individually apply to new products, processes, and services. They allow each participating organization to greatly leverage, or extend the reach of, its research dollars.

MCC -- Microelectronics and Computer Technology Corporation -- is under way in Austin, Texas, with 16 companies participating. I'm proud that Control Data provided a major part of the initiative to get MCC organized and launched.
MCC's four initial projects involving very large-scale integration (VLSI), software technology and systems architectures are aimed at producing major breakthroughs in the development of specific computer systems for selected applications. These basic technologies will be essential to the full development of the third generation as well, of course, to its successors. No one of the participants could fund that scale of R&D on its own.

The long-term vitality of any industry -- and certainly of high tech industries -- rests squarely on the existence of a large number of competitors -- individually innovating and creating new products and services. Yet, the history of most industries indicates a natural tendency toward consolidation into fewer and fewer firms as the need for efficiency and scale economies in production gains ascendancy. The debacle of the auto and steel industries are only the most obvious examples of the long-term results of this phenomenon.

So another area of cooperation involves the sharing of technology by existing companies with new, more innovative companies the existing companies help spawn.

Last summer, Control Data established and staffed ETA Systems, Inc. The business purpose of ETA is, very simply, to design, manufacture, and market the world's fastest, most powerful scientific supercomputers. In order to do this, the
architecture, the circuit technology, and software being
developed for successor machines to our Cyber 205 have been
transferred to ETA. Thus, initially then, the technology is
flowing from Control Data to ETA. But over the years, that
flow will reverse. One of the major benefits of supercomputer
development at Control Data over the years has been the flow of
technology from it to the lower computer product lines. So, in
the case of ETA, that flow will continue and the ultimate
beneficiaries of this exchange will be all of our customers.

At a national policy level, however, we seem immobilized by the
jaws of growing interdependency and economic instability.
Rather than a more integrative, cooperative approach, we are
experiencing a rising tide of special interest bickering. This
policy dilemma also is evidenced by a misplaced debate with
regard to a so-called industrial policy, that concentrates
almost entirely on the financial dimension of such a policy.
But this is not the place or time for discussing that complex
subject.

Suffice to say that in recent years there has been a pernicious
discussion of choosing between "services" and "manufacturing"
industries or the "death of smokestack America" discussion.
Traditional interests need not die. The industrialization of
the U.S. economy did not mean the elimination of U.S.
agriculture but rather its transformation to take advantage of new technology. And new educational infrastructures (e.g. the agricultural extension system) were essential to that process. Just so, the move into a service-dominated economy should not mean the elimination of traditional manufacturing industry but rather its transformation to take advantage of new technology. Not every farmer or each and every segment of agriculture has survived. Not every company or industry need survive the current transition, but manufactured products must be a vital part of our economy. The computer-aided engineer, factory process, and marketeer will make that possible.

CONCLUSION

Let me conclude briefly by quoting from Irving Shapiro's new book, America's Third Revolution, which will appear next month. In it he says:

"America has launched three revolutions. The first was for political freedom. The second, the Industrial Revolution, was technological and material in focus. It took a nation rich in potential and made it rich in fact. Though we think of that revolution as history, it is still going on. The third revolution, unnamed, lies even more in the column of unfinished business. It is a revolution to make real the notions of social justice and equality, a revolution driven by a vision of a nation as rich in quality as in quantity.....one of its premises is that a wealthy society has few, if any, excuses for not being just and humane....."
And Shapiro goes on to state that his main concern is with the question of what it will take to deliver on the promises of the nation's revolutions..... Nothing is more essential to the answer to Shapiro's question than microelectronics and computer technology. But mere technology is not enough. Successful application in the future will require new patterns of individual as well as corporate behavior.

In short, what is required is human leadership to shape a societal fabric of cooperative endeavors. If we can, the third generation of computers will be there -- ready to take its place at our side.

Thank you.