Beckman Palo Alto: 1961-1962

I moved to Palo Alto in June of 1961 and rented an apartment at 18360 Bayshore Drive, which was a cheap but reasonably pleasant one-story apartment complex next door to the Bayshore Freeway. It was a bit noisy with the freeway traffic but the delicious fragrance of the honeysuckle made up for it. Also, the rent was reasonable, $95 per month for a furnished efficiency, and the location was a convenient, seven miles from the office. I bought a bicycle and biked to work from time to time.

Beckman Systems was an aerospace oriented systems group, set up by Beckman Instruments, which designed and built custom data acquisition systems and telemetry data reduction systems for aerospace companies, NASA, the Air Force, among others. Among the noteworthy systems it produced are the Lunar Module test system, a Rocket Engine Test system for NASA's Mississippi Test Facility (where the motors for the Saturn rocket were tested), the Telemetry Data Reduction system for the Ranger series of lunar landers, Sonar Data Collection systems for the Navy's underwater test facility in the Bahamas. The biggest of these systems was something called Programmable Integrated Control Equipment, or PICE for short. This was essentially a store and forward system designed to collect telemetry data streams from the Air Force's launch site at Vandenberg as well as its satellite tracking stations around the world (about four or five as I recall) and to distribute them suitably formatted to various tape units, strip chart recorders, plotters, and printers. The data from the tracking stations was transmitted over phone lines using something called Data Line Translators, modems in other words. The central PICE system was located at the Satellite Test Center at Lockheed in Sunnyvale. Beckman Systems had set up a group in Palo Alto under the leadership of Jim Tillotson with a mission that included the support and maintenance of this system, continuing development of the system, especially writing software for it, as well as working with Lockheed on planning, design, and proposals for follow-on systems and activities. One of the key satellites supported by this system was MIDAS which was an infra red sensing satellites designed to detect intense heat sources on the earth's surface, such as those arising from rocket launches or nuclear explosions.

My assignment was to work on a new advanced system called PICE II which we were to propose to the Air Force jointly with Lockheed. It involved preliminary design and technical definition of various sub-systems, things we would call special interface units in today's terminology. One was the tape interface unit that was used to connect magnetic tape units to the PICE main frame. Another was the Midas Intercept Assembly Register which was designed to manipulate Midas telemetry data into suitable format for input to and manipulation by the PICE processor.

When we reached the point of having a firm (and short, it goes without saying) deadline for presenting the proposal, Tillotson decided that we should go offsite

to do the actual writing so as to be undisturbed by other people or activities. The site we went to was a PR company called Mellonics Audio Visual in Tucson, Arizona. Mellonics Systems was founded by a man named Frank Druding who headed up its technology part and worked as a consultant for Beckman, and Lockheed, on various PICE issues. The Mellonics AV part was managed by a man named Bill Bell who had moved the AV part of the company to an old dude ranch in Tucson because the dry climate was beneficial for some medical condition that he suffered from. One of the artists working there was Duane Bryers, who had as a sideline to draw an ample and buxom pin-up lady called Hilda which was used as a calendar girl by many companies in their give-away calendars. Mellonics was later acquired by Litton Industries and was known as Litton Systems. Bill Roberts, David Lytle and I spent about a week at this dude ranch writing the technical portions of this proposal and some of the Mellonics staff was doing the graphics. We invented various subsystems for detecting and classifying different Midas intercepts, as they were called. A missile launch would be characterized by a sequence of hot targets extending over some distance representing successive intercepts from the missiles exhaust. A possible false target we postulated which we had to discriminate against was known as a BOTRAD (burning oil truck running across desert).

This being in the early failure prone stages of the US space program, launches were always a cause for excitement and worry. Would the launch go off as planned and blow up or not, or would it be delayed and by how much. (The joke was about the rocket engineer's kid who learned to count as follows: ten, nine, eight, seven, six, five, four, three, two, one, zero, shit.) The launch procedure was extremely lengthy and structured, sometimes extending over several days with numerous check points inserted in the sequence at which the various on-board subsystems as well as ground based systems were checked to see if they were still go for launch. If some system was not OK the responsible party was supposed to inform launch control who would then call a launch sequence hold, and charge it to the subsystem at fault. Since the different subsystems typically were provided by different vendors, this meant that the hold was actually charged to the vendor involved. With everything on the ragged edge of not working, the vendors were continuously and desperately trying to fix problems before the next checkpoint at which they would have to ask for a hold if it wasn't working. This resulted in a poker game among the vendors to see who would be forced to ask for the hold first, betting on the ability to find and fix the problem if none other asked for it.

I resumed my flight lessons, flying out of the Palo Alto airport next to Dumbarton Bridge, and after a few months of a little more concentrated training I passed my tests and received my private pilot's license in September of 1961. I passed even though I came in high and overshot the landing to the Santa Cruz airport on my test ride. As part of my training I took cross country flights to Yuba City and Stockton, and got chastised by the controller at Stockton for not reporting down wind. (I rogered his request to do so without having understood it, which he found

a little bit upsetting.) With my brand new private pilots license in my pocket I rented a Cessna 172 and invited my friends Joyce and Bjarne to go to lunch at the Nut Tree, a restaurant in the Sacramento Valley with its own airstrip. And sure enough, I overshot the runway trying to land there as well and had to go around, no doubt scaring the pants off both Bjarne and Joyce, although they were too polite to say anything.

I had brought the Triumph from Pennsylvania but found it less suitable as time went by, especially on the California freeways, where open top driving with the elbow about a foot above the concrete was not as appealing as it was on the winding country roads of Bucks County, Pa. I started scanning the classifieds and found an ad for a 1959 Arnolt Bristol, which struck my fancy immediately. I visited the owner and took it for a test drive and closed the deal on the spot. I realized that the cockpit was a little too small for me, with the top down my head was about 3 inches above the windshield, with the top up I had to sit with my neck bent to the side about 15 degrees. I figured I could solve the problem by lowering the seat a couple of inches, which should not be a big problem. It turned out, however, that the seat was mounted on top of two very massive frame members and lowering the seat was not an option. I drove the car for a few months, but when returning from Laguna Seca one evening, where I had been to see a race with people like Dan Gurney and Stirling Moss, driving with the neck at an angle for two hours made me conclude that I had to get different transportation. The next week I traded the Arnolt Bristol for a 1961 Porsche 356 Coupe.

Since I had never gotten into any significant contact with my contemporaries in San Francisco my social life tended to focus on familiar territory, which at this time was best represented by the Rathskeller club where they had a German band playing European style dance music on Saturday nights. I would go there to hear familiar tunes, dance familiar steps and meet women who I would have something in common with. One evening there I met a Swedish girl named Anne Marie Anesten who was there with her girl friend Ingrid. We hit it off right away and started serious dating. She was a beautiful and sexy woman that attracted me very much, but more importantly she seemed to be attracted to me. This was not a situation I was very spoiled with and it made a big impression on me that she wanted me. She was 10 years older but I was so attracted to her and overly impressed that I could have this beautiful woman who came from so much better background than I that I ignored the issue of the age difference and asked her to marry me.

The guys I met at Beckman could be sorted into three categories from my perspective, the really sharp guys from whom I could learn stuff, the sophisticated business types who traveled and talked to customers and brought in business, and the other project types whom I did not work closely with. The sharp guys were Bill Roberts, of whom we will hear more later, Cy Harshman and two programmers whose names escape me. The business types were David

Lytle (who was also technically very sharp), Jim Tillotson, of course, and Jerry Meyer, the Director of Sales. Among the others were Chris Lianides and George Kostakos, Maynard Kuljian, and Richard deKimpe.

The most lasting knowledge was learned from Bill Roberts, especially his description of the Ferranti Atlas computer, which was one of the contenders for the PICE II project. This was my first introduction to concepts such as interrupts, page addressing, and probably even buffered IO. These concepts became fundamental parts of my computer architectural repertoire and have stayed with me ever since.

One of the projects I was assigned involved designing a circuit to read bit-serial data from tape and format it into a different format, probably character parallel. For whatever reason, there was no clock signal associated with the data signal so I had to try to somehow read the signal with derived timing information. I tried to do this with an open loop clocking circuit which I hoped I could adjust well enough that reliable bit detection would result. This was of course a totally ridiculous hope based on an ignorant engineering approach. (I tried a similar trick again at Paradyne once, even though I should have known that it was guaranteed not to work. Once I had heard about phase-locked loops I was amazed at how stupid I had been to even for a moment think that these tricks would work.)

When Beckman failed to get the follow-on PICE II contract the lab in Palo Alto was to be closed and I was offered a transfer to Fullerton. Southern California had about as much attraction for me as I imagine Siberia had for Russians. I had been totally indoctrinated in the disdain that Northern Californians had for Southern California, especially San Francisco for Los Angeles. When the new Jack Tar Hotel was built in San Francisco it was widely criticized and derided for being too much like Los Angeles with its multi colored wall panels which gave it a truly rainbow-like appearance that really stood out on Van Ness Ave. In a contest reported by Herb Caen about who could say the nastiest things about the Jack Tar architecture the winner was “it looks like the box that Disneyland came in”. At another occasion Herb Caen reported about a group of San Franciscans who had visited the Forest Lawn cemetery on a slumming trip to Los Angeles. Again there was contest to see who could come up with best put-down and the winner was, “the trouble with this place is that it takes all the fun out of dying”.

I had bought into this attitude wholeheartedly, so moving to Fullerton was not high on my list of desirables. One choice I had was to join Dalmo Victor where my old buddy, Frank Lanza was working. I had had some informal discussions with Frank and with an HR person and was informed that if I applied I would be hired. The other option was to go back to Pennsylvania to get my masters degree from Penn, mainly to erase the “stigma” of my Heald’s education and degree. As mentioned, I had taken some evening courses at Penn, but my record was not fantastic (I did have a D in Physics), so I was not sure how welcome I would be

into their graduate program. I decided that the best way to find out would be to have a face to face conversation with the dean of the Moore School of Electrical Engineering. To pay for the trip to Philadelphia, I decided to apply for a job with some East Coast company and have them fly me there for an interview. I justified this somewhat unethical scheme in my mind with the thought that if they were to give me an irresistible offer, of course I would accept it. I applied to ITT Federal systems in Paramus NJ and they invited me for an interview. After the interview I went down to Philadelphia to meet with Dr. Weigand at Penn. His answer was that they would accept me on a probationary status, which could be converted to regular graduate student status if my performance was satisfactory at the end of the fall semester. However, he cautioned me, that based on my grades so far it might be better that I take some more evening classes to bump up the GPA and then enter directly into the graduate program.

Shortly after I came back to Palo Alto I received a good, but not fantastic, offer from ITT. I now had three options, Penn, ITT, and Dalmo Victor. I decided to go for Penn. We packed up our then still limited belongings and gave them to Consolidated Freightways, bought a pop tent for overnighting, and headed out across the country in the red Porsche. Driving across the SF Bay Bridge we passed a Consolidated truck in the back of which we could glimpse our stuff also heading out across the country.

Back to Pennsylvania: 1962-1963

Our route took us to Seattle where we visited with Anne's cousin Eva who lived there with her husband and son. From there we drove across the state of Washington through Spokane and into Idaho, where we camped in Coeur d'Alene. The next stop was Fargo, ND where we visited Anne's Uncle Bill. Other noteworthy places we visited were Madison WI, Chicago, IL and the Indiana Sand Dunes where we also camped. After about ten days of driving and visiting we arrived in Philadelphia where the first order of business was to find a place to live. We wound up in the third-floor (or attic apartment) at 535 55th Street, tenants of Mr. and Mrs. Weitzman, a retired Jewish couple, complete with the requisite doctor son.

The rent was reasonable and it was within walking distance of the Moore school where I enrolled in four classes (Probability theory, Switching Systems, Computer Engineering Principles, and Feedback Control Systems), amounting to 16 semester hours which was enough to complete the masters if I handled them well enough. As it turned out, I aced all four courses.

The Moore School is famous for being the birthplace of the electronic computer. There in 1944, professor John Mauchly and his grad student Presper Eckert

developed the ENIAC (Electronic Numeric Integrator and Computer), a room sized monster that contained about 18000 vacuum tubes and a truly impressive rats nest of wiring. One of the skeptics of this project based his prediction of fiasco on the calculation that the mean time to failure (MTTF) of 18000 vacuum tube filaments is in the range of minutes rather than hours or days, thereby making the thing totally unusable. Fortunately vacuum tubes seemed to run better than that in real-world practice so the MTTF was on the order of days which made useful work not only possible but very impressive. My professor in the Computer Engineering course, Harry Gray, had worked on the ENIAC as a student, and would tell various amusing and/or interesting anecdotes from the project. He also had as part of his lecture notes a manuscript of a book by Dr. Mauchly about the project, from which he would read suitable passages. One of the topics of the book concerned the invention of the stored program concept. John von Neumann is generally given credit for this achievement, in fact the basic computer architecture that is almost universal today is known as the von Neumann architecture. Mauchly took issue with this view of history and devoted significant space in the book to the story of von Neumann's visit to the Moore School to see the ENIAC, and how Mauchly discussed his plan for the next generation in which he planned to implement a form of stored program control. He speculates that although he did not describe his concept in detail von Neumann was quick enough to pick up on the concept and adopt it as his own. In any case, shortly after his visit to Philadelphia, von Neumann published his famous paper in which he proposed a stored program computer.

There is no doubt that his insights into the organization of machines led to the infrastructure which is now known as the "von Neumann Architecture". However, von Neumann's ideas were not along those lines originally; he recognized the need for parallelism in computers but equally well recognized the problems of construction and hence settled for a sequential system of implementation. Through the report entitled First Draft of a Report on the EDVAC [1945], authored solely by von Neumann, the basic elements of the stored program concept were introduced to the industry. A retrospective examination of the development [3] of this idea reveals that the concept was discussed by J. Presper Eckert, John Mauchly, Arthur Burks, and others in connection with their plans for a successor machine to the ENIAC. The "Draft Report" was just that, a draft, and although written by von Neumann was intended to be the joint publication of the whole group. The EDVAC was intended to be the first stored program computer, but the summer school at the Moore School in 1946 there was so much emphasis in the EDVAC that Maurice Wilkes, Cambridge University Mathematical Laboratory, conceived his own design for the EDSAC, which became the world's first operational, production, stored-program computer.

While I was going to school, Anne took a job as a secretary for a group of doctors in downtown Philadelphia. As an additional source of income I did some part-time work for a new company founded by my old rally partner Frank Hannon and his

friend Ed Blumenthal. This company was developing a magnetic tape tester while keeping things afloat doing miscellaneous custom designs as opportunities arose. One of those was a machine for loading pills in bottles for a small pharmaceutical manufacturer. Another potential was a Loran-based navigation system for the coast guard that was supposed to provide direct position read outs. The theory of operation was to have two receivers tuned to the two Loran transmitters that would provide the differential delay signals. These signals were used for the x and y drives that moved the Loran chart (actually a glass or other transparent sheet with its hyperbolae lines for that transmitter pair printed in black) under an optical spot reader which would keep track of the number and direction of line crossings which could then be directly translated to position numbers. The whole scheme fell on the seemingly trivial grounds of the weight of the transparent Loran charts. Somebody at the coast guard calculated that the total weight of all those glass sheets that would be needed for a typical mission was an unacceptable load for the airplanes and helicopters that the coast guard was then flying.

The job I did was not very technical; I was hired as the wire wrapper to build the first prototype of the magnetic tape tester. I worked on a big back plane about 3 ft by 3 ft, wiring it up directly from hand drawn logic diagrams. (I guess Frank could justify hiring me instead of a real wire wrapper, since he did not need to make a net list for me to work from.) The unexpected benefit of this approach was that I was able to do a considerable amount of debugging in the process of wiring. Nobody had told me how the thing was supposed to work, but in the process of reading the diagram and wrapping the wires I came to understand the design and to spot errors in it. Thus my job changed from being just the wire wrapper to also being the checkout technician who brought the errors to the attention of the designer who then could correct them before we even had smoke tested it. This experience was the first one that demonstrated to me the amazing tendency for a mindless repetitive task involving minute details of a complex system to spotlight bugs in the system. The other times I experienced this effect was when I hand coded modems at both Paradyne and Kinex.

Having made the commitment to go back to school, and having bet so much of my future on it, I had no problem motivating myself to work hard enough to insure a successful outcome. I spent virtually all available free time on my work, was constantly worried about my grades and mostly pleasantly surprised when the results came back.

Although I still had the Porsche, we spent very little time driving and sightseeing in Pennsylvania. My plan was to sell it at the end of the term to finance a trip to Finland and Sweden for Anne and me to meet our respective families. Since I was unsure how hard it would be to sell it I put it on the market fairly early in the spring of 1963 and when it sold unexpectedly quickly we were without wheels for a few weeks. To get it ready for sale I needed to fix up a couple of items, one of

which was to replace the glove compartment lock. To minimize cost I went to a used sports car dealer in Media who also had a car junk yard in the back. I went in to the store and asked if they had the part that I needed and the clerk said there was a wrecked Porsche of the right model out back that might have it. I went out, found the car and determined that it had the part I needed. I got a screwdriver from my car and proceeded to remove the lock when the owner saw me and came at me with a furious assault of accusations and abuse accusing me of trying to rip him off and ordering me off the lot or he'd call the police. No chance to explain that I had gone to his store in good faith to buy this part and had no intention of stealing it and, etc, etc. Maybe this asshole had had problems with thieves ripping him off and that explained his abusive behavior towards me, but it sure didn't excuse it. As far as I was concerned he deserved every misfortune that could possibly befall him, just for calling me a thief, and I still feel that way about him, and anyone else who shoots first and asks questions later. I hope he died broke and friendless in some cold, wet ditch.

At the end of the fall term I was admitted to the graduate program as a regular student on the basis of my results during the term. Noah Prywes, my professor in the Feedback course became my thesis advisor. After rejecting some of my ideas for a thesis project he suggested I do an analysis of the waiting times in a multi-user time-sharing system. He indicated that this was something he needed done for a time-sharing business he was trying to set up, whether as part of the University or not I didn't know. This was not on the top of my list of interests, but I figured it could not hurt me to go along with him, and it would make use of some of the probability theory that I had so laboriously acquired. As the spring term was drawing to a close I started my job search with a view of landing a suitable position in the SF Bay Area where I hoped to return. After sending a number of letters and resumes and responding to all the employment ads I could find I was able to round up one interview, which did not result in a job offer. Nine months earlier with nothing but my measly BS degree from unaccredited Heald's College I had two offers in one-and-a-half interview, and now with an Ivy League masters degree in my pocket I could hardly get an interview.

But no matter, when I left Beckman, the HR guy had told me to come back when I finished at Penn and they would hire me. So with this as my back-up plan we happily embarked on our trip to Europe, including sightseeing in London and Paris, in addition to our visits to Sweden and Finland. Everything went well, we spent a pleasant six weeks visiting family and friends and then returned to the US. When we landed at Idlewild (now JFK) airport I had between $10 and $20 in my pocket, which represented the sum total of our liquid assets. We went to Uncle Ed's house from where I put in a call to the HR guy at Beckman and said I was finished at Penn. He immediately made the arrangements to have a prepaid ticket waiting for me at the airport, reserved a rental car for me at LAX and a motel room for me in Fullerton. I flew out the next day, interviewed with a couple of people (Ray Kramer and Mel Bartz), received an offer and accepted on the spot. I then sent for Anne, whose ticket Beckman also paid, and we were moved

to Southern California. We found a nice apartment on Hillside drive in La Habra which is a small city right next to Fullerton on either side of Harbor Boulevard. Now that I had a job again we also bought a car, a used Volvo PV544 which was nice and roomy albeit somewhat spartan in its appointments. It ran fine, the only time I had any problems with it was once when I ran it out of gas, and we kept for about three years.

Beckman Fullerton: 1963-1965

My title at Beckman was System Applications Engineer and the job consisted of generating technical proposals for various custom systems that Beckman was selling to aerospace companies such as Lockheed, North American Aviation, Northrop, Grumman, Rocketdyne, Thiokol, as well as NASA and the Air Force. The systems were typically some kind of data acquisition system for wind tunnels and rocket engine test stands, telemetry data reduction systems for different satellites and space probes, and other kinds of test systems. The proposal preparation was often a four to six month effort and involved studying the customer's specification, which were sometimes an inch thick (often containing features wired into them by our competitors); then designing a system to meet the specification using Beckman standard modules, and buy-out items where needed; then costing the system using Beckman standard models for labor hours and material costs; and then writing a complete technical description which explained the whole thing, as well as a formal response to all the points in the requirements specification.. The designs were taken down to the level of individual circuit boards which typically contained a pair of flip-flops or a few gates and were expected to serve as the basic design for building the system if we got the contract. The three successful proposals that I wrote in my two years at Beckman were 1) a data acquisition system for the rocket engine test stands at the Mississippi Test Facility (MTF) built to test the Saturn rockets used in project Apollo, 2) the LEM data acquisition system for Grumman Aircraft which was used to production test the Lunar Excursion Module, and 3) a data acquisition computer system for General Dynamics to be placed on large oceanographic buoys that GD was building for NOAA. I also worked on proposals for telemetry data reduction systems, that to my recollection did not result in any sales. (This was a period in my life when I was somewhat familiar with the orbital parameters and telemetry formats of most NASA and Air Force satellites and space probes.)

The MTF and LEM systems were typical data acquisition systems with multiplexed front ends for acquiring low and high level analog signals as well as digital signals and events. They typically used one or two wide-band instrumentation amplifiers for amplifying the low-level signals (coming from strain gauges and thermocouples, and the like, and having typically about 5 mv full-scale amplitude). The amplified signals were digitized using a single A/D converter preceded by a sample-and-hold circuit, then formatted and sent to digital tape recorders or to D/A converters for output to strip-chart recorders. The

front-end multiplexers consisted of stepping switches or cross-bar switches; solid-state switches for low-level signals were not practical at the time. Another subsystem which was often included was a time code generator, the purpose of which was to provide a timing reference for all the signals and which was capable of being synchronized to embedded timing from the test stand.

Much of the equipment, such as A/D converters, instrumentation amplifiers, cross-bars and tape units were purchased from outside vendors; what Beckman provided was the digital and analog building blocks that were needed as well as the system engineering to hook up these major components together in the particular configuration and with the particular features that the customer required. These building blocks were a series of standard circuit boards, known as the 210 series, which contained things like gates, flip-flops, one-shot multi-vibrators, comparators, etc. Each board contained roughly the same functionality as the SSI chips like the 7400 series popular in the seventies.

The NOAA system was a complete computer to be installed on oceanographic research buoys which were to be anchored in an extensive grid pattern all over the Pacific Ocean. The buoy was a large vessel: 40 ft in diameter, held in place by an instrumented anchor cable containing sensors for measuring temperature, salinity, speed of current, pressure, and one more parameter, maybe conductivity, at regular intervals along the cable all the way to the bottom. The signals from these sensors were to be sampled periodically and stored on magnetic tape units for removal by service personnel which would visit each buoy twice yearly. The system was powered by batteries and the batteries were charged by an LPG motor generator set. The LPG gas was to be replenished during the bi-yearly service visits. Since the sensors were all connected with a single cable they needed to share this transmission medium in some orderly fashion. This was done by having them addressed logically in a programmed sequence running in the computer. The data storage operation was also programmed in a couple different phases; normally data was acquired and stored in core memory and when core memory was full it was dumped to tape. This approach was used to minimize the frequency of tape operations and thereby increase longevity. Another sensor that was monitored was battery voltage which, when it decreased below a set limit, caused the motor generator to be started to charge the batteries. I believe there was also a radio for sending emergency messages under certain conditions. Because of the multiplicity of operating sequences that had to be controlled the system designers had specified a general purpose type computer as the controlling element. The customer for Beckman was Convair-General Dynamics in San Diego and their customer was the Navy. The salesman was Jim Wylie and the engineering manager who would be responsible for building this thing if we got the deal was Dick Given and I had the assignment to write the proposal.

There was some preliminary work done by someone else at Beckman that I

started with, but I soon discovered that it was not based on a good understanding of the system so I had to really delve into the requirements spec and think through in detail how to design this thing. It was during this process that I realized that I had figured out how to design a computer; doing state machines to control various sequences, command decoders to decode the different instructions, logic to activate subsystems such as the arithmetic unit and program address generator, etc. I also invented a scheme for switching in a redundant memory circuit in case of failure of any of the memory bit-slices. The result of my effort was that Beckman was awarded the contract by General Dynamics, but they were never able to sell more that the first prototype buoy to the navy. I believe the program was canceled or at least postponed for a number of years. One other result was that Jim Wylie was so impressed with my work on the proposal that he latched on to me as his key technical guru for the next decade.

Two reduce the amount of reinventing the wheel on every new system our management decided to develop a general purpose computer that would be suitable for task such as data acquisition and telemetry data reduction. This was built out of the standard 210 series logic modules and was called the Beckman 420. Although only a handful of these systems were built it represented a significant advance in the state of the art of real-time computer systems. Its scheme for direct memory access (DMA) IO with automatic buffer chaining is something that even the Pentium IV has yet to catch on to. The peripheral equipment available with this computer was limited to paper tape I/O (punch and reader), and a console typewriter/printer. The software included an assembler, a bootstrap loader, and drivers for the console and the tape punch. I was one of the users of this computer in completing my thesis work. To validate my analysis of the time-sharing system response times I wrote a program that simulated the system as well as the user load offered. Running this program through some large number of cycles generated statistics for the response times which was in reasonable agreement with the predictions from my analysis, although I must confess that I did have some nagging doubts about my approach. In any case it was good enough for Dr. Prywes, so I received my Masters Degree from Penn in the spring of 1964.

The other big thing that happened in my life in 1964 was that Eric was born on New Years eve. He was big handsome guy from the start, and for the first time in my life I realized what people could see in babies.

The only other person from Palo Alto that had moved down to Fullerton was a technical writer named Arleigh Chute who had been my closest friend among all the people in Palo Alto. He was an amateur actor among his other creative and presentational activities and I was very impressed with his communications skills and easy, winning personality. I thought he was a great asset to the technical writing staff at Beckman, bringing to it as I saw it, a highly unusual creative flair that technical documentation was sadly lacking. For whatever reason, management did not share this view, maybe because Arleigh was not always

diplomatic in his dealing with them. The outcome after a period of stress and strain in the organization was that he was fired. He did not find another job for a number of months and hung on as well as he could by doing freelance work where ever he could find it. We figured he was probably not making enough money to live on so we would invite him home for dinner from time to time to make sure he'd get a good meal now and then. After a few months in this mode he managed to land a great job with a former employer, Picker X-Ray, which hired him as the manager of their technical writing group in Columbus Ohio (I believe). This was a great opportunity for Arleigh and he was very happy there. Added to his happiness was his marriage to Peggy who was also an artist like himself. She later went back to school at the UCLA film institute and has been active in motion picture production. Tragically, their happiness was not to last. Arleigh was struck by throat cancer about a year later and died after about a year of ineffectual surgeries and chemotherapies. They visited our home in San Diego when he was still hopeful he would recover, but racked with so much pain that he could sleep only with the help of powerful medication and able to ingest only liquefied food such as milk shakes. I still remember the awful feeling I had imagining his wake-up every morning from that drug-induced sleep to become aware of his situation. Could anything be more cruel!

The last time I saw Arleigh was in San Francisco at a party that some friends there gave for him. By that time he was in very bad shape, but he held on with obviously extreme effort and socialized with his friends, laughed at our jokes, but was no longer able to speak. The next day we visited him in his apartment where he and Peggy had been spending the previous days making Christmas presents for their friends by turning drinking glasses and such into vases with their painting and other decorations. He communicated then by writing and was still hoping for a miracle from the doctors at Stanford university hospital. A few weeks later Peggy called and told us he had died.

One of the enhancements in my life that I received from my association with Arleigh was my introduction to Harry Pollard and the Henry George School. Harry is one of the most articulate people I have met and an extremely intelligent explainer and arguer of the Henry George theory of economics. He is also a viciously sharp debater whom I had the pleasure of watching on television a few times as he eviscerated Joe Pyne's sidekick Whiffletree on the Joe Pyne show. According to Arleigh, Harry had perfected his skills as a tutor to people who wanted to hone their debating technique for performances in Hyde Park in London. I went to some of their meetings and was able to listen in on lots of fascinating discussions expounding a variety of nonconformist philosophies and political theories from Henry George's Single Tax idea to extreme libertarians and Goldwater enthusiasts.

Briefly, the single tax idea is that all income taxes, personal property taxes, sales taxes, customs duties, etc should be eliminated and all government revenues should be generated by a single tax assessed on the value of land. This tax

should be equal to the total land value, such value to be determined by the free market. It might work something like the following: If someone want to acquire a lot in say Manhattan to put up an apartment house he would not purchase the lot from a private owner but would instead make an offer to the city of New York that he is willing to pay x dollars per year for the right to occupy that lot. What about the guy who is already occupying lot you ask. Well, the city would just go to him and say that we now have an offer for x dollars per year, does he care to match it, or vacate the premises. If he is unable to match the x dollars it is probably because he not generating enough revenue from his use of the property, maybe he has only a ten-story building on it, and the entrepreneur is planning to put up a twenty story building. It is not hard to see that this scheme will tend to drive the productivity of every piece of land in Manhattan, or elsewhere, to its maximum potential.

I read George's book Progress and Poverty from beginning to end and was very impressed with the rigor of his reasoning. It certainly exceeds by far the intellectual quality of conventional political debates, whether by amateurs or experts, such as those pontificating on cable television. I am still persuaded that the single tax idea is an potential winner from an economic point of view, but unfortunately destined to remain a political loser because it gores too many valuable oxen. One weakness of George's analysis, which does not invalidate his argument for the single tax, is that it is only a steady-state analysis and does not consider the transient behavior of economic systems.

Adcomp-Control Data Corporation: 1965-1969

Somewhere along the final stages of the Convair sales effort Dick Given resigned from Beckman and went to work for a small start-up in Chatsworth, called Adcomp Corporation.. Shortly thereafter Jim Wylie followed him there, and very soon after that, around mid-year of 1965, Jim talked me into coming there also. Adcomp was a company that Joe Looney had started and recently sold to Control Data Corporation. Its product line had been limited to an 8-bit A/D Converter, a couple of D/A Converters and a peak reading volt meter which was based on an extremely clever analog memory circuit invented by a high-school drop-out that worked for Joe.

The basic idea was that the input was sampled by two Sample and Hold (S&H) circuits, one with a long time constant and one with a short time constant. The outputs of the two S&H circuits were fed to a comparator which fired when the difference between the two inputs exceeded a certain small value. At this time an incremental charge injected into the short S&H which thus was replenished back up to its original value. The long S&H was replenished by a proportionately smaller charge, since it would have lost less voltage due to its longer time constant. This scheme works because the time it takes for the two S&H outputs to differ by a fixed amount is a function of the original input voltage, thus the rate

of adding the small increments is also a function of that voltage.

Since Chatsworth was about 50 miles from La Habra, it was necessary for us to move a bit closer and we found a nice apartment on Kittridge Street in Reseda. My job at Adcomp was to provide sales support to the Control Data field sales force in situations involving Adcomp products and systems. One amusing project I worked on was for a system for Holloman Air Force Base to automate the training of chimpanzees in preparation for space flight experiments. The system, which I called APES (Automatic Primate Evaluation System), was intended to monitor the chimps' operation of switches and levers in response to stimuli, which were also triggered by the system. In this way an accurate time-based record of stimuli and responses could be obtained for a large number of simultaneous experiments with only one or two operators. It seemed like an absolute winner, greatly improved results with much less effort in man-power. For whatever reason, however, the project fell through. I can imagine that somebody up the chain in the Air Force got cold feet about having to justify a half-million dollar chimp training system to congress and the American public after somebody like Drew Pearson or Senator Proxmire got wind of it.

The amusing part of the project was reading about the program in Sports Illustrated, where a vignette along the following lines was published. One of the skills that the chimps were taught was to play TicTacToe. At first they played against the machine and some of the chimps fairly soon became very good at it. Then the experimenters decided to have the chimps play against each other. One chimp, named Big Mean, was much better than the others and won almost all the games. After some time the other chimps refused to play with him since they could never win. Big Mean then adopted the tactic of letting the others win once in while to keep them interested. Based on the statistics collected by the experimenters and herewith published for the benefit of casino operators and other interested parties, Big Mean determined that it took about one win out of three to keep a sucker in the game.

Another project I worked on was for a hybrid system for Boeing Wichita to be used in some B52 work that I don't recollect. We did not get that business because we obviously had no experience with Hybrid Systems at that time. Later we worked with Boeing again on a hybrid system for an SST training simulator which was intended to simulate the handling and flying characteristics of the plane by actually simulating the aerodynamics using finite element simulation of wings, fuselage and control surfaces. We worked on this proposal at Boeing in Seattle, where we got to see the full-scale SST mock-up (I last saw it in a roadside museum in Kissimmee, Fl), and other neat things in an airplane development lab. We were the selected bidder for this system, unfortunately the program was canceled, so we never sold any equipment. But it was an interesting experience.

One Hybrid Computer System proposal I was involved with that did result in a sale was to Lockheed Marietta for the C5A project. We were joint bidders with Mac Donnell Douglas Automation who were responsible for the hybrid software, while we provided the hardware. Other proposals were for seismic data acquisition systems to geophysical exploration companies such as Dresser Industries and Ray Geophysical. These included special hardware for digital filtering known as SPAM (Sum of Products Algorithm Module) boxes. I remembered these SPAMs when I went to design the processor for the MP48 modem at Paradyne. I also worked on a telemetry data reduction system for IABG in Germany and went there to negotiate the technical part of the contract and statement of work. On this trip I also visited Sweden and Finland. In Sweden I saw my father for the last time, he was in a hospital in Gothenburg where he had gone because they could not figure out what was wrong with him in Mariehamn. They diagnosed his pancreatic cancer but could do little to treat it. He died a few months later.

Control Data San Diego: 1965-1967

Control Data's purpose in acquiring Adcomp was to leverage its analog skills into a broader capability in analog-digital systems such as process control systems, data acquisition systems, telemetry systems, hybrid computer systems, medical instrumentation systems, and so on. CDC had earlier acquired a Daystrom Division, located in La Jolla, which was already building and selling process control systems to the chemical industry. This set up a certain amount of rivalry between Chatsworth and La Jolla, which was resolved when Adcomp was merged into the La Jolla group, with Joe as the general manager, Jim as the marketing manager and Dick as the engineering manager.

When this happened, in late 1966, we had to move down to San Diego, of course, which was not an unpleasant prospect from my point of view. To start, we rented a small apartment in Mission Beach, just half a block from the Ocean and stayed there until we were able to buy our very first house in Poway, on Willow Run Road.

Jim made me the Manager of Hardware Product Planning for the division, which made me very proud, even though I had only one guy, Doug Baker, working for me. The only problem was that David was a little older and more experienced than I was and this made it difficult for me to see myself as his manager. I could not find an acceptable way to tell Doug what to do or tell him when he'd done something wrong, so I just hinted here and there and kept hoping he would more or less figure out what need to be done and do the right thing of his own accord. The vital thing that I did not have firmly in my mind and soul was that Doug wasn't doing favors for me. He was working for the company, and it was my obligation to the company that required me to direct him. This is a piece of management understanding that has never become strong enough in my

consciousness to drive my behavior in dealing with subordinates. I have taken self assertiveness classes and management seminars, but I still to this day find it impossible to take my personality out of this relationship and replace it with my role as manager.

While at the La Jolla division, which was Control Data's primary centre of expertise for real-time systems, I had the opportunity spend considerable time in Minneapolis with the architects of the new super computer known as Star-100. The chief of that project was a CDC VP, Jim Thornton, who was one of the foremost computer architects in the business and second in this respect at Control Data, only to Seymour Cray. I felt very proud to be consulted by Jim on the real-time aspects of the interrupt system and task switching capabilities of the Star-100.

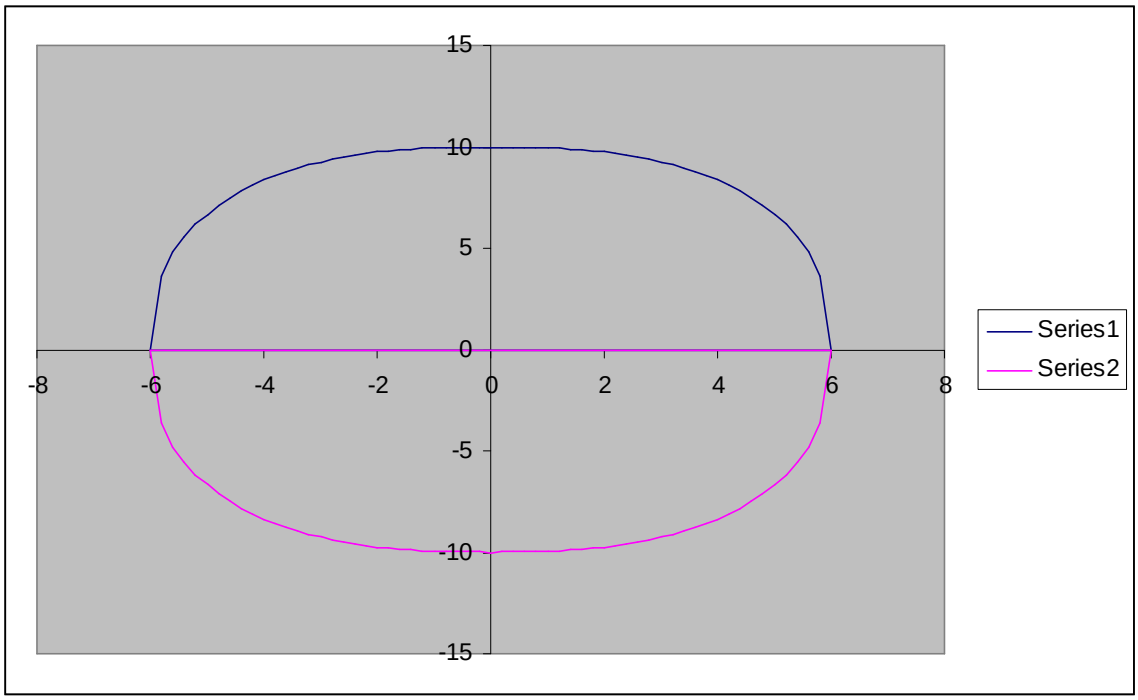
During this period I learned about a number of other R&D efforts in other companies, some of which eventually resulted in real products and others which did not. There was the atomic rocket propulsion system that my neighbour was working on at General Atomics, the concept of which was to periodically release and explode a nuclear device behind a space ship with a giant blast shield and shock absorber behind thereby generating the necessary acceleration for extended space travel. This one did not make it from the drawing board. Two other innovations that I first heard about in the 1964-1965 timeframe were optical fibres and reverse osmosis filters. Both of those made it to the market place, the first one about 25 years later and the other about 35 years later. A very instructive example of how difficult and time consuming it can be to bring even well understood concepts to fruition in mass producible products.

The house on Willow Run Rd was a large nice ranch house with four bedrooms, a living room with a fire place, and at least two bathrooms. The yard was nearly an acre, with trees and bushes in the front (a lot of Pyracantha and Eucalyptus) and mostly bare dirt in the back yard. As part of my projects around the house I undertook to build a good size patio off the living room with access though sliding glass doors. There was a significant slope involved so I had to build a retaining wall about 35 feet in length and about two to three feet high. I did all this work myself, pouring a footing for the wall and laying the concrete blocks. The next step was to shovel the dirt around to fill the insides of this concrete pit nice and evenly to be ready for the top deck, which I did have a contractor do. It was a truly backbreaking job and looking back on it I am amazed that I was willing to tackle it and stick it out to the bitter end. My body must have been much better at handling abuse then than it is now.

In addition to the patio I also put in a lawn to cover up some of the bare dirt. I had recently read a story about Piet Hein and his super ellipses, so I laid out the lawn according to the formula for this curve :

$$(x/a)^{2.5} + (y/b)^{2.5} = 1$$

where a was about 50 feet and b was about 30 feet. It looks something like this:



Piet Hein was a Danish scientist and philosopher who invented the superellipse to solve an architectural problem in the building of on/off ramps to highways and parking buildings. He was famous for writing short aphoristic poems he called GROOKS, such as the following:

PROBLEMS
Problems worthy
of attack
prove their worth
by hitting back.

THE ROAD TO WISDOM
The road to wisdom? - Well, it's plain
and simple to express:
Err
and err
and err again
but less
and less
and less.

A PSYCHOLOGICAL TIP
Whenever you're called on to make up your mind,
and you're hampered by not having any,
the best way to solve the dilemma, you'll find,
is simply by spinning a penny.
No - not so that chance shall decide the affair
while you're passively standing there moping;
but the moment the penny is up in the air,
you suddenly know what you're hoping

A MAXIM FOR VIKINGS

Here is a fact
that should help you fight
a bit longer:
Things that don't act-
ually kill you outright
make you stronger.

Sometime in 1965 Joe Looney was transferred to Minneapolis to be the General Manager of the Control Data Military Systems Division and Nate Dickinson, who was from the old Daystrom team, became the GM for the La Jolla Division. About

the same time Jim Wylie took a job as District Analyst Manager for Control Data in Downey with a territory that covered everything in LA south of the Harbor Freeway. Jim Hunter and Paul Wolf left to form Digital Scientific and took Billy Vinson and Bev Norris with them. Billy had an idea to build ROMs in some especially cost-effective way and they decided to develop a micro-coded computer around this ROM. The target system they decided to emulate with this computer was the IBM 1130, which was a 160A class of process control and real-time systems computer.

Control Data Downey: 1967-1969

After landing in Downey, Jim Wiley went to work convincing me to join him there as an applications analyst. At around the same time Fred Cox tried to recruit me for a new company he and Bill Roberts had just founded, called Microdata, whose business idea also was to develop a microcoded computer, the Micro 800. I turned Fred down and agreed to join Jim in Downey, so a little more than a year after we bought the house in Poway I uprooted the family to move to Los Angeles. This in spite of the fact that Nate had promoted me to Manager of Product Planning for the whole division and had me deeply involved in writing the strategic plans for the division. This was the second step in a sequence of moves where Jim talked me into following him around to his various job assignments in Control Data. In retrospect it was not a smart move career-wise, had I gone with Fred it is likely that I would have had more financial success earlier on, but not as much at the tail end because I would probably have stopped trying. And for sure, I wouldn't have jerked my family around so much. Fred sold Microdata to MacDonald Automation after a few years and made a pretty nice profit on their investment, sweat and otherwise. After that Fred and Bill started a company called Emulex in 1979, which specialized in building DEC compatible peripherals. Emulex went public in the early eighties and made a huge amount of money for the founders, of whom I could have been one. Oh well.

As an analyst in the Downey office my job was to help the CDC salesmen sell the big iron, i.e. the CDC 6000 series super computers. This involved talking to data center managers and other software heads about the details of the 6000 OS and other technical aspects. To learn more about this I took some Training Courses on the 6000 software at the CDC Institute which was basically a waste of time because I couldn't understand half of what they were talking about, and I was too embarrassed by my ignorance to ask any questions. It was obvious that I did not have the proper skill set for the job of Applications Analyst for CDC6000's but this was the only job Jim had to offer so I took it. Fortunately I was assigned to help a salesman with his campaign to sell a CDC6400 to the data center at USC and there the main portion of the job was to get a benchmark job-stream running on a 6400 and prove that we could run it faster than IBM, which was the competition. The job-stream consisted of about a three-foot deck of punch cards which was a sample of the jobs they were running on their existing Honeywell computer. The task was to modify it as necessary to make it compatible with CDC 6000 software

and run it and optimize as needed to make it run faster. To do this I needed access to lots of CDC 6400 time and this was available at the CDC data center in Los Angeles and at the Stanford Research Institute (SRI) data center in Palo Alto during off hours, say between midnight and 6 am. So I wound up spending a number of nights at these data centers becoming reasonable familiar with the CDC 6400 hardware and software. I succeeded in getting the entire job stack to run, and run fast enough that we beat the IBM runtime by a factor of at least two or three. We naturally went around to all the selection committee members and talked up our advantages and the superior performance of our machine, but they were not as impressed as they should have been. They pointed out that the poor IBM results were due to the fact that their analyst had screwed up in configuring the job-stream for the IBM 360 machine. Our rejoinder that the quality of IBM support that this indicated they could expect did not look promising for the university. The data center manager, a man named Glen Lewis, who previously had been the data center manager at NCAR in Boulder, a CDC shop, favored us but some other members of the selection committee were questionable. Lewis was a fairly unconventional type even for a university environment, very smart but not politically astute. Maybe he didn't care. One anecdote that shed some light on his personality was his claim that to while away the time while waiting for his wife to get ready for parties he had started a project to translate some books from French to English, and that he had already finished one volume and was working on the next one.

Bob Warner, a math professor with an advanced case of multiple sclerosis was for IBM, Richard Bellman (of Linear programming fame) seemed neutral, and a couple of others whose names I forget tended to be IBM people. But in the end all technical arguments were trumped by the IBM offer of a $300,000 research grant they promised if their machine was selected. When George and I learned about this, our managers were in Bermuda attending the 100-percent club meeting. Our desperate calls for help and pleas for something similar from CDC did not bear fruit and we just had to watch as IBM walked off with the contract. Shortly thereafter Lewis resigned or was fired and the IBM salesman became the new data center manager at USC.

During my time in Downey I got involved with an ex CDC salesman named Rod Burreson, who had gotten into business of selling unimproved land as investments. I fell for it and bought 10 acres in Victorville in the Antelope Valley, north of Los Angeles. The pitch was that would be the next San Fernando Valley, especially when Lockheed built their new plant there to turn out SST airliners. As was pointed out to me after I made the deal Antelope Valley is so big you could move the population of Red China in there and it wouldn't be as crowded as San Fernando Valley. So, no population pressure, thus no land price increases. Bummer.

We bought a nice house with an atrium at 17071 Newquist Lane in Huntington Beach from which I commuted to Downey on Long Beach Freeway most of the

way. I built a slump stone wall in the front yard which dressed it up fairly nicely, and still looks good today, thereby starting a tradition of masonry improvement projects on all the houses I bought.

San Diego again: Jan 1969-Sep 1969

When Jim was offered the position as District Manager for the San Diego district he naturally asked me to join him there. He did not have any analyst position open so he offered me a job as a salesman. It was almost criminally irresponsible for him to offer and for me to accept such a mismatched job. Of all the things I have attempted to do or could imagine attempting, selling anything is the one best guaranteed to fail. Its successful practice requires self discipline, internal motivation, goal orientation, competitiveness, assertiveness, sociability, communications skills, and sharp character judgment, all of which I am woefully deficient in. It thus manages to draw on all characteristics which constitute the catalogue of my personal weaknesses. In addition, the part of the San Diego market which was assigned to me consisted primarily of business accounts which did not provide a lot of opportunity for Control Data to lead with its strength in large scientific computers.

We put the house in Huntington Beach up for sale and I commuted to San Diego for a couple of months until we sold the house. After that we rented a small townhouse on Trenton Ave in San Diego with a great view of Mission Bay. It was a modest but very attractive place and we enjoyed staying there. During our time there, Leif made his appearance. The other noteworthy thing that happened that year was that humans landed on the moon.

I made some halfhearted calls on the VA hospital, a local community hospital and few other small business accounts, but the main target was UCSD which was in the process of upgrading its computer center. I worked this account together with Hub Knittel, who at least was able to strike up relationships with people and get some rapport going, even if he didn't embody some of the other successful salesman traits. The director of the computer center was a guy named Ken Bowles who was enamored of the elegant architecture of the Burroughs B5500 and thus represented an obstacle to a CDC selection. The selection team, however, consisted of about ten high-profile users including people such as Roger Revelle (of global warming fame), Gustaf Ahrrenius (authority on Cosmo chemistry and astrogeophysics and Irving Jacobs (later founder and CEO of Qualcomm). Hub and I tried to work around Bowles by romancing some of the other committee member who had specific user requirements we thought could best be met by the CDC 6400. As part of this effort we visited these people in their offices, learned about their interests and hobbies and tried to cater to them

to the best of our limited ability. We enrolled in a class in digital communications that Jacobs was teaching. We even tried to charm Bowles by taking great interest in his sailboat and his exploits in it. We called on the Chancellor of the university and spent a lot of money on lunches for the operations manager of the center, but alas, it was to no avail. Bowles carried the committee with him and the University bought the Burroughs machine. In all honesty, I must admit that the B5500 was even more appealing architectural design than the CDC 6000 series. Although the 6000 was a tour de force of architectural simplicity and effective implementation full of creative solutions to circuit design, packaging, and cooling, the B5000 boasted such architectural innovations as pop-up instruction stack that directly executed arithmetic in polish notation, virtual memory management and user isolation by hardware.

However, the real reason I was in San Diego was so that I could participate with Jim in the planning and strategizing for starting a new company, which Jim and Joe had by that time pretty much decided on. I worked with Jim and his wife Pat on various product ideas, which initially focused on the then emerging market for key-punch and printer replacement solutions. Key-to-tape was one of those approaches which was gaining some traction in the market, another was photo printers that converted digital data to microfilm and/or micro fiche output. Pat generated a fairly complete product specification for a key-to tape device using a CRT display for the user interface as part of this exercise. Another area which caught our interest was voice-band modems. We had heard that a company in Florida called Milgo Electronics was moving into this area. Then we learned about a company called American Data Systems in Chatsworth, which had already managed to go public based on its leased line modem product. This product advertised a bit-rate that was greater that the available telephone bandwidth. Up to that time I had carelessly thought that bandwidth in Hertz equaled bit rate in BPS. But here was a modem that used 2400 Hz bandwidth and provided 4800 bps bit rate. I got my first glimmer of excitement about modems, when I realized how this trick was accomplished.

While Jim and Pat Wylie and I were trying to figure out what our product plans should be, Joe Looney was working the financing aspects from his vantage point as GM of a sizable Control Data division in Minneapolis. After looking at key-to-tape terminals and related things we decided to focus on data communications. Their early IPO by American Data Systems made a big impression on us and convinced us it was the best bet for us also. However, we also had auxiliary plans. One of Joe's cohorts in Minneapolis, a mathematician entrepreneur named Glenn Preston, had established a great reputation in DOD with his signal processing techniques that the military was applying to radar with great effect. He became a member of the team with the hope he would lead us to R&D contracts from DOD for development of custom LSI chips for signal processing that we could turn to commercial use in modems.

As part of my CDC sales activities I quite frequently traveled to Minneapolis. Once when both Jim and I were there we had dinner with Joe Looney in his home. During that evening we did the initial planning for the founding of Paradyne, a name which Joe's wife had suggested. On the basis of the above ideas the Paradyne Corporation was founded in August of 1969 with initial capital provided by Joe, Jim, Glen Preston, Bob Acker and myself. I put in $5000 which was all the cash I could scrape up at that time, including $2,000 that I borrowed from my aunt Annie.

And so, in September 1969 I pulled up stakes in San Diego again and moved my family to the east coast, with me driving one car (the Valiant) with Eric, and Anne driving the Volvo (which had air conditioning) with Leif.

End of Part 3

Outside Hillside apartments in La Habra

Back

House in Poway

Back

Working on the patio and retaining wall

Back

The finished patio and lawn

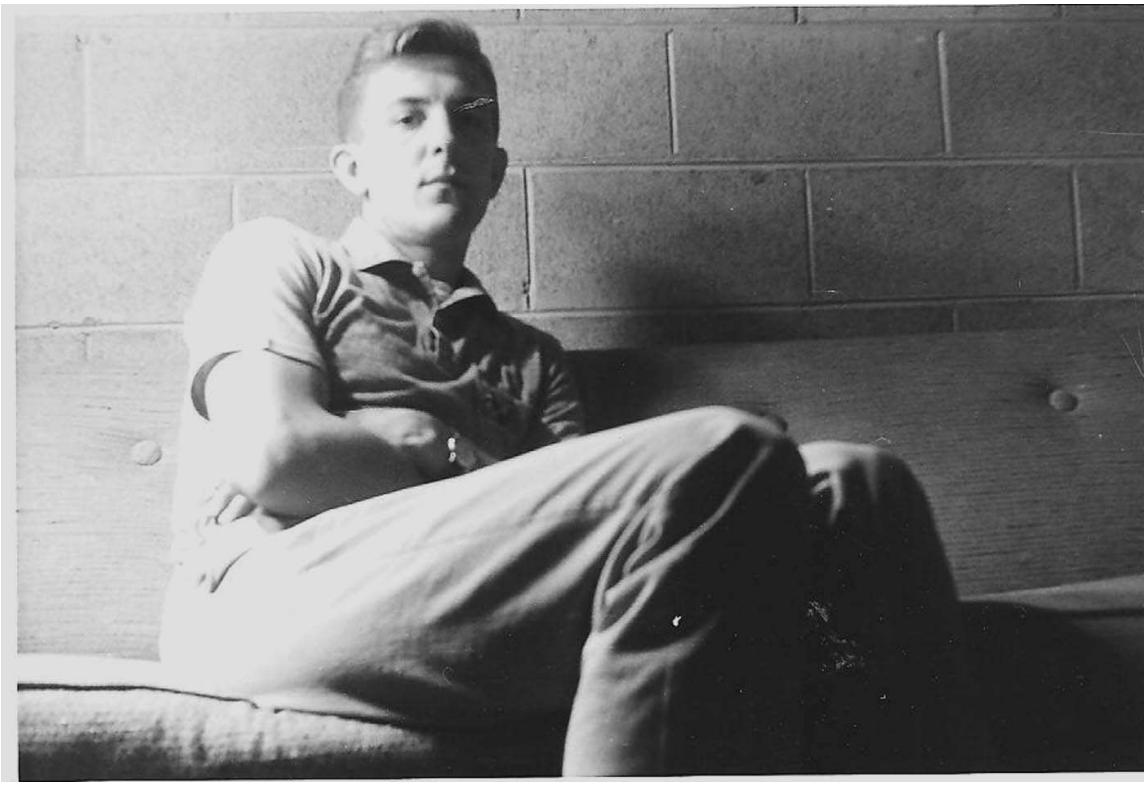
Back

Eric outside our house in Huntington Beach

Back

Back

The house in Huntington Beach as it looks today



In my apartment on Bayshore Drive in Palo Alto

Back

Typical Hilda girl of the month

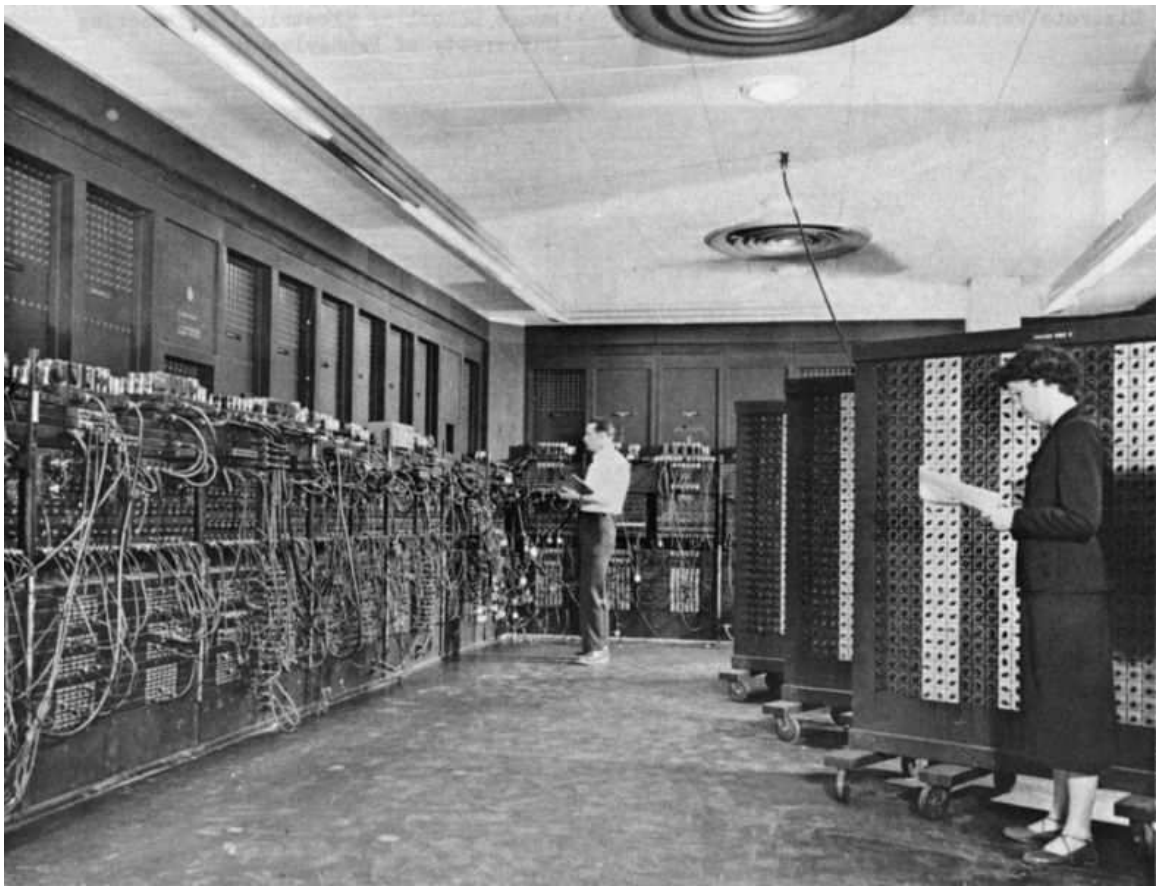
Back

Arnolt Bristol, possibly the on I had

Back

The Porsche 356 that I swapped the Arnolt Bristol for

Back



Eniac with its programming plug boards

Back

Cousins from Björkö, Nils, Tor, Dad, Anne

Back

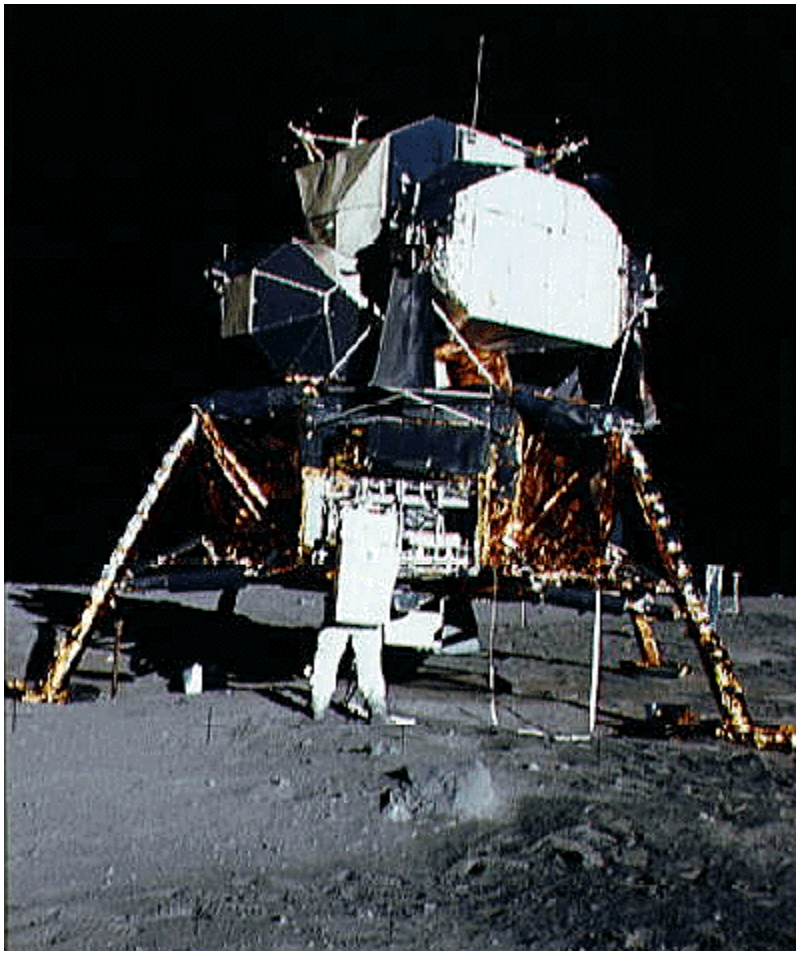
Volvo PV544, affectionately known as the 3950, since in the back it looks like a 1939 model and in the front like a 1950 model. Back

With Bjarne and Joyce at Nut Tree air strip

Back

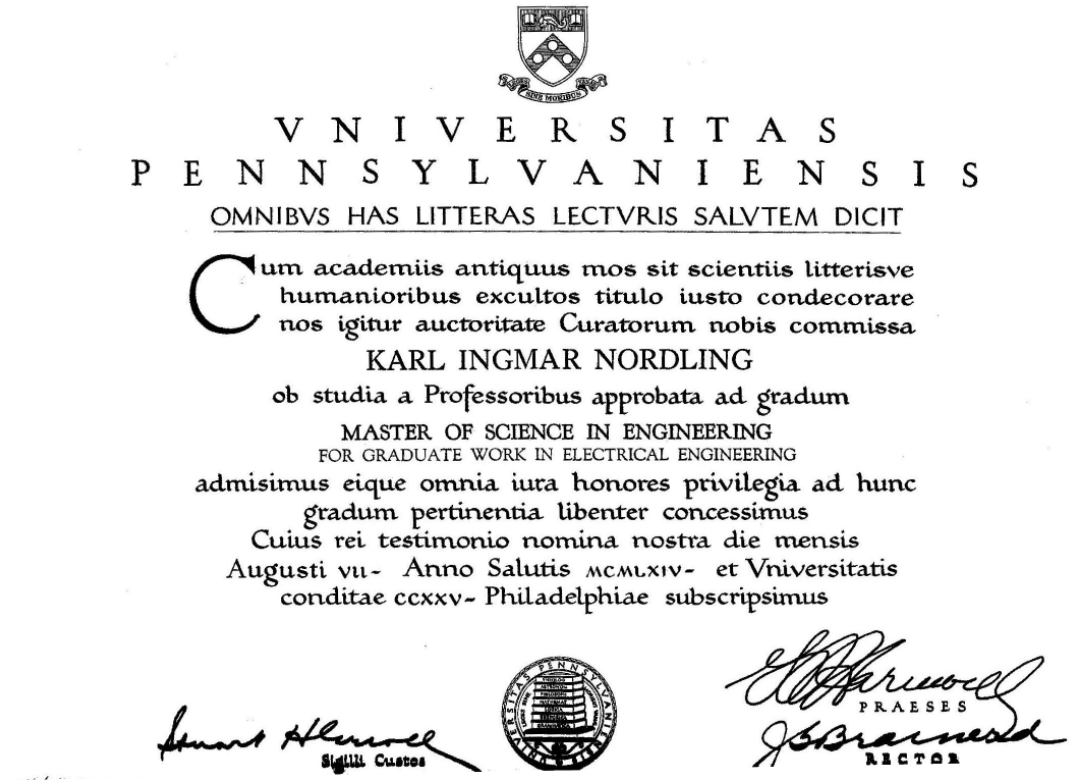
Saturn rocket

Back



Lunar module on the moon

Back



VNIVERSITAS
PENNSYLVANIENSIS

OMNIBVS HAS LITTERAS LECTVRIS SALVTEM DICIT

Cum academiis antiquus mos sit scientiis litterisve humanioribus excultos titulo iusto condecorare nos igitur auctoritate Curatorum nobis commissa

KARL INGMAR NORDLING

ob studia a Professoribus approbata ad gradum

MASTER OF SCIENCE IN ENGINEERING
FOR GRADUATE WORK IN ELECTRICAL ENGINEERING

admisimus eique omnia iura honores privilegia ad hunc gradum pertinentia libenter concessimus
Cuius rei testimonio nomina nostra die mensis Augusti VII- Anno Salutis MCMLXIV- et Vniversitatis conditae CCXXV- Philadelphiae subscripsimus

Sigilli Custos

PRAESES

RECTOR

MSE diploma from Penn

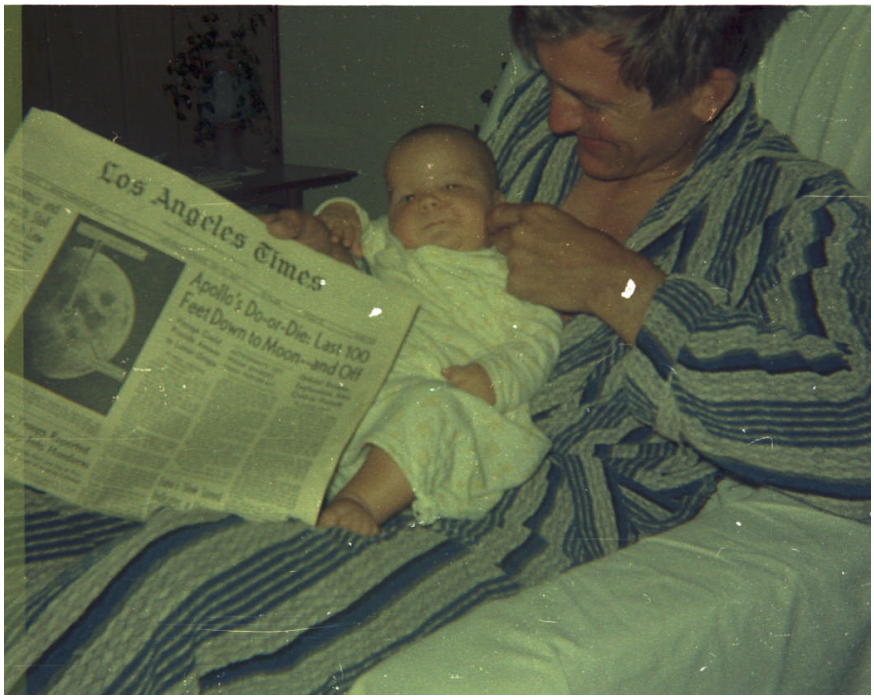
Back

Back

My first wife, Anne Marie

Eric at about one year of age

Back



Leif and I reading about the moon landing

Back

Going to work at Beckman

Back