INTRODUCTION

Good evening. What a wonderful day I have had. Besides being informative and stimulating I must confess it also has evoked more moments of reminiscence in a few hours than I can remember. Thirty-five years ago this month I made a trip to Oak Ridge, Tennessee to discuss potential employment in their computing section, and 34 years ago last month, while in graduate school at Berkeley, I was privileged, at Livermore, to begin a career in computers -- one which has brought excitement, challenge and fun.

More than anything, however, it's been my privilege over all these years to know a lot of wonderful people, many of whom are here this evening.

So, the words: "thank you, ____________, it's a pleasure to be here," are much more than the usual perfunctory rhetoric.

Some 20 years ago speaking to the Society of American Historians, Dean Acheson observed:
"When Mr. Lincoln said that 'we cannot escape history -- we, even we here' -- he meant that we cannot escape historians, escape from being written about, gossiped about, and, perhaps, made the target of epithets. This is a tolerable fate. 'Sticks and stones will break my bones,' says the nursery rhyme, 'but names will never hurt me.'

Acheson continued:

"While public men cannot escape historians, they would do well to forget about them while they get on with their job.....a sense of history seems to suggest finding the test of action in imagining oneself appearing well in a great pageant of human life, reaching back into the mists and moving on into the clouds .... [Gentlemen, I say] to hell with it."

Acheson's advice to those in public life is equally applicable to those of us whose task is to provide the world its products and services. Meeting today's needs, solving today's problems, requires every ounce of will and energy we possess. There is no room for excess concern over history."
Even so, perhaps, a small serving of "historical perspective" may help to put matters into a frame of reference that offers a more realistic appraisal of where we are and where we may be within the coming decade or so. And that is what I would like to do for the next few minutes this evening.

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 charge 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. Actually that's misstated -- the industry has not yet reached the cosmetic efficiency of the automobile industry, so it's only been able to turn out a truly "new model" every five years or so -- thus we have been spared the generation hoopla except on a quinquennial basis. As we gather here tonight, then, we are told that we are about to enjoy the benefits of the fifth computer generation. Nonsense.
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, to recapitulate, 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, new architecture and new software -- embodying the marvelously encompassing term: "artificial intelligence." Now all that is obviously a technologist's view of the world.

A societal view of computers would be a quite different one -- one in which a "generation" of computers is determined more by their role in our world rather than by the technology of their innards. As we shall see, not surprisingly, the time span of such a computer generation is 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.

II. 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, the pathfinding of Alan Turing, and so on. But the first true 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 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 solving equations of fluid flow and stamping out payrolls. 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 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 economic need. These computer immigrants were, in short, the cheap manual laborers of the new information age.

III. THE SECOND GENERATION

For the last 15 years or so, 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 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 not exactly 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. A few have even made it into the profession of teaching. Slowly, then, the offspring of the immigrants have made 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.
No one observing the introduction of word processing into the clerical function of an organization -- much less the feeble attempts of executive management 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 a couple of years back 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 doting, hard-working, first generation parent bragging about how smart the kid is.

And yet the pace of change is very great -- we are a bit more than 3/4 of the way through the second generation -- by the '90s the third generation will be fully with us.

IV. 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.
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 is faithfully following that generational pattern.

V. The Future -- Questions and Pitfalls

It is not my purpose this evening to paint some grand picture of the third generation at work. In this first place each of you is no doubt as skilled an artist as I in that regard. But I do wish to discuss for a moment the role of the United States in providing future leadership for this industry.

In that regard it is well to remind ourselves that while the "third generation" goes to work far and wide, the driving force of advanced computer technologies remains, as it has been from the beginning, the requirements of high speed computing. Without a healthy U.S. supercomputer industry the third generation may well be the last of American origin.
To those of us who are involved this may seem obvious, but there are a disturbing number of people who would have us believe otherwise. Worse yet, there are many who simply don't care or who don't understand the long-range implications to the United States of losing indigenous capability in advanced technologies.

To cite just one example consider a recent paper from the National Science Foundation. While it gave nodding recognition to the capability of new advanced supercomputers such as the ETA-10, its major implication was that a handful of supercomputers would suffice and in any event, that "....mini-supercomputers, supplying the equivalent of one hour of Cray time in 4-10 hours are competitive because the average turnaround time for a one-hour job on a Cray can easily be this long."

The policy implication of such thinking in terms of funding to support the use of supercomputers is a cause for considerable concern. That concern is far more profound than some esoteric argument of minis versus maxis or one computing architecture versus another. Rather it is rooted in the seminal role supercomputers play in advancing the underlying technological capability of the United States --- their role in furthering scientific knowledge, methods of numerical comp., and counterpoint of the economics of the supercomputer business.
Technology Fallout

First then, it is worthwhile to remind ourselves of just how much important technology development has resulted from supercomputers. Almost by definition, supercomputers incorporate state of the art architecture, circuit devices, packaging, and cooling technologies to provide the highest possible level of performance.

Take circuit devices. Twenty-five years ago this meant pushing vendors for the fastest possible transistors. A few years later it meant cooperating with semiconductor vendors to develop high performance small scale integrated circuits -- ECL logic circuits, ECL register file and memory chips, and ECL gate arrays. The most successful ECL product families - the MECL 10K-100K grew out of supercomputer needs in the late 60's. The ECL 1K RAM was a workhorse for the CYBER 205 and CRAY 1 (prior to that the semiconductor industry saw TTL as the only volume RAM business). Highly successful standard gate array such as the Motorola MCA-2500 came about in similar fashion. This push for performance through advanced circuit devices continues today, and ETA using high density 20K CMOS circuits is a prime example.
Packaging is another technology that is frequently challenged by supercomputer designers who constantly seek denser packaging in their quest for performance. In the past this has led to such things as the cordwood module in the 6600 and the multi-board module in the 7600. Continued emphasis on packaging is evident in the fact that an ETA-10 processor is contained on a single board. SRAM and DRAM densities require die to board requirements of 400-1000 I/O ports and high reliability chip coatings.

Beyond circuitry and packaging there have been advanced architectural concepts -- parallel functional units, memory hierarchy, what we call today the RISC architecture, vectors and many others -- all of which resulted from supercomputer development. And further yet there has been and continue today to be, innovations called for in connectors, fibre optics, coax, plating and ultra high quality process control techniques.

In short, no matter where you look across our industry you find technologies and processes spawned a decade or more ago by supercomputer development. Will the same be true a decade from now?
VI. ARE WE WINNING OR LOSING?

Well, five years or so ago there was a re-awakening in the U.S. as to the need for supercomputers and by 1983 it was sufficiently vigorous enough to give rise to headlines such as:

"U.S. companies need help in high tech fight Congress told" (Washington Times, 6/30/83), or:
"Supercomputers -- can the U.S. beat Japan?" (Newsweek, 7/4/83)

That concern, however, centered more on the computers themselves and not their role as technology incubators. Nevertheless this was a healthy development, and many no doubt feel that with the FCCSET report, NSF's Advanced Scientific Computer Program, the commercial success of Cray Research, the advent of ETA and so on, that we have regained momentum and an industry infrastructure sufficient to success. We have not.

First of all we are woefully dependent on foreign sources for much of the technology for supercomputers. Second, we have restored neither the breadth of policy nor the practices which were the essential underpinning of success in the first place. Third, there is little recognition of the importance of non-U.S. markets in the economics of supercomputers.
The Japanese, I assure you, well understand that advanced technology is both the result of and the underpinning of supercomputer development. They also understand world market dynamics as well as the essential weakness of the U.S. in both regards.

A forceful reminder of this was given a State Department delegation in Tokyo just last month. They had gone to discuss trade and market access (with regard to supercomputers), and returned from the meeting in a state of shock. The State Dept. people told us they had never experienced such blunt language from the Japanese. Not only did the Japanese refuse any kind of market access accommodations, the statement was made that neither Cray nor ETA could survive; that had neither the financial strength nor the access to advanced technology available in the large vertically integrated Japanese companies. In fact, the Japanese stated that Cray and ETA are anachronisms — passing anomalies. They suggested that they could be merged or perhaps alternatively the U.S. might just let them die and have IBM take over the supercomputer business.

That arrogance is not without foundation. For example, let me go back to the technology "spawn list" I recited a moment ago.
The economic workhorses which justify all basic semi-conductor processing equipment advances are the SRAM/DRAM. U.S. industry is just now stabilizing 256K DRAM. The Japanese are delivering 1 meg. and have announced 4 and 16 meg. DRAMS. The implications are particularly profound when you consider who builds the machines to produce those devices. Packaging is even more serious. Simply stated we are dependent on Kyrocera. When we tried to work with them on some advanced requirements for ETA we were told by policy they would not work on requirements outside those of their Japanese customers. I could go on, but there is no need. The proof is there for anyone to see. And there is no evidence that that situation is changing for the better.

Next consider the second factor that I mentioned, that of appropriate policy and practice, or more broadly stated the appropriate infrastructure.

First it is necessary to note that supercomputers are the highest risk business in the computer industry. The reason is straightforward because there is both great technical risk and great market risk. The technical risk is obvious since by definition one is working at the limits of technology. The market risk is great because the market is quite small relative to other available markets which have the potential for far greater financial return for the equivalent investment.
The thing that has made possible past success is cooperation by government, industry and the universities. In the 50's and 60's the environment was characterized by enlightened self-interest and financial support from knowledgeable government agencies working with small entrepreneurial teams of computer engineers. The work was underpinned largely by government funding in the National Labs, universities and major company basic and applied research efforts.

The orders from Livermore for the first 6600 and 7600 computers was of enormous help in reducing the risk for Control Data. Of perhaps even more importance was the technical expertise in the Labs, particularly with regard to system software. The same was equally true of the National Labs and Cray Research. In a very real sense there was a partnership between the most advanced builders and the most advanced users in making reality of a dream.

In every case there was also a crucial cooperative relationship between the computer company and a major merchant semi-conductor company -- in other words, large company-small company cooperation. Again there was a partnership.
Some years ago we gave this mode of operation the name "vertical cooperation." Vertical cooperation can and has made it possible to operate without vertical integration, to reduce the inherent risk of supercomputer development and to capitalize on the strengths of the American economy: entrepreneurism and risk capital, active government support for research through its procurement practices, strong support for university research and vendor-customer partnerships.

Today that fabric of cooperation has both a lot of holes and some ragged edges. For one thing there is the obvious ragged state of the U.S. semiconductor industry. There is the funding problem facing universities as they have worked over the past five years to recover from a decade of serious funding neglect. More subtly and more devastatingly, there are many more avenues of exploration in terms of both applications and computing devices, which beckon seductively. It is not necessary tonight, after a long day and a great meal, to examine each and every one of these problems. What we can do, however, is understand one salient fact: that the uniqueness of supercomputers both technologically and economically demands creative and cooperative approaches to procurement and use, and that it is vital that we do so.
VII. CLOSE

It has been the privilege of those of us here in this room to have taken part in fostering the seminal element and driving force of the entire computing and information industry. As our third generation offspring make their way throughout the world, it's an appropriate moment to acknowledge our good fortune and renew our determination to provide for their future as well. My company and I intend to do so. And we look forward to working with you who are the wellspring of technological leadership in high speed computing to assure that future.