The Rise and Fall of the General Electric Corporation Computer Department

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The computer department of the General Electric Corporation began with the winning of a single contract to provide a special purpose computer system to the Bank of America, and expanded to the development of a line of upward compatible machines in advance of the IBM System/360 and whose descendants still exist in 1995, to a highly successful time-sharing service, and to a process control business. Over the objections of the executive officers of the Company the computer department strived to become the number two in the industry, but after fifteen years, to the surprise of many in the industry, GE sold the operation and got out of the competition to concentrate on other products that had a faster turn around on investment and a well established first or second place in their industry. This paper looks at the history of the GE computer department and attempts to draw some conclusions regarding the reasons why this fifteen year venture was not more successful, while recognizing that there were successful aspects of the operation that could have balanced the books and provided necessary capital for a continued business.

Introduction

There are truly four intertwined, and in some aspects disjoint, stories that epitomize the almost 15 years of association of the General Electric Corp. with the production of computers for general consumption.

- First there is the story of the ERMA (Electronic Recording Machine Accounting) for the Bank of America;
- Second, the development of larger lines of computers from the NCR 304 to the GE 600 series;
- Third, the development of time-sharing; and
- Fourth, the story of the corporate management portion of the Company[1] trying to achieve a second place standing in the computer market.

Even before the stories told here had their start, the possibilities of developing a line of computers by GE appeared doomed. While the company had built special order machines including the OARAC and the OMIBAC, and had incorporated computer technology into their network analyzer and the power control simulator, there was no organized project to produce computers for the open market, and in particular there was a policy not to compete with IBM in this area. George Metcalf was general manager of the Specialty Electronics Department of the Electronics Division of GE, under the vice-president of the Electronics Division, W.R.G. (Doc) Baker, in the late 1940s. He had been responsible for the design and construction of a machine for the Wright Field Aerodynamics Laboratory, that he considered a candidate for sale to the insurance industry. After visiting two insurance companies in New York City in early 1950, he received a message through the president of GE, Ralph Cordiner, that he was to attend a meeting with the president of IBM, Thomas J. Watson, Sr. Metcalf recalled the one-sided conversation:[2]

> Young man, you have been calling on my customers, and I will not tolerate this. You will stop immediately or we will withdraw our substantial annual purchases from General Electric Company. Thank you for responding so soon. Good day!

While the annual purchases of GE products by IBM (primarily for motors to drive their card processing machines and vacuum tubes) were only a very small portion of the GE income, Cordiner took the threat seriously, and not only ordered Metcalf to desist but retained the apprehension of confronting IBM throughout his years as president of GE. In late 1954, Metcalf, perhaps forgiven for his previous errant salesmanship, was asked to head a group of five engineers to produce an "Electronic Business Study." The 1955 report proposed that the company "should enter the electronic digital processing or computer business at the earliest possible date."[3] Cordiner distinctly said "No."

In fact, in later years many of the participants in GE computer operations had to keep a constant eye out against stepping over that mystic line that would activate Cordiner's wrath. That aura seemed to permeate GE corporate offices at 570 Lexington Ave. for the next 20 years, with proponents of

1. As General Electric referred to itself.

2. See Metcalf, 1992, pp. 79-80.
3. See Metcalf, 1992, pp. 88.

general purpose computers always having to jump through hoops and climb hurdles to justify their activities. The lack of quick profits and the inability of the managers of the computer never seemed to endear them to the head office.

William C. Norris, president of Control Data Corporation, believed that the only computer companies that could succeed were those that had only one business—computers. Considering the track record of the "seven dwarfs," those companies who were in competition with IBM (Snow White) in the late 1950s—Burroughs, RCA, Control Data, GE, Remington-Rand (UNIVAC), Raytheon, and Honeywell—within twenty years there were a few left, and those were the ones that were in only one business—computers. So why was GE any different? Is there a lesson to be learned from the GE experience? This paper tries to answer those questions.

ERMA and the Beginnings of a Department[4]

"Doc" Baker, having had a career in digital electronics, had a belief that the corporation could make a business in computers, and considering the financial power of GE could soon become number two behind IBM. Notwithstanding Cordiner's paranoia against delivering anything more than special purpose computers to satisfy client's specific needs, Baker was open to the possibility of mounting a "demonstration" project that would prove his point. Thus, when he got wind of the request for proposal (RFP) from the Bank of America (BofA) to manufacture a set of special purpose computers on the basis of a prototype built by the Stanford Research Institute (SRI, now SRI International), he jumped at the opportunity. The nearest GE facility to SRI in Menlo Park was the GE Microwave Laboratory located on the Stanford University campus in Palo Alto, and managed by H.R. (Barney) Oldfield. George Haller, director of laboratories of GE's Electronics Division who had previously been the dean of engineering at Pennsylvania State College (now Pennsylvania State University), was sent out to Palo Alto to suggest that the Laboratory respond to the RFP. In the meantime, Baker had made a verbal agreement with Cordiner that if the Laboratory could succeed in getting the BofA contract then "the Company," as employees were encouraged to refer to GE, would create a computer department[5] within the Electronics Division, or else Baker would give up his crusade. Oldfield took up the challenge by creating an Industrial Computer Section within the laboratory, and designating himself, Connie Krehoff, and George Trotter the first employees. He appointed Bill Edson a part-time consultant.

As early as 1950, the BofA had realized that before long, its burgeoning business would be limited by its ability to process the growing millions of checks that it handled every day. Taking the initiative to get ahead of the problem, the BofA contracted with SRI to develop a mechanical solution. By 1955, the prototype machine at the SRI Menlo Park laboratory contained 8,000 vacuum tubes, 34,000 diodes, 1 million feet of copper wire, and two magnetic drums, supported by several magnetic tape transports, and was supposedly capable of handling 50,000 bank transactions per day. A hardwired machine, the key to its operation was to be the handling of customer's checks through the use of a specially imprinted documents using magnetic ink. Thus besides the central processing unit the SRI machine, named ERMA (Electronic Recording Machine Accounting), required a means of imprinting the amount on each check after it had been processed by the tellers, not to mention the production of magnetically encoded checks by the printing industry. Additionally these documents would have to be sorted prior to processing; card sorters were commonly used data processing machines but the documents (cards) that they used were carefully maintained in pristine condition as contrasted over what might be expected from the pockets and purses of the bank's customers.

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After consulting with Al Zipf, vice president of BofA and Ken Eldredge, SRI, who was responsible for magnetic ink character recognition (MICR) project, Oldfield requested a budget of $50,000 from Baker to complete development of the proposal. Baker had got further approval for the proposal project from Cordiner arguing that ERMA was a special-purpose process control system, not a general purpose machine for wider marketing. Cordiner felt confident that the proposal would not be successful, but confirmed the prohibition on the development of a "business machine" by Baker's division.

It was decided early in the process of developing the proposal that the GE version of the SRI machine would be transistorized, though in that same early thinking, the concept of a stored program computer had not yet been considered. Oldfield recruited George Jacobi, Bob Johnson, and Gene Evans from other GE departments to prepare an estimate of the cost of the implementation of the vacuum tube ERMA machine using transistors. Jacobi noted:[6] "it was hard-wired—which is to say, every time you wanted to add a routine or changed your mind on something, out would come the wire machines and the soldering iron. They kept the logic diagrams there in some other secret place, and the relationship between the machine and the diagrams was two months apart. The change notices were in the minds of some very fine SRI people whose minds seemed intact, but not quite adequate to keep all that data. So the logic diagrams and what you saw on the floor had no relationship to each other. And what you saw on the floor, you sure wouldn't want to build. The problem then was not how to replicate the SRI machine but how to develop

4. See also Fisher and McKenney, 1993, McKenney and Fisher, 1993 and Oldfield, this issue.

5. The corporation is organized hierarchically into groups, divisions, departments, and sections.

6. Liar's Club, GE Computer Department, Alumni Reunion, Scottsdale, Arizona, 1994.

a meaningful estimate of the costs of production for the proposal. The solution was simply to ignore the logic and architecture of the system and simply to count the boxes, flip-flops, logic gates, and peripheral devices. In the mid-1950s transistors simply did not have the reliability we have come to expect today, but that reliability was still greater than that of vacuum tubes. Transistors were also more expensive than the individual tubes, but required less space and simpler connectors to the logic boards. The cost estimate was then based on the assumption that each vacuum tube and flip-flop would be replaced by two transistors, with the addition of extra resistors and capacitors, and additional costs for board and plane design and manufacture.

The Bank of America requirements specified that each facility would be capable of handling 55,000 transactions per day with the relevant updates to customer accounts, the distribution of checks to the appropriate external banks, and the balancing of the daily operations. By this time named ERMA 1A, it was determined that the overall installation would require 36 machines at a cost of $31 million. Among the uncertainties at this stage was the actual means of placing the data to be processed from each check—the bank number, customer identification, and the amount of the check. At this point there were still three competing possibilities, even though SRI, developer of the ERMA prototype, was also working on the MICR system designed by Ken Eldredge. Burroughs Corp. was promoting the use of florescent dots, while IBM was offering bar codes as a step away from its preferred use of punched card checks. The decision as to which would become the banking industry standard was the responsibility of the American Banking Association (ABA). The close association between ERMA and MICR[7] within SRI did not necessarily forstall the decision as to which system would become the banking industry choice. The prototype ERMA, in fact, used bar codes for feasibility testing.

While GE had prior experiences building special purpose computers, including the OARAC and OMIBAC, as well as incorporating computing technology into their network analyzer and the power control simulator, it had little experience in the design and manufacture of the peripheral devices that would be required for the ERMA Project—the check sorter, magnetic tape drives, and printers. What was required were partners, or subcontractors, who would be capable of filling these deficiencies. National Cash Register (NCR) was the first of these to be approached with the expectation that the company could produce the check sorter and the printers. Later the magnetic tape drive supplier would be AMPEX; the company was not chosen however at the time of the proposal development.

One of the concerns of the GE proposal development group was identifying and countering other bidders for the ERMA contract. Other bidders included Texas Instruments (TI), and Radio Corporation of America (RCA). IBM, the expected primary competitor, in fact, chose not to offer a proposal, but instead made a bid to buy the concept from SRI and Bank of America. It can only be surmised that IBM intended to take control of the technology and, rather than marketing it, would replace it with the check marking system that they favored—the punched card or bar code. This was not an uncommon practice of the corporation at this stage of the history of computing; they had cornered the market on core memory by purchasing the rights to the competing patents of An Wang and Frederick W. Viehe[8]. TI was primarily a manufacturer of electronic components (including transistors) and had not at this point, like GE, built a product line of computers. RCA had the BIZMAC, a business computer, but their major product (and profit) was to be found in television.

Oldfield and company, working closely with SRI and the Bank of America, completed their proposal on time and hand delivered it to the bank's offices in San Francisco. After the usual nail-biting period of waiting, during which the GE staff could catch up on their other duties, the GE proposal was accepted by BofA board of directors on April 9, 1956. Texas Instruments had been so sure of their prowess in creating the successful proposal, that they had already given Al Zipf a model of their ERMA implementation bearing a plaque identifying it as a TI product. Zipf presented this model to Oldfield, and he, in turn, presented it to "Doc" Baker when they met later to approve the contract. Besides getting the contract written and approved up the GE ladder, a next stage was to call on "Doc" Baker's commitment to appoint Oldfield as general manager of the computer department if the Industrial Computer Section (Electronics Division) landed the Bank of America contract. Oldfield flew east to meet with Baker who was ready to meet his promises but who now had to brave the wrath of Cordiner in getting into the "computer business" in spite of his prior pronouncements. The strategy was to portray the Bank of America contract in the same light as other departments of GE built computers for the military—as a special purpose machine without competition from IBM. Baker signed the BofA contract without Cordiner's review.

Having managed the development of the successful proposal, and at the very least, having given the Electronics Division the opportunity to take a detour into the computer business in (internal) competition with the Military Systems Division, Oldfield began to realize the complexities of managing a department. The first task was to develop the "department charter" which was GE's means of casting into concrete the mission and domain of the department. To Mrs. Oldfield this was not a good plan, since development of the charter had to take place in Syracuse, New York, not Palo Alto. Oldfield would have to do the staffing of the ERMA Project remotely, but his current staff was not only competent to develop a winning proposal but also ready to recruit the additional staff needed to complete the contract. Neither of these turned out to be the critical problem; the unknown dilemma was where to place the manufacturing facility. Up to this point the Palo Alto group had assumed that they would move into special facilities for design near Stanford University and SRI, and that the manufacturing facility would be (perhaps) in a Stanford Industrial Park. GE, however, hurting from some recent union debacles[9], regarded California as an inappropriate site for a major manufacturing plant. A design facility or a laboratory could be located in a facility that could be leased without the cost of major renovation, or remodeled for other uses after the completion of

7. James McKenney.

8. See biography of An Wang in Lee, 1995, pp. 698.

9. Borsch, in his autobiography, pp. 167, suggests that "... unlike IBM, General Electric was heavily unionized."

the project. A manufacturing plant would require a major capital investment. On the other hand, the commitment to a major investment could not necessarily be recovered in the short period of the ERMA contract, and so by implication the Company was looking toward a long term investment beyond the expectations of the ERMA contract. California was ruled out plant placement because of labor union activities, "punitive labor legislation," high taxes, and high living costs. Initially, the preferred sites were Nashville, Tennessee and Little Rock, Arkansas, neither of which met Oldfield's preference for a location within easy reach of Palo Alto. George Snively recalled[10] that an additional reason for not choosing California was that the Bank of America was "exempt from use taxes but not sales taxes" and so did not want GE in the state at a cost in $1.2 million in sales taxes. After considering several alternatives, Phoenix, Arizona was the city of choice; reasonably close to the BofA in California (about eight hours drive from Los Angeles) with a reasonable climate, and presumably a location that would attract experienced computer engineers, though there was no expectation of locating a ready work force in place already.

Since the background of the majority of ERMA developers was in the hardware side of electronics, after the decision was made that the GE version of ERMA would be a stored program computer, it was necessary to hire a programmer. Joseph Weizenbaum was that person. Weizenbaum had previously been employed by the Bendix Corporation in Berkeley, California, working on programming the G-15 computer that had been developed by Harry Huskey[11]. There he developed a pseudo-machine programming language, similar in stature to the early work of John Backus on Speedcoding[12], named Intercom 100. While the G-15 was a hexadecimal drum machine with machine language programs that needed to be optimized to execute efficiently, the programmers required a one-address, floating point arithmetic, system to do their work efficiently; Intercom 100 solved that problem. There were probably more programs written for the Bendix G-15 in Intercom 100 (or its successor, Intercom 1000) than any other language. Unlike the ERMA system, the G-15 was planned as a "personal computer" to be operated by a single person in the era before operating systems or supervisors, and was also designed for easy maintenance. On one occasion, the machine on which Weizenbaum was operating stopped responding, and he discovered there were no pulses emanating from the drum. Weizenbaum explained, "I called Los Angeles and to tell them the situation and to tell them that I'm just puzzled. It turned out that the coupler between the motor and the drum had broken, and the drum wasn't moving. The humming of the motor, of course, convinced me that the drum was moving. It never occurred to me that the drum wasn't turning. Then came the question of what to do about that. I was talking about taking an airplane to Los Angeles, but they said, 'No, no. Just go to Sears and get the parts.'[13] With this background, Weizenbaum responded to an advertisement to hire engineers for the ERMA project. Interviewed by Bob Johnson, Weizenbaum explained the programming process and the need for programmers on the project and was hired as the "manager of the engineering programming." With no more experience in banking than cashing his own checks, Weizenbaum was able to provide the leadership to supply the software that provided that additional facilities required to support the capabilities provided by the transistorized hardware designed by Johnson and the peripheral check sorters and MICR readers, and the subsequent posting of customer accounts. Part of that task included designing the instruction set for ERMA. Within this assignment Weizenbaum included special instructions that initiated larger than normal jobs to frequently execute applications such as sorting. Though not implemented by way of microprogramming, this design provided a highly efficient means of meeting the bank's processing requirements.

With the addition of Weizenbaum the basic staff for the ERMA project was now complete. John Paivinen was in charge of the hardware and Henry Harold was the logic designer. Between Weizenbaum and Harold, Paivinen was the final arbitrator. Weizenbaum recalls: "There were essentially no personality conflicts. It was all very, very smooth. We all had something to do and we were doing it, and we had small signs of success now and then, and I think the morale was just super. And so it worked very well—it wasn't a question of struggling when I wanted something. Henry Harold might say, 'No, you can't have it,' and Paivinen would say, 'Well, let's see, you have it [this time]—you gave in last time,' and stuff like that. The real driver was Jay Levinthal. He was the architect of the system. He knew when the checks would arrive at the machine, how much time there was to work with the checks, what had to happen with them afterwards, how they needed to be sorted, and things like that. I think of all the people there, with the exception of Bob Johnson, truly Jay Levinthal was the most important guy. Not that if Henry Harold hadn't been there, that they would have collapsed, too. Jay Levinthal was very, very important. He had the very best overview [of the project] of anybody. That was his job. And then he was superb at doing it."

Weizenbaum remembers the decision process: "I'm not a mechanical engineer, and the problems that had to be confronted seemed to me to be impossibly hard—just because I wouldn't know how to do them."

There were two problems however—the development of the peripherals for the system including the check reader and the check sorter. Clearly GE had little or no prior experience to draw upon to design these devices. SRI had created the prototype MICR reader and the ABA committee had developed a character set (E13B) that maximized the readability of the symbols on each check. The project had to produce a commercial version of this prototype. The check sorter does not appear to provide an obstacle at first glance, since obviously in the mid-1950s the card sorter was a common data

10. Snively, 1988.
11. See Huskey, 1991.
12. See Backus 1981.
13. Oral interview, May 1994, Scottsdale, Arizona.

processing center appliance. However, the check sorter would have to rely on the reading of MICR characters and would have to transport flimsy checks that were not all the same precise size, were perhaps torn unevenly from checkbooks, and whose usage would not have preserved their flawlessness. NCR had been chosen to be a partner in the original proposal and their responsibility was to be the construction of the mechanical device that would accomplish the task of sorting the checks. However, the GE team was to be responsible for writing the requirements for the sorter. But in fact no such document was developed. Weizenbaum remembers the decision process:

"I'm not a mechanical engineer, and the problems that had to be confronted seemed to me to be impossibly hard—just because I wouldn't know how to do them. NCR got into the picture, and it was said that they would build the check sorter with the help of Pitney-Bowes, who had a lot of experience with handling paper. It was up to us now to write the technical specifications. One day there was a big conference in Palo Alto at Ricky's Motel and there were people there from NCR. We argued and argued and it wasn't coming to any closure, we weren't reaching agreement. Not that it was panic time, but we certainly weren't converging.

ERMA is put through its paces. The check sorter is watched carefully during this demonstration. © CBI

"Mr. Cordiner[14] and the president of NCR walked into Ricky's and told us that it was settled. They had shaken hands, and it was all agreed upon, and thank you very much. And of course, we were appalled! What do you mean 'settled'? Suppose they built something and it didn't work? This was the first time that I had ever learned about the doctrine of a workman-like product. I asked them, 'Now suppose they drive up a Rolls-Royce and said, 'Well, here's your check sorter.' 'You would have to sign the acceptance, and there you are [without the machine you wanted.] They told me, 'No, the CEO's are not that dumb. They would insist on a workman-like product, which means it has to be a sort of a common-sense solution to the original problem, even if everything isn't spelled out in the contract.' And it worked somehow. I never would have believed it."

Years later when the check sorter was finally delivered, it worked. Cordiner and the NCR president visited the Palo Alto Laboratory to examine the product. Cordiner took a check, crumpled it up in his hand, stepped on it, and then put it back in the stack of checks to be sorted and it went through.

14. Oldfield believes that is was probably not Cordiner, but instead, Strickland or himself.

Phoenix Opens Up

With the choice of Phoenix as the site of the headquarters of the yet to be confirmed computer department, Oldfield and his family returned to the west to begin the establishment of a capability beyond that of the ERMA project. It had already been decided that ERMA would not be built in Palo Alto, so the primary task was to put together a manufacturing facility in Phoenix to assemble the 36 systems designed by the California team, now named the GE Palo Alto Laboratory. Looking around, Oldfield considered an association with Arizona State College in Tempe, that providentially had recently constructed a new engineering building that, in contrast to the situation today in American universities, would not be completely occupied. The space would be sufficient to accommodate the engineering design group, though the headquarters of the group would be maintained in downtown Phoenix in the building occupied by KTAR radio and television stations. The association with ASC matched Oldfield's previous experiences at Cornell and Stanford where he had managed GE laboratories.

The Palo Alto Laboratory, still in the design phase of ERMA, made the decision that the BofA machine should be true stored program computer rather than a hard-wired device as implemented in the prototype by SRI. This change would allow both a simpler machine design and the later easier modification of execution when requirements changes were anticipated. The concept was readily accepted by the GE team, but SRI, acting on behalf of the BofA, were not ready to give up on their proven prototype scheme. George Jacobi, project engineer at Palo Alto, took on himself the task of selling the stored program concept change, but as right as he may have been, came out on the short end of the argument with SRI. His credibility was questioned to the extent that it became difficult for him to work with SRI, even though he did convince Zipf of the correctness of this approach. As a result Jacobi was forced to leave Palo Alto and take up the position of manager of advanced development in Phoenix. The new design of ERMA contained 5,000 transistors, 15,000 diodes, and 4,000 resistors as contrasted with the prototype's 8,000 vacuum tubes, and 34,000 diodes. The method used to compute the cost of each machine in the original proposal by replacing flip-flops and vacuum tubes by multiple transistors was, after all, incorrect but in the favor of GE.

Things were not much better back east; in late 1956 "Doc" Baker was reassigned and Harold Strickland took over the computer section as a part of the newly formed Industrial Electronics Division, with strict instructions from Cordiner to keep the computer group in check. For the first time the computer section had a new boss, an event that was to be repeated often in the future. Unlike Baker, Strickland was not sold on computers and was much more respectful of Cordiner's expectations. His first task was going to be to inspect the computer section's readiness for being upgraded to a Department. Oldfield also began to feel the pressure of his position and the responsibility to attend Division manager's meetings with Strickland.

In the annals of the history of the computer department, Strickland was the first direct manager who conformed to the general company archetype of a generalist and professional manager, but by no means was he the last. Truly Baker had been a professional manager and generalist, but at least he had an enthusiasm for computers and a belief that the business could be a successful addendum to the GE collection of products. Strickland had no prior experience in computing and in particular had never managed an operating, manufacturing department. The GE management policy, assiduously supported by Ralph Cordiner and by a long succession of corporate officers, maintained that a professional manager is capable of managing anything—independent of prior experience or preparation. In fact, management trainees were sent to a extremely well organized and documented management course that had been in place since at least the 1930s to give them not only the "company spirit" but also to prepare them for a wide variety of management assignments. With one exception, as we shall see later, the division that contained the computer operation would never have another computer literate manager. Indeed the management of the department itself would have similar problems after Oldfield left in late 1958.

One of the unexpected additions to the Phoenix establishment was the transfer of Herbert R.J Grosch and his band of programmers from Evendale, Ohio, to found the service bureau of the fledgling computer department. By this time, Oldfield had made contacts with Arizona State College (ASC) and discovered the availability of space in the new engineering building in Tempe, Arizona, that could temporarily accommodate the GE engineering staff. Grosch[15] had been an early IBM computer aficionado, working with Wallace Eckert at Columbia University in 1945. As may be expected, Oldfield and Grosch have different views of the introduction of the service bureau business in the computer department, the former having a feeling of having an orphan operation being foisted off on him[16], while Grosch felt that he was there to "save" the department. At least Grosch brought with him an order for an IBM 704 computer that would be the centerpiece of his facility. The center was set up in the engineering building at ASC on the understanding that it would also serve as the computing center for the college. Grosch's extravagant lifestyle and elegant, first-class-only business trappings did not fit the more low-key style that Oldfield had set for himself, and the work-a-day world of both Palo Alto and GE Phoenix. Moreover Grosch had built his reputation through the upper levels of the GE administration and was not averse to using those contacts to get what he wanted. He regarded the Phoenix engineering group second class professionals who "hadn't the faintest idea how to use a computer to design another computer, and were too busy doing it by hand to find out." The two groups were in competition from the very beginning, and despite some successes in locating service bureau customers, Grosch's group had almost no influence on the development of the GE line of computers. Grosch was an advocate of the plan to replicate the IBM 700 series of machines and to go head to head with IBM in the market, as well as replacing all the other IBM machines within GE by home built systems. On the positive side, the failure to establish the service bureau within the computer department would not have led to the eventual foundation of a commercial time-sharing service that, as we shall see later, was to be one of the few major successes of the department and the only business that was still in profitable operation in the 1990s within GE. Grosch left GE (and Phoenix) in 1958 to return to his beloved IBM and a plethora of other jobs over the next three decades, but not before he tried to get Oldfield replaced as general manager of the computer department through his contacts.

He regarded the Phoenix engineering group second class professionals who "hadn't the faintest idea how to use a computer to design another computer, and were too busy doing it by hand to find out."

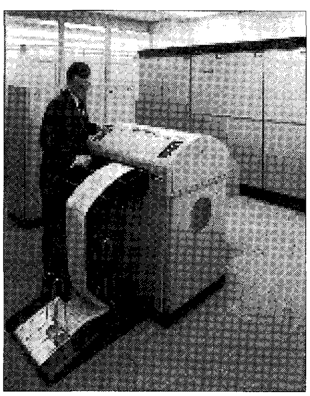
As a part of his learning about the components of his new division, Strickland planned to visit Phoenix and Palo Alto with the intention of confirming the company commitment to establish the computer operation as a department and to approve the requisition to build the manufacturing facility in Deer Valley, off the Black Canyon Highway, in Phoenix. It was not a totally positive trip. During a visit to the KTAR building he found that the title "computer department" had already been painted on the door, and refused to enter until it was corrected to the then official name "Industrial Computer Section"; not an auspicious beginning to a visit that was intended to approve that very sign! In Palo Alto he found that the staff were not enamored with Phoenix either as a place to visit or to work, and presumably were not looking forward to their move to that city when the ERMA project was finished. Irrespective of the shortcomings, Strickland did approve the upgrading of the computer operation to a department, the appointment of Oldfield as general manager, and the establishment of the manufacturing facility.

By the end of 1957 the anticipation of a manufacturing facility capability in Phoenix beyond that needed solely for the ERMA project meant that the computer department could look for additional activities. The first of these was an agreement for NCR to build the peripherals for ERMA; in return GE would build the NCR 304, the sales of which (by GE) would have violated Cordiner's restrictions. In conformance with the restrictions however, there was a plan to build industrial computers for insertion into one-off projects. Arnold Spielberg, recruited to Phoenix in February 1957 after a short stint at GE Schenectady, New York, was originally involved in the development of the RCA BIZMAC computer, and was now assigned to lead the work on the design of an industrial control computer. The first opportunity came with the chance to respond to an RFP from Jones and Laughlin Steel Co. for an automatic inspection system for their plant. The success of this project led to the designation of the new system as the GE 302 that eventually led to the GE 312, officially designated a digital control computer. Staying with the steel manufacturing business, department next bid on the controller for a steel strip mill for McClouth Steel in Michigan. The process control business was

15. See Grosch, 1989 and 1991.
16. See Oldfield, 1995..

well established and continues in 1995 through the Drive Systems Division in Salem, Virginia.

By mid 1958 the ERMA system was having problems with meeting contract requirements as a result of less than satisfactory products from the sub-contractors. The printer by NCR could not print customer statements so that the characters on a line were in alignment, and the magnetic tape drive by AMPEX could not even meet the least of the expectations originally set in the sub-contract. On the other hand, the check reader (incorporating the MICR subsystem) and the check sorter were operating almost flawlessly. Fortunately John Paivinen and Bob Johnson had set their schedule to provide a buffer zone between the completion of their original plan and the contract delivery date to take care of such contingencies; unfortunately both of these problems were not "in-house," but the solution would have to solved in-house to meet the schedule. Pressure was put on AMPEX to re-engineer the tape drives, and the interfaces would be redesigned to meet the best specifications that could be achieved. Both men had had confidence in the ability of NCR and Pitney-Bowes to build a printer to specification, but it took Jay Levinthal to come up with a "way-out" solution. The primary problem with the printer was the wavy lines it printed; Levinthal noted that after the printer had been supposedly set up at the specification speed of 750 lpm, it at least maintained a good alignment at lower speeds. So why not perform the set up at 1500 lpm to achieve alignment at 750 lpm? It worked! A final concern was the fidelity of the programming that supported the ERMA software; Weizenbaum and Zipf worked through the programs paying particular attention to the reconciliation routines as a fundamental criterion for validating the correctness of the system. It worked!



The ERMA printer. **© CBI**

Notwithstanding the last minute problems, the first ERMA system was installed in the San José, California, branch of BofA on December 28, 1958 and accepted three days later (New Year's Eve) by Al Zipf on behalf of the bank. This system, capable of only handling 100 transactions per day, at least proved the correctness, if not the efficiency of the system. The next step was to speed this up to the contract requirements of 55,000 transactions per day.

While the ERMA project was coming to a successful conclusion, Oldfield was getting ready to leave Phoenix for personal reasons. He planned to relocate his family in Boston, Massachusetts, in order to get medical treatment for his wife. Looking around, Oldfield recommended Claire Lasher as his replacement general manager for the computer department. Lasher had been manager of marketing in Phoenix since 1956, previous to which he had managed the sales activities within the Government Division, and for planning within the Technical Equipment Department. His primary computer experience had been in his writing of the computer section of the so-called Metcalf report in 1955. A "company man" he initially had doubts about the viability of a business computer activity within GE, he eventually cast his lot with Oldfield and provided the fledgling department with marketing support. Oldfield, having submitted his resignation, assumed he would be let go with little recognition for his accomplishments of swimming against the tide for so long, but was delighted when he was offered a "golden parachute" in form of three-month special project assignment in the Boston area, together with the payment of his moving expenses, and a separation bonus.

Within a year the computer department had seen two more management changes, neither of which improved its position in the company with respect to its computer expertise. Strickland appointed Lasher as the acting general manager of the computer department until he could prove himself through the next business plan.

Meanwhile the Military Equipment Department in Syracuse was building a tracking system for the ATLAS missile system named MISTRAM that was in fact an advanced computer system. This was quite in accordance with Cordiner's directions since it would not develop a line of machines that be placed on the open market in competition with IBM. This project also had the advantage that the up front development expenditures were to be paid by the U.S. government rather than GE, an arrangement much more satisfactory to the 570 "bean counters." Grosch was also looking in the direction of Huntsville to sell computer time from his service bureau[17] and while he was moderately successful in this venture, the association also brought about the possibility of duplicating the MISTRAM opportunity for the computer department. Much later, the result was an order for 32 computer department machines. However, the MISTRAM was the first in a line of developments by John Couleur that led to what may be regarded as the most successful and long-lasting machine—the 600 line.

As the machines for the BofA were being successfully installed there was growing interest from other banks to acquire similar systems. However, Strickland restricted further commitments until the systems were shown to "proven," a policy that was distinctly different from IBM's strategy to take enough orders for a paper machine to justify its development[18]. Eventually this restriction would be lifted for West Coast banks, though there was never an attempt to go head-to-head with IBM in serving banks on the east coast of the U.S.

The location of the GE computer department manufacturing facility in Arizona brought about a not-so-usual fabrication opportunity. The early machines still used magnetic core memory consisting of minute toroids of ferrite through which three wires needed to be threaded. The ability of Navajo women to make beaded artifacts was thought to be a qualification for their being employed to assemble core memories. It worked for a while, but then the technology being used in other companies in locations where there was not an indigent population to thread beads, took over from the Navajo women.

By March 1959, the Palo Alto Laboratory was concentrating on the final tweaking of each ERMA installation to meet

17. See Grosch, 1989.
18. Jacobi suggested in private correspondence, 1933, "It is easier to sell a machine before it is built htan afterward."

the requirement of processing 55,000 customer accounts per day. Bob Johnson and George Trotter, manager of sales in Phoenix, modified the intended installation plans by adding an additional sorters and printers so as to make the overall system of 13 processing centers meet the overall requirements of 2,000,000 transactions per day per multiple machine installation instead of the assumed requirement of 55,000 *per* ERMA system. Shortly thereafter the BofA declared the system to be "operational," accepted it, and began plans for a public celebration. The first question was whether Cordiner would appear for the affair since this would surely be tantamount to his accepting the fact that the company was in the computer business, even if he had lost the wager with "Doc" Baker on the ability of the Microwave Laboratory to win the BofA contract. Cordiner did attend, along with Ronald Reagan who was then the host of the popular TV show "GE Theater of the Air." Lasher expected this event to be the highlight of his candidacy for the position of general manager of the department, and even perhaps the instance for a reversal of the Cordiner policy against getting into the computer business. Using the Los Angeles installation as a backdrop, the celebration was broadcast by closed circuit to several locations in the U.S. where other banking representatives could witness the opening of a new industry. The date of the celebration was September 14, 1959, but it was not the day for Cordiner to give up on his resistance to computers. Dismayed by what he saw, Cordiner, while courteous at the celebration, demanded that Strickland and Lasher attend him in his hotel room on the morning after. There he ranted over the fact that the company appeared to be in a business that he had not authorized, and demanded that a business plan be developed forthwith that would wean the computer department *away* from the business computer industry and toward process control while at the same time developing an operation that would be grossing $25 million within five years. Aware of the impact of rescinding orders from existing customers, Cordiner permitted the fulfillment of existing orders, but "no more." Restricting the development of the required business plan to only himself, Ken McCombs and George Snively, so as to not panic the staff of the department, Lasher developed his own alternative plan including aggressively selling ERMA systems and beginning the development of a line of machines that could serve equally well as a general purpose system as well as a process control device. Lasher's upbringing in marketing showed through. His foresight was later justified when Cordiner backed down; apparently his banking friends were exuberant about the pioneering GE entry into the automation of the banking business. He did leave in place one restriction—not to go head-to-head with IBM!

With the introduction of the ERMA machine, it was now christened the GE 100, and its upgrade to a more general purpose (but still banking oriented) machine was designated the GE 210. The plan for a line of compatible 24 bit computers named MOSAIC was established. In the meantime, Spielberg was completing the development of the GE 312 process control computer that was to be converted to a general purpose 20 bit machine named the GE 225 that could be available almost immediately, and well before the MOSAIC line would be ready. The 200 line by Spielberg, including GE 265 timesharing system, was perhaps the most profitable for GE.

The business plan mandated by Cordiner, but modified in concept by Lasher before Cordiner relented on its scope, became the basis of the 1960 business plan—named the "BIG LOOK." The development of the GE 225 as a immediately available product provided the primary cornerstone for the plan, with the MOSAIC long range development plan now containing a hierarchy of machines identified simply as W, X, Y, and Z. In the meantime, GE was looking at three ventures as their "wave of the future"—nuclear power, jet engines and electronic computers, though the biggest profitable venture on the horizon was color television. After the review Cordiner approved the business plan. It appeared that the future of the computer department was well established; irrespective of what was to be manufactured, the corporate view of the success of the operation was not focused on the product but on the adherence to the financial forecast. Except for the dependence on the GE 225, the plan relied on innovations and inventions on a fairly tight schedule for the "outyears."

... their customer responded, "Well, you know, we really don't want this thing right now. We've got this inventory system going so well that we just don't think we want to spend the money on the communication processor."

GE Phoenix built the NCR 304, the first being delivered in December 1960. The staff responsible for that machine formed the Special Systems Engineering Unit and began looking around for their next task. Not planning to go out into the wide world of computer marketing in accordance with Cordiner's restrictions, they looked inwards to GE for work. The accounting section of the industrial sales division, already a relatively large financial management system with a monthly lease of about $30,000 a month, was a candidate for several GE 225 machines with disk drives. Half of the cost of the current system was in communications to 75 locations around the country. The computer department had a product, the DATANET 15, that was a controller connected over a phone line with a teletype and containing some registers. One of the difficulties with this product was that every time a character was to be transmitted, the controller had to interrupt the system that would then suspend the execution of current program, bring up the service subroutine, read in one byte, store it in an appropriate location, and then restore the original activity. Happening ten times a second with one teletype line (assuming paper tape input) the computer could not get much else done; it was input bound. The DATANET 15 was so-named because it could be connected to 15 terminals, but it could only service one terminal at a time. What was needed was some way of collecting the data from the teletypes, and assembling it into complete messages before the computer needed to be interrupted, cutting down not only the number of interrupts but also the overhead in system turn-over and recovery. The result was a small special purpose computer that operated much the same manner as the BIOS chip in modern personal computers. It was, in a way, similar to the I/O processor for modern microprocessors.

The GE 225 system solution to the financial management system was ready and the inventory management application was operational about the time the prototype controller was ready. Bill Bridge, who had been responsible for the design remembered that at that point their customer responded, "Well, you know, we really don't want this thing right now. We've got this inventory system going so well that we just don't think we want to spend the money on the communication processor." Looking around now for a problem, having a solution in hand, Clint DeGabrielle and Vic Casebolt noted that Chrysler Corp. had a semi-manual teletype processing system that could benefit from automation. The Chrysler teletype center operated by receiving messages on the paper tape punch of one teletype and then having an operator tear off the tape, transfer it to a second teletype and then forward the message to the intended recipient—a so-called "torn tape system." By adding a dual access disk drive to store the data from the controller, and accessible independently by the computer a complete store-and-forward was implemented.

On Memorial Day 1963, the newly named DATANET 30 was delivered to Chrysler, and made operational by Thanksgiving. With a nice write-up in *Business Week*, the computer department soon had a number of other orders for teletype message switching systems, including one for General Electric, one for Clark Equipment in Corning, and, among others, Weyerhauser Paper. This was the arrangement that came to the notice of Kemeny and Kurtz at Dartmouth College that triggered their thoughts of how to build an effective time-sharing system. This view also explains why Kemeny and Kurtz have suggested that GE had not realized what they had in hand until they came along with the suggestion of using this arrangement for their peculiar application. Clearly Bridge and his colleagues had developed the concept of data collection and buffering prior to the suggestion of the Dartmouth application in 1962.

By 1961 national sales activities were beginning to gear up, and the computer department broke out of the Phoenix enclave and created 25 district sales offices to sell the growing range of products. GE was beginning to compete on the open market with IBM! In June the last of 32 ERMA systems was delivered to the Bank of America.

The work of the Palo Alto Laboratory related to the Bank of America system was now complete, and decisions had to be made as to the fate of the personnel and the facility. For some Phoenix was the logical next assignment, while for others their love of the California Bay Area made them chose other pursuits. Among the latter was Joe Weizenbaum; he chose academia:

> There certainly was no explicit deal [to go to Phoenix]. There wasn't anything written down. I don't remember anybody actually promising that to me, but I think that was an assumption. I think as part of the recruiting, people went initially to GE, like me for example. We were told a lot of GE history and all that sort of thing, because the old timers were fairly proud of their product. One of the things that was implied was that nobody ever got fired, except for incompetence, or something like that, and when a project was finished there was always a place for you. GE was a very, very big outfit, but I don't think we were promised anything.
>
> Bob Johnson went to Phoenix to become manager of engineering, and we looked for a new director. [The new director] wasn't suited to run the outfit. While he was a very, very nice guy, easy to get along with, he had no vision, and nobody else did either. I think what happened was that some people in New York, Mr. Strickland for example, had the idea, correctly, that here was a "gung ho" team, that had actually accomplished something, and worked with one another with minimum difficulty for many years. That's not common. "It would be a shame to split this team up. So we'll tell people they can come to Phoenix if they want to, but nobody has to"—that was more or less the situation. Then I think they simply forgot about us. People in New York and Phoenix no longer asked, 'What are these guys doing?' There was really nothing to do, I had no task. There was nothing I was supposed to do, and I thought I'd make up my résumé [and in the meantime] I'll just start to work on things I'm interested in."

Weizenbaum joined the artificial intelligence group at MIT led by John McCarthy and Marvin Minsky, and developed the ELIZA pseudo-psychiatrist that was to mark his accomplishments for the rest of his career; his involvement in the development of the first effective banking system was forgotten outside of GE.

Ask any of the alumni of the early days of the computer department what was the most vivid memories of those years, and before long they will mention the First National Sales Meeting held at Apache Junction, outside Phoenix, where Ronald Reagan again acted as toastmaster. The meeting was noted not only for its enthusiastic sales pitches, but also for the social events that supposedly included several senior members of the department finishing their evening in the swimming pool. Though the Phoenix scene included an active social program, Apache Junction topped it all. This may have been the high point in the life of the computer department.

John Kemeny and Thomas Kurtz at Dartmouth College had been concerned with the delivery of readily accessible computer capabilities to their general student body since the late 1950s, initially using a Royal McBee LGP-30 to implement an ALGOL-like language for student use. By 1962 they were ready to take the next step toward a campus-wide system building on the experiences at MIT with the Compatible Time-Sharing System (CTSS) developed by Fernando Corbató, but much simpler in concept—a student system.

Kurtz recalls:[19]

> GE had no thought of marrying the GE 225 (later the GE 235) with the DATANET-30. They did have a disk drive that had a dual access port on it, although I never knew

19. Private correspondence, 1994.

why they developed or had such a product. We got proposals from IBM, NCR, GE, Bendix, and one or two others. IBM proposed a two-computer system, with the 7044 as the CPU and some machine with a similar number as the communications interface. But even with the 60% educational discount, the IBM proposal was much more expensive than the GE proposal. The problem with the NCR proposal was that it did not have floating point hardware. The Bendix proposal was way too expensive, although it did have the attraction that a similar machine was being used at Carnegie Mellon by Alan Perlis. The GE proposal had these advantages:

- It was far cheaper than any of the others,
- it had fully-buffered input-output, and
- it permitted the two-computer approach which certainly made it easier for us.

The general manager of the GE computer department when we were dealing with them was Clair C. Lasher. He was an acquaintance of Myron Tribus, our engineering school dean at the time and a strong supporter of our project.

We received a standard 50% or 60% discount from the Eastern Regional Office of GE, which was responsible for actually dealing with us. The plan was to provide a GE-225 and a DATANET 30, with that dual access disk, and to later replace the 225 with a GE-235, which was about three times faster. The floating point was provided by a separate unit which was accessed sort of like a peripheral. The deal was a lease with a purchase option since we didn't know, in middle 1963, whether our National Science Foundation grant would be approved. Incidentally, the peer review of our grant suggested that what we proposed (building a two-computer operating system) could not be accomplished. But we had friendly relationships with the NSF at that time, and Kemeny had an excellent track record. So we got our grant.

The NSF grant was approved in January of 1964; the equipment arrived in February of 1964; we got it running physically in March of 1964; and we had the first gasps of the time-sharing system running on May 1, 1964, at, so the legend goes, 4a.m. Since the test programs were written in Basic, that point in time is also described at the "birth of Basic."

The GE-235 arrived in July of 1964. We had to do some work on the operating system. For example, all the code was written in assembler, and the assembler was a card-image assembler. So the cards were blocked on the tape between passes one and two, and passes two and three, one card per record. Not such a good design! So one of the students fixed that to block 10 or 20 images per record, and the assembly time went down from over an hour to about 10 minutes.

The time-sharing system was an instant success. We were running about 32 ports by September of 1964, and had terminals in several off-site locations. I believe the first were Hanover High School and Mt. Holyoke College. Exeter Academy was also an early user.

In fact, the connection to Mt. Holyoke College may have provided the first inklings of e-mail and the Internet. One of the capabilities of that early system was the ability to share files between users, and so it was not long before the men of Dartmouth were corresponding by file sharing with the women of Mt. Holyoke. The difference, of course, was that this was all within one system, and not between computers as in today's Internet and e-mail.

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In mid-1962 the GE 225 was in full production, fulfilling the BIG LOOK plan, and Spielberg was developing the GE 235—an upgraded 225, at three times the speed—and the GE 215 at one-third the speed. The GE 215, 225, and 235 were the first family of compatible systems prior to the IBM System/360 that was announced two years later in 1964. The IBM 704 at Arizona State College system installed by Herb Grosch was replaced by a new machine, the GE 304, that was simply the NCR 304 with a GE name plate. The Advanced Development Section was giving major emphasis to the development of the MOSAIC line of machines. But changes were in the wind. First the W machine name was changed to S since W was the company symbol for Westinghouse, and then the slow progress on the Y machine at annual review time suggested that Y machine development activity be eliminated.

There was a machine within GE that could replace the Y machine in the MOSAIC line effectively, but from without the computer department. John Couleur, GE Syracuse, had taken the MISTRAM machine (a 1959 development) to create a solid state machine named the M236[20] (*M* for Military) and proposed its upgrade, the M2360, as replacement for computer department Y machine. Lasher rejected the suggestion on the basis of its lack of compatibility with the MOSAIC line (36 vs. 32 bit machines) and the lack of advanced technology. See the article in this issue regarding the "Core of the Black Canyon Computer Corporation."

Bob Johnson was a member of the computer department

20. The Defense Systems Department of the Defense Electronics Division of GE offered two machines, the M236 and the M2360. The latter was described as "employing the same techniques as the M236 Computer except that it is modularized for adaptability to multiple computer complex requirements. The instruction repertoire is expanded to permit floating point arithmetic operation." (From GE brochure DSD-1024, 10-62).

team that went to New York to participate in the December 1962 annual departmental review of the "BIG LOOK" in from of the executive office team led by Ralph Cordiner. He remembered:[21]

> The way these things were done then was there was a little theater at five-seventy [570 Lexington Avenue, New York, Headquarters of GE], and the team under review was on stage with spotlights on us. The management executive officer sat out in the dark and we couldn't see who was there, but we could hear voices. In my remarks, I made the comment that in ten years I thought half of the computers that we were [manufacturing] would be talking to each other by telephone. And Cordiner's voice boomed out of the dark saying, 'On what basis do you make such a preposterous statement?' I made some feeble attempts to defend it, citing for example, all the trouble the bank had in trucking checks around. I failed to persuade them that this was an important subject—data communications.

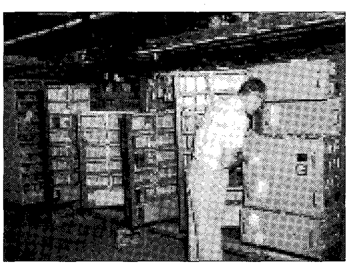
Irrespective of the success of the GE 225 and the other positive technical developments, the December 1962 annual review was predominated by the concern that equipment rentals were not achieving the goals set out in the BIG LOOK; the reviewers were looking for *sales*. Cordiner began to believe that his earlier concerns about getting into the computer business were being justified by this lack of financial progress in computer department—even though department sales had grown at 60% per year. Cordiner resolved then and there to replace Lasher for not meeting the financial goals he had promised enthusiastically earlier. Lasher's resistance to Strickland's suggestion that the M2360 be considered as a replacement for the Y machine probably did not provide him with an advocate in the executive office.

On February 13, 1963 Harrison Van Aken was appointed general manager, computer department and Clair Lasher was not quite sent to Outer Mongolia, but instead was appointed manager of offshore operations. In that position he would open Australia to the marketing of GE systems and recommend that GE acquire interests in the French company Compagnie des Machines Bull, and the Italian company Olivetti. Van Aken was a dyed-in-the-wool professional GE manager, an accountant by training, and previously general manager of the Communications Equipment Department in Lynchburg, Virginia. His computer experience was negligible; communications and computers did not yet share a common thread of development, even though some, like Bob Johnson, saw that future.

George Snively remembered[22] Harrison Van Aken as "a big, iron-jawed guy with the booming baritone bass that could project from the Metropolitan Opera stage to the far balcony without any difficulty whatsoever." The first week on the job, Van Aken called his first staff meeting for 8:00 am. on the Monday morning. Promptly at 8:00 am. he locked the conference room door, which left several of the staff outside pounding to get in, including Lacy Goosetree and Ralph Barkley.[23] But Van Aken was unrelenting, and they were told, through the locked door, to come back on time for the next meeting. The message got around quickly. Snively's secretary was in tears at 8:00 am. on the next day. For years, she had religiously punched in at three minutes to eight, but that morning she was ten minutes late, since there was the worst traffic jam on the Black Canyon Highway that had ever been seen. Everybody was trying to get to work on time!

Van Aken's first task was to reverse Lasher's decision about the replacement of the Y machine with the M2360 as the large computer project. He was supported by John Couleur (from Syracuse) who, coincidental with the proposals of Herb Grosch, favored the continued development of M2360 to replace IBM computers in GE computer centers. This time the rationale was based on the expectation that the savings in lease payments throughout the company would offset the cost of the machine development. At the same time the elements of the MOSAIC line of machines were renamed as the GE 400 and GE 600 to expand on the concept of the GE 200 line being the low end of a line of compatible machines. To this end Van Aken reorganized the computer department to give individual management to each of the three lines of machines.

Changes were happened up the line; after many years at the helm, Ralph Cordiner retired to be replaced by Fred Borch as president of GE, while Hershner Cross replaced Art Vinson as group vice president, who himself had only recently taken the position held by Jim LaPierre. As far as Strickland was concerned he was reporting to a completely new executive office. Cross began to seek additional markets for the computer operations by looking overseas for an international market and possible partners; he identified Compagnie des Machines Bull[24] and Ing. C. Olivetti & Co.



The General Electric production facilities in Phoenix, Arizona.

Independent of these management changes, Spielberg was putting finishing touches to the GE 235 that turned out to be highly reliable machine that would, in the future, compete well with the IBM System/360 machines. However, not seeing any major innovations in the future of the computer department, Spielberg left the company to join IBM in September 1963. With a continuing interest in process control, he was to design the small desk size process control machine in the same genre as the IBM 1620 and the 1401. The combination of the success of the GE 235 and high level of production of the DATANET 30 provided the opportunity for GE to provide an upgrade to the GE 225 system at Dartmouth and at the same time market a new machine to be designated as the GE 265 (235 plus 30).

John Couleur, having done the initial work on the upgrade to the M2360 line at Syracuse, now moved his group to Phoenix to continue work on the GE 600; the animosity between the engineers in Phoenix and the new transplants became evident when Couleur's team were nicknamed "the Syracuse Mafia." Couleur brought with him Ed Vance as the

21. From the Memory Dump session, GE Computer Department Alumni Reunion, Scottsdale, Arizona, 1994.
22. Liar's Club, Scottsdale, Arizona, 1994.
23. Though recalled by Snively and confirmed by Goosetree and Barkley, Van Aken, in private correspondence with Oldfield, denied the story of the locked door.

24. See Mounier-Kuhn, 1989.

software manager of the 600 project responsible for putting together the operating and applications software; for the first time "GECOS" (GE Comprehensive Operating Supervisor) became part of the GE jargon. Having lost the leader of the 200 series design activities, having the work on the Phoenix Y machine replaced by the Syracuse Mafia, and being led by a general manager who was not a socially adept as Clair Lasher, morale at Phoenix was by this time low.

The first few months of 1964 were a time of further departures; Bill Bridge, developer of the DATANET machines, Bob Johnson and John Paivenen, veterans of the ERMA project, all prime leaders in the Phoenix operations, left the company. During the same period, Ray Barclay, who had served as manager of engineering in Phoenix since its inception was moved aside and Bill White became his replacement. Phoenix was in a distinct state of flux.

By mid-1964 Cross had persuaded Borch that it would be in the company's interest, and of benefit to the computer department, to acquire a 75% ownership in Olivetti and a 50% position within Bull. This would provide an outlet for GE products in Europe and allow GE to take advantage of the integration of their products into the U.S. operations. It would appear that the preliminaries to the acquisition of Bull did not include the understanding that the laws of France would require that a Frenchman maintain the senior management position in the company. Initially this position was left vacant pending the new changes planned for the Industrial Electronics Division—the replacement of Harold Strickland.

Lou Rader, a Canadian by birth, had joined General Electric in 1937 and was subjected to the standard GE management schooling, but after a couple of years friends from Chicago approached him to serve as chairman of Electrical Engineering Department at Illinois Institute of Technology. Two years later he decided that he was not cut out for academia and returned to GE where he eventually ascended to the post of general manager of the Specialty Department of the Industrial Electronics Division. The department, located in Waynesboro, Virginia, was primarily responsible for process control style applications using computer-like systems. Rader recalled why he left GE for a second time:[25]

> People have asked me "why did you leave GE?" And the reason was, simply, that various groups within GE kept calling me up and saying, "We have a job for you. It's in Scranton." and I said, "I'm not interested." Then "We have a job for you. It's in Syracuse, or Philadelphia, or in Milwaukee." I said, "I'm not interested." Doc Baker finally said, "Rader, you can't keep turning down jobs." to which I replied, "Why not?" He didn't know.

Rader joined ITT as vice president of U.S. commercial activities. As opposed to GE, Rader discovered that the President of ITT, Harold Geneer, only hired mercenaries, staff who worked for money only, had no loyalty to anything, "whereas" he recalled, "in the GE Company, you always expected your people to be loyal to the company, and that what was good for the company was good for you, and vice versa." But Geneen had as great a paranoia about computers as did Cordiner, and Rader, like Baker and Strickland, had to keep any computer activity carefully concealed. He subdued his interest in computers for only a time though, moving on to serve the Remington-Rand Corp. as president of the UNIVAC division. Going in, he knew the business plan suggested that they were to lose about six million dollars in the next year, and he recalled that the day he got there the financial authority said "Dr. Rader, I don't know what they told you, but all my figures say we going to lose forty million bucks next year, on a revenue of three-hundred million." Within two years, UNIVAC would break even.

I made the comment that in ten years I thought half of the computers that we were [manufacturing] would be talking to each other by telephone. And Cordiner's voice boomed out of the dark saying, 'On what basis do you make such a preposterous statement...?' I failed to persuade them that this was an important subject—data communications.

In 1964, after six years absence, Rader got a phone call from Marian Kellog at GE who said, "Lou, has anybody from GE talked to you recently? If somebody from GE calls you about the possibility of coming back to GE would you talk to them?" He said, "Of course. I'll talk to anybody." Hershner Cross, group vice president, set up a meeting for Rader with Borch and Chairman of the Board Phillippi. They were to offer him the position of vice-president and general manager of the recently reorganized Information Systems Division, that would include not only the Computer Department but also the Process Control Department and Communications Department. Having turned the UNIVAC Division of Remington-Rand around, GE now wanted him to do the same for their computer department. Though having not heeded the happenings within GE over the period of his absence, Rader was interested in using this opportunity to return to Virginia, even though his native land was Canada. He insisted that he be headquartered in Charlottesville, Virginia, planning to make his home in Waynesboro, the site of his previous managerial experience, just across the Blue Ridge. He insisted on picking his own consultant, lawyer, and recruiter, to all of which Borch acquiesced. He never thought to ask for his own aircraft to fulfill his obligations to oversee what was to be a far-flung empire from Waynesboro, Virginia, to Lynn, Massachusetts, Oklahoma City, Oklahoma, and Phoenix, Arizona, but GE provided a Cessna King Air. They were almost ready to give him anything he desired. But in retrospect this may all have been up-front benefits to ensure Rader's acceptance of the position. Before long, there were pressures to modify these initial commitments. For the first time the Computer Department had a divisional general manager who understood computers.

25. Memory Dump Session, Scottsdale, Arizona, May 1994

Somewhere along the way Rader had either not been informed about, or had missed the comment on, the plans to acquire an interest in Bull and Olivetti. A month or so later he inherited 10,000 Frenchmen, whom, he recollected: "... hated Americans. They were aided and abetted by Charles De Gaulle in disliking Americans. So I told them I'm not really an American, I'm a Canadian. But they thought Canadians chased Indians on horseback. So it didn't make any difference." GE bought Olivetti a month later, but he had no trouble with the Italians because he was Italian by descent. Olivetti had a marketing organization in Germany, who would take a task and just do it the way it was proposed. The Italians said, "If it works for the Americans, it'll work for us." But the French insisted there must be a better way. Charlottesville was not, after all, so far from the center of Rader's activities that spread from Phoenix in the west and Italy in the East. Three months after setting up shop in Charlottesville, Cross called Rader and said, "Most of the problems we have are in Phoenix, aren't they?" Rader agreed. Responding to the affirmative reply, Cross suggested: "I think you ought to move to Phoenix, and we'll bring in Lou Wengert to run all the stuff in the east." That was not the basis on which Rader had returned to GE; the problem was already almost twice as big as he had been led to believe, though the operation was still not as large or diverse as the 17 plants he ran for ITT and Geneen. Rader's refusal to move house and headquarters to Phoenix was the turning point in his relationship with Hershner Cross, who tried to solve *his* problem by appointing four deputies to become vice-presidents and general managers of the (still) recently reorganized Information Systems Division. Rader explained, "GE had an appointment procedure that was 'one over one,' I was supposed to appoint them, and he had to approve them. He didn't even do that; didn't even ask me if I approved of those four names." They were all people who had worked for him on a study he had made for marketing a few months earlier—Wengert, Coe, Van Aken, and Maier. The writing was on the wall for Rader, but the machines of the Phoenix plant were beginning to be noticed.

Joe Weizenbaum was on the scene at MIT when the search began to choose a machine that would support the ARPA-supported Project MAC[26]. Part of the project was to "commercialize" the compatible time-sharing system (CTSS) developed by Fernando Corbató which had been implemented using the IBM 709X machines that had been part of the MIT scene for almost 10 years. Weizenbaum recalled:

> What happened was that we were using the enhanced [IBM] 7090 and we had done everything with it that we had set out to do—and now comes the question of doing something that's not entirely experimental so that in a certain sense we were using it for real time or something like that, and we needed a new machine. And we let it be known that we needed a new machine—we asked for time sharing basically.

There was a list of companies, and some of them refused, and some of them looked into it, but General Electric was not among them. Some companies did not respond to the RFP on the theory that it would go to IBM anyway. IBM had given MIT a lot of money over the years, a lot of technical support,—of course it was going to be an IBM machine. Weizenbaum remembers:

> IBM sent people around to talk to us, and they were simply the wrong people. Initially they sent marketing big shots, who didn't understand anything technical at all and just said, "Well, we couldn't do that" and we were very unhappy. They sent technical people, who just had the attitude, "You tell us what you want, and we'll do it for you. We're the technical people. We're the engineers. We know how to do these things, and we're business demand driven. Tell us your requirements. We'll invent the solution." And not only that, "It'll be so good—we'll have it Wednesday." We couldn't communicate with those guys. What were going to do? So I suggested that they call GE. My colleagues said they didn't even know that GE had anything to do with computers!

The requirements for the Project MAC machine included the implementation of hierarchical interrupt facilities and memory protection to prevent users from accessing or modifying each other's working areas. The then in-vogue System/360 machines did not possess these facilities and apparently IBM was not willing to modify any particular model to meet these demands. On the other hand, John Couleur had already developed his "look-aside" system for the GE 600 series, and the Company was willing to make other changes to develop the machine that became known as the GE 645, and that would be chosen and delivered as the Project MAC machine. Bell Laboratories, also partners in Project MAC, confirmed the design and choice of the GE 645 by placing orders for that machine to supplant their own IBM computers. Of considerable advantage to GE was the ARPA support of Project MAC that would help pay for the actual implementation of Couleur's designs instead of depending on capitalization from "570." For the first time since ERMA and the Bank of America, GE had a partner in the development of state-of-the-art equipment.

In response, IBM reacted to the potential lost sales for System/360 replacements of 7000 series machines by cutting prices and rushing to develop 360/67 TSS system.[27] In many ways TSS was more like a remote batch system operated from a teletype-like terminal utilizing multi-programming techniques, rather than a true time-sharing environment as conceived by Corbató and as implemented later by Honeywell Information Systems as the Multics system.[28] Though later more prevalent than Multics, TSS was buoyed by the marketing capabilities of IBM rather than its technical superiority; the sales of Multics did not have the same support and were later stymied by the poor service capabilities of Honeywell.

The time-sharing system at Dartmouth College still

26. See Lee, J.A.N. (Ed.) 1992. "Project MAC," Special Issue, *Ann. Hist. Comp.*, vol. 14, no. 2.

27. O'Neill, 1995.

28. Organick, 1972.29. The Dartmouth system was not actually named DTSS until the second system ws implemented on the GE 645 in 1969. Herein we have used the generic term DTSS to refer to all versions of the Dartmout system to distunguish them from any GE version. Kurtz noted in private correspondence, "One of the few executive decisions I made as director of the conputation center was to declare that the system would be known as DTSS, one letter later than CTSS at MIT, rather than (GEs name) Phase II which was a brand of bath soap.

impressed Don Knight and the other 200 engineers in Phoenix. However the mean time to failure of the Dartmouth time-sharing system (DTSS)[29] was about 20 minutes, clearly too short for commercial purposes. It was agreed that Phoenix would assemble a duplicate of DTSS. Two of Dartmouth's student programmers, Mike Busch and John McGeachie, were hired for the 1964 Christmas vacation to assist in this project. GE got the best programmers in Phoenix, the best compiler people, the best operating systems people, and sat them down with the system listings and the students. The GE programmers went through these listings, line by line, and would say to the students, "Now what were you trying to do here?" And the students would explain, "we were trying to do thus and so," and then the professionals would say, "Now here's how you should have done it." Through that rewrite scheme the GE version of DTSS went from a timesharing system that would crash every twenty minutes to one that ran for a one-and-a-half to two days before crashing. The other thing they tried to do as part of that exercise was put in some good security. This was tested later by MIT students. Don Knight recalled:[30]

> One morning the timesharing systems—we had seven of them by then—came up across the country, and every user that signed on got "The Jolly Green Giant strides through the Valley of the Giants. Welcome to [some funny farm]," instead of "Welcome to GE Timesharing." There were some very angry people at 570 Lexington Avenue. With the time difference [between New York and Phoenix] Ralph Cordiner was already in his office at 570 Lexington Avenue. I was still in bed. My wife came into the bedroom and said, "Don, Ralph Cordiner wants to talk to you." And I said, "Yeah, uh huh," She said, "Really." So I got on the phone, and it wasn't Ralph Cordiner, it was his secretary. And she said, "Wait a minute." He came on, and he informed me what our timesharing systems had said that morning. He wanted to know the story, and he wanted me to report to his office every hour on the hour until I had run down how it happened, and so forth. So we had a very brief, very succinct conversation, with me lying in bed. Well, some of the students at MIT[31] had heard that GE thought that they had put good security in their timesharing system; you never should tell a student you can't do something! Any professor learns that really quick. So these MIT students had taken this as a challenge. They cracked the security, got in the system, planted the Jolly Green Giant message, to show us that it could be done, that our security wasn't perfect. It was innocent, and it wasn't all that bad. We knew the names of the students; there was no big secret about it, and after I found out what had happened, they wanted credit for it. So I got hold of Ralph Cordiner's office and left a message about what was going on. We had a group of General Electric lawyers go to MIT and pay a little visit with these students. We ended up putting them on the payroll; their part-time job was to try to crack our security system, and tell us all we needed to do to improve it, but not put any more messages in for our user-customers to find. So I had a very scary first relationship—and only relationship—with Ralph Cordiner.

Accounting said, "...That machine is fully depreciated. Engineering has written that machine off, so as far as we're concerned, it doesn't exist. You cannot transfer a machine from one set of books to another set of books, because there is no such machine."

The GE timesharing business started shortly after Dartmouth got the first timesharing system going and after the "commercial" version was rewritten from the student original. By the mid 1960s it was a multibillion dollar per year business for General Electric, and it has been extremely profitable for the company for over two decades. The time-sharing business was not part of the sale to Honeywell in 1970. While Herb Grosch had set up the service bureau business, it had never been profitable. The thought came to Charles Thompson that providing a commercial time-sharing service would be the way to turn around this activity and at the same time save the job of the Helmut Sassenfeld who was serving as the manager of applications, in charge of the service bureaus. Since the marketing group had been forbidden to market the ERMA system outside of the west coast, the service bureaus were offering a package named "BankPak" to banks that were not ready to operate their own computing centers. This was not profitable; the service bureaus needed some other service to put a profit into their bottom line. Don Knight remembered that the 1965 time-sharing activity started with a stolen GE 235 computer:[32]

> We wanted to test the commercial feasibility of timesharing. A lot of people in GE really didn't think we could sell timesharing commercially, anymore than we could sell BankPak commercially, or any other kind of machine time. But what they didn't realize was how frustrated engineers had been for years going through the batch processing mode of operation. So we wanted to get a machine, the engineers wanted us to get a machine, and marketing wanted us to get a machine. Larry Hill wanted to give us his machine, which was in the engineering laboratories. It was a good example of how the walls between functions came tumbling down when everybody really wanted to do something at the

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30. From the "Liar's Club" session in Scottsdale, Arizona, May 1994.

31. Kemeny and Kurtz attributed this hack to Dartmouth students.

32. Liar's Club, Scottsdale, AZ, 1994.

> lower levels. So we had a meeting with accounting and said, "We want to transfer this timesharing system that is in the engineering laboratory over onto the services bureau's books." Accounting said, "You can't do that." We asked, "Why not? You know, it's just a transfer." "Well," they said, "That machine is fully depreciated. Engineering has written that machine off, so as far as we're concerned, it doesn't exist. You cannot transfer a machine from one set of books to another set of books, because there is no such machine." The meeting went on for quite a while and we were trying to be creative. And finally we said to the accountants, "Fellows, if the machine doesn't exist, it can't be stolen. Isn't that right?" They thought about that for about another hour, and they finally agreed, "You cannot steal a machine that doesn't exist." So we hit upon a plan. On a long three-day weekend, we hired a moving van, went out to the GE plant—the appropriate people had written the relevant gate passes—and we stole that sucker. And we took it downtown to the Phoenix Information Processing Center (IPC).

Unknown to Knight, the burglary did not solve the problem immediately. The thieves had gotten the wrong kind of moving van that didn't have the air ride, and when they got it downtown they bounced it like a dribbling basketball up the front steps of the IPC building. By the time the machine was in place its chassis was warped; the boards would not make contact in their sockets. They had stolen a pile of junk. The engineering group quickly responded by replacing most of the parts to produce a working machine. IPC had the start of its timesharing business. Soon it was being used by up to 80 customers who were in seventh heaven for being able to get up to twenty iterations of program debugging in a day instead of the one or two they could get with the batch system. The paying customers effectively paid off the original cost of the machine in less than 90 days. Harrison Van Aken was not impressed, believing that GE should not be in the service bureau business. To satiate Knight and Sassenfeld he suggested that they go to Lou Rader with their plan; if he approved then the responsibility for the failure would be on Rader's shoulders not his. The single IPC model became the market test on which to base the business plan prepared by George Snively that would be presented to Lou Rader proposing to convert all of the seven IPCs to timesharing within the first year. The plan called for an initial outlay of eight million dollars with an expectation of a second year appropriation for $21-million.

One of the unexpected demonstrations of time-sharing that perhaps influenced the decision to support the IPC time-sharing make-over came during a meeting chaired by Fred Borch, by that time president of GE. Larry Hittel recalled:

> We found a champion in New York City—Dr. George Finney, who was an operations analyst for Mr. McKittrick, who was, in turn, the corporate finance vice president. Finney, who was using our system via the GE telephone system on a minute-by-minute, hour-by-hour basis, would sit and crank new numbers for the financial people. McKittrick, Borch and others were trying to figure out how to squeeze the cash cows and how to feed some of the kittens that needed nurturing. They needed some new numbers, so they called Finney in, and he said, "I'll have them back up here in 30 minutes." And they looked at him as if to say, "he can't do that." Finney had the results back up there in about 20 minutes, and soon he was explaining how he was doing this off our time-sharing system in Phoenix. Of course this was a totally incomprehensible concept to these people, so McKittrick invited Borch down to the finance office to show how they did time-sharing. Borch reluctantly went down, and saying that he only had about 20 minutes before another meeting. When his secretary called about 30 minutes later to remind him that he had a meeting, he said, "Well, I'm going to be a little bit late." He was sitting down there playing what-ifs with George Finney, cranking it through the system and looking at the results. We had a lot more cooperation about a week later when the word permeated down from 570 to Phoenix. We got new equipment, we got new disk drives, we got a lot of things.

Two years later GE had 28 operational time-sharing centers and the capital outlay was mostly recovered from customer fees. Still Sassenfeld lost his job as manager of applications.

During the latter part of 1964 Thomas O'Roarke, manager of the Regional Customer Support Center in San Francisco was also experimenting with the provision of time-sharing to his customers to salvage the lagging bureau operations. O'Roarke had been a salesman in the early 60s, selling 11 ERMA systems to Security Bank in Los Angeles before moving to Phoenix, and then on to San Francisco in 1963 as western regional manager, reporting to Bob Sheeley. Having worked closely with Sheeley for several years, Vern Cooper, who was put in place in the changes initiated by the appointment of Lou Rader as division vice-president, did not appreciate O'Roarke's efforts. Cooper decided that the Western Regional Office needed a "proven computer professional"[33] to run its operations, and O'Roarke was given a four month "umbrella" to locate another position. Having watched the success of the Dartmouth time-sharing system, and by now convinced of the efficacy of time-sharing as a potential business opportunity, and equally convinced that his family did not need to move out of the San Francisco Bay Area, O'Roarke persuaded George Snively to help him develop a business plan to create a new company doing time-sharing business using the GE 235. The plan involved using the $17,000 cash assets that O'Roarke had accumulated in his 17 years at GE and support from the Bank of America through a Small Business Investment Grant of $250,000, to place an order with GE for the lease of a GE 235 and DATANET 30 in a company named TYMSHARE. Harrison Van Aken, upset by the audacity of O'Roarke going into competition with GE using its own machine, summoned O'Roarke to the Phoenix office (after his separation from GE) and demanded that he purchase the machine for cash on the nail-head rather than continuing with the lease arrangement that had been set up by Snively. The rationale for the change was the lack of an acceptable line of credit to support a lease for a machine to be

33. Personal communication to H.R. Oldfield, 3 Aug. 1993.

delivered in the first quarter of 1966. In the meantime, Arnold Spielberg, having designed the type-1800 process control systems for IBM, was now at SDS (Scientific Data Systems) and was working with the University of California, Berkeley, to develop a time-sharing system. This was the ideal situation for a start-up company especially when the relationship with SDS would revitalize the Bank of America venture funding. TYMSHARE was born. Just short of 20 years later, TYMSHARE was sold to MCAUTO, with over 3,000 employees, 50 sales offices, and annual revenues of $350 million. The selling price was $350 million—a good return on an original $17,000 investment.

The development of the GE 600 led to a contract with Martin Marietta Corp., but the delivered system, what today might be designated a "beta test" system, was having problems meeting the expectations of the customer. In a period when it was rare that an installation was productive immediately, Martin Marietta was prepared to accept this delay but sought some relief from the full lease price until the machine was finally accepted. George Snively, recognizing the advantage of debugging the system on the customer's site, proposed that GE and Martin Marietta share the leasing costs while the problems were being resolved. Considering that this was a multi-machine installation with a seven year leasing contract, the $3 million difference was a small price to pay to satisfy the customer and at the same time resolve the obstacles to a satisfactory performance that would be required for acceptance. But this was not a solution that Snively could approve alone; Vern Cooper, as manager of marketing had the last say. In an unfortunate meeting with the Martin Marietta staff, Cooper undermined Snively's proposal and the contract was canceled. While on the one hand Cooper was complimented by the GE administration for getting them out of a difficult and potential costly situation, on the other hand the word got around the industry very quickly that GE had reneged on its agreement to provide computer services to Martin Marietta, and there was a rapid loss of customer confidence.

The problems of integrating the European acquisitions into the GE family of operations were far greater than Rader had expected when he belatedly learned of the expansion of his domain. He quickly discovered that the efficiencies that he brought about at ITT where he had reduced inventories drastically and eliminated several obsolete product lines, could not be duplicated. There was a competing printer manufacture facility in each company, and an unprofitable line of tabulating machines within Bull, but there was no Geneen to mandate changes. The labor union structure combined with the intransigence of Charles De Gaulle to accept the direction as an outcome of ownership, made it impossible for Rader to reduce the staffing within Bull or to consolidate manufacturing capabilities between Olivetti, Bull and GE. What he had inherited was an acquisition, not a manageable entity that could be a natural extension of the GE (U.S.) Information Systems Division. One of his only successes was the termination of the Gamma 140 program within Bull in late 1965.

At the same time that Project MAC was searching for a machine on which to base their upgraded time-sharing system, Dartmouth was not forgotten by GE. After all, the Dartmouth system was the basis of GE's commercial time-sharing services and the interaction between the two groups was still harmonious. Kurtz recalled:

> It was our system, not MIT's, that became the backbone of the GE time-sharing business. Sometime, it must have been mid-1965, Dartmouth was attempting to raise money for a computation center, and was contacting Peter Kiewit, the Omaha mega-contractor. Lou Rader had the idea that, if the first time-sharing system was such a success, why not try again with the GE-600 series computers, which were then just coming out? Plus, he felt that it would look better for GE to display the 600 series in the new computer center rather than the old 200 series. So a joint project was mounted. It began in the summer of 1966 with the construction of a crude time-sharing system for the GE-625 to be used as a systems development tool. This was our assignment. We called it MOLDS (Multiple On-Line Development System.) Sidney Marshall designed and built it. In so doing, he discovered undocumented things about the GE-625, such as the timing of instructions, that were useful later one.
>
> The GE-625 was located at the Rome Air Development Center at Griffis Air Force Base, and was greatly underused (wonder of wonders.) At the time I felt their policy was to own just about every modern piece of high speed computing equipment, even if they did nothing with it.
>
> We used MOLDS remotely during the fall. At the time of the Kiewit Center dedication in December 1966, the new 600 equipment was just arriving at Dartmouth. The plan was to have GE develop a "Phase I" operating system, using quick and dirty methods, while Dartmouth would develop a better "Phase II" system at their leisure. Dartmouth was also responsible for the Basic compiler and some of the editors on Phase I. Actually, GE was concerned that Dartmouth would not be able to develop an operating system soon enough to permit commercial utilization in the fall of 1967, which was part of the GE plan to minimize the cost impact. They were probably correct. In any case, Phase I was a crude system, but it worked. And GE continued to use descendants of it even when the superior Phase II system became available in the spring of 1969."

Computing is about putting large, complex systems together. It isn't about writing little programs—to sort a few numbers, or whatever—the exercises that undergraduates do.

The Project MAC and DTSS objectives were quite different, and if both were successful GE would have a hand in two systems that could serve very disparate communities. DTSS was targeted toward the educational and student communities where production systems were not the prime purpose of program development; in fact DTSS was designed for student development not system development. Project MAC and the Multics system had plans for the development of an environment in which commercial, complex systems could be produced. The involvement of Bell Laboratories in Project MAC also had this goal in support of the telephone services of AT&T and their customers. Weizenbaum commented, "Computing is about putting large, complex systems together. It isn't about writing little programs—to sort a few numbers, or whatever—the exercises that undergraduates do. Computing is about putting large tasks together, and creating large, complex systems. And that's what Kemeny didn't grasp." Of course, Kemeny did grasp the needs of students.

As part of the purchase of an interest in Compagnie des Machines Bull, GE also acquired a company that marketed computers in the UK, De La Rue Bull Machines, Ltd. In 1966, Vic Casebolt was sent over to become managing director of this company that was 50% owned by Bull General Electric, 25% by General Electric, and the other 25% by a company that printed bank notes, De La Rue. Casebolt was aware of the problems with the 600 series machines in Phoenix and dissuaded them from putting too much effort in those sales. Instead he convinced them to start a time-sharing service similar to that in the IPCs in the U.S.; the service was inaugurated in the summer of 1967. The prices were set to be 10% higher than those in the U.S., but the business was soon a sell out. Knowing that Bull had 20 affiliate companies located in 20 countries in Europe and Latin America it was clear that they were prime candidates for the installation of similar systems. Six systems were placed in continental Europe in the six largest countries, with service to 11 different European countries. Before long each of the companies was profitable. Time-sharing had again made the difference.

The 1965 business plan, while realistic, did not carry through previously expected profits that had been introduced in order to make the earlier plan acceptable to the executive officers, rather than to reflect reality. In the review Rader realized that he needed to spend more time with the computer department to better defend its operations with the group. It was probably too late in any case, since Cross had resolved to replace Van Aken as general manager of the computer department. Cross also decided to get a handle on the working of the division and thus the department by appointing four deputy division managers for Rader, but actually reporting to Cross. None of these deputies had any computer experience. In late 1965, Lou Wengert, deputy division general manager, also assumed the position as acting general manager of the computer department, to be renamed the Computer Equipment Department to bring it into line with other departments, and to eliminate the connotation that this was the only location within GE where there was computer manufacturing. Other changes did not improve the capabilities of the department to satisfy the requirements of its administrators. What was needed was leadership with the confidence of the executive office and sufficient capital to test out ideas—everything was expected to be profitable immediately. Marketing, Field Engineering, and the Information Processing Centers were reorganized not to report to Wengert, but instead to the newly appointed deputy division manager for data processing and communications. At the same time the headquarters for the Information Processing Centers was moved from Phoenix to Bethesda, Maryland.

The 1966 business plan was an improvement of the 1965 plan that had been Van Aken's downfall, but it still required an additional $100 million investment that would be recovered over the next five years. This was not deemed satisfactory and so Rader was charged with coming up with a better projection independent of reality. In August 1966 Cross decided to extract the non-computer elements of Rader's division and to create a new Industrial Process Control Division of which Rader would be general manager. The computer department, though managed by a computer illiterate, had lost its first divisional general manager who understood the business but who had been too distracted with other wildfires to give enough attention to the department. Cross put himself in the position as acting GM of the reduced Information Systems Division. By this time none of the supervisory management of the computer department, from department general manager to corporate president, had any real computer background, though the plan was still to achieve the position of number two in the industry.

Stranger appointments were to follow. Wengert, as deputy division general manager, appointed Erwin Koeritz as general manager of the Computer Equipment Department; like others, Koeritz was a professional manager without computer experience. To replace John Weil, who had been serving as the manager of the special products section responsible for the GE 600 line of machines, Eugene White (another non-computer type) was appointed from outside the department. John Couleur, who had been involved in the GE 600 development for many years, would have been the natural selection; he left the company shortly thereafter. At the same time the lack of understanding of the needs of clientele for leased systems was revealed when the market support group was disbanded, causing immediate concern among customers, and the resulting loss of further sales. The department was falling apart.

Not the least of the problems of the department was that the GE 600, after the delivery of 25 successful systems, was having problems meeting the final test requirements. Eventually this was tracked down to the change of the supplier of transistors that did not meet the previous requirements. Wengert withdrew the GE 600 from market destroying customer confidence once again. Things were not getting any better. In December 1966, Cross, who had made so many personnel changes, was replaced as vice president and general manager of the Information Systems Division by Stanford Smith; while Cross retained his position as group vice-president, Smith was to report directly to Borch. The situation was summed up in a pair of articles in *Forbes* magazine entitled "GE's Edsel?"

In January 1967, Phoenix laid off 450 people, the first time, apart from the exodus of IPC, that the staffing of the department had been reduced. And changes were to take place at the group and division level. The reporting scheme in which Stanford Smith reported directly to Borch was confirmed when the Information Systems Division was moved up to group level and Rader's Industrial Process Control Division was moved to the Industrial group headed by Cross and further away from the Computer Equipment Department.

The one area that did not seem to be affected by all these changes was the time-sharing business. For the first time GE moved time-sharing to Europe where there was very little comparable activity, even in the universities. Using the GE 265 software upgraded from the Dartmouth system, Vic Casebolt, who by now had moved to Bull-GE as directeur-generale adjoint in Paris, introduced interactive computing to a market outside the U.S. ahead of IBM and European computer companies. By mid-1969 there would be over 100,000 customers using GE time-sharing in Europe.

In 1967 the decision was made to move the GE 645 development for Project MAC from Phoenix to the Special Information Products Department in Syracuse to be headed by Walter Dix. This was to provide a closer liaison with the Cambridge, Massachusetts, where the Multics software was being developed, and to Dartmouth where the upgrade to their time-sharing system was underway. While Dix's influence was very positive, to the extent that many of the GE computer department alumni singled out Dix as one of the unsung heroes of the 600 series development, the departure of this operation from Phoenix was yet another blow to the prestige of the Department. In the next year a GE 635 was delivered to the Kennedy Space Flight Center to be used for several years in support of the Apollo launches in preparation for the moon landings and the GE 645 came on-line in Dartmouth. It looked like the transistor problems of the 600 line of machines were being solved. However, the further work of the Special Information Products Department on the GE 600 project was canceled on the grounds that the design using CML (Current Mode Logic) chips was inferior to the design in use at Syracuse, and so another Syracuse operation was transferred to Phoenix to become the Large Scale Systems Department.

A bright star began to shine for the division in April 1968 when John Haanstra was appointed as general manager of the Information Systems Equipment Division and Wengert moved to the Industrial Group Division; once again the computer operations had a computer literate manager. Haanstra had come from IBM with considerable experience in the design and manufacture of computers, and it was expected that he had both the technical and managerial skills to turn around the computer product problems in the division. Not long afterward there was another change at the group level when Hilliard Page was appointed to head the Information Systems Group. Even as late as 1968 GE was unable to locate managers with computer experience.

Before the end of the year, Richard Shuey and Don Shell (GE Research Laboratory, Schenectady) began to implement a new GE 600 operating system that would become GECOS IV, and one of the most effective versions of the operating system. Their work proved that the GE 600 line of machine could be competitive with the machines of other manufacturers. However it would not be ready in time for the delivery of machines in 1969 that had to be equipped with GECOS III systems. A plan to supplement the capacity of the GE 600 time-sharing system by using an Olivetti small system, designated as the GE 115, to act as smart terminals failed due to the incompatibility of the two different systems.

The 400 line of machines was not forgotten. Four years previously, in 1965, the Department had initiated Project ISIS to develop a retail trade information system, later named TRADAR, to provide point of sale devices using GE 425. In 1969 the system was ready for its first field testing, and in April the J.C. Penney Co. signed a contract to install TRADAR in their stores. Like the ERMA system, this innovation would require the acceptance of a tagging system by the clothing manufacture industry. Unlike MICR where the Bank of America could control its the printing of its own checks, and the imprinting of the check amounts after customer user, TRADAR depended on the sales articles arriving in the store with the tags attached—after a minimal test, Penney backed out of the contract.

"Hilly" Paige resolved to solve all these problems with a clean sweep by effectively starting over again in the computer business with a new line of equipment. He hired Richard Bloch from Honeywell to head super secret "Shangri-La" Advanced Product Line (APL) project based in Hollywood, Florida, far away from any other of the computer operations, and provided a staff to brainstorm a solution to GE's large machine problems. With great secrecy certain employees from Phoenix were seconded to Hollywood for varying amounts of time, much to their spouses displeasure, to provide input into the process. Eventually the Shangri-La project proposed to phase-out the existing lines of equipment while the APL was being developed at cost between $500 million and $1 billion. Development would take five years and be profitable in 10—that is, by 1980. Considering that such long amortization periods had been the downfall of prior attempts to capitalize the product development, it was most unlikely that such a proposal would be acceptable, even with a different cast of managers at the divisional and group levels.

The writing on the wall was becoming clearer; GE had only two alternatives—to spend up to $1 billion on resurrecting its place in the computer business ... or get out of the business ....

After ten years the Bank of America ERMA systems and those sold to other banks, were reaching end of their life-time. Service by this time was not spectacular and replacement parts were not being manufactured by either GE or NCR. GE had no follow-on machine, since no other machine-lines would interface with the MICR equipment. Casebolt, having returned to Phoenix to fill the position of manager, information systems sales operation, proposed upgrades to the GE 600 including developing interfaces to high speed check sorters and MICR to keep this business. Paige insisted that Bloch's Shangri-La group look over proposal since it would imply extending the life of the 600 series of machines. The proposal was rejected for "lack of innovativeness." IBM came to the rescue of the banks, by buying out the remainders on the contracts and replacing the ERMA systems with its own equipment. The machine that made GE the pioneers in providing services to the banking industry and that had gotten the GE computer department off the ground was gone, and primarily forgotten. GE lost a large portion of its customer base. Later Casebolt took his plea to save the banking business and the 600 line to a confidential friend at 570, where he was told to wait a while, "plans are in the works to solve problems." He may have gotten the first hint that GE was to get out of the computer business.

With all these disasters, a calamity was about to occur; John Haanstra was killed in small plane accident. Later the National Transportation Safety Board (NTSB) determined that with one engine failing, Haanstra had feathered the wrong (and working engine) and was unable to recover. The hopes of a turn-around in GE fortunes in the computer business seemed to go down with Haanstra's aircraft. John Burlingame was hired to replace Haanstra. While it was true that the GE 200 line was still profitable, the U.S. operation was still not overly successful. The 400 line being built in Angers, France, and the majority of 600 machines were being shipped to Europe. There were sales of GE 50s, designed in France, and GE 100s, originally developed by Olivetti, selling in Europe but lacking compatibility with any of the other machines. The BIG LOOK concept of a family of compatible machine was long forgotten.

The writing on the wall was becoming clearer; GE had only two alternatives—to spend up to $1 billion on resurrecting its place in the computer business (and perhaps another large sum to promote their machines to a customer base that had lost its confidence in GE products), or get out of the business recovering as much as possible of the capital outlay of the previous years. The *Data Management* magazine summed up the expectations of the industry.

The Shangri-La proposal to develop the Advanced Product Line at a cost between $500 million and $1 billion drew rampant skepticism from 570 primarily on the expectations of recovering the costs in a reasonable time. Clearly IBM's System/360 line was highly successful and not likely to be breached by an undesigned, paper system; the mini-computer market was in its prime and GE did not have a competitor there; only the process control and time-sharing businesses were effective. 570 never considered the upgrading of the existing lines of machines.

President Borch, looking at the bigger GE picture ordered Reggie Jones (VP for Finance) to study three "problem" areas—nuclear energy, jet engines and computers, on the understanding that it was unlikely that the company could support large outlays for each of these burgeoning areas. GE nuclear energy and jet engines were already established as number one or two in their respective industries, but computers were still way down the list. The group of three vice presidents that formed the committee headed by Jones quickly recognized that $500 million was too much to spend on computers and that instead GE should sell the computer business; GE should stay with nuclear energy and jet engines and maintain their leading position there. The details of this decision were not public until several years later when the U.S. Justice Department prosecuted IBM for antitrust activities; the story was revealed by the *Wall Street Journal* (see side bar) in 1976.

Roger Rosburg, claimed he was the first "nobody" who had a very good idea that General Electric was selling the computer business. General Electric had a policy of holding their shareholders' informational meeting each Fall and then hold the shareholders' meeting the following Spring. The Fall meeting of 1970 was scheduled into Minneapolis where Roger Rosburg was a salesman; he was responsible for the local arrangements for the members of the board of directors.

Reggie Jones and Bob Penigan had some work to do and they needed some space where they could put out some papers. Rosburg took them to a room where there was going to be a cocktail reception that evening, gave them the key, and ordered a compliment of liquor, ice and mixers. About 3 p.m. Rosburg went to see if everything was satisfactory but Jones did not want to let him in. Rosburg recalled, "I was really wondering why he would be bothered by my going in to look at the liquor?"

Later Rosburg observed Reggie Jones, Robert M. Estes and Jack Parker entering President Borch's room from the rear. He also observed and identified Jim Binger, of Honeywell, with the group. Waiting for Estes to leave for the airport, Rosburg and Jones got into a conversation in which the former tested the waters of a Honeywell take-over; he said, "Next week, Honeywell's going to have a little more trouble with their annual meeting than we did today." Vietnam protesters were threatening to picket the Honeywell meeting against their manufacture of napalm. Without blinking, Jones replied: "Yeah, I expect they will." The next question Rosburg wanted to ask was, "I wonder if you guys are trying to sell out, because that looked like the Honeywell crowd to me." At the airport, Rosburg remembered that Borch was nice enough to come off the plane and to thank him for his hosting the visit to Minneapolis, and was tempted to say, "Fred, I don't think I'm going to see you anymore, either."

It was several years later, on a sales call when Rosburg convinced Binger to talk about how it the sale got started. According to Binger, Fred Borch called and said, "You know, we're both in the computer business, and neither one of us has been quite as profitable as we'd like to be. I think there's some potential for some way to change all this. Do you happen to come to New York ever on business?" Binger said that he responded, "Sure. Next time I'm heading to New York I'll be sure to call you." Binger called his staff together and informed them that they were going to New York. After a philosophical discussion with Borch ranging from the fact that the business has not turned out exactly the way he would like it to be, finally Borch paused and Binger looked at him and said, "Fred, are you buying or selling?" Borch responded, "I'm selling."

GE had made approaches to several companies, but only Honeywell was considered that would be able to serve as partner for what was projected to be a five year transition period. Honeywell was anxious to acquire the 600 line as an adjunct to its own line of equipment, and, like GE several years before, anxious to expand into the European area by acquiring the Bull and Olivetti sales networks. Perhaps because they were located in different divisions within GE, the sale to Honeywell did *not* include process control, communications, and time-sharing, though process control would be sold to Honeywell in a later, separate deal. For several years, GE would own an interest in the business, but not take an important part in its management. On October 1, 1970 the merger took place, and the Computer Equipment Department became part of the new organization named Honeywell Information Systems, Inc.

Conclusions

About the same time that GE was extracting itself from the computer business, the Bank of America was ready to shut down the last ERMA system, it having been ignominiously replaced by its earlier competitor—IBM. On the occasion of the shut-down, ERMA sent its last message to its co-workers, not mentioning its designers and manufacturers:

> A MESSAGE TO ALL MY CO-WORKERS FROM ERMA
> IN MY ELEVEN YEARS OF SERVICE TO THE BANK OF AMERICA, I HAVE BEEN PRIVILEGED TO WORK WITH SOME OF THE BANK'S FINEST EMPLOYEES. FROM PEOPLE LIKE EMMETT JENKINS, DICK DAVIS, JOHN COOMBS, AND MANY MORE WHO WERE WITH ME FROM THE BEGINNING, TO BOB LEE AND ALL OF MY CURRENT CO-WORKERS WHO ARE ASSISTING ME IN THE PROCESSING OF TRAVELERS CHEQUES—MY FINAL APPLICATION—I CAN ONLY SAY THANK YOU. TOGETHER WE HAVE MADE GREAT STRIDES IN BANKING, AND I CANNOT HELP BUT FEEL, AS THE FIRST COMPUTER SYSTEM TO BE USED FOR BANKING APPLICATIONS, THAT MY RETIREMENT BRINGS TO A CLOSE AN HISTORIC ERA. TO BE THE FIRST IN SOMETHING IS A GREAT ACHIEVEMENT, AND I AM VERY PROUD. BUT MY SUCCESS COULD NOT HAVE BEEN POSSIBLE WITHOUT THE HELP OF SO MANY FINE PEOPLE.
> ALTHOUGH THE END OF AN ERA IS NEAR, AND WE WILL SOON PART, I WILL NEVER FORGET MY FRIENDS, AND I WISH YOU ALL THE GREATEST SUCCESS IN THE FUTURE.
> TO MY CURRENT—AND FINAL—ASSISTANTS, I BID FAREWELL —
> MY BEST TO ALL ERMA

But really that was not the end. It was perhaps the end of the GE Computer Department, but it was the start of Honeywell Information Systems (HIS) in which GE had a minor role. GE retained the time-sharing business and the process control activities, though the latter was later transferred to HIS. The 600 line of computers proved to be very robust, even surviving the lack of HIS support for Multics, and eventually becoming part of the architecture of machines built, even today, by Bull. John Couleur, who survived GE and continued to work with HIS, pointed out that in fact one should look at this continuum as not three successive companies but instead as the virtual organization that he named "The Black Canyon Computer Company."

Probably the most successful of the products of the computer department, and one which, like almost everything else, had to overcome 570 Lexington Avenue resistance, was the time-sharing services of the Information Processing Centers in the U.S. and the comparable services in Europe. Based on the concepts prototyped at Dartmouth College in the 1960s, time-sharing provided the kind of quick turnaround service that was not eclipsed until the personal computer came to the market. For almost 20 years time-sharing provided the only form of personal, interactive computing that scientists and business people desired; no wonder that when the personal computer became available they were well prepared to accept it and to integrate it into their environment. The Multics time-sharing system that was developed by Honeywell Information Systems using the GE 645 was not quite as successful, but that was not offered as a service, but instead was for sale or lease. At least GE had the foresight to exclude the time-sharing service from the sale of the computer department to Honeywell, but by that time this was a product and service that had proven that it could return the capital investment in time periods that were much more aligned with the 570 Lexington Avenue expectations.

The financial controllers in the company were never able to adjust their thinking to the extended amortization required to support the leasing of computers that was the norm in the business world in the early years of computing. Refrigerators, military systems, light bulbs and such were paid for on the spot, if not in advance, and the GE mentality was not prepared for expenditures that were not recovered until years later.

It would be possible from this distance to play "what-if" with various decision points in the history of the computer department for a long time. What-if, for example, Herb Grosch had been successful in persuading the Phoenix engineering group to duplicate the IBM 700 machines? Obviously one outcome would have been the commitment to a machine that IBM would abandon before long in favor of the System/360 line of computers. What-if Cordiner had not been so negative with respect to general purpose computer development and the computer department had been able to spend less time watching its back, and instead vice-presidents like "Doc" Baker had been able to wring a little more venture capital from 570 Lexington Avenue? On the other hand, what-if Kemeny and Kurtz had not used a GE machine to implement their Dartmouth time-sharing system and the programming language Basic?

It may be self-serving of one who has been embroiled in the computer business for almost 40 years to state that financial and technical problems of the field are different from those of any other business, and that the GE management never truly understood the differences. The fact that the management of the department, and the division in which it was ensconced, was more often than not computer illiterate, not withstanding all their manufacturing and financial backgrounds gained elsewhere (primarily in other GE divisions), never provided an environment at the upper levels of corporate management where the computer department could be properly supported. Palo Alto and Phoenix had the technical know-how in the early days, but came up short trying to produce a large scale machine that initially was named the Y machine, and then the 600 line. The recovery operation that substituted the M2360 machine for the Phoenix proposal, evaluated today on the basis of its eventual longevity, was the salvation that was then stymied by the lack of adequate peripherals, and, in the end, simple lack of commitment to staying the way. With that the customer base dissolved and the market for a machine that had no upper management support went to those companies that had only one product—the computer.

Two elements seem to predominate our assessment of the weak links in the chain that brought an end to the GE expedition into the computer business are the lack of computer literate upper level managerial support to develop company-sponsored business plans and the lack of adequate venture capital to allow for diversity of product lines and the occasional failure on the way to successful machines.

The financial controllers in the company were never able to adjust their thinking to the extended amortization required to support the leasing of computers that was the norm in the business world in the early years of computing. Refrigerators, military systems, light bulbs and such were paid for on the spot, if not in advance, and the GE mentality was not prepared for expenditures that were not recovered until years later. Consequently the financial outlays for computers were not to be matched with revenues within a normal (GE) business plan period, resulting in a reluctance to put up the capital to fund new ventures as compared to other ventures in the Company that would have a more rapid return.

While there is nothing wrong with a subsidiary operation being required to justify its existence and its future plans to the upper administration, that administration must be capable of making informed judgments in approving or disapproving those proposals. Some organizations will accomplish this by having (semi-) independent consultants who can provide executive level management with second opinions on the activities of the subsidiaries, but this does not appear to have been used in this case. The process of evaluation for the GE computer department was "straight-line," that is, being dependent on the judgments of each intermediate level of management, with little value being added in the process of a proposal rising through the hierarchy. The two possibilities for success represented by John Haanstra and Lou Rader were offset by the former's early death and the latter's choice of Charlottesville, Virginia, for his headquarters. While Rader's choice of location may have made sense with respect to the other operations that he managed, his remoteness from Phoenix did not provide the day-to-day oversight for the department and lacked the day-to-day knowledge of activities to promote them effectively upward.

The overall financial positions of GE and IBM between 1964 and 1994 are interesting to note. *Forbes* (1967) showed in a chart that IBM cash flow exceeded that of GE for the first time in 1958 and that by 1964 the positions were as shown in the table below:

Company	Cash Flow	Net Income
GE	380 M	230 M
IBM	880 M	420 M

Company	Revenues	Earnings
GE	64,052 M	5,155 M
IBM	60,109 M	4,726 M

Data for both figures are in U.S. dollars. The top table presents figures from 1958, while the lower presents revenue and earnings from 1964.

In fact in the 1960s the GE cash flow was only increasing slowly while the IBM rate was much greater. IBM itself had hard times over the next 30 years and did not maintain the rate of increase over GE that it had in 1964. In 1994 the financial reports of GE and IBM are interestingly similar, though obviously GE is not now in the computer hardware business.

The 1994 report for GE Information Services, Inc. showed that the time-sharing business was still profitable and still attributes its establishment to the work at Dartmouth College. If GE broke even up to the time of the 1970 sale, then it is almost certain that through 1994 they have done much better. At least one element of the work of the GE computer department has been successful.

In 1992 the Bank of America recognized the pioneering ERMA system with a twenty-fifth anniversary celebration at their Concord Technology Center. The occasion was marked by the opening of an ERMA museum and the presentation of anniversary plaques to the primary contributors. The BofA recognized the personal contributions of Tom Morrin, SRI for his work in developing the prototype; Al Zipf, for his leadership within the bank and for his work on the standardization of MICR; Bob Johnson for his design of the ERMA 1A. They had planned to honor H.R. (Barney) Oldfield for his leadership in the development of the GE proposal and the subsequent manufacture of the systems, but having lost contact with him, there was a rumor that he was dead.

On the corporate level, the two organizations to be recognized were NCR and GE. The award for NCR was graciously accepted by Elton White, president of NCR; GE was represented by a sales manager from the local area.

Acknowledgments

The story of the General Electric Department and the need to bring it to print was first brought to my attention by Richard Schuey and Lou Rader, and we spent some time together trying to create a manuscript based on their recollections. Shortly thereafter the *Annals* received the manuscripts on ERMA written by James McKenney and Amy Fisher, but it was quickly clear that this was neither the whole story nor totally in agreement with the memories of the GE pioneers. One of the outcomes of McKenney and Fisher's work was the location of Homer (Barney) Oldfield whom we had thought to be dead! Providentially we found that the GE Computer Department Alumni Association was planning a reunion in Scottsdale, Arizona in the summer of 1994, and we were able to use this as

a vehicle to encourage the pioneer GE alumni to tell their stories and to give their opinions of the reasons for the rise and fall of the department. The organizers of the reunion, led by Nate Norris and Vern Schatz, took our suggestions to arrange for two open sessions in which the attendees could tell their stories.

With the support of the National Science Foundation we were able to assist in the travel for a few attendees, and to support Carolyn Cagle, a graduate student in the Science Technology Studies program at Virginia Tech, in conducting and transcribing interviews with selected pioneers. We have based much of the content of this paper on the comments of the speakers at the reunion, on the pioneers who were interviewed separately, and on the responses to questionnaires that were mailed to many others who were not able to be in Scottsdale. Our thanks to all the contributors:

For their participation in the Liar's Club Session, I thank George Snively (Moderator), Robert Bentley, John Hogg, Arnold Spielberg, Lacy Goosetree, Don Knight, John Couleur, Ed Vance, George Jacobi, Larry Hittel, Bob Bemer, Donald Graf, Jim Barford, Joe Weizenbaum, Roger Rosburg, Ed Belt, and Don Knight. While not all their anecdotes fit into this story, we will try to include them in future issues as part of the Anecdotes Department.

For their participation in the Memory Dump Session, I thank Vern Schatz (Moderator), Bill Bridge, Vic Casebolt, Bob Johnson, Lou Rader, John Couleur, Robert Sullivan, and Roger Rosburg.

For the participation in individual interviews, I thank Walter Dix, Joe Weizenbaum, John Couleur, Bill Bridge, and Arnold Spielberg.

Many GE computer department alumni also took part in a survey of their activities and opinions that substantially assisted in the piecing together of this story. With one possible exception, not a single person ever survived the complete period of the life of the computer department (under its various names) and certainly no one had an overall view of the happenings in Palo Alto, Phoenix, Syracuse, Schenectady, and New York. My apologies for not including all their names and not using all their stories. The whole story will have to wait for another, much larger publication.

Finally my thanks to Richard Shuey, Lou Rader and Barney Oldfield who have become my close friends during the prosecution of this project. Barney has given me many insights into the story, and we have shared information equally; for him to write a forthcoming book of his view of this history and for me in preparing this special section of the *Annals*.

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