TEKTRONIX: THE ENTREPRENEURIAL PERIOD, 1946-1954

PART 1: BIOGRAPHIES

Charles Howard Vollum

Charles Howard Vollum was born on May 31, 1913, in Portland, Oregon. He graduated from St. Agatha's School and St. Stephens (now Central High School), and he attended Columbia University (now the University of Portland) for two years.

Legend has it that he built his first oscilloscope while at Columbia University. An early acquaintance, Frank Hood, remembers one of those early instruments as looking like a "breadbox crammed with parts with a piece of sewer pipe on top" (the sewer pipe was to shield the display from the earth's magnetic field).

Legend also has it that Howard tried to transfer to Oregon State but was turned down for lack of credentials; he then took his oscilloscope over to Reed College, where he was accepted.

Reed College at the time had some extraordinary educators in its physics department, including Dr. Marcus O'Day and Dr. A. A. Knowlton. Dr. Knowlton particularly was noted for the quality of students he trained which resulted in Reed College ranking ahead of colleges such as Stanford in numbers of graduates listed in American Men of Science during the 1930's. Dr. Knowlton published a textbook in 1928 which revolutionized college physics instruction by approaching physics from a humanistic rather than purely technical standpoint. Dr. Knowlton was also noted for his fierce and lifelong espousal of academic freedom. He taught at Reed College for 33 years. Dr. Knowlton consulted for industry and found, for example, a method for solving the problem of static electricity blotting out airplane radio reception.

Howard's senior thesis in physics at Reed was "A Stable Beat Frequency Oscillator Equipped with a Direct Reading Frequency Meter". The thesis reflected Howard's determination to design instruments that would, as Frank Hood remembers that Howard said many times during this period, "produce not qualitative readings, but quantitative readings." In fact, the instrument that Howard built and described in his thesis offered an accuracy in measuring frequency of 1 percent at a time when conventional designs could measure to only 10 percent. Howard also built an oscilloscope at Reed that was still in regular use 22 years later (on the 10th anniversary of Tektronix).

After graduating from Reed in 1936, Howard worked on his own for a while repairing electrical appliances, then joined the M. J. Murdock Company. Howard worked at servicing and installing home and auto radios and air conditioning devices for four years until, in 1940, he placed first in a competitive exam and for $150 a month supervised the Radio Project of the National Youth Administration, a defense project to teach young people the basics of electronics.

At the age of 26, Howard Vollum was drafted. He would later say that it was "the only lottery I ever won". On March 4, 1940, his military career started with infantry training at Camp Roberts, where he stayed for nine months. Legend has it that during this period the Camp General's radio broke down, and Howard fixed it with ease. In any case, Howard received the first direct commission ever given at Camp Roberts and was transferred into the Signal Corps and was assigned to the Electronics Training Group.

At the time, the custom was for members of the Electronics Training Group to be sent to England for a period of eight months duty as radar maintenance officers since British radar technology was foremost in the world. Instead of radar maintenance, Howard was sent to the English radar laboratory, the Air Defense Research and Development Establishment. The January 10, 1956, issue of <u>Tek Talk</u> describes that assignment as follows:

"There he worked for almost two and one half years as a development engineer on a high resolution radar for aiming the 15-inch Coast Artillery guns at Dover. This radar was easily the most accurate in service at that time, having a range error of three yards at 20,000 yards (about 11½ miles) and asimuth or angular error of 1/20 of a degree. This radar was very effective in aiming guns which sank German ships trying to sneak out of the English Channel at night. For this work, Howard was awarded the Legion of Merit Medal."

"On his return to the USA just a few days before 'D Day', he was assigned to the Evans Signal Laboratory at Belmar, New Jersey. There he worked on radar detection and location of enemy mortars. This is accomplished by observing the flight of the shells and using this data to compute the location of the mortar. The same radar-computer combination is used for laying our own mortar fire on enemy mortar positions. For this work, he was given an Oak Leaf Cluster indicating a second award of the Legion of Merit Medal."

While at the Evans Signal Lab, Howard met Bill Hewlett, who was stationed at a nearby Signal Corps lab in Washington, D.C. Bill Webber, who knew Howard at the time, remembers Bill Hewlett saying years later, "our biggest mistake was not hiring Howard Vollum. I wrote Dave Packard telling him to hire Howard, but he never did it . . . ."

In any case, after the war, Howard Vollum decided not to move to Palo Alto, California, where the electronics industry was starting to form. Instead, in late 1945, Howard returned to Portland.

Melvin Jack Murdock

Jack Murdock was born in 1917 in Portland, Oregon. While attending Franklin High School he wrote in an autobiography the following:

"After leaving high school and establishing a business of my own, I intend to go further into the study of radio phenomena. I would like to learn all there is to know about radio, if it is possible. I shall probably carry on many experiments in this field, and also, possibly some other branches of science. If I do all that I hope to do, I shall probably make some inventions. I have at present several ideas for inventions, which if put to use would be of great benefit to the people of the world . . . . . I believe that the possibilities of radio are unlimited, and that the majority of the people have no idea of what radio's future holds in store."

When Jack Murdock graduated from high school in 1935, his father told him that some money had been set aside and that Jack could use it either to go to college or else to start his own business. In 1935, Jack opened a radio and electrical appliance sales and repair shop at 67th and Foster Road in southeast Portland. About a year later he met and hired a recent Reed College graduate, Howard Vollum, to handle the radio service duties.

The January 10, 1956, issue of Tek Talk continues the story:

In 1939, the 67th Avenue location became too small for Jack's operation. As a result he bought a building at 59th and Foster. After remodeling and painting, this became one of the most complete and attractive appliance stores in the city. The main feature was a G.E. model kitchen, complete with everything necessary to cook and serve meals."

"Just as things got going in good style, World War II broke out. Appliance manufacture stopped and Jack closed up the appliance business to join the Coast Guard. His knowledge of radio was immediately put to use. First assignment was at the Seattle maintenance base. After a year of this duty, Jack came back to Portland, in charge of a group of radio technicians. His last assignment was as radar and racon installation man, operating out of Seattle."

While in the Coast Guard, Jack Murdock seemed to make friends easily. Later some of these friends would work for him: Miles Tippery, Milt Bave, Bob Davis, Ken Walling, Howard Gault, Paul Belles, Sandy Sanford, Chuck Gasser, and Jim Castles.

In the January 10, 1956, issue of Tek Talk the following description of Jack Murdock appears.

"In characterizing Jack, we can say he gains the respect and admiration of all who know him by his quiet, sincere and genuine interest in arriving at the most fair, reasonable and considerate solution to an individual's and to Tektronix's problems.

"Jack's personal philosophy is of interest to all. He believes that success is available to anyone with ability, initiative, and a willingness to risk personal security . . . . ."

Shortly after Jack Murdock's death on May 16, 1971, as a result of a seaplane accident on the Columbia River, Howard Vollum wrote of Jack:

"Jack was a modest and unassuming man with no taste for the limelight. Yet he was warm and outgoing. . . . .a person you could bring your problems to. . . . . Jack was always oriented toward the customer's viewpoint, and toward the ideal of service. . . . .He led by setting an example. Despite his achievements, he was a humble man, without pretense. He always felt that knowledge was the key to solving any problem, and that if you knew enough about it you could arrive at the appropriate solution."

W. K. "Dal" Dallas

W. K. Dallas was born and raised in Galion, Ohio. His first job was with North Electric performing wiring and assembly on telephones. His next job was in New York in 1924 working as a field salesman/engineer for Cutting and Washington (later Colonial Radio), a small manufacturer of radios. In 1926 he returned to Galion; then in 1928, he returned to New York to join Electrical Research Products (ERPI). Electrical Research Products was a subsidiary of AT&T formed to handle by-products of Bell Labs, principally "talking movies." At ERPI, Dallas was a field engineer whose job was to sell, install and maintain movie equipment. In 1930 Dal was transferred to Hollywood, California, as a part of the Recording Division of ERPI, where his job was to install and maintain electrical equipment for recording and movie producing studios. During this period in 1930, he married the boss's secretary, Hazel. In 1932 they had a daughter.

In 1941 Dal transferred to the Radio Division of Western Electric, where he was a radar engineer attached as a civilian to the Navy and Air Force in a liaison role in numerous places in the Eastern U.S. In 1942 he was assigned to an Air Force anti-submarine squadron and served in Newfoundland, Britain and North Africa. In late 1943 he returned to New York where he was the supervisor of field engineers going into the Pacific Theater.

One of the field engineers that Dal supervised had long had a dream of returning to Portland and to establish an FM station. Dal agreed to join him and at the conclusion of the war drove from New York to his home in California, via Portland. At that time, however, Dal stayed with his recording studio job.

Finally, in 1946, Dal came to Portland to join Stanley Goard in starting KPFM radio. Since this was the start of FM broadcasting, times were hard financially so he became a manufacturer's representative for Neeley Enterprises, a distributor of electronic components. One of Dal's first accounts in 1947 was Tektronix, then located at 7th and Hawthorne. At the time, however, selling electronic components was difficult because there was really not much of an electronics industry. One day, Howard Vollum asked Dal whether Neeley was going to be able to successfully maintain an office in Portland, and Dal expressed some doubt. Then Howard said, "Well, someday we'll need a sales manager," and in May 1948 Dal joined Tek as sales manager. Dal was Tek's thirteenth employee (not counting the five founders).

Later Dal would say, "I had had contact with these people as a supplier of components. I had other job options, but what made me really want to be a part of what they were doing was their integrity."

COMMENTS ON PART I: BIOGRAPHIES

Few people in our times have ever had an experience even remotely comparable to the risk-taking inherent in starting a new business. This lack of experience might make it hard, for example, to make guesses about the various roles of Howard, Jack, and Dal. (In fact, guesses may be all that are possible because so little of the early lore of Tek remains. In fact, this lack of information does support an impression that Tek, in the early years was not a documents or memo oriented firm and that a face-to-face, oral, trusting style of management apparently typified the company then.)

Here are some thoughts which seem to follow from the biographies:

1. These men came together in their mid and late 30's, each of them with at least 15 years of directly related experience: Howard was "always" interested in calibrated oscilloscopes; Jack was "always" interested in starting a company with something to do with electronics; Dal had "always" been commited to a unique approach to the selling of electronic equipment.

It is a familiar approach to apply the experience curve notion to explain steady improvements in corporate performance, and perhaps the concepts of persistence and energy also have relevance to the achievements of people. In any case, by the time they started Tektronix these men had thought of little else for many years but their selected fields of endeavor. . . . .indeed, the two key men, Howard and Jack, had not even taken the time to get married even though they were by then in their early thirties.

Years later Dal Dallas reflected upon the early days of Tek in these words: "The usual picture of a small firm is that it is highly vulnerable, powerless in its market. But there is a force that develops when problems are handled with a clarity based upon a lifetime of experience and when they are handled one at a time rationally and in consultation with one's colleagues. Also, the state of management affairs is such that even outwardly awesome competitors (in this case RCA and Dumont) often run their businesses in patterned ways, thus being vulnerable and getting into rigid ways of seeing themselves and their situation. . . ."

Speaking of his own life, Dal also noted that every job he had had led up naturally to the Tektronix situation. "Particularly relevant was the concept of a technically trained sales force, dedicated to meeting customer needs and desires. Factory experience, followed by Field Sales and Engineering for Colonial Radio was the initial spark. Further experience in the same direction resulted from the Sales, Servicing, and Adaptation of sound motion picture equipment to the needs of theatres throughout the East and Mid-West and later with the major studios in Hollywood." What Dal did at Tek, then, was an expression of a business lifetime of learning, doing, and thought. . . . .much in the same way that Howard Vollum seemed always in his early adult years to have been interested in designing, manufacturing, and marketing oscilloscopes.

2. The timing of the start-up (just after the War). (See also the teaching notes for Part 2.) As big as the potential market was (in retrospect), remember that these were not rich men. . . . .it is significant that they had nothing to lose and their choices were to either take an attitude of

"risking everything" or else look for other, safer jobs. Note particularly the description in the Tek Talk excerpt of Jack Murdock's "willingness to risk personal security". This willingness to bet all later proved critical to the firm's success.

3. The technology: Howard Vollum clearly was and is a brilliant man. It does not detract from his achievements to note that he studied at Reed with some of the foremost men of the times. A. A. Knowlton, who was a famous fighter for academic freedom, a noted industry consultant, a top physicist, a developer of people, a writer of a reknown textbook, and a believer in the humanistic side of technology. We can note in Howard's life some similar elements of tolerance for viewpoints other than his own, a commitment both to instrument performance and practicality, development of people, and so on.

More directly relative to Tektronix was Howard's exposure during the War to some of the most advanced electronics technology in the world related to CRTs, signal amplification, automatic triggering, and sweep timing. The British at the time were the world leaders who had developed advanced radar systems through the efforts of brilliant men who were highly motivated and product oriented. Good science gets done under conditions of national peril, even without fancy laboratories and all the administrative and support paraphernalia so necessary in calmer times. In the space of a very few years during the 1940's these things got done: the atomic bomb, the jet engine, the Ultra project in cryptology, the V-2 rocket, advances in feed-back circuitry for electronic servo-mechanisms, synthetic rubber, synthetic gasoline from plants and coal, advanced airplane design, bomb sights, and so on. . . . .not to mention a shift from a coal-based economy to an oil-based economy, training of millions of soldiers and factory workers, involvement of women in new social roles, advances in production methods in fields such as ship-building and tanks, and so on and on. Many of these technological advances were not widely spread due to conditions of wartime secrecy, but some key electronics technology was available to Howard Vollum. . . . .indeed, he made such significant contributions to it that he received the Legion of Merit award, twice.

TEKTRONIX: THE ENTREPRENEURIAL PERIOD

PART 2: THE FOUNDING

Tektronix was founded on January 2, 1946, to produce oscilloscopes of unique and advanced design. The premises of the firm were the corner store of one of the founders, Jack Murdock. To support the firm through the design period, a separate company was formed to sell and repair electrical appliances.

The principal owners of the firm were Howard Vollum and Jack Murdock. Howard had been involved during the Second World War in advanced radar design and application work in England and the U.S. and had twice received the Legion of Merit award for his work. Jack had employed Howard in his appliance store before the War.

The first product, the 511, took a year and one half to develop. This was a hard period for the firm, as the retail appliance store did not do well. One of the founders lost his nerve and left, taking the retail operation. He was replaced by two other men, bringing the total number of partners to five: Howard, Jack, Miles Tippery, Milt Bave, and Logan Belleville.

The 511 incorporated many of the advances in radar circuitry that had been developed during the War, including automatic triggering. The scope was calibrated to an accuracy of ± 5 percent, had a good bandwidth, and weighed 65 pounds; preliminary estimates suggested that it would cost under $400 (all expenses). It used a CRT tube produced by the Dumont Company. Dumont was also the principal competition, although their product was uncalibrated, did not trigger automatically, weighed 200 pounds, and cost $2000.

By mid-1947 the first oscilloscope was ready for sale. The founders gathered to decide upon how best to sell this new product.

COMMENTS ON PART 2: THE FOUNDING

These were the courses of action taken with respect to sales of Tektronix products:

1. The price was set with respect to the costs, not the market conditions.

2. Although distributors were used initially, every effort was made to set up a direct sales network as soon as possible.

3. Service was emphasized.

4. Advertising was underplayed.

5. Electronics shows were utilized beginning in 1948.

6. Initial sales came from personal contacts.

In retrospect we can say that these courses of action worked and worked well. It is important to understand, with the perspectives of time, particularly why the pricing, distribution, and service elements were important.

1. Pricing with respect to cost; (the initial price of the 511 was $595):

   a. The pricing at a "fair level" based on costs essentially eliminated potential competitors, once it was shown that the Company could deliver. Prices, over the long term, reflect costs, and either a company anticipates the situation, or it watches its market suddenly crumble with the entry of new companies. Costs, in turn, are affected by accumulated experience, which means, in a word, that a company which enters a new area, manages itself well, expands capacity at least as fast as the market growth rate, and also <u>brings prices down with costs</u> should always remain the dominant firm. Pricing with respect to cost was the best long-term decision, although it may have sacrificed some short-term gains.

b. The "fair" prices reflected a high level of integrity on the part of the founders, once it was clear that the product would perform as claimed. The integrity reflected in the product and the prices soon became a significant company asset. Some years later Company legend has it that Howard Vollum was at a show with a $3000 instrument when W. B. Dumont walked up. The Dumont Company at the time was selling a product at a lower price level. Reportedly Dumont said to Howard, "that's a nice scope, son, but it will never sell at that price". But it did, because the value was there.

Also, it is truly remarkable that when some of the key contributors to the company were interviewed recently, many of them mentioned being attracted to Tek by the integrity expressed by its products, prices, performance claims, and service.

2. Direct Selling:

A recent study of successful instrument manufacturers conducted by M.I.T. focused on two types of marketing information: information about market sizes and information about customer needs. The study determined that information about customer needs was the overwhelmingly important variable in distinguishing successful instrument firms. The researchers found, for example, that fully 80 percent of successful instrument designs came from customers or competitors. The history of Tek echoes these findings, although for Tek the situation has many particular features. For example, at Tek the "next bench" philosophy has been an important one. . . . .the next bench philosophy asserts that the problems inherent in designing new instruments are similar to the problems of electronic instrument users, so important product design information can be gained by "looking at the problems of the scope engineer at the next bench". However successful the next bench philosophy has been to Tek, it is also true that: 1) the present portables business, today contributing about 40 percent of the firm's profits, came about only because IBM took the initiative to set up their own design efforts when Tek politely declined to build to their specifications (Oliver Dalton led the catch-up effort that saved the day); 2) IDG originally tried to capitalize on the bi-stable storage tube by developing facsimile machines for electronic mail applications; customers who bought bi-stable storage tubes on an OEM basis put them into terminals as part of products stimulated by the "computer-assisted education" craze of the mid- and late- 1960's; the customer applications defined the need for graphic terminals for computers; 3) even the 7000 series effort, although launched in 1964 by Howard Vollum personally, did not achieve clarity and specific focus until the H-P 180 series appeared in 1967 to set specific challenges in terms of performance, size, and design.

On the other hand, consideration of market potential led Tek into developing the electron microscope. Numerical control for machinery, the rapid scan spectrometer, and (most recently) the Microprocessor Development Aid. The MDA's are expected to break the string of bad luck.

This point may need some belaboring because of it's importance. The contribution of Dal Dallas, based on an entire life of selling and servicing technical equipment (first in the radio industry, then the movie industry, then at Tek) cannot be stressed too strongly. The plane crash of Dal's in 1959 was tragic in both human and corporate terms. Although Dal returned to Tek after a long convalescence, the men who filled in for him and who eventually succeeded him, principally Byron Broms and Keith Williams, spoke more of the need to sell and to focus on market sizes and dynamics. They were right in the sense that those things needed to be done, but direct contact with the customer is of first importance, for this direct contact is the only way to build into the organization the evolutionary forces for change that will later, as the company begins to get very large, serve to substitute for the personal vision and brilliance of the founders.

3. Emphasize Service:

Another related aspect of Dal's vision (thoroughly shared by Howard) was customer service. During the early years, an effective means of selling more instruments to a customer was the prompt air-mailing of parts when an nstrument broke down after purchase. The FE's (strictly hired from Beaverton manufacturing and engineering ranks) were very capable, and customers who were experiencing technical difficulties of their own were sometimes known to call an FE and claim that their oscilloscope was not working in order to get the advice and help of their Tek F.E.

(Corrections on this page made using hand-written notes in margin 3/24/2011 by Ed Sinclair)

This service policy was opposite the prevelant philosophy of the time, which was sell cheap and then make it up on parts and service. Elements of the Tek situation at the time were:

- Tek was small and virtually unknown.

- Tek's customers were either a) large firms whose engineers were used to bureaucratic slowness and so would be impressed by fast service, or b) small firms whose existence often depended on the functioning of its tools.

- Electronics was a new industry and skilled repairmen were few, so customers were dependent on the suppliers for help.

- With an after-sales service entry into a customer area and with the glow of fast repair response still illuminating the situation, the FE would be well-placed to recommend additional equipment for additional applications.

TEKTRONIX: THE ENTREPRENEURIAL YEARS

PART 3: THE FIRST FEW YEARS

In mid-1947 Tektronix offered the 511 for sale at a price of $595 (cost plus a "fair" profit). The 511 featured automatic triggering, calibrated readings, high accuracy, good bandwidth, and relatively light weight. The primary competition was a product without calibration and triggering that sold for about $2000.

Early sales were handled by sales representatives, but by 1950 Tek began to set up its own field offices in order better to channel product design information to the design engineer. The Field Engineers were chosen from factory personnel for their technical abilities and were directed to place first priority on restoring malfunctioning instruments to service. The home office regularly air-mailed replacement parts and charged cost plus a small margin for the replacement parts. However, neither the Field Engineers nor the factory personnel seemed to be able to provide much information on how the products were being used; no information system existed that would tell who bought how many; and manufacturing and sales forecasts were consistently inaccurate.

In order to maintain product leadership, a team of men from the Portland area was assembled. The engineers, as well as other employees, were not sought out but rather were hired only after lengthy interviews and written and manual tests of ability. Often the selection process would stretch over a period of several months. Friends and relatives of existing employees were given preference in the hiring process.

In general, the new engineers each strove to be identified with a product, and a steady stream of new products resulted. During this period, individual work teams were often fiercely independent, and occasionally the tools and designs of rival groups disappeared during the night.

During this period the founders were familar sights. Howard Vollum in particular walked about and was known for asking a favorite question: "why are you doing it <u>that</u> way?" Howard also taught electronics courses for employees in perhaps a throwback to his NYA days before the War. Every now and again an engineer angered at some comment or decision of Howard's would storm into the office of Jack Murdock, who would listen quietly and sympathetically and smooth the engineer back to work.

During the late 1940's and early 1950's no significant competition appeared. The Dumont Company was engaged in a broad sweep of activities principally centering on production of televisions, establishment of broadcasting companies, production of television entertainment programs, and manufacture of radars and television transmitters. The R.C.A. Company was similarly distracted by other ventures. The Hewlett-Packard Company did not produce oscilloscopes at the time and shared with Tektronix a common distributor in California, Neely Enterprises.

By about 1952 a new crisis had begun to develop. The limitation on product advancement began to be components and not circuit cleverness. The CRT tubes purchased from RCA and Dumont were particular problems. The investment required to develop a CRT facility and hire the necessary industry experts, however, could break the small company.

Another problem also began slowly to develop. The oscilloscope was proving to be a ubiquitous instrument indeed, finding uses in a wide variety of applications. The Field Engineers, however, were not in a position accurately to gauge market sizes or even to specify how the products were used once sold. The FE's could, however, speak for the customers in specifying in detail the performance and feature requirements needed. Since each instrument was designed to perform within specific parameters, it increasingly seemed important to determine with precision the nature and sizes of the markets involved or else find a way to design more flexibility into the instrument. Another alternative was for the company to focus only on selected segments and diversify into other instruments based on the success of such products as the 105, a square-wave generator.

COMMENTS ON PART 3: THE FIRST FEW YEARS

In 1952 the young Tektronix faced these critical issues:

- o Whether to make CRTs in-house.
- o How to design more flexibility into the already ubiquitous scope.

Taken together these issues highlight the role of Howard Vollum.

1. Components:

Poor CRTs were the problem. The solution could ruin the Company. As Derrol Pennington remembers:

> "We had tried to get Dumont and RCA to make better tubes. But it finally came to the point where Howard had to say, "We are going to make tubes, and they will be radically new, and we will design our new line around them. If the tube effort fails, then the Company fails."

Only a founder/owner could make a decision like that, and nobody would have ever criticized him if he hadn't made that decision. But he did.

2. Flexibility/diverse customer needs:

A market research program to determine market sizes and natures would have been a decision that no one would have criticized. Instead, Howard designed a way out of the problem by coming up with the plug-in concept. . . . .one of the most successful single conceptual breakthroughs ever made in instrument design.

The plug-in decision was not well received by the minority shareholders, particularly Logan Belleville, a brilliant MIT engineer. Already nervous about the Company's future, the minority shareholders were glad to be bought out by Howard and Jack in 1954.

3. Team Leader:

The case notes that a team of engineers began to be assembled in the Portland area. We can guess that it took a Jack Murdock to get the venture started and to provide a safety valve in human terms, but Howard as a distinguished engineer developed the products and lead the team of creative geniuses.

Remember that many engineers on the West Coast were being drawn down to Los Angeles or up to Seattle to be a part of the on-going aviation effort or to Palo Alto, where the Stanford-H-P-Varian world was taking form. So how did Howard get such results with the people available?

These seem to be elements of Howard's approach as suggested in this portion of the case:

1. Clear assignment of product responsibility: each engineer was personally responsible for a particular product; Howard had decided, within broad terms, what should be done, which is by far the most difficult decision; now the engineers were asked to implement, to compete on friendly terms within a society of peers on technical tasks easily defined in performance terms. The plug-in approach came along just as the Company started to become of a size such that Howard could no longer provide close leadership. The plug-in approach did two things: 1) allowed a tailoring of the product to customer needs, thus resolving the diverse customer needs issue, and 2) broke down the product engineering task further so that specific engineers could hold full responsibility for specific products that were intended to improve specific types of performance in specific ways.

2. Personal example: It is hard to imagine that such brilliant men as John Kobbe, Dick Ropiequet, Clif Moulton, and the many others would have accepted orders or would have flourished under any person other than Howard Vollum who all in one represented technical excellence, a lifelong commitment to oscilloscopes, and personal standards of fairness and hard work. Howard personally led his men into battle.

3. Attention: The case hints that Howard gave the engineers what they most wanted: attention. He would ask "why are you doing it this way?", but he would rarely say, "do it this way". Years later some of the engineers involved in the Company during this period mentioned the fear that Howard's terse questions would inspire. Other engineers, the ones that, by and large, rose to responsible positions, remember with clarity how

they finally got up the courage to challenge Howard when they were sure that they were right and that he was wrong. Whatever, even as many as twenty years later they all implied that Howard's simple but tough questions were important in inspiring them to their best efforts often leading to results far beyond what they thought they could achieve and very far beyond anything that they have been able to achieve since. We can only guess at this date what there was about Howard and his questions that were so effective. We might say, on the basis of the comments of the engineers interviewed, that there were four main elements: 1) Howard gave people a chance to explain their work; the process of explanation to a learned listener seems to have been extremely important to the person making the explanation, forcing new insights; 2) by avoiding directives Howard made it clear that each person was responsible for his own work and that he was not going to think for them; 3) Howard recognized clearly that he could be wrong, and apparently he even encouraged a faint atmosphere of disrespect so that the breakthrough ideas, which could come from anywhere in the company after all, could be heard and not quashed; and 4) the criteria for knowing a good idea when it came along was clear: better oscilloscopes in terms of performance, cost, and useability. . . . .there was no diffusion of effort into areas of diverse new products far from the main concerns and strengths of the company.

The essential thought here is that an effective leader makes a difference, and Howard made a difference.

4. Education: Part 3 mentions in passing that Howard taught some electronics courses for the engineers. These teaching efforts had, as it

turned out, a major impact on the Company. For example: John Kobbe was the engineer that developed many of the 500 series plug-ins. . . . .some observers have estimated that Kobbe was responsible for perhaps half of the total number. John Kobbe, however, was a high school drop-out. He joined Tek in the manufacturing area and was spotted by Howard in an electronics class, although Kobbe apparently chose to distinguish himself by challenging Howard on virtually everything Howard had to say. In fact, contemporaries of Kobbe assert that he really never thought of circuits in terms of resistors, capacitors, and so on, but rather he reasoned in terms of hydraulics: valves, diameters of water pipes, water pressure, and so on. In any case, John Kobbe could apparently look at a complex circuit and in minutes reduce it to its essence, thereby improving performance and reducing the number of components needed to build it. None of this would have happened if Howard was not commited to professional development and so interested in results that he would ignore other criteria.

5. Constrainer: The temptations to diversify must have been many. In the light of "modern management theory" (as well as traditional military theory) concentration of forces is everything. A key decision was staying with oscilloscopes as long as the growth and profits were there.

TEKTRONIX: THE ENTREPRENEURIAL YEARS

PART 4: THE EARLY 1950's

In late 1952 Tektronix commited itself to producing its own CRTs. The principal persons involved in the effort were Derrol Pennington (a biochemist who had taught at a medical school for the previous six years), Jean Delord (a physics teacher at Reed who at first worked only during summer breaks), and John Griffin (a glass blower). None had expertise with CRTs, but they were given total responsibility for the task.

The principal method for developing the CRTs was brute force. In Derrol's words:

> "We worked hard making the first tubes. We had to succeed. But we could move much more quickly then. We would make a gun during the day, insert it into a tube, then put the tube on a pump to pump all night. We would test it the next day, design a new gun and repeat the cycle day after day. Over time that sort of schedule was tiring, but it was thorough and effective. Every idea got tried out."

And, typically, at a key moment Howard Vollum made a suggestion--to try a helix shaped accelerator--which revolutionized CRT technology.

Tektronix by that time also made other components: transformers, capacitors, and instrument panels.

The new Tek CRTs were principally used in a new line of plug-in scopes, the 530 series, which were flexible and could be adapted to a wide range of customer needs. The 535, introduced in 1954, was so flexible and of such quality that it sold steadily for 22 years.

All suggestions that the firm diversify into other product lines were rejected by Howard Vollum who preferred to stick with oscilloscopes as long as the growth and profits were there.

By the early 1950's Tek also began to be known for its innovative personnel practices, including: profit sharing, reluctance to fire employees, good working conditions, free coffee, few status symbols, informal dress styles, company newsletters and magazines, open cash boxes in the cafeteria, open stock shelves in the engineering areas, area representatives kept informed of company business, employee development, promoting from within, encouragement of friends and relatives to work at Tek, a full-fledged human relations department, open offices, and no reserved parking spaces.

CONSOLIDATED FINANCIAL STATISTICS

Calendar Years

	1956	1955	1954	1953	1952	1951	1950	1949	1948
NET SALES	16,061	8,651	7,294	5,935	5,540	4,022	1,206	742	257
EARNINGS	2,293	822	798	395	490	388	117	135	26
% of Sales	14.3%	9.5%	10.9%	6.7%	8.8%	9.6%	9.7%	18.2%	10.1%
Per Share	29¢	10¢	10¢	3¢	4¢	3¢	1¢	1¢	0.3%
INCOME BEFORE INCOME TAXES	5,021	1,779	1,733	1,367	1,737	1,279	246	236	41
% of Sales	31.3%	20.6%	23.8%	23.0%	31.4%	31.8%	20.4%	31.8%	16.0%
ANNUAL INVESTMENT IN FACILITIES	784	238	174	472	200	304	75	13	3
FACILITIES	2,256	1,482	1,247	1,073	604	404	100	25	12
DEPRECIATION EXPENSE	146	95	72	49	38	18	2	2	--
ACCUMULATED DEPRECIATION	417	276	182	110	61	23	5	3	1
PAYROLL BEFORE PROFIT-SHARE	3,950	2,212	1,614	1,245	1,120	301	282	176	113
EMPLOYEE PROFIT-SHARE	2,140	1,585	857	794	638	330	77	46	--
Employees at Year End	1,241	665	501	385	359	321	109	77	32
COMMON SHARES OUTSTANDING*	7,980	7,980	7,980	12,000	12,000	12,000	12,000	12,000	8,820
CURRENT ASSETS	5,470								
CURRENT LIABILITIES	3,679								
WORKING CAPITAL	1,791								
INVENTORY	2,464								
LONG-TERM BORROWINGS	--								
TOTAL ASSETS	7,309								
SHAREHOLDERS' EQUITY	3,630								
COMMON SHARE CAPITAL	266								
RETAINED EARNINGS	3,364								

(DOLLARS AND SHARES IN THOUSANDS)

EXCERPT FROM TEK TALK DECEMBER 1960

Ideas That Have Built Tektronix:

Believing that Tektronix owes its growth and stature not only to the research, engineering and productive skills of its people but also to the unique and vigorous ideas of its leaders, Tek Talk has begun a search to learn just what some of these ideas are.

All too often, because we've grown big fast, we lose track of these philosophies. Often they become hearsay, and sometimes even distorted, but still they are a pervading influence.

The first interview is with President Howard Vollum.

Tek Talk: We hear a lot about the "Tektronix philosophy." Just what is that philosophy?

Vollum: It's more an atmosphere than anything else. We try to give the maximum amount of responsibility to everyone--depending on what his job is. It's preferable to do that rather than set up a series of rules or laws.

Here, it's the responsibility of each person to do as he sees fit, within the framework of his job.

Although some things we do are governed by our job-for example, how we must dress--others things like common parking facilities, open cash boxes, trusting people to do their own timekeeping, these are things common to all of us as human beings.

We prefer not to have a series of status symbols--two more feet of office space when you get promoted, then a rug with the next promotion, then a pad under the rug. . .

Tek Talk: Do you feel people have no need of status symbols?

Vollum: The needs of individuals differ. We try to meet those needs reasonably. I believe people who do have to rely on status symbols are insecure. My experience has been that the most valuable people are those who don't have to.

In any case, it's a matter of degree. If it doesn't interfere with others, we don't pay too much attention. The big problem is, once you get this status thing going, it gets competitive.

Some newcomers may mistake lack of status signs here for lack of position or authority. This is not so. . .

Your real status is the status you've earned--and when you've really earned it, you don't need the symbols.

Tek Talk: How much does our atmosphere contribute to the company's success?

Vollum: It's hard to make a formal assessment, but many customers have told me they like to deal with us, and that if our product and that of another company were equal they would still do business with us because of our attitude toward service and quality of product.

The willingness, for example, of our field engineers to do more than is called for is quite an important thing. . .

Tek Talk: From what does our attitude of service and quality stem?

Vollum: One factor is that good morale tends toward good products. We don't ever want to let the customer down.

I'm convinced that almost everyone wants to do a good job. The percentage who do not is very, very small. One of the biggest causes of frustration is the inability of a person on a job to meet his own standards. No one knows better than he himself if he is or isn't meeting them. . .

Tek Talk: How important is backing up each employee with all the equipment he needs?

Vollum: I don't know that quality depends on equipment. You can go overboard on this very easily. Several unsuccessful companies I know of concentrate more on ways to do things than the atmosphere to do them in.

Often you hear, "If only we had this or that machine. . ." We have to guard against this attitude.

Once again, it's a matter of judgment. You can pay a tremendous price for having too little equipment--and you can decrease your profitability with an excessive amount. Often, here because we're growing and changing so fast, the life of equipment is short as to actual usefulness.

Buildings are no different. Inefficiency results from having too little space. Yet they're pretty costly to build and maintain. We're doing our best to steer an optimum course in our present building program.

What is really needed to do the job? This is an extremely important question to work on.

Tek Talk: Is it hard to keep the Tektronix atmosphere as we grow bigger?

Vollum: It's a lot harder to maintain the atmosphere, just as it must be in any company of any size, but it's still possible. Sometimes growth is used as an excuse for lack of a creative atmosphere, just as, "If only we had this or that machine" is.

Or at Tektronix we may hear, "It's not as nice as it used to be, but that's the price we must pay for growth. . ." It's a convenient excuse, but not necessarily true.

Keeping our atmosphere can be done, but it requires hard work. A company accomplishes this goal almost automatically when it's small, because then everybody sees everybody else.

When it gets big, directly informing each other is difficult because the top people are insulated by the requirements of their job. The solution is to get the people who are in direct contact to act like the top people did at the start. This isn't easy, because the people we hire for this purpose have different backgrounds, outlooks and obligations to the company.

We feel that promoting large numbers of people from the plant to supervisory positions, even if some may not be quite ready, is better than hiring supervisors from outside. It gives each employee a feeling he has a chance.

Tek Talk: What about hiring staff from outside? There seem to be feelings both for and against.

Vollum: There are times when both sides are right, and I'd hate to see either in a dominant position. Some jobs require training--especially education--that it's hard for us to duplicate.

There are exceptions, but we can't count on them happening in sufficient numbers, and we can't expect to grow if we do.

However, sometimes there's a tendency for the grass to look greener elsewhere, and just because we and our people are unable to do something, we may feel there is a person somewhere outside who can. All too often this is not true.

Our basic philosophy is to attempt to develop the abilities of our own people to meet our needs. Many things contribute to this development: Experience, natural ability to adapt, private study and reading, formal courses, Tektronix training programs. . .

Tek Talk: Does our attitude toward profit differ from other companies?

Vollum: I don't think we're much different from most well-managed companies.

It's easy to confuse long- and short-term goals, but we try to balance them. We can't do everything just to maximize the profit this year, nor can we put off the idea of making profit to never-never land.

We try to look ahead, and also to act now in the way that customers like to see us act. They don't expect us to give them anything. They expect to receive something of value for their money. By giving just a little more than they expect, we gain a great deal in dollars and good will.

Tek Talk: Could we be more efficient if we had a more highly structured organization?

Vollum: There is a very serious tendency in some areas to do too much time-wasting, but it's offset by the employees' willingness, energy and enthusiasm for work when the pressure is on.

Again, somehow we must come to a balance and compromise between the two extremes. Too much restriction brings on this attitude: "If they're going to make me act thus and so, then the heck with any extra effort. . ."

We have to be careful we don't destory morale. I don't think the problem of goofing off is true of anything like a majority, nor does anyone do it consistently, but some have more of a tendency than others.

Just because there are a certain amount of abuses in our system doesn't mean we should condone them. We should do all we can to see that they stop.

Such abuses don't produce happiness for the persons who indulge in them. The only happy persons are the ones who do good jobs and know it.

We don't want to give up the atmosphere in which each person is free to contribute as much as he can. Yet it's not fair for the creative person--who thrives on such an atmosphere as ours--to carry others who may take advantage of it. The individual supervisor should talk to these latter people.

We can maintain our atmosphere by educational programs, by setting personal examples, by counting it as a "plus" for an employee who does work hard. . .

Whatever faults we have, attempts should be made to correct them without the necessity of making them the subject of a new rule or law. It's easy to develop habits which can become insidious growths and can sap our strength very rapidly.

Tek Talk: Does growth of the company mean adding more rules?

Vollum: We do have to add rules when we grow bigger--or to express those we already have more formally. Everyone's needs are different, including the rules and regulations optimum for him.

There is an optimum number of rules which gives a maximum of freedom. No rules at all means anarchy. Without traffic rules you probably couldn't have driven to work today. On the other hand, it's bad to have rules that are disregarded.

We have a general policy of permissiveness. Management people differ in their approach. Some are more authoritarian. Some only seem to be--and vice-versa.

There are different styles in management. A person is best off in his individual style. When you try to put everyone in the same mold you have trouble. We all can still have the same goals and so on, but just take a little different route to reach them.

Some people prefer one type of management in a company, some another. . .

Tek Talk: How much individual difference will our system tolerate?

Vollum: We couldn't have dishonesty, in the broad sense--persons who may say one thing and do another. I don't think we can stand much in the way of alcoholism either. These are the basic things. . . Also, actual insubordination is a problem for the supervisor. It indicates the employee's basic insecurity, and his need for help.

By contrast, take a person who maybe is too outspoken at the wrong times. There is no disgrace or moral failing to that, only bad judgment.

The more individual differences we can tolerate, the better off we are.

COMMENTS ON PART 4: THE EARLY 1950's

The preceding materials raise many issues, two of which are:

1. What were the driving forces for all this growth?

2. What was the rationale for this enlightened employee philosophy?

The Driving Forces

Not mentioned in the case are some of the events that were occuring in the larger world at the time:

1. The immediate post-War period: Immediately after the Second World War there was an explosion in the field of electronics--principally radio and television electronics--as skilled radar and communications personnel returned from military service and as cheap surplus components became easily available.

2. Atomic and hydrogen bomb research (incidentally, so important were Tektronix instruments that the first hydrogen bomb test was held up for several days due to a malfunction in the Tektronix oscilloscopes that were the principal measurement devices).

3. The Korean War: Which stimulated aviation and communications electronics.

4. Early work on computers.

5. Development of electronic servo-mechanisms based upon the feedback circuitry developed during the War for aiming large guns.

6. On-going advances in commercial and military aviation radios and radar.

7. Increased use of electronics in telecommunications.

It should be noted in passing that "you can't sell from an empty cart". After product design customers need to be assured that the producer is a reliable one and that the products are available. Even in the early years Howard and Jack supported by key figures such as Earl Scott, Bob Davis, and many others, showed a remarkable ability to double production and redouble it and then triple it and so on.

Rationale for the Employee Relations Effort

Most stories and histories of Tek begin and end with the employee relations story. These cases are meant to get more at the business decisions, but so powerful a business force has the employee relations been, that some mention must be made here.

Most probably the enlightened personnel policies resulted from the personal values of Howard and Jack, and most certainly the policies collectively made Tek almost a social movement in the context of the business world of its day. Still, it does not detract from those policies to note the good business sense the policies embodied, for as one observer has stated, "if it made sense to whip people, by now there would be many areas within Tek whipping people daily . . . ."

Some basic facts about electronic instrument manufacturing:	The basic facts imply the following:
Designing and manufacturing oscilloscopes is labor intensive	So morale is important to productivity
Short production runs and frequent changes in product types are common	A flexible work force is essential to deal with shifting work loads
Electronics is basically a clean manufacturing process	Attractive working conditions are possible at a reasonable cost
Rapid expansion is necessary to keep up with market growth	Good conditions attract new workers; the new workers once they have arrived must be quickly educated and motivated; motivation can be best accomplished

	either by pay (expensive) or peer norms (probably the more effective method anyway); the needed skills improvement requires a commitment to employee development
Creative designs are important	Creative people need to be both challended and freed from routine inconveniences and abrasions. . .you can't order them to produce and you can't afford to have them jerked around by petty martinets.
Often, because of geographical location in Beaverton, "experts" or "geniuses" are not readily available	So development of people from within becomes more important
Key employees become acquainted with proprietary technologies and processes	So holding key employees (or at least keeping them interested in the company welfare if they leave) becomes important; so, a key employee stock plan makes sense and it also makes sense to involve key employees in company decisions so they feel involved

Periodic sales down-turns are likely and there is also a risk to the firm that the products might suddenly become obsolete with technological break-throughs	So, profit share represents a way of cutting payroll costs quickly if there is extreme danger to the firm
Good ideas and technical breakthroughs literally can come from anywhere in the company, not just from the top managers; in fact, engineers often do their best work when young and as they rise hierarchially their importance in the product design process often diminishes	So, status symbols based upon seniority or managerial rank make little sense for they can foster a "we-they" mentality and emibtter the young and/or creative
In situations of real complexity better decisions get made if as many facts as possible are available and if as many perspectives on those facts as possible are considered	So regular use of committees and groups in the governance and decision making processes makes sense

TEKTRONIX: THE 7000 SERIES STORY

Note: references to sales performance by years refers to fiscal years and not calendar years. (Tektronix fiscal years end on May 31).

Part 1: Prelude

On June 5, 1962, Howard Vollum, co-founder and co-owner of Tektronix, re-entered Company affairs in a decisive manner. Although sales had doubled in the last three years to a level of $60 million, the return on equity had dropped from 34 percent to 19 percent with no prospects of improvement in sight. Further, the Company had recently been stung by the actions of its arch-rival, Hewlett-Packard, and a tiny firm known as Lumitron. These firms had both announced in 1962 sampling oscilloscopes which represented significant advances in the state of the art; both the H-P and the Lumitron products were elegant approaches to the problem of capturing a high speed signal, while the Tektronix product response (which required the hiring of expertise from outside the Company) was not only a year later, but it also got hung up in manufacturing and when produced showed an alarming tendency to destroy with large bursts of current whatever it was supposed to measure.

In any case, the Company seemed to be getting out of control, so Howard's first act was to edge out his dynamic and aggressive--albeit disorganized and abrasive--Executive Vice President (who had been running Company operations for the past four years) and take the reins himself. As events were to prove, Howard's reassertion of control was well-timed, for the following fiscal year, 1962-63, was a period of down-turn in the electronics industry although Tek came through with a sales increase of 16 percent (the 1963 annual report still called it the "year of the down-turn").

About a month after taking over again, on July 17, 1962, Howard presented plans for a thorough re-evaluation of Company problems, which he saw as primarily deriving from a lack of "horizontal flow of information among managers at various levels" which was causing "unnecessary duplication and. . .a frustration in trying to get things done. . . . ." Accordingly, Howard announced the formation of a "Management Group" consisting of nine principal officers who would each head up one or more ad hoc planning groups on topics such as the long-range building program, coordination of domestic and overseas operations, central vs. dispersed services, cost accounting procedures, training at all levels, and so on.

On November 30, 1962, the "Ad Hoc Committee to Recommend a Product Planning System for Tektronix" published its final six page report. Principal recommendations were:

1. The various segments (Marketing, Research, In
Products, Manufacturing) should be adequately
phases of planning and development.

missing words

2. Innovation should be encouraged. Adequate sc
jects to be initiated within the departments
should exist whereby creative abilities are f

3. Effort should be made to develop products con
goals that will open new markets both here an

4. Activities of the various departments should

5. The Tektronix product line should contain the
to customer needs and the minimum harmful red

6. Tektronix products should be adequately teste
a maximum degree of reliability taking into c
the product.

7. Instruments, accessories, and auxiliaries sho
the various stages from development through p
priate availability and compatibility.

8. Marketing strategy (advertising, timing of an
should be an integral part of product plannin

9. Those most directly responsible for product d
the product planning system and know how to u

10. The overall success of the product planning s
and used to improve the system itself.

This Report also listed the activities necessary to be carried out by the total system for product planning and set up a Product Planning Strategy Group headed by Howard Vollum himself. A year later, in October 1963, this start was reinforced by a major reorganization of the Engineering function into five product related groups: Advanced Circuitry, Instrument Engineering, Cathod Ray Tube Engineering, Electron Physics Research, and Pre-Production Engineering. Somewhat later the manufacturing areas were also reorganized into separate product manufacturing and component manufacturing groups and the overseas manufacturing operations were integrated organizationally with domestic manufacturing.

The reorganization and the Product Planning Strategy Group must have had good effect, because by 1964 significant new oscilloscope models began to appear. Seventeen years after the first 500 series oscilloscopes, the 511, had been launched, Tektronix announced a new 500 series line of general purpose scopes: the 544, 546, 547, and 549. The 547 particularly represented perhaps a new "ultimate" in performance and is remembered fondly to this day for its sophistication, crisp and sharp display, and reliability based upon years of product development in circuitry, vacuum tubes technology, mechanical design, and CRT displays. Also part of this new line was the 564, a storage oscilloscope of exceptional capability.

On February 20, 1964, Howard Vollum wrote a memo to his new Executive Vice President and new Engineering Manager outlining a next generation of scopes and then, well-pleased as we must imagine, he withdrew from daily affairs to watch sales and return on equity start rising again.

In 1965 a second new line of oscilloscopes, the portable 400 series was launched with great success, although Tek had had to be forced into developing the product line by the IBM company, (they had backed up their threats by setting up a 50 man engineering group to design oscilloscopes). In 1966 the <u>Annual Report</u> noted that the firm's substantial increase in sales (25 percent) was "in large part attributable to new instruments to meet unsatisfied needs of the computer and television industries."

A further triumph occured in 1965 when the 3A5 plug-in was announced. The 3A5 "searched for its own correct settings". . . . .a stunning programmable instrument whose capabilities would not be copied by competitors for ten or more years.

A final triumph was a military version of the 547, called the 647, which was fully transistorized and ruggedized.

Fiscal Year	Sales	Return on Equity
1959	$31.6 million	34%
1960	43.0	30
1961	50.3	24
1962	60.1	19
1963	70.5	16
1964	75.5	16.5
1965	81.1	16.5
1966	101.8	20.3
1967	129.0	19.8

TEKTRONIX NEWSLETTER

#114 Dated: June 5, 1962

On December 18, 1958, the directors of Tektronix decided that Bob Davis would be given the responsibility for the operation of Tektronix, thus taking over many of the duties which up to that time had been mine. It was the intention of the Board, and my own too, that Bob be free, within the general Tektronix philosophy, to operate as he saw fit. As you can see from the growth of Tektronix facilities, employment, the establishment of our Guernsey and Heerenveen operations and in many other ways his operation was effective.

It was my hope when Bob took over that in a few years I could devote most of my time to a number of personal projects in which I have a strong interest. As time went on, however, the rapid expansion of Tektronix brought with it many problems. Efforts to provide solutions to these problems resulted in decisions which appeared to me not in the best interest of Tektronix. I emphasize "appeared to me" since it is quite possible that I am wrong, and I know of no way to find out except to wait some months or years. I hope, however, that the impression is not made that my viewpoint was superficial. It may be incorrect but it was the result of much study and discussion. As a result of my effort to get an adequate basis for the evaluation of these decisions and, more importantly, their basis, there has been an increasing confusion in many people's minds as to whether Bob Davis or I was the chief operating executive. As you probably know, Bob and I have different managerial styles. Which is better or even more appropriate I cannot say, but in any case, Bob and I agree that we had to use one or the other, not both.

Since it was my duty as president to make the decision, I studied the problem to the best of my ability and reluctantly concluded that the best way to meet my responsibilities as I saw them was to take over the duties of chief operating executive. Under these circumstances Bob feels that he should step out rather than take a subordinate operating position. He has agreed, however, to stay on as a member of the Board of Directors. This seems to be an excellent way to benefit by the years of experience and many good ideas which Bob has.

Any change in top management brings up fears and questions as to future changes in organization, policies, etc. I have no plans for any sudden changes, in fact, the opposite seems most important. Any changes that do come will be the result of meeting needs as expressed by the people concerned, and will, whenever possible, be those recommended by the people concerned. When these changes affect various areas and conflicts come up, I will take the responsibility for the necessary decision. I would like to assure you that changes will be made only after as careful and thorough consideration as conditions permit.

I am confident that we have the abilities and willingness to work out policies and practices which will be to the benefit of all.

Howard Vollum

President

TEKTRONIX NEWSLETTER

#115 Dated: July 17, 1962

A little over one month has gone by since I returned to an active operational role in Tektronix management.

It seems appropriate that a report be made as to some of the activities which have taken place in that period.

As stated in the June 5 Newsletter, I have no plans for sudden major changes. Some changes, mostly of a preliminary nature, have been made. One of these has been the transfer of the responsibility of Hawkin Au's Company Planning group to Bob Fitzgerald. This enables Hawk and Frank Consalvo, who are working closely, to coordinate their efforts more easily.

One of the problems which I feel is not being well taken care of at Tektronix is the horizontal flow of information among the managers at various levels. This has at least two results. One is unnecessary duplication, and the other, a frustration in trying to get things done which must involve the cooperation of several areas. The logical starting place for an attempt to improve in this area is at the top.

The method which I have chosen to attack this problem is the formation of a group chosen from those people already reporting directly to me. This is called the Management Group.

The membership of this group at present is as follows: Byron Broms, Jim Castles, Don Ellis, Bob Fitzgerald, Guy Frazier, Jack Murdock, Bill Polits, Bill Webber, Howard Vollum.

As you can see, all areas of the company are represented, but certainly not equally. The choice of people for this group was necessarily a compromise between adequately representing all areas and viewpoints and keeping it small so that effective discussions could be obtained. The particular choice made may not be optimum but it was made after much thought and consideration. One of its principal functions is to study and recommend the organization and management which is best for Tektronix; therefore the present group may well be changed when those recommendations are made. At present we meet on Tuesday from 9:30 to 12 and Wednesday from 10 to 12.

The principal functions of the Management Group at the present time are as follows (not necessarily in the order of importance):

1. Be the principal two-way link between the Board of Directors, President and the operating managers.

2. Be the center for ad hoc groups formed to study and recommend solutions of problems affecting more than two areas of responsibility. (Items affecting only two areas should be solved by the two managers concerned.) The topics assigned to ad hoc groups may range from long-term items, such as optimum company organization, to problems needing only a single meeting.

3. Serve as a central focus from which flow the policies and decisions resulting from the ad hoc groups or the Management Group itself.

4. Serve as advisors for individual members of the group on their problems and problems brought to their attention.

5. Inform each other by means of formal, detailed, weekly reports regarding operations and plans of their respective areas.

6. Be well-informed individuals on Tektronix policies and plans, and communicate these to their areas of responsibility.

This is accomplished by the weekly reports mentioned in Item 5, the general discussions of problems and by setting aside portions of the meetings for hearing formal prepared presentations of important subjects. For instance, the July 17 meeting will hear a presentation on Long-Range Planning.

All of these functions are built around the principle of individual responsiblity, not group responsibility. To carry out this principle each ad hoc group will have a chairman who will be a member of the Management Group. He can choose members of the ad hoc group from anywhere in the company and use outside consultants if necessary. The chairman can delegate any or all of the detail work but remains accountable for completing the task and reporting to the Management Group.

I will be responsible for:

1. Defining the mission of each ad hoc group.

2. Naming the chairman.

3. Approving and disapproving recommendations of ad hoc groups. Except in unusual circumstances I will not approve recommendations which meet with opposition from more than one member of the Management Group.

4. Designating the method of carrying out approved recommendations and checking to see that they are accomplished.

Each member has made up a list of topics he would like to see studied by ad hoc groups. I am in the process of combining these into a single list which will be ranked in priority by the group at our next meeting. Some examples of the topics suggested: Long-range building program, planning for specific buildings, coordination of domestic and overseas operations, central vs. dispersed service functions, cost accounting procedures, training at all levels, patent policies, priority of various product areas, and many others of equal or greater importance. We hope to have ad hoc groups operating very soon.

When people act as members of ad hoc groups they act as designated representatives of Tektronix central management and not in their normal job capacity. All members of an ad hoc group have equal status as members of that group.

I hope the impression is not given that the Management Group and the ad hoc groups will solve all of the problems posed by a dynamic and growing company like Tektronix. My hope is that it will be able to hasten solutions of some important company-wide problems and further develop a climate which will encourage problem solving at all levels.

As you can see, the success of this effort depends on a high degree of cooperation from everyone. I am confident this will be obtained, and ask your patience and understanding for the times when things do not go as smoothly or rapidly as expected.

Howard Vollum

President

TEKTRONIX NEWSLETTER

#125 Dated: November 30, 1962

FINAL REPORT OF THE AD HOC COMMITTEE TO RECOMMEND A PRODUCT PLANNING SYSTEM FOR TEKTRONIX

Between September 17 and November 19, 1962, the ad hoc committee met twelve times. We published rough draft statements on the objectives of the system (October 3, 1962) and of the activities it would require (October 31, 1962). In response to these we received letters or had conversations with a number of employees who were interested in the development of a more effective product planning system.

On November 19, we decided that we had enough agreement on the general details of the system that it could be put into effect and the finer points worked out within the operating system itself.

Accordingly, Howard Vollum, President, authorized the preparation of this report as the statement of the intent and general details of the Tektronix Product Planning System.

PHILOSOPHY

Successful product planning results when individuals are enabled to use their creative abilities cooperatively to initiate and develop products in the best interests of the company and its customers.

Each individual directly concerned with the product planning process should know the long-range goals of the company as well as what is considered to be currently in our best interest. He has a right to expect that careful study by responsible and competent people will precede decisions about projects of interest to him.

Management needs to assure that projects considered essential to our success (current and long-range) are being carried out effectively.

The effectiveness of product planning and development depends upon the mutual confidence and respect displayed by those who create and innovate, those who make decisions for the company, and those who carry out projects.

OBJECTIVE

An effective product planning system should assure that: Projects are effectively carried out that have been carefully studied by responsible and competent people who have decided that they are (1) in line with long-range goals of the company, and (2) in the best interest of our world-wide customer group and of Tektronix.

<u>POLICIES</u>

We believe the possibility of reaching this objective will be increased if the following policies are used as guides.

1. The various segments (Marketing, Research, Instrument Design, Future Products, Manufacturing) should be adequately represented throughout the phases of planning and development.

2. Innovation should be encouraged. Adequate scope should exist for projects to be initiated within the departments themselves. An environment should exist whereby creative abilities are fully utilized.

3. Effort should be made to develop products consistent with our product goals that will open new markets both here and abroad.

4. Activities of the various departments should be effectively coordinated.

5. The Tektronix product line should contain the best of overall solutions to customer needs and the minimum harmful redundancies.

6. Tektronix products should be adequately tested prior to market to assure a maximum degree of reliability taking into consideration intended use of the product.

7. Instruments, accessories, and auxiliaries should be correlated throughout the various stages from development through production to assure appropriate availability and compatibility.

8. Marketing strategy (advertising, timing of announcements of new products) should be an integral part of product planning.

9. Those most directly responsible for product development should understand the product planning system and know how to use it.

10. The overall success of the product planning system should be evaluated and used to improve the system itself.

ACTIVITIES

Important: This is a list of the activities to be carried out by the total system for product planning. Various departments must work together if our product planning is to be effective. Many of the activities listed are already being done by various departments. They will continue to be done as at present. We hope that most of the new activities can be carried out by existing departments. Those activities that do not fit into the present organization will be carried out by the Strategy Group or the Implementation Group to be described in the last section of this report. Here is the detailed view of the activities making up product planning.

I. ACTIVITIES RELATING TO PRODUCTS

A. To provide a point where people may submit proposals and to initiate proposals for:

1. New products.

2. Major revisions of current products.

3. Technical research projects (aimed at exploring technical problems rather than producing additions to the product line).

B. <u>To study or request departments to study and report on</u>:

1. Feasibility of specific proposals.

2. Customer needs; uses of Tektronix products.

3. Profitability of current products by items.

4. Estimates (developmental costs, proposed selling prices, ease of selling, areas of application, order rates, profitability).

5. Competitors' products: Specifications, effect on our sales, customer reaction to, etc.

6. Total product line: Compatibility and interrelations, duplication, etc.

7. Technical information about:

    a. Engineering design problems.

    b. Manufacturing problems.

8. Present commitments and to decide for which inventions patent applications should be made and in what countries.

C. <u>To evaluate proposals and authorize (or disapprove)</u>.

1. To authorize commitments of personnel and funds to:

   a. Exploratory projects.

   b. Technical research (investigation of specific areas of interest. For example, semiconductor devices, automated measurement systems).

   c. Development of a new product.

   d. Projects for major revision of current products.

2. To authorize an addition to or withdrawal from the product line and to decide the best timing.

3. To decide about compatibility within the product line.

   a. To decide whether and on what new products compatibility with existing instruments will be sacrificed.

4. To decide whether or not to provide modification for instruments already in use.

5. To decide the warranty and the service policy that will accompany an instrument added to the line.

D. <u>To develop coordinated plans for authorized projects</u>.

1. To assign and change priorities for various stages of projects.

2. To set target dates and establish review points for amount of effort and costs involved in various stages of projects.

E. <u>To increase inter-departmental coordination by assuring that information is distributed about projects and products</u>.

1. Information to each department about similar, related, and interlocking projects elsewhere in the plant.

2. Information about individually initiated exploratory projects.

3. Information for the field about new products with emphasis upon potential uses, design concepts, compromises.

4. To recommend changes in deployment of engineering and research manpower.

F. <u>To assure that prototype products are demonstrated to the field and to selected customers whose opinions are valued</u>.

G. <u>To advise regarding the use with Tektronix products of equipment made by other manufacturers (pulse generators, sweep generators, etc.)</u> To make such information available to the field.

H. <u>To compare obtained versus expected results</u> by establishing criteria that will insure review and re-evaluation when appropriate of:

1. Status and progress of all projects in development.

2. Status and future of all products currently marketed.

I. <u>To recommend changes of types or classes of products to the President</u>.

II. <u>ACTIVITIES RELATING TO THE PRODUCT PLANNING SYSTEM</u>.

A. <u>To educate in the use of the system</u>.

1. To develop consistent definitions for such terms as "product", "accessories", "components", that will be agreed to by departments throughout the company.

2. To prepare and keep current a description of the steps and phases in product planning.

3. To see that information about how the product planning system works is available to any who need it.

4. To prepare and keep current a linear chart that records the decision-making structure for product planning.

5. To develop an effective system of meetings with clear agreement on the purposes of meetings, the responsibility of individual members for agenda, minute-taking, etc.

6. To develop a system for evaluating the meetings and the effectiveness of the members.

7. To publish advance notice of topics on the agenda that various departments might wish to influence.

8. To record decisions (such as authorizations and disapprovals) and the reasons for the decisions, and to report these to people involved in product planning.

B. <u>To measure the effectivenes of the product planning system</u>.

1. To secure information about customer acceptance of new products.

2. To determine whether the needs of departments (regarding product planning activities) are being met.

3. To secure information to enable evaluation of our methods of developing a new product. Information about costs, problems,

successes, etc., in the research, design engineering, and manufacturing phases.

C. <u>To recommend changes in the product planning system to the president</u>.

OPERATING DETAILS

<u>Accountability</u>: Ultimate accountability for the effectiveness of product planning at Tektronix rests with the President. He delegates responsibility for certain results to the Vice President, Operations, and holds him accountable for achieving them. Likewise, delegation and accountability pass along the managerial line. Nothing in this system should be interpreted as changing this basic principle of accountability.

<u>Communication</u>: Product Planning Representatives will be located throughout the company. They will be contact points for any person who wishes to initiate suggestion for new products or major revisions of existing ones. The Product Planning Representative will consult with appropriate people to evaluate such ideas. He will let the initiator know the results. If preliminary screening indicates the idea is worth more consideration, the Representative will follow through to make sure it is appropriately described and presented to the Product Planning Strategy Group.

The Representatives will also participate as members of:

1. The Product Planning Strategy Group, chaired by Howard Vollum, or

2. The Product Planning Implementation Group, chaired by Bob Fitzgerald.

Advance agendas as well as minutes of both groups will go to each Representative.

Overlapping memberships in the two groups should provide more background than could be given in minutes and written reports.

Product Planning Strategy Group: This group will consider topics of longer range concern and those most directly related to external relations such as with customers, the military, etc.

This group will advise the President on decisions listed under I-C in Activities. These are such as: (1) authorization of projects or products, (2) authorization of addition to or withdrawals from the product line, (3) deciding about compatability within the product line, (4) deciding about modification for instruments already in use, and (5) deciding about warranty and service policy.

This group will have an executive assistant (a member of the President's staff) who will prepare agendas, see that decisions and supporting reasons are recorded and communicated where needed, assure that materials and displays for the group are developed and distributed, supervise the correlation of information from different sources, ensure that matters requiring review are brought up at the proper time with the necessary information and other tasks as the group or the President shall determine.

Product Planning Implementation Group: This group will help the Vice President, Operations, with his responsibilities for implementing decisions made by the President with the Strategy Group. They will develop coordinated plans for authorized projects, review the status of various projects and products, assure that information is distributed that will increase intra-departmental coordination, and other tasks to be agreed upon.

Members: The following are Product Planning Representatives. Their assignments to the groups are as shown.

Product Planning Strategy Group

Chairman: Howard Vollum

Executive Assistant: Doug Cure'

Byron Broms	Derrol Pennington
Frank Consalvo	Bill Polits
Jean Delord	Jack Rogers
Egon Elssner	Dick Ropiequet
Bob Fitzgerald	Oz Svehaug
John Kobbe	Norm Winningstad
Mike Park	

Product Planning Implementation Group:

Chairman: Bob Fitzgerald

Erwin Ashenbrenner	Frank Kopra
Byron Broms	Mike Park
Jack Cassidy	Derrol Pennington
Frank Consalvo	Bill Polits
George Edens	Bill Walker
King Handley	

Further Details: Will be worked out by the managers, representatives, and groups as the system operates.

Byron Broms

Bob Fitzgerald

Bill Polits

Howard Vollum

TEKTRONIX NEWSLETTER

#150 Dated: October 7, 1963

For several months now we have been studying ways to improve our engineering effectiveness. Study and discussion brought out clearly the desirability to consolidate our design efforts. To bring about this integration we have combined all product design and developmental efforts into a single organization. Bill Polits has been assigned the responsibility for overall Engineering activities.

Our success is highly dependent on our ability to bring out advanced products at the right time. Engineering will have a prime responsibility for product and project planning. To this end, planning activities within Engineering are being established. In light of these the Product Planning Strategy Group will be reassessed. Howard Vollum, Bill Polits and myself will form the nucleus of a group that will re-evaluate the activities of the Product Planning Strategy Group and provide during the interim a review of our technical programs.

The new Engineering group will include the activities carried on in Research and Future Products and will embrace the Cathode Ray Tube Design Engineering now carried on within Manufacturing. Engineering will now consist of five departments, described briefly below:

Instrument Engineering: This group will be responsible for the design and development of all products including instruments, accessories, cameras and scopemobiles, and the technical content of the related manuals. It will have a primary responsiblity in product planning. It will contain its own supporting facilities. The group will have the responsibility for a product from the idea to the stage where it is suitable for manufacture.

<u>Advanced Circuitry</u>: Will be responsible for investigation and development of new circuits. It will explore developments and demonstrate their application to new products. Products resulting from this activity will be transferred at an appropriate stage of their development to Instrument Engineering. This group will also have an important role in planning products and programs and will fulfill a technical staff requirement for Bill.

<u>Cathode Ray Tube Engineering</u>: Cathode ray tube development efforts formerly carried on in Future Products together with design efforts in the present Cathode Ray Tube Engineering group will be assigned to an overall Cathode Ray Tube Engineering group. This group is now responsible for the design and development of cathode ray tubes and display devices. Some projects with Research relating to cathode ray tubes will be continued there until they are completed or until it is determined that they are best reassigned to Cathode Ray Tube Engineering.

<u>Electron Physics Research</u>: Research will now be called Electron Physics Research. It will have a similar mission to its present one. The group will be responsible for investigation of the basic physics of new devices and the exploration and development of basically new devices. They will do physics and materials research on a project basis in support of other programs. Programs relating to physics of display devices will be carried on in Electron Physics Research and be implemented at the appropriate stage of their development in Cathode Ray Tube Engineering.

Pre-Production Engineering: Will assist Instrument Design in the preparation of products for production. They will be responsible for building engineering models, preparing drawings, performance specifications, parts lists, reliability studies and environmental testing. They will contain component evaluation and have cognizance of component design and see to the assurance of their specification and availability to new products. They will provide the major liaison between Manufacturing and Engineering regarding products. They will provide design for custom and special instruments.

Although there are specific departmental responsibility assignments for basic research and advanced circuits, it in no way is intended to exclude investigation into advanced products and methods from the other groups. Each group will be expected to carry on exploratory work.

Because many individuals are involved in the above changes and it will take time to firm up responsibilities within these groups, Bill Polits has asked me to announce for him appointments of the managers of the Engineering departments:

Pre-Production Engineering	Lang Hedrick
Advance Circuitry	John Kobbe
Cathode Ray Tube Engineering	Norm Winningstad
Electron Physics Research	Jean Delord
Instrument Design	Jack Rogers

Bill Polits will have, in addition to the above, an administrative staff.

Within a short time Bill will announce Engineering assignments among these groupings and will expand the definition of the mission of these groups for those whose work requires further explanation. Thank you.

Robert G. Fitzgerald

Vice President, Operations

COMMENTS ON PART I OF THE 7000 SERIES STORY

Part 1 begins to raise these issues which are the overall themes of the 7000 series case taken as a whole:

- o The transition from entrepreneurial management to structured, professional management.
- o The importance of protecting core business areas.
- o The conditions under which good engineering gets done.

Here are the problem symptoms as outlined in Part 1:

1. Financial:

- o The slde in ROE from 1959 to 1962.
- o The lackluster sales from 1963 to 1965.
- o The 1966 sales increase which is due to portables and not the 500 series.

2. Personnel:

- The need for Howard to reassert control in 1962, which implies lack of succession and professional team.

3. Organizational:

- The bureaucratic tone of the Committee Report with the solution of having a committee be responsible (despite a weak disclaimer) for making recommendations formally and decisions. (The formation of the Ad Hoc teams by Howard in July 1962 formally inaugurated a management style that is now as characteristic as it is much discussed. Alternately this unique, committee and project team style is blessed as "democratic" and cursed as undercutting the in-line management chains).

- Organizing engineering functions in a way that is overlapping and neither product nor market nor business oriented (probably oriented around available talent, which may be expedient or serving of management development needs, but not yet a professional or principled approach).

- Conflict between problem identification (lack of horizontal communications) and the solution chosen (fragment the engineering and manufacturing functions into semi-automous areas; although a common overall engineering manager is provided, the conflicting charges to the sub-groups are likely to cause trouble <u>with reference to the</u>

task of developing a replacement for the 500 series line of general purpose instruments).

4. Strategy:

- o The core business (general purpose oscilloscopes) needs attention:
  - Note the slow response to new technology in the sampling case and the lack of visible response to transistors.
  - Note the emphasis given to peripheral areas, like programmable plug-ins.
  - Note the stable sales in the core areas (see #1 above).
- o The sampling example also suggests that Tek is not watching its competitors very closely.

Here is a statement of the problem and situation:

1. THERE IS NOTHING MORE IMPORTANT THAN PROTECTING THE CORE BUSINESS AREAS.

One of the most common and oldest of Western folk tales is that of slaying the dragon to protect the homeland. In modern management lingo this is referred to as "protection of the core business is of first importance". The next part of the case will bring on the dragon, but this part certainly shows the homeland to be vulnerable.

A concept related to protecting the homeland comes from military theory. Basically the first principle of warfare is the concentration of forces to achieve objectives in the order of their priority based upon benefit/cost.

2. THE TRANSITION FROM ENTREPRENEURIAL TO PROFESSIONAL MANAGEMENT IS A HARD ONE.

Perhaps the second oldest folk story is that of succession--the warrior king trying to make his gains permanent and his peoples praying that he can. The problem of succession at Tek has had to be faced three times before an effective professional appears. In each case Tek has survived largely because of the willingness of the founding entrepreneur to step up to problems with people. A related question is from where does the new leader's mandate come--from mere designation by the former leader or/and from service in time of need.

And another often used folk plot device is the guardian warrior who appears to save the day when most needed. In the parts which follow Howard does appear, and he fights both as head of a team <u>and</u> as an effective individual warrior.

Incidentally, the McKinsey Company of management consultants has studied extensively the transition of entrepreneurial firms to professional, structured firms. They have found that ten years after founding in 60 percent of all entrepreneurial ventures the founder is no longer the chief executive, and that in half of those cases where the founder is no longer the CEO the founder is no longer even a part of the firm. In this context, we shall see that this man, Howard Vollum, is a remarkable person, and that the organization that he has created is capable of a remarkable, top to bottom response when its existence is threatened.

TEKTRONIX: THE 7000 SERIES STORY

PART 2: HOWARD VOLLUM'S PROPOSAL ON FEBRUARY 20, 1964

INTER-OFFICE COMMUNICATION

To: Bill Polits
Bob Fitzgerald

Date: February 20, 1964

From: Howard Vollum

Subject: New Tek Wide Band General Purpose Oscilloscopes

As agreed at our meeting on February 12 I have written down my suggestions for a new generation of Tektronix wide band general purpose oscilloscopes. The oscilloscopes described here are proposed as replacements for 530, 540, 550 and 580 series. Because of the widespread use of the letter series plug ins I suspect the 540B, 544, 546, and 547, and the letter series storage scope will be in production for sometime. No effort is made in this memo to consider other important segments of our line or any extension of it.

The ideas included in these proposed instruments have come from many people. My purpose in presenting them is to stimulate thought and have a starting point for discussion.

The following basic instruments are proposed:

1. 20-30mc single beam

2. 50mc single beam

3. 100mc single beam

4. 30-50mc single sweep dual beam

5. 30-50mc dual sweep dual beam

6. 75-100mc dual sweep dual beam

All of the instruments would share the following features, not necessarily all in one instrument though.

1. Accept 560 series plug-in.

2. Split screen storage with remote erase, supplemented, if possible, by a "write through" ability.

3. Powered operation of sweep speed, vertical sensitivities, beam position, trigger polarity and trigger level. Operation of these controls would be any of the following ways:

   a. Small remote box on cord.

b. Push buttons on probe.

c. Easy to turn control knobs on plug in (small knobs would ease panel crowding).

d. Sensing of signals for amplitude and/or repetitive rate.

e. Punched cards (could also operate auxiliary input and trigger selector unit).

4. Easily changed, graticule projected on the CRT phosphor.

5. In addition to the traces and graticule the following would be visible on the CRT phosphor at the same brightness as the stored trace.

   a. Sweep time/on (one or both sweeps).

   b. Sweep uncal. signal.

   c. Sweep magnification.

   d. Vert. sensitivity for appropriate number of channels (could be four).

   e. Vert. sensitivity uncalibrated signal for each channel.

f. Polarity for each vertical channel.

g. Digital readout of time and amplitude (see 6).

6. Digital readout of time and amplitude difference between any two selected points on a stored trace.

7. Provision for easy mounting of a 1-1 camera which photographs the back of the CRT screen. Automatic exposure and processing would provide a black on white paper print ten seconds after the exposure was started.

Now, in an effort to give some of the background and suggest possible ways of accomplishing these goals, let us consider in more detail the numbered points.

1. The 560 series plug-ins are widely used, convenient in shape and would form the essentials for a complete line of low frequency and sampling plug-ins for the new series of instruments. We could thus concentrate on the necessary new wide band and power operated plug-ins.

   The single beam instruments proposed would be intermediate in size between the 560 and the 540 scopes and would have vertical and sweep output amplifiers of appropriate characteristics built in. 560 series would connect to the output amplifiers via appropriate attenuator-DC level changing circuits.

   If the sweep output amplifier had magnifier capabilities controled by reed relays or diodes, only two sweep plug-ins would be needed; one with sweep delay and one without. Faster sweep could be available if necessary on the 100mc instrument by means of faster sweep output amplifiers and appropriate magnifications. The dual sweep dual beams could use either of these units in either hole thus giving excellent sweep flexibility. It could, for example, have sampling and real time simultaneously available in one scope. The first five of the proposed instruments would replace ten existing instruments. The 75-100mc dual beam would, I believe, be an excellent addition to the line as judged from the popularity of the 580 and 555 series.

I would suggest making 5 and 6, and perhaps 4, (the dual beam instruments) in 17" wide units so that the same instrument would serve for normal and rack mounts. The 129 has four plugs-ins mounted in this fashion.

2. Having used a 564 for some time now in my extra curricular electronics work at home, I am more convinced than ever that at some time in the next few years all lab-grade general purpose oscilloscopes will have a storage ability. This may entail in the beginning some loss of conventional mode writing rate but since the only loss is in single shot photography it would not seem too serious. For respective signals the "integrate" storage mode gives easy viewing and photography of fast signals.

The split screen can be considered an extension of the dual beam or dual trace concept since it enables one to compare two signals, but without the necessity for them to be happening at the same time. The popularity of multi trace and dual beam instruments shows how valuable signal comparison facilities are.

In addition to the split screen comparison technique I feel we should work hard to achieve the ability to display a non-storing trace at the same time a stored trace is being viewed so that superimposed comparisons could be made. Perhaps a combination of increasing the range of non store to store, contrast enhancement techniques, and the development of equal brightness for differing writing rates by varying CRT beam current inversely with signal writing speed, could make "write through" practical. The idea of a writing beam of relatively uniform brightness is an old one and one which many customers have suggested. Perhaps it is worth a look now to see what could be done in this area.

3. The ease, speed and convenience with which a scope can be operated is becoming increasingly important. It now seems possible to provide remote powered operation of the essential controls with a flexibility and low enough extra cost to make this feature attractive to a wide range of users. The use of power operation is not to merely make the knobs turn easier, but to permit operation from a more convenient position, from perhaps a punched card or even by the signal itself.

The basic feature needed in the scope or its plug-ins would be the replacement of the complex multi section sweep and attenuator switches by a group of reed relays, conventional relays and diodes. Since these components can be placed throughout the instrument directly in their associated circuits rather than concentrated on the rotary switches as now used, better mechanical and electrical layouts would be possible. With panel space at a premium the small, easy to turn switches controlling the powered system would be a great benefit. Since the position is indicated on the CRT face, a very small knob and scale could be used (see 5).

The possibility of changing sensitivity or sweep speed from a small control box on a cord, or from buttons or switches on the probe would seem attractive. Four buttons on the probe might be labeled; Increase Sensitivity, Decrease Sensitivity, Increase Sweep Speed and Decrease Sweep Speed. Each time a button was pressed the appropriate circuit would change one step with the result always shown on the CRT face. Provision could be made for insertion of circuit boards in the plug-ins which would sense the characteristics of the signal and operate the switches which set the sensitivity and/or sweep for optimum observation of the trace. I feel that vertical sensing would be valuable, but except for certain cases, sensing the sweep would be difficult and not too desirable.

When oscilloscopes are used to check to check out complex electronic devices such as radars or computers, etc., it would be very desirable to be able to set the controls quickly and without error to the correct positions. With powered controls this would be easily done by a punched card. If a plug were provided on the plug-in connecting directly to the relays and diodes the contacts made through the punched card could operate the appropriate circuits and set up the scope for a particular measurement very quickly. It could change the characteristics from one end of a range to the other without going through any intermediate positions. A very large number of operations could be made without the problems of mechanical wear present in rotary switches. An auxilliary input and trigger switching box, also controlled by the cards or perhaps by a punched tape, could make a long succession of observations rapid and error free.

4. With non-parallax graticules now standard, the need to provide a more flexible method than a permanently printed one on the tube is evident. A very simple projection system using a glass photographic negative which can be easily changed as graticule seems an easy answer. An inexpensive f3.5 lens requires only a small port of flat, clear glass in the CRT envelope. For a 70mm lens the opening need be only 2cm in diameter. 10w or so of light seems ample since only 100 sq. cm needs to be illuminated. The same projection system can also project the data referred to in the next item.

5. The concept of having indications of the sensitivity, sweep rate, etc., visible on the CRT face or in the CRT area is obviously a desirable one if it can be achieved at reasonable complexity and cost.

   If a projection system is to be used for the graticule it seems logical to use the same system to project these data also. The problem comes in transferring the switch positions from the plug-ins to the film plane of the projection system.

   In the scheme suggested here the sensitivities of the various channels and sweep speeds would be on concentric dials having transparent numbers. Each dial is one row of numbers larger than the preceeding one. When projected on the CRT screen through a suitable mask, a column of numbers, one for each channel and sweep would be seen at the top of the tube. Other information such as polarity, uncal., etc., would be projected through the same lens but each illuminated by a separate small bulb which could be switched on or off.

Now consider the means of turning the dials in the projector from the plugin unit panel. For this I am proposing a stepping servo which can also serve to position the control switches of the powered controls mentioned in item 3.

The largest number of positions needed is on the sweep dial. Thirty-six positions in a 1, 2, 5 sequence will cover 10 picosecs/cm 10 secs/cm. This seems adequate for the present at least. On the vertical, luv/cm to 100v/cm takes only 24 positions.

The basic idea is to standardize on some agreed voltage to represent each step. For example, use 1 volt / step. Then on the sweep scale 15v would represent lusec/cm, 24v lusec/cm, etc. These voltages would be obtained from a precision divider on the sweep switch. The dial in the projector has a 36 position divider, and a step servo to position it to the voltage of the sweep switch. If all dividers were powered from the same supply, voltage variation would have no effect. The only requirement would come on the precision of the dividers. For 36 positions a little better than 1 percent is needed. These, I believe could be large production devices consisting of a small ceramic disc on which a pattern or resistive metal film would be deposited. Metal contacts could be silk screened or otherwise put on connecting with the resistive pattern. It would seem possible to make a fairly simple automatic machine to grind or otherwise adjust each step of the divider to be equal resistance. The absolute value of each step would not matter within wide limits.

The actuator could take several forms. A simple one consists of two solenoid operated claws which move two ratchets in opposite direction. Thus operating one solenoid with a pulse would move the dial or switch one segment forward for each pulse. The other solenoid would move the dial back a segment for each pulse.

The voltage for the dividers would come from a pulser in the scope operating at a few cycles/sec. The error signal from the dividers would be amplified and applied to the solenoids to position the dividers and dials to a null.

Bob White thought up an actuator which steps like a ratchet but has no ratchet wheels and would seem to be excellent for this application.

The same components and pulsed power source could be used to position the switches in the plug-in from a remote control box, as suggested in 3.

This system makes it easy to take the attenuation of the probe into account automatically for 10X probes. Since three volts represent three steps and therefore 10 times on a 1, 2, 5 scale, it would seem easy to have the locking collar of the BNC on the probe have a small protrusion attached, which would actuate a switch which would add three volts to the output of the divider and thus cause the dial in the projector to decrease the indicated sensitivity by ten. A 10X magnifier on this sweep could be indicated by a contact on the Mag. switch.

6. The idea of being able to read digitally selected amplitudes and times on a waveform has been suggested many times. The problems of actually sampling amplitudes at selected times is very difficult for fast signals. Fractional name second samples have very little energy and thus need repetitive signals. The problem of seeing the actual spot being sampled is difficult too, since very small differences in time between the sampling and viewing pulse cause large errors. In order to make the mark visible on a wide range scope the viewing pulse must be lengthened as the sweep is slowed down thus requiring additional complications.

A scheme suggested for the scan conversion oscilloscope might be a solution. The basic idea is to measure on the stored trace. This is made possible by the signal obtained when the storage surface is scanned with a beam. Briefly, the idea is this. Store the image to be measured. Change the sweep speed by a "Readout On" switch to cause it to scan at say 30 per sec. Two identical pick-offs are provided, each positioned by an uncalibrated knob. Among other things, the "Readout On" switch positions the sweep at the bottom of the screen. When the beam reaches the stored trace a signal is sent to the pick-off to reset it, leavng the capacitor charged to a voltage equal to the signal as measured from the base line below the graticule. At the same time the stop signal is sent to the pick-off, the CRT beam is brightened putting a bright spot on the trace. The second pick-off is identical with the first so we now have two capacitors changed. The difference in voltage of these capacitors can be measured by a servo driven helipot coupled to a digital dial. This could be projected by the graticule projection optics to the CRT screen. A similar system reads and projects the voltage difference between the two pick-offs which is proportional to the time difference. In both cases, the digital readout must take into account the correct scale factor from the attenuator or sweep switch. The accuracy should, of course, be as high as possible but I believe a 1 percent system would be very satisfactory.

7. The problems of viewing and photographing with the camera and viewer looking at the same side of the phosphor are familiar to all of us. It seems logical to separate these functions. Some time ago Maurie Merrick suggested photographing the back of the phosphor. Magazines have reported this being done for military purposes. Maurie suggests a port on the top of the tube parallel to the beam, with a 45° mirror inside the tube just out of the way of the beam. This seems an excellent idea. An additional mirror is necessary to get the image correctly on the paper, but this helps rather than hurts the mechanics of the camera.

Since all photography with this camera is on a stored image (you can store any repetitive signal) a very slow inexpensive lens can be used. For Ektaline paper and an f-11 lens about five seconds exposure is necessary. This means a very simple shutter. The camera would contain a roll of paper and the chemicals and heated rollers necessary for rapid development. Ektaline paper is rated to be processed at 150 ft/min. This paper has a water resistant base. Since only the emulsion need be wetted by the chemicals it would be virtually dry when it was delivered, ten seconds or so after the exposure was started. The operating cost of this camera giving actual size prints with a white background so that it is easy to make notes on them would be about 20 percent of the cost of Polaroid prints.

If all CRTs had the camera port, the camera could be plugged on to the top of the scope when needed and thus be an optional accessory.

COMMENTS ON PART 2 OF THE 7000 SERIES STORY

In summary here are the goals set by Howard Vollum:

1. Six basic instruments: 30-100 MHz.
2. Accept the 560 plug-ins.
3. One model to offer split-screen storage with write-through capability.
4. Remote operations.
5. Easy to turn control knobs.
6. Sensing of and reaction to signals.
7. Projected graticule.
8. Read-out.
9. 2-dot system.
10. Camera.

Here, in brief, are the methods proposed to achieve the goals:

1. Transistors.

2. Alter power to suit plug-ins.

3. Bi-stable storage.

4. Control unit to actuate relays, solenoids, motors.

5. Use of fiber optics for read-out.

6. Scan conversion for 2-dot system.

7. Back face photography through CRT ports and mirrors.

Regardless of the technical feasibility of each of these proposals, the work effort proposed is a major one, for it involves:

1. The design of at least six new instruments to comprise a new product line family.

2. A major mechanical effort.

3. A major effort to coordinate industrial, electrical, and mechanical design.

4. A development of many and major new technologies, including fiber optics, programmability, camera optics, and scan conversion.

A key question is how the Tektronix organization will react to this memo from the President/founder/co-owner.

Part 3: "Oh, My God"

On February 20, 1964, Howard Vollum presented the key managers of Tektronix with a specific proposal for a new line of general purpose oscilloscopes. What happened next is clearly remembered by the engineers present at that time: nothing much happened at all.

Then, as Wim Velsink remembers, "one day in 1965 Howard Vollum said to John Kobbe (head of the Advanced Circuitry Group), "do it, today". And then John Kobbe went to Wim and said, "do it, today". And so we finally got started."

The first task was to establish the basic architecture. Critical issues during this period included the number of plug-ins, the height of the plug-ins, and various technical approaches for readout, two-dot automatic measurement capability, an internal camera that would spit a picture out the front, the interface specifications, the power requirements of the plug-ins, and the circuit logic needed to orchestrate the functioning of the various plug-ins. Key tasks were trying to build the first TEK-made ICs, designing a new CRT, developing new interface connections, designing new cam switches, color coding the front panel, developing readout ICs, working out a camera arrangement, and developing probes. As it turned out just one of the architecture decisions, the power supply voltage decision, got started in September 1965, involved virtually every engineer in the company, and was not settled until March 1967.

The implementation effort had just started when Hewlett-Packard's 180 series was announced. Suddenly, the situation became one of crisis, for the H-P oscilloscopes were superior to the 500 series instruments. In the words of Win Velink, "we realized clearly then that our ass was in a sling . . . we had had a 'king of the mountain' attitude because of the 547, but all of a sudden it was, 'Oh, my God.'"

From then on developing the 7000 series was an intense project requiring an all out effort from virtually all areas at TEK. During this period, Howard personally pushed the various groups hard. The top talent of the company was gathered into a "riotous but stimulating" group. The engineers involved were innovative and probably close to their peaks of ability. At night, the parking lot would be filled to about 10 to 20 percent of the daytime level. On Saturdays, the engineers would come in, and a familiar sight was Howard in his blue jeans picking components from supply bins.

But Howard then threw another challenge to his group: plug-in height. Work up through late 1966 had assumed a seven inch plug-in height which would provide room for the needed components using readily available and proven parts. But the H-P scopes were smaller in size and quite attractive in appearance. So, one day, Howard said, "the plug-ins will be 5¼ inches in height."

Oliver Dalton recalls the decision to reduce the plug-in height as a traumatic one:

"The decision set us back at least one year. . . . .for the height decision required three major electro-mechanical component efforts in addition to the IC read-out effort: 1) new lit push-buttons. . .we needed 25 on a panel; 2) cam switches-these were Howard's ideas. . .we needed them to be small and reasonably cheap; 3) relays. . .we needed them to be small and reliable. . .We then largely had to make do with other available parts, like potentiometers.

Today, over ten years later, it is difficult to piece together how everything got done. For example, the components effort proceeded in parallel with the instrument design effort even though the instrument design obviously depended on the components.

Going back to Howard's 1964 proposal, here is basically what happened:

1. Performance: Using transistors, the performance goals were easily met. . . . .but, as it happened, the transistors allowed a broader bandwidth than proposed, but in the press of events the additional performance potential was not pursued.

2. 560 Plug-ins: The power requirements of tubes proved to be so basically different frm transistors that after much effort the goal of making the 560 plug-ins compatible with the 7000 series series mainframes was abandoned.

3. Split-screen Storage: Split-screen storage was accomplished but abandoned after the product was on the market because the tube and its sur-

rounding circuitry were so complex that the instrument was unreliable and hard to service; also, the main thrust of the storage idea was to handle higher speeds, but the bi-stable storage tube was not fast enough.

4. Powered and Remote Operation of sweep speeds, vertical sensitivities, beam positions, trigger polarities, and trigger levels:

To accomplish this small, cheap, reliable switches were needed. As Oliver Dalton recalls, "the problem was that there were no components available that could do the job. The switches, buttons, and relays available were either too large or too expensive, so to perform powered and remote operations we would have had to develop our own components. We did have two or three project teams work on this and Howard Vollum had many ideas. We ended up with a standard relay that we still use although they are not cheap or reliable. (We still operate some front panel-switches through these relays, as on the 7A13.) To really do remote operation we would have needed small motors to turn the switches. But these motors required too much power. . .they really took a jolt of current. And space considerations were a related problem, especially when it was decided to reduce the size of the plug-ins."

5. Easily Turned Knobs: Easily turned knobs were developed after a major electro-mechanical effort.

6. Programmability: Microprocessors were not developed until the early 1970's, and programmability just could not easily be accomplished given the technology available in the 1967-69 time period.

7. Projected Graticule: Howard's memo suggested an "easily changed graticule projected on the CRT phosphor." This was to be done by projecting a

film image through a side port on the CRT onto a mirror mounted inside and then onto the CRT screen. Two principle problems were encountered:

next page should follow directly

1) it was hard to get enough light to project thin, bright lines. . .it would take perhaps a 250 watt bulb using 35mm slides, which was a lot of heat to dissipate, and 2) the mirror inside had to shine through all the gun apparatus. Also, the related electro-mechanical components were too expensive and unreliable. However, something similar was used on a TV vectorscope prototype.

8. Read-out: Howard's memo suggested a read-out that would include the following: sweep time cm., sweep uncalibrated signal, sweep magnification, vertical sensitivity, vertical sensitivity uncalibrated signal and polarity. All of these goals were achieved, although there were many false starts. As Oliver Dalton remembers:

1. We first tried a wheel run by a motor and switch. The wheel had a negative image of the numbers we wanted to display, and a light would shine to project the image onto fiber optic strands which would carry the image to the front panel.

2. Another approach was to use gas discharge tubes, but a major problem was that we could not get a good life. Sperry and Owens-Illinois are starting to use them for displays.

3. We also tried using little motors to drive tapes with numbers on them.

4. Finally Barrie Gilbert came up with a readout IC and we all breathed a sigh of relief. It was a medium scale integration IC and was years before its time.

9. <u>Two-dot</u>:

*The memo also suggested digital readout of time and amplitude and time and amplitude difference between any two selected points on a stored trace (a two-dot system). As Oliver remembers:

"We had two, high-level people work on this part-time for perhaps three years. We couldn't solve the basic problems, so we couldn't involve more people on the project. In those days memory was much too expensive, so we couldn't just digitize the signal and then make the required measurements on the memorized waveform. Even if this were feasible, the small computer needed would have been far too expensive for a general purpose instrument. Now we would just use a microprocessor and some cheap IC storage."

"So the two-dot system failed for technical reasons. It would have made the instrument too complicated and expensive and at even moderate speeds it was hard to make sure the dot stayed on the trace and didn't hover just off the trace (we had problems at only 30 MHz). At higher speeds the accuracy was much less than visual estimates with reference to the graticule. Wim was the overall manager and asked me to decide. I said we should drop the effort. But the exploratory effort may have been worth it and I often pull out my old notes for reference as it now becomes possible to do something similar.

"John Horn did work on a system that would get the electrical information from the trace by 'worming' the signal back through a 'hole' on the left side of the screen. The signal generator output required to put the trace through the 'hole' or gap would then be the signal you wanted. The correcting signal was to be displayed on a paper/pen recorder. There were some problems with this method too: voltages of 20 KV were present; it was hard to get precise registration between the screen graticule and the recorder graticule; and an unknown was how to handle multiple traces and readout. In the end it was felt that the system was too complicated and so much accuracy was lost that the customer might not like it.

10. Cameras

"Morris Merrick did come up with a processing camera that would do the job, but there were a lot of problems: it was expensive, there were nasty, wet chemicals (Xerox circuitry would have taken up too much space), and the system was unreliable." In the end a Polaroid camera shooting from a mount on the front of the scope was adapted and used.

11. Plug-ins

Oliver Dalton also recalls the outcome of the plug-in proposal (the memo suggested using the 560 plug-ins as a model for size and shape).

Number of Plug-ins

"It was Wim's idea to use "up to" four plug-ins and somewhere along the line it became assumed that there would be four holes. The reasoning was that most people wanted dual trace, but it was a good idea to use two kinds of amplifiers, one for each trace. Then it was felt that maybe there should be two horizontal time-base plug-ins so that the oscilloscope could be used normally or a second plug-in could be added for a delaying sweep. We had originally thought we would sell mostly single trace, amplifier plug-ins, but we had made a dual trace plug-in so four traces could be displayed if desired. What happened is that people mostly bought the dual trace plug-in and used the extra hole for other purposes. Now the dual trace plug-in outsells the single trace by ten to one. The extra hole is, for example, used for the logic analyzer (which takes two holes) or for sampling (the extra hole allows using the oscilloscope both for real time and for sampling simultaneously.)

Configuration of plug-ins

"There were many discussions on configurations, and the final decision was made in a committee. Kobbe proposed square plug-ins, although nobody else seemed to like it. Howard seemed to like horizontal, "wide" plug-ins stacked one above the other. Wide plug-ins might have been a good way to go, because they made it easy to associate a trace with a plug-in. But they were bad for cooling and would have required fans. The "tall" configuration made cooling and connections somewhat easier, so after the decision to have four plug-ins was made, the arguments went on for awhile and then vertical plug-ins were decided upon. There were problems in getting the dual time base into one hole, and in fact it's still a problem.

Height of plug-ins

"Plug-in height was the most traumatic decision. H-P's 180 series plug-ins had a height of 5¼". . . . .(so Tek had to match that height)".

At the WESCON show in mid 1969 Tektronix announced the 7000 series. Oliver Dalton recalls what happened.

*"As a result of the one year delay due to redesign of mechanical components, when the 7000 Series came out it was too expensive and the performance was out-of-date. . .we had had no time to make a new CRT and develop better performance. At the WESCON in 1969 we announced the 7504 with a bandwidth of 75 MHz and the 7704 with a bandwidth of 150 MHz. The 83 had just previously announced a bandwidth of 250 MHz with a new mainframe and new plug-ins. We had known H-P was coming along with something better, but we had to just go ahead and finish what we had. We then had a crash program to improve performance and lower cost. Val Garuts, Thor Hallen, and Dave Hannaford worked on higher speed; Val got the project started then Bill Peek managed it after DC. We announced the product, the 7904 with a bandwidth of 500 MHz, about nine months before delivery. The 7904 now in production is virtually the same instrument they developed then. Phil Crosby worked on a cheaper instrument, the 7403 N, the N meaning "no read-out." A later effort was high-speed storage.

The 7603 which had a bandwidth of 100 MHz and the 7613 (variable persistence storage) instruments were brought out simultaneously with the 7623. The 7003 replaced the 7403N. Many years previously (1964?) Tom Hutchins had demonstrated storage of an 100 MHz sinewave on a MgO "fuzz" target. However, it faded very rapidly. Someone then came up with the idea of transfer storage which made it practical to use the fuzz target and transfer the "image" rapidly from it to a slower, more stable, storage target. Chris Curtin's group developed the first transfer tube which was used in the 7623.

"The rest of the story is one of filling out the line and developing the product over the years.

As it happened the H-P 180 series did not destroy Tektronix. Jim Walcutt attributes Tek's survival during this period to Tek's Field Engineers. . . "H-P's salesmen just didn't know how to sell oscilloscopes effectively. . . they couldn't, for example, counter customer objections. There seems to be something special about oscilloscopes. . . . ."

Other observers credit a general economic down-turn in 1970-1971 as freezing the market share positions. (Certainly the down-turn did have the effect of shaking out numerous smaller competitors.)

Today, in the words of Wim Velsink:

"Today, the 7000 series is in a strong position. It includes a full line with 9½ orders of magnitude spread in voltages and 12½ orders of magnitude in speed. It can measure in time, frequency, and logic domains. In terms of sheer capability, there is "nothing like it. . .the 7000 series can measure virtually anything."

Reflecting on the 7000 series development, Wim Velsink also said:

> "the technical leadership role of Howard was critical. We would not have been so motivated if he had not understood the degree the company was exposed by the technical advantages of H-P.

And, after the intense, epoch-making effort, in 1969 the Tektronix Annual Report noted in a diffident manner:

> "We don't vary much from year to year, presenting rather a continuum. Its ingredients are technical innovativeness; youthful and assertive management (the average age of our vice-presidents is 43); heavy investment in research; and, we are sure, the finest employees."

Or, as with the closing lines of the movie Grand Hotel:

> "People come, and people go. Nothing much ever happens here."

APPENDIX A: THE RECOLLECTIONS OF BARRIE GILBERT REGARDING THE READ-OUT EFFORT AND THE 7000 SERIES IN GENERAL

NOTES FROM INTERVIEW WITH BARRIE GILBERT

November 30, 1977

The Read-Out Effort

*Barrie Gilbert joined Tek in 1964. He had previously been working on sampling oscilloscopes in Britain. After only two months of working for Al Zimmerman on sampling scopes, he joined the "New Generation Group" under Wim Velsink.

*A critical issue at the time was a readout system for the New Generation. Fiber optic, mechanical and simple electrical systems were being proposed, but there were problems with each of these approaches. Barrie was convinced from the beginning that the readout should be done electronically, although the cost of prevalent character generators was estimated at about $1,000. Some of the many advantages of electronics readout included the potential for virtually any message content and a same-plane display, which would make it easier to take a picture of the information.

*It was clear from the first that custom ICs were needed to meet most objectives; and, anyway, general purpose ICs were not available. Barrie also decided that the coding should be in the form of analog current levels, which would greatly simplify the plug-in coding circuits. Barrie also adopted several other ground rules: the code organization should be optimized for the major plug-in applications and yet every plug-in should have the potential of being used with a mainframe with the readout; there should be built-in accounting for probe multiplication factors; all alphabetic characters, numerals, mathematical symbols, and some Greek characters should be available; there should be two ten-character words available per plug-in; there should be no restrictions on the message content; a set of preprogrammed instructions to the readout system should be included; future expansion of the coding matrix should be possible; etc., etc.

*One of the concepts that Barrie felt strongly about was "superintegration." Most electronic circuits are built up by inter-connecting discrete elements. The conventional approach to IC design is to continue this approach, except put them on a chip. Barrie felt it desirable to try to achieve the desired electrical functions by merging elements and by relying upon the electrical functions by merging elements and by relying upon the electrical interplay that occurred between the elements themselves (a "juxtaposition of diffusions"). The result of the superintegration approach is a "sort of glob" that does not make sense in any schematic terms. Although to this day superintegration is still an esoteric approach not much used, Barrie's thoughts about superintegration are credited with inspiring IBM's Berger and Weidmann (who developed I^2L) and Barrie used superintegration extensively in the final design of the readout system.

*Barrie's first design generated the analog input signal spatially on the chip itself. This approach took advantage of the two-dimensional nature of an IC chip and drew the characters as a series of vector strokes. Barrie checked out this approach on a 'boot-legged mockup'. . .a prototype fashioned with teledeltos paper and dime store earrings (a prototype made from ICs would have been very expensive). Although the mock-up worked, in practice it would have required fashioning a separate IC chip for each character desired. Also, in Barrie's words, "it was a misapplication of the superintegration concept."

*Since Barrie wanted to put at least ten characters on each chip, he abandoned the two-dimensional replica approach. Each character was conceived of as consisting of eight points with seven vector strokes connecting the points. Barrie then represented the points with an "x," "y," positional scheme which was scanned by a dee-shaped region. There was still a snag with this approach. . .it required separate emitter masks for each set of ten characters, which was undesirable from the point of view of low-cost manufacture.

*Barrie's third design required only one mask to program. It was an "analog read-only memory" which could deliver two waveforms, one for the "x" coordinate, one for the "y." The majority of the circuits involved were designed by Barrie Gilbert with Les Larson also supplying some crucial contributions.

*The read-out effort had been started in mid-1965, and a prototype version that could simulate the performance desired was completed by about September, 1967.

*Barrie Gilbert has recently returned to Tek after a six and one-half year absence, working for Plessey and Analog Devices in Britain. On reflecting of the differences between Tek and Plessey and between Tek and other firms in general, Barrie remarked on two differences that seemed important: 1) at Tek, you were assumed to be able to do things until you failed whereas at Plessey (and in Britain, generally) you were assumed incapable until you proved yourself, and 2) all materials to do a job were readily available at Tek, many on an open-shelf, at Tek, it was assumed that you would make good use of the material. . . .if you used them for a hobby project, then that at least improved your technical ability; in Britain, everything had to be ordered, and you had to go to a stock man who would go get things for you; the Tek System is "invigorating" and gives you a feeling that the company is ready to support you; the Tek System also reduces schedule shippage and helps engineers evaluate instrument cost. (Unfortunately, many of these erstwhile advantages under Item 2 are less tangible, as cost accounting procedures in engineering development tighten their self-defeating grip.)

NOTES FROM SECOND INTERVIEW WITH BARRIE GILBERT - JANUARY 17, 1978

BIOGRAPHICAL NOTES

*Barrie Gilber seems always to have been interested in electronics and oscilloscopes. At age nine he became involved with a deaf friend who made his own hearing aids from tubes wired into tobacco tins. This friend helped Barrie to make a three-stage triode amp and taught him how to solder. By age 11 Barrie had made his first oscilloscope using as a display a VCR 97 (Valve Common Receiving Tube. . .six inch green phosphor. . .war surplus). Barrie also built several of his own televisions and vividly remembers watching the Coronation in 1952 on a set he had made. To Barrie this was a "golden age" for a boy learning electronics because of the availability of cheap, ex-government radar tubes and beautifully-built surplus equipment. A small hardship was the refusal of his father to have electricity installed in their home (because he had just redecorated the house throughout), so Barrie had to take his early oscilloscopes to his friend's house about a mile away to try them out. So, while Barrie's engineering experience has centered around circuits and semiconductors, he has always been interested in visual displays and oscilloscopes.

THE 7000 SERIES IN GENERAL

*Soon after Barrie had joined Tek, Lang Hedrick called and Barrie was shifted to the 7000 series. Other people on the team then were Roy Hayes, Les Larson, Bill Peek, Joe Burger, John Horn and Wim Velsink (the leader).

*The ideas for the 7000 Series seemed to come from a variety of sources. . . the 540 and 530 series had been in existence for a long time and a catalog of ideas for improvements had been built up over the years. And, Howard had a lot of ideas. It was clear that with the maturation of transistors and the age of the 500 series, "the time was right for a new line. . ."

*"There was no master architect for the 7000 series. . .no one as an individual planned the features. It was a democratic evolutionary process. There was no awareness or feeling of enforced management. We dealt with matters in a pragmatic way. All the engineers were in this together. We knew the project was important: we were piecing together the Cadillac of Oscilloscopes."

*The preferred form of communication was verbal. There was a lot of common discussions. "We were excited by the project. . .all the technical talent was assembled in Building 50 and there was no sense of diffusion. There was still a small company feeling. And, usually all the materials and components we needed for the job were readily available. . ."

*There was little emphasis then on what it ought to cost in terms of engineering effort to do this project. We knew we had to do it whatever. Today we think (necessarily) in terms of our limited resources and think in terms of costs. Now and again a project comes along that short circuits the long approval process because it is so important."

*"I had the feeling that somebody, somewhere knew what the 7000 development was costing, but guys like Kobbe and Velsink thought as engineers not managers. . .they also were not hierarchical. So I knew that I could always do

what I had to do--there was no need to write proposal documents that would then get approved. I could basically lay out a plan verbally and then do it. Documents were not written as required by a process, but rather they were written to explain with great excitement what now could be done. . ."

*"At the time we knew that not even a founder could stand in the way of a good idea. . .and Howard never would stop a good idea if it was presented to him. . . he was reasonable. I never thought of him as a barrier, even though he doubtless had veto powers. He was more visible then, interested in everything, but still he was not a barrier.

*"Most importantly, from my experience, the very best ideas were bootlegged into existence, often by working through the night."

GENERAL COMMENTS

*"The development of Integrated Circuits has altered the way we now approach instrument design, but not in any inconoclastic way. Rather ICs have opened up new possibilities. The key thought is not whether IC designs are becoming mature, it's that ICs have added a new dynamic to the profession. These days, in the course of the development of a product you never really know what will happen before you are through that will change your basic approach. Before it was easier to decide what to do--and then the struggle was in doing it. Now the struggle is to decide what to do--what will have market appeal. Almost anything is possible. . .there are fewer challenges in which purely physical constraints are the problem."

Growth at H-P is from the inside out, but we seem to need to take our cues from the outsides. . .reaction engineering vs. action engineering."

*"We do have the inclination to pursue high technology in projects where the state-of-the-art is involved. . .But these projects are usually undertaken only when its clear everybody else is going down the same road. We are not a strong research outfit. . .we do not really have a Tek Research Lab in the way H-P does. Tek Lab programs sit squarely on the shoulders of other companies' processes and inventions, in the majority of cases, and they are much more tightly coupled to short-term needs."

*"Maybe we can do more by making clever adaptations of available technologies rather than trying to pioneer new and better technologies. We might be able to cut off all advanced projects and still address our market, but that seems unlikely. Once we were out there all alone, and we were forced to do our own research into basic technologies. . .The 7000 Series was a dazzle, a broad spectrum triumph. There was nothing else on the market like it. When it came out we were good at everything from circuits and CRTs to read-outs, relays and push-buttons. Our human engineering was way ahead. But now the rest of the world has caught up and now we have fewer distinctive abilities."

*"In the 7000 Series development days, engineering was the center of Tek universe. . .the success of the entire company rested on the engineers. I sometimes feel that engineering is becoming almost a service operation. . .there to serve the entity which is 'The Company.' We are no longer primarily a superb engineering company. . .we are now a manufacturing, marketing, money-making <u>machine</u>. I am not saying that it is necessarily bad. . .it pays my

salary. But we need to be aware of these things and make our management decisions in accord with these realities. I liked it better when our slogan was "Committed to <u>Technical</u> Excellence."

APPENDIX B: RECOLLECTIONS OF BILL STRONG ON THE BACK CONNECTOR DESIGN EFFORTS

New Gen Connector Efforts

The first idea for a plug-in connector involved an intermediate connector. The circuit board edge idea was originally received with skepticism by those who thought it would not work and by those who felt that it unduly committed circuit designers to working with a circuit board spatially inmovable with the plug-in frame.

The specifications for the back connector were challenging:

- Less pull-out force--the goal was five pounds for 76 contacts at a time when the best available commercially was greater than five pounds for 30 contacts.
- Wear--the goal was 4,000 cycles at a time when the best available was 500 cycles.
- Spacing--the goal was to reduce the spacing between contacts from 156/1,000 to 100/1,000.
- Flow solderability--the contacts had to be easily soldered.

The design effort started in March 1967. The first task was to establish specifications in detail. This was difficult, and, for example, some finally had to be set arbitrarily. . . .Tony Sprando finally said, for example, that the contact force should be 20 grams.

The first design called for individual pins held in a plastic holder. This scheme worked, but it was much too hard to assemble, especially as run lengths would not justify automated insertion of the pins.

Soon Marlow Butler conceived of a carrier strip approach, and design work started along those lines. By August 1967 Bill was going step by step through the design process, looking for ideas. He would do a layout, look at it, and then try something else. He was close to final design by September 1967.

The concept of the final connector design involved the following:

- The carrier strip and pins were designed to hold themselves on the body of the connector carrier, which would aid hand assembly.

- Long, thin strips were desired in order to use a low spring rate, to minimize tolerance problems, and to reduce withdrawal force while maintaining contact force; a cantilever scheme was out, because of tolerance problems, contact force problems, and deformation problems; the final scheme was to use a snap-on cover to pre-load the contact against the body. The cover also protected the contact and positioned it.

The conceptual design and layout were, by and large, finished by September 1967.

The next steps were performing dimensional analyses, choosing materials, making dies, considering alternate assembly procedures, and working on assembly details. Tolerances were a particular problem. These considerations required major efforts. In July 1968 changes were made to the ramp angles for the snap on cover. In August 1968 Bill was still testing prototypes and evaluating different materials. Final design drawings were not prepared and released until September 1968.

A particular problem was the cracking of the snap-on cover due to grain structures set up during molding. The final resolution required locating two gates at just the right position in the die. . . .no other location or number of gates would work.

In October 1969 design efforts were still going on in terms of re-evaluting screws and dielectric constants of the plastics. In 1976 there was a switch from overall gold plating to a gold inlay. In Bills words, "the fine tuning never ends. . . .old projects never die, they just hand around the designer's neck. . ."

APPENDIX C: RECOLLECTIONS OF TONY SPRANDO ON THE RELAY AND SWITCH DESIGN EFFORTS

The Sprando Relay

Bill Walker approached Tony Sprando in spring 1966 and hired him because of an urgent need for new switches and relays for the 7000 series. When Tony joined Tek two other groups were working on relay concepts, one group focusing on pizo- electric approaches and the other focusing on an air-driven relay (apparently Howard Vollum was interested in developing a fluidic scope). Tony with the help of a draftsman (Dick Sollors) were to develop the electro-mechanical possibilities.

The specifications for the new relay were developed by Oliver Dalton and others and were for a "remotely operated switch with two contacts and extremely low power consumption." The first step was to engineer the design: lay-out a contact system, then develop a motor circuit, then tailor the design to the envelope specified. The next step was to determine the materials to be used. Then the effort turned to how to plate the materials and what manufacturing processes to be used. All of this was essentially a one-man effort. Tony found it hard to describe this process. . . . ."it was based upon a lifetime experience, not upon a particular breakthrough. . . . .Howard would come by and ask some questions to make sure I knew what I was doing. . ."

Problems developed when the relay was passed over to manufacturing. "They would try to redesign the relay or substitute materials without understanding the engineering concepts involved. For example they decided on their own to use a plastic pivot. The problem was they didn't tell us they were going to do this, so there were problems with the relays, of course. Other times they decided not to thermal cycle to our specifications, or keep the parts clean enough, or relax quality control. . . . .I was responsible for the product, but didn't have the authority I needed. . . . .so there were lots of meetings, a lot of time spent trying to influence the process."

The Cam Switches

The next major effort that Tony was involved in was the development of cam switches. At the time the Switch Department had developed expertise in the acquisition of commercial switches and had not attempted to do original designs. Then Howard Vollum made the decision that Tek would develop its own switches, and Tony, Bill Verhoof, and Howard jointly developed the cam switch. The design ideas emerged from a "a lot of way-out brainstroming. . ."Howard played a key role by taking an "unlimited funds, the sky's the limit" attitude, while the other members would bring the ideas back to reality.

Once the concepts were established, the manufacturing problems began. The prototypes had been made on numerically controlled machines, and the proposal was now to cast key pieces in plastic. But the Plastics Group said it could not be done. Finally, Tony came up with a four piece die design that would do the job (previous approaches to die design had assumed there would be only two pieces). The four piece die was the critical breakthrough which then made production possible at a reasonable cost.

There were then the usual difficulties in establishing tolerances, materials, fixtures, and so on. The skill involved in making a device producable cannot be over-emphasized, for it is a key element in the mechanical design process.

Tony remembers that "there was a lot of manufacturing resistance; they kept insisting at every meeting we held that they couldn't make this switch. It was tough going. And they would keep changing the specs on their own, which would make the final product unusable."

The Push-Button Switches

Howard Vollum was the person who started the push-button effort because he wanted small buttons. Some of the key inputs on the design came from the Model Shop, such as from John Winkelman who came up with a latch mechanism.

General Comments

"Tek would give you rope, but you had to be sure you knew how to use it."

COMMENTS ON PART 3 OF TEKTRONIX: THE 7000 SERIES STORY

The 7000 Series Story illustrates a number of principles regarding technological innovation, as well as illustrating some vital principles of management.

Let's focus in this analysis on the impact of a single innovation, the transistor, on the oscilloscope. Perhaps the best way to get perspective on the decisions taken is to consider first how the transistor affected two other products: portable radios and televisions.

The analysis which follows owes much to the work of George R. White, Corporate Vice President, Xerox Corporation.

Transistors first showed up in radios in the U.S. in 1956 or so. In 1955 the U.S. market for portables was two million sets (each weighing about six pounds). All of these portables contained tubes and all were made in the U.S. By 1956 eight models of portable transistor radios were on the market, all U.S. made. By 1959 there were 25 models of U.S. made portable transistor radios on the market. But by 1962 the Japanese had captured 58 percent of the portable radio market in the U.S., <u>without</u> making any advances in the key component, transistors. Why? Production efficiencies? Not particularly, and certainly not during the entry years. So why?

The Japanese penetrated the portable radio market by recognizing that the U.S. manufacturers had done little more than substitute transistors for tubes. So the Japanese entered <u>not</u> by innovating in transistors, but by methodically down-sizing all the other components to take advantage of the potential of the transistors. . . . .the Japanese developed smaller loudspeakers, tuning capacitors, batteries, and antennas. The result was a 10 oz. radio as compared to the U.S. 20 oz. radio.

This analogy applies directly to the now famous 7000 Series decision to down-size all components, including switches, relays, push-buttons, power supplies, plug-ins, and so on.

But as soon as this point is made, we must next try to understand the flip side of the questions. . . . .why has the 7000 Series managed to go on so long in essentially the same form through the decade of the 1970's relatively immune to further technological breakthroughs? Certainly the rest of the electronics industry has been completely made over during this period. So, why the calm around the 7000 series?

To answer that question let's look at the impact of transistors on the television.

The first transistorized television did not appear on the market until 1968. Transistorized televisions did not become common until 1974, <u>almost two decades after transistor radios became common</u>. Why?

The essential fact about televisions is the display, the cathode-ray tube. Even after decades of research no viable, cheap, solid-state replacement for the CRT is in view. So, for televisions, transistors did not provide an opportunity for a major advancement in useability, design, effectiveness, or reliability, because of the limitation of the CRT. So, the introduction of the transistor in televisions meant only some small increase in reliability, hardly noticeable to the consumer.

The 7000 Series of oscilloscopes represent a case somewhere between the radio and the television. The essential question in evaluating a potential new technology is whether it offers to the consumer a visible increase in product effectiveness, regardless of other criteria such as the profoundity of the innovation involved.

Now we are ready to move on to the basic question of this case: what are the ways in which a large firm such as Tek could be hurt?

Basically there are three ways Tek could be hurt:

1. By a head-on attack.

    The H-P 180 series was H-P's third generation of oscilloscopes. A "threat" is something that you don't see coming or that you can't do something about. Tek should have seen this one coming, and it certainly could do a lot about this threat once it arrived. But it is unlikely that any competitor is going to take Tek head-on and win, although it is true that some firms, such as Philips and Gould, have recently found holes in the Tek line of low-cost oscilloscopes, Tek can and is responding to this sort of threat, for the most basic fact is that Tek has the resources to respond to a head-on attack, and it also has in place an effective organizational means for identifying this sort of threat and responding to it.

2. By a technogical break-through.

It can be argued that IDG has in recent times misjudged the moment when refresh displays became more effective than bi-stable displays. But, again, no matter how much engineers love to second-guess the every move of Tek labs, the basic fact is that Tek has in place in organizational means for identifying technological threats and responding to them. In fact, the present head of Tek Labs was a critical leader in developing the 7000 Series, and we can well suppose that he learned from the experience.

Another consideration is that the first use of a new technology is usually a non-optimum application, which would give Tek a chance to recover. A final consideration is that Tek has a very broad line and a particular technological break-through is not likely to hurt the whole line.

3. If the way customers make measurements change.

The 7000 Series of oscilloscopes is magnificent, but the way measurements are being made may change. For example, as the core of instruments become more similar due to the impact of microprocessors, the importance of other factors rise, particulary: high-speed signal acquisition and storage (with analysis proceding at a slower rate because of the inherent slowness of microprocessors,) and the man-machine interface. In this context, such developments as IBM's device coupler and Series 1 compatability with instrument links and Exxon Enterprises' rumored focus on signal acquisition devices become faintly ominous, although still distant, signs of the times. Whatever the meaning of these events, Tek may have in place no particular organizational method for channeling this sort of information back to product designers (the sales force was the traditional source of such information).

In a word, what are the morals of the 7000 story? There are many, but here are five:

1. Pay most attetion to guarding your core business.

2. Watch your competitors.

3. Consider, in your response, more than just the specific new technology that may have precipitated the threat. . . . .consider also whether a redesign of surrounding components may also be called for.

4. Beyond a certain time in the life of a project, a fairly clear management chain is required. In the 7000 series case the development effort was split between Wim Velsink (who directed the 7504 effort, which was the "low-cost" effort, the 7514, which was the split-screen storage effort, and the two-dot effort) and Oliver Dalton (who directed the 7704 effort,

which was the "high-performance" product). But Wim reported to John Kobbe, and Oliver reported to Lang Hedrick. . . . .which violated all principles of management. There was a heavy demand on the good-will and willingness to cooperate of the key, managers of the middle levels. This need for cooperation was heightened when later much or most of the plug-in effort was transferred to Oliver.

Note also how few of Howard Vollum's early suggestions were actually adopted (most were too far out or too expensive). A firm chain of command _might_ have made it easier to freeze the product earlier and get the product to market.

5. A key decision was to develop a complete line. In retrospect it may have been better to come out with a partial line. . . . .although the 454 which came out in the mid-1960's and was oriented at the lab market may have served the purpose of getting _something_ out. In any case, a complete second wave of engineering and product development had to take place anyway. (The 7504 had to be replaced by the lower cost 7403, and the 7704 had to be supplemented with the higher performance 7904). In general, whenever a development project extends over a long period (the first wave of 7000 instruments took over four years to develop) the market and technology change significantly while work is proceeding; but if the development effort is continuous with no products thrown out for trial, the danger of becoming locked-in to out-moded concepts increases enormously.

To these morals could be added many others, of course. Some of these others, such as watching your customers closely, will be brought out in related case studies.

Why was Tek so successful? Here are some of the many reasons:

1. The enginering effort was superb in every way and in every area; all members of the engineering team rose to the occasion.

2. Howard Vollum: in preparing this case engineers responsible for widely varying parts of the final product were interviewed. . . . . the switch people, the back-connector person, the people responsible for the cameras, the read-outs, the circuits, the industrial design. Without exception these able engineers remember Howard personally and vividly. . . . .Howard was there giving encouragement, Howard was there with the breakthrough idea, Howard shook up the management structure when that needed to occur, Howard made it happen. But also important was Howard's apparent willingness to back down when his engineers finally had to stand up to him an say, in effect, "hey, some of these ideas don't make sense and in any case we have to get this product to market."

3. The other areas of the company were in fine shape: there were adequate financial resources because of decades of plowing the earnings back into the business; the employees were eager to contribute due to decades of fair treatment; the manufacturing areas were well run, the Company was geographically centralized which facilitated the cooperation of all areas

of the endeavor, the decision making style was well-suited to the situation, and so on.

INDUSTRY OVERVIEWS: SIGNAL AND DATA PROCESSING INDUSTRIES

INTRODUCTION

The exhibits and text of this section provide an overview of the semiconductor, minicomputer, computer, general purpose test equipment, and telecommunication test equipment industries. These industries are all driven by a semiconductor performance/cost push. The products of these industries have certain functional elements in common: They acquire data, process data, display data, and operate under instructions.

The various individual industries separate into three general categories: instruments, semiconductors, electronic data processing. Semiconductors are key components that are central to both the EDP and instrument industries. The instrument industries produce products that help other manufacturing industries in design, manufacturing, test, and service tasks. The EDP industries produce products to help end-users process data.

To provide an overview several exhibits have been prepared. Exhibit 1 lists and defines the principal industries involved in signal and data processing. Exhibit 2 discusses the relationships among selected industries. Exhibit 3 provides a competitive overview of these industries.

With respect to Exhibit 3, it may be useful first to look at the column labeled "semiconductors". Industries to the right are data processing industries selling to end users, and industries to the left are instrument industries selling to other manufacturers. The further each industry column is from the semiconductor column, the lesser the dependence on strictly semiconductor expertise and the greater the relative importance of understanding the complex and diverse needs of relevant customer groups. Such is the pace, technologies, and human talent requirements of the various industries, that in general it is relatively easier for a firm to move from the center outward than from the outside in. This is not a usual pattern, incidentally, as in non-electronics industries most firms find forward integration very difficult.

Exhibit 3 will provide a reference point for the following sections. In general, it should be remembered that the most important historical trend at present is the crumbling of the barriers between these various industries. Perhaps in a few years similar overview charts will have labels not based on product descriptors but upon customer descriptors. An increasingly customer orientation will perhaps be caused by the general purpose nature of VLSI devices which make it easily possible to dedicate products through use of software to the needs of each specific set of customers.

SPECIAL COMMENTS ORIENTED TOWARDS THIS MOMENT IN TIME

CURRENT COMPETITIVE SITUATION

HEWLETT-PACKARD: Has both the EDP and Instrument industries in turmoil with a distributed processing network approach to both.

GOULD, PHILIPS: these "newcomers" (actually Philips has been in the test and measurement business since 1896) see technology turmoil, industry fragmentation, price politeness, complacent leaders, and some good chances to make money.

INTEL, T.I.: these aggressive determined companies are pushing both into instruments and EDP, determined to diversify and become major world forces.

IBM, DEC: the powerful EDP firms, typified by IBM and DEC, are sweeping back and forth looking for every possible market segment and route for expansion. Their technology, marketing savy, and size are unparalleled in human history.

AT & T/WESTERN ELECTRIC: there is no longer any important differences between the computer and communications equipment industries, and these two interrelated, huge, capable, politicized companies are coming alive.

DISTRIBUTION ISSUES

If one blurs one's eyes while looking at Exhibit 3, it may occur that something new is occurring in terms of product groupings: a lot of products, particularly in the instrument and small scale EDP areas, are coming up in complexity and down in cost. These new clumpings of products, unprecedented in power for their prices, are costing in the range of $1,000 to $4,000. Products in these price ranges just cannot go through conventional distribution channels: they are too cheap for direct selling, and they are too complex for conventional distributors. So how are these awesome, compelling products to be sold?

The Yankee Group recently published a light-hearted look at this crucial problem. They first noted "Moore's Law" (named after Gordon Moore, President and CEO of Intel). Moore's Law notes that the number of components per semiconductor chip has doubled every year since 1959 and appears as if it will continue for the foreseeable future. This is a common observation and a profound one. Yankee then offers their own law: "The Yankee Lemming Theorem": "Any number of semiconductor manufacturers will gladly throw themselves, like Lemmings, into the sea of red ink by drastically reducing costs to gain a fractionally larger market share".

At first glance these two laws taken together seem to promise a new golden era of virtually free computers, cheap communications, and televisions as common as tubes of toothpaste. But not so.

IBM Self-Correcting typewriters cost \$965 to buy and \$100 to make. Razors cost \$0.25 to buy and \$0.0025 to make. In general, copiers, intelligent terminals, and computers have a manufacturing cost of 15 percent of sales cost. That means, if the products cost nothing to make, prices might only come down 15 percent.

Where, then are the remaining costs? It's advertising, distribution, service, selling, and overhead costs that account for 60 percent of the selling price, with 25 percent going for profit and taxes. Seen in this light, calculators were not only a revolution in technology, they were also a revolution in distribution with prices coming down so drastically because of the new channels of distribution. If calculators were sold through direct sales forces then their economics and volumes would be entirely different.

Because of the increasing performance/cost ratios of a critical component, semiconductors, small instruments and data processing devices will become ever more powerful. But it will take a rationalization of distribution to create a true revolution in these areas. Oscilloscopes through Sears? In fact, T-900's are sold in retail shops in Germany at the present time. Television ads for counters? Walk-in instrument stores similar to walk-in home computer stores?

Exhibit 1: Signal and Data Processing Industries

INDUSTRY DEFINITIONS:	1977 World Market Size ($ Billions)	1977/82 CAG
1. Telecommunications Test Equipment o Centralized Test Consoles o CB/Land Mobile o Analog Line Impairment o Microwave o Digital	$1.2	11%
2. General Purpose Test Equipment o Signal Sources o Counters o Signal Analyzers o Recorders o Voltmeters o Power Supplies	$1.5	9%
3. Computer Aided Manufacturing (ATE) o Component Testers o Subsystem Testers o System Testers	$0.2	14%
4. Computer Aided Engineering (MDA/CAD) o Software Development System o Documentation Drafting System	$0.2	29%
5. Semiconductors o Discrete Devices o Memories o Microprocessors	$6.3	15%
6. Small and Dedicated EDP o Intelligent Terminals o Dedicated Microcomputers o Small Dedicated Minicomputers o Small Business Computers	$5.0	25%
7. General Purpose Minicomputers o General Purpose Microcomputers o General Purpose Minicomputers o Mainframes, peripherals, software, support	$3.5	29%
8. Computer Mainframes and Memories o Commercial and Scientific o Medium to Very Large Computers o Mainframes, Software Support, Non-Intelligent Peripherals and Add-On Memories	$13.0	11%

9.	Telecommunications Equipment (U.S. Only)	$8.5	12%
10.	Medical Instruments	$0.2	12%
11.	Analytical Instruments o Spectroscopy o Electron Microscopes o Chromatography o Analyzers	$1.3	14%
12.	Other o T.V. Test o Data Loggers o GPIB Controllers o Logic Probes	$0.2	18%

EXHIBIT 2: COMMON THREADS AMONG SELECTED

SIGNAL AND DATA PROCESSING INDUSTRIES

COMMON THREADS:

1. Driven by semiconductor performance/cost push
2. Products that:
   - o Acquire Data
   - o Process Data
   - o Display Data
   - o Operate Under Instructions

DIFFERENCES:

1. Product applications
2. Mechanical packaging
3. Users
4. Competitors

<u>INDUSTRY</u>

Telecommunications Test

General Purpose Test Equipment

Computer Aided Manufacturing (ATE)

Computer Aided Engineering (MDA/CAD)

Semiconductor

Dedicated EDP

General Purpose Minicomputers

Computer mainframes & Memories

Telecom. Equipment

Telecommunications Test Equipment is general-purpose-test equipment dedicated to specific applications in telecommunications service.

GPTE instruments can be seen as components of a AM system with a controller as a centerpiece.

CAM systems test semiconductor systems and components; CAE systems develop application systems using semiconductor systems and components.

MDA's are essential to the sale and application of microprocessors.

VLSI means a system on a chip. . .system design will shift from EDP specialists to semiconductor designers.

Larger bit structure, general purpose CPU's and larger/cheaper memories make it easier to provide flexibility (i.e., HP 250).

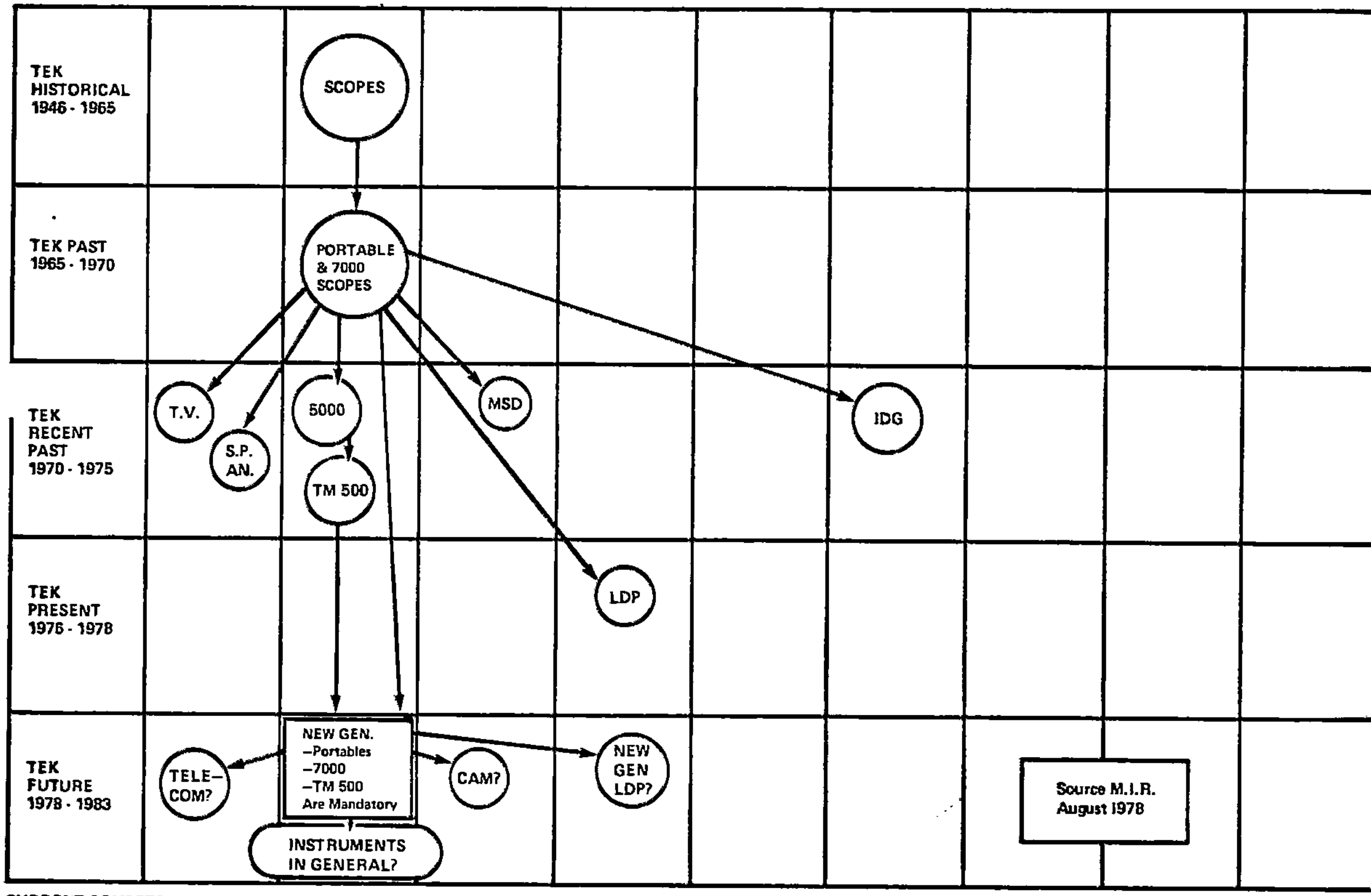
The increasing power and complexity of semiconductors and the increasing capabilities of minicomputer networks are blurring traditional computer definitions even as all categories drift upwards in performance/cost. The semiconductor companies participate in virtually all computer categories by providng add-on memories.

Large Telecom "switches" are really computers in all but name; further overlap occurs as AT&T provides point of sale terminals in Seattle trials; networks with computers as centerpieces depend upon cheap, effective communications; data communications are a subset of telecommunications.

COMPETETIVE ANALYSIS OVERVIEW

	INSTRUMENTS ← DOWNSTREAM APPLICATIONS				SEMICONDUCTOR COMPONENTS	DOWNSTREAM APPLICATIONS → EDP			
INDUSTRY	TELECOMMUNICATIONS TEST EQUIP.	GEN. PURPOSE TEST EQUIP.	COMPUTER-AIDED MFG. (ATE)	COMPUTER-AIDED ENGINEERING (MDA/CAD)	SEMICONDUCTOR	DEDICATED EDP	GEN. PURPOSE MINICOMPUTER	COMPUTER MAINFRAME	TELECOMMUNICATIONS EQUIPMENT
INDUSTRY RELATIONSHIPS	DEDICATED GPTE-LIKE INSTRUMENTS FOR COMMUNICATIONS SERVICE	GEN. PURPOSE INSTRUMENTS FOR ELECTRONIC & EDP RESEARCH, DESIGN, MFG.	INSTRUMENT SYSTEMS FOR S/C AND S/C SYSTEMS MFG.	INSTRUMENT SYSTEMS FOR S/C AND S/C SYSTEMS DESIGN	A KEY COMPONENT OF EDP & INSTR. PRODUCTS	SMALL, DEDICATED SYSTEMS ON A CHIP	MEDIUM CPU'S, MEDIUM MEMORY	LARGE CPU'S, LARGE MEMORY	DEDICATED COMPUTERS
SIZE: 1977 CAG: 1977-1982	$1.2 B 11 %	$1.5 B 9 %	$0.2 B 14 %	$0.2 B 29 %	$6.3 B 15 %	$5.0 B 25 %	$3.5 B 29 %	$13.0 B 11 %	$8.5 B 12 %

TEKTRONIX SITUATION



CURRENT COMPETETIVE SITUATION

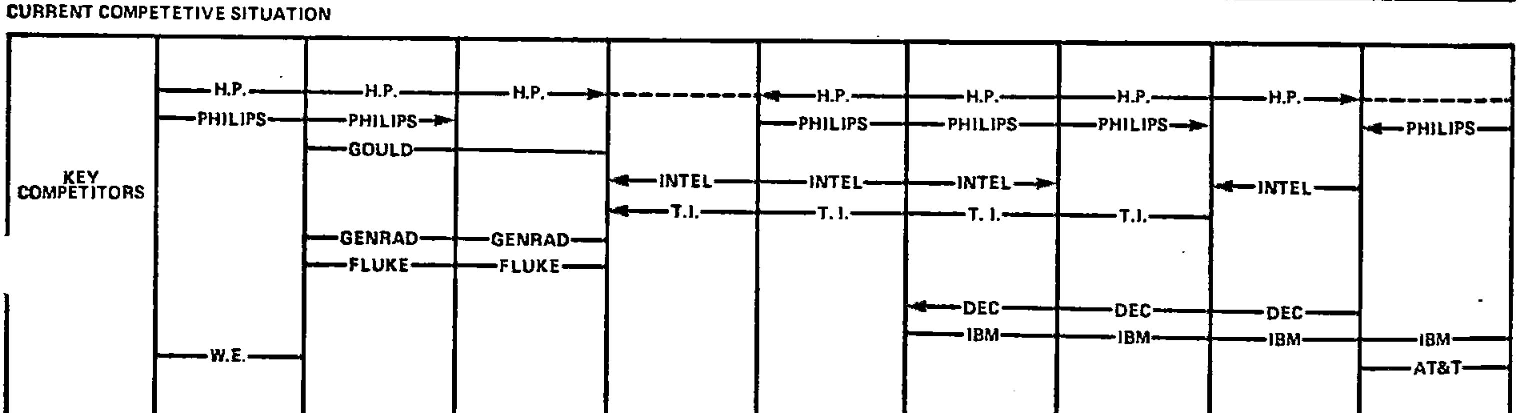


EXHIBIT 4: RELATIVE SIZES OF KEY PARTICIPANTS
SIGNAL AND DATA PROCESSING INDUSTRIES
1977 FY SALES IN BILLIONS OF DOLLARS

	1977 SALES	RELATIVE SIZES
Tektronix	$ 0.5 Billion	1.0
Hewlett-Packard	1.4	2.8
North American Philips	1.9	3.8
Philips N.V.	13.7	27.4
Fluke	0.06	0.1
Genrad	0.07	0.1
Gould	1.7	3.4
Intel	0.3	0.6
Texas Instruments	2.0	4.0
Digital Equipment Corporation	1.1	2.2
International Business Machines	18.1	36.2
Western Electric	7.0	14.0
American Telephone and Telegraph	$ 36.5	73.0

COMPUTER INDUSTRY OVERVIEW

1. Industry Structure & Basic Trends

One computer industry executive has suggested that "If we compare the automotive and computer industries over the last 30 years, we fnd that if there had been similar progress in the auto industry as there was in the computer industry in coming from the gigantic Eniac computer system (developed at the University of Pennsylvania's Moore School of Engineering in the 1940's) to the modern microcomputers, then the auto industry would today be able to offer us a Rolls-Royce for $2.50 with an EPA gas rating of 2,000,000 miles per gallon." This trend is continuing. Indeed, the driving facts of the computer industry as a whole are clear:

- Semiconductor costs are coming down.
- Semiconductor performance is steadily rising.
- Communication costs are not dropping.

These facts have led, in turn, to a number of competitive, design and marketing trends that are, increasingly changing the structure of the industry:

- Cheap semiconductor memory heightens the importance of software as larger, more complex, more specialized applications become economically possible.

- Larger microprocessors CPU's allow minicomputers to rival in power the mainframe computers of only a few years ago; some large "minicomputers" equal in power small "computers".

- The continuing drop in semiconductor costs have reduced the value of hardware in absolute terms, which forces computer companies to look towards new applications.

- The major area of growth is data handling, not scientific data processing.

- Unchanging communications costs are making central, large computers fed by remote terminals less attractive than distributed processing networks.

- Semiconductor expertise is widely available so even small companies can produce plug-compatible products.

- U.S. firms are being increasingly vigorously challenged by German and Japanese competitors.

These trends are occurring in a very concentrated industry: IBM's revenues approached 50 percent and the top seven firms accounted for 78.5 percent of total U.S. computer industry revenues in 1977. IBM's domination of the computer industry means that IBM's response to the above factors will inevitably shape the industry.

2. IBM's Response

As benefits its massive size, IBM has responded in a multitude of ways to these trends. (For a more complete treatment of IBM see the separate article in Vol. I.) IBM is increasingly:

- o Looking to The Office for growth by tying together data processing and communications with products ranging from typewriters to PBX's. This heightens the importance of two areas of IBM strength: (1) specialized terminals, and (2) the ability to tie diverse elements together into a system.

- o Looking to The Decentralized Work Station for growth (the lab, shop, store, bank. . . . .i.e., distributed data entry and distributed data processing). Connected with this effort, IBM has attempted to (1) make it difficult for non-IBM terminals to tie into an IBM system, (2) use "building blocks" to achieve manufacturing economies of scale, and (3) provide upward "migration" paths for its customers.

- o Emphasizing software (one-half of R&D budget) and selling complete solutions. Prices have been unbundled.

- o Redesigning key computer elements in order to better protect the software (by putting the software into microcode).

- Looking for ways to cut communications costs.

- Pressing forward in marketing practices.

- Developing denser VLSI for the long-term.

- Contracting with Intel for 303X memories in order to bring down the backlog (over three years, which is dangerous and tempts Seimens/ Fujitsu).

These strategies will have the effect of dictating the nature of the changes yet to come in the industry, for, as was implied above, IBM and the computer industry as a whole tend to move in lock step together. Not all goes IBM's way, however. In addition to a governmental anti-trust lawsuit that has been in process since 1969, IBM faces vigorous competition from a host of competitors that is at least, occasionally painful, if not truly dangerous.

3. Competitor Strategies

IBM's competitors try either to emulate IBM's strategies or to specialize in specific segments of the computer marketplace.

Burroughs has always had a very loyal base of users, and a computing system that set it apart from the other suppliers. During the past year it has been announcing many new generation computers and just in April 1978, brought out the latest versions of its 6800 series, complete with the most sophisticated memory electronics being used at the time. More than 20 percent of its business is with banks, almost as much is with computer service bureaus, and an additional 10 percent is represented by state and local government installations.

Control Data got its start with supercomputers and still concentrates its EDP business on very large, scientifically oriented accounts. Some 70 percent of its computer base is installed at educational or federal government sites, or with service bureaus. Many of these are its own. Between its Cybernet operations and the Service Bureau Co. operations it received from IBM in settlement of a lawsuit from the late 1960's, CDC does more than $300 million in computer service business. It is also a major factor in peripherals, both selling to the IBM marketplace and operating joint ventures with NCR and Honeywell. And CDC has begun to produce a computer for competition in the IBM-compatible marketplace.

Honeywell from its origins has tried to compete with IBM on a broad basis. So when it acquired the General Electric computer business in 1970, it began to use the GE 600/6000 architecture as an approach to larger computer systems. An outgrowth of this--the Level 66 and 68 Distributed Processing Systems--forms the basis for Honeywell's current competition with IBM's new 303X line. Honeywell is no longer in control of the French computer operation it acquired along with the GE base, and during the last year has been positioning itself for the 1980's. It recently acquired Incoterm so that it could satisfy specific demands for application-oriented terminals such as those required in banking, finance, manufacturing, and airline reservation systems. It has reoriented its marketing thrust to focus on distributed systems and small stand-alone business uses.

NCR in many ways has been forced to develop computers to support its more traditional lines of business--and during the last few years has been applying its computer technology to terminals such as cash registers and bank teller stations. One-third of NCR's computer business is concentrated in wholesale, retail, and banking. The company has developed specialized hardware/software packages for applications such as hotel reservations and medical services. And because of its customer base, it is bringing computer power to smaller companies in the distribution industries. As a result, its total computer-related revenues for 1977 were almost $2 billion, second only to IBM's.

Sperry Univac traditionally has emphasized larger mainframes and government business. . .and its installed base reflects this. About 30 percent of its computers are in various government installations. Otherwise, its customers are distributed across the board in fairly normal fashion. Having absorbed the RCA computer base it picked up in the early 1970's, Univac recently has made some moves directed toward broadening its computer activities. With the purchase of a disk drive manufacturer in the mid-1970's, Univac got an entry into the IBM plug-compatible peripheral market as well as a source of disk drives for its own computers. Last year it bought Varian and about $35 million worth of minicomputer business, and launched its BC-7 computer for small business. In the general purpose area, Univac has introduced several models of its 1100 series computer and competes with IBM at most levels, offering more performance at equivalent prices.

In general, the major growth of all these "other" mainframers is from within their own bases--growing with the customer--and from new users. The competitive "wins" from IBM are more or less balanced by losses. The most significant competition among the mainframers comes at the entry level for new users and when sophisticated computer users go out for bids and benchmark tests on new applications they plan to implement. If some degree of standardization comes to the computer industry, this sort of business could increase in volume.

There will be additional pressure on these "other" companies. Over the next few years, a growing number of new companies will begin to offer hardware replacements for IBM computers. This immediately makes the IBM base harder to chip away at; users who are going to move are likely to move to hardware that is compatible.

In addition, the threat of one or more companies beginning to manufacture hardware replacements for Burroughs, Honeywell, Univac, etc., cannot be overlooked. The amount of equipment installed by these mainframers is large enough to make an attractive target.

The Target: IBM

Within the IBM base itself, there are additional forces chipping away. For years, plug-compatible peripheral manufacturers--companies such as Memorex, CDC, Storage Technology, Intel and National Semiconductor--have made disk drives, tape drives, printers, and additional memory for IBM System/ 360's and 370's. These companies shipped over $500 million worth of IBM-compatible peripherals last year, and have gained, collectively, market shares of 15 percent to 35 percent of the IBM-type equipment with which they compete.

A newer and potentially more powerful force arrived in the mid-1970's, intent on replacing the heart of IBM's computer systems: the processor and main memory. Since often these plug-compatible processors would be surrounded by plug-compatible peripherals, all that remained of IBM in the system would be the software--the instructions that tell the electronic equipment how to operate and perform specific user tasks.

This marketing ploy is possible because, today, IBM operating systems (control software) are in the public domain and thus "free." Anyone who buys an IBM computer gets a copy, so the instructions are available for use in the compatible processors.

In addition to other mainframe producers and manufacturers of IBM compatible equipment, IBM is receiving substantial competition from makers of minicomputers and microprocessor based systems. These latter two segments of the computer industry have become industries in their own right and are discussed at length in separate reports in Volume I of the M.I.R. Annual Report. But, in aggregate, it is clear that competition in the computer industry is fierce and can have only an accelerating effect on the pace of change.

4. Some Future Implications

In discussing the probable directions that computer technology will take as it moves into the 1980's, C.W. Spangle, President, Honeywell Information System, states:

> The computer industry continues to offer improved product performance with each announcement. . .bucking the inflationary trend. It is a dynamic business with a relatively short lead time from the product development stage to the marketplace; it remains capital intensive--requiring massive outlays for research and development and investment in rental assets. These characteristics will continue into the 1980's and beyond, even as the marketplace and needs of users change substantially. Systems of the 1980's will feature:
>
> - Very high performance and more cost-effective hardware technologies;
> - Hierarchies of storage devices that are faster and have larger capacity;
> - Utility grade system availability;
> - Support of large distributed data bases;
> - Standardized communications links.

In short, the comprehensive system architecture for the 1980's must be flexible enough to accommodate widely differing requirements.

But the competitive nature of the industry can only increase; one tends to wonder what characteristics will typify the firms that survive in the future. Paul C. Ely, Jr., Vice President and General Manager, Hewlett-Packard Computer Group addresses this issue:

> Competition among mainframe makers, small-computer manufacturers, local specialists, and other third parties will be keen, but the final decision on whose services to purchase, in taking advantage of the new possibilities in computer technology, will rarely be on the basis of who has the most advanced hardware, nor even the best price-performance ratio, although advanced performance and good value are important considerations.
>
> The final decision will continue to be made, I think, with heavy consideration for the reliability of the supplier's products and services, and for the ease with which the supplier makes it possible for the user to adopt the new capabilities that are offered.
>
> This does not mean the large mainframe supplier will always win, or that the small-computer maker has the edge, or that the local supplier has little change of success. On the contrary, the small house near the customer may well develop the best reputation for local service and equipment reliability. In the coming shakeout, suppliers of all sizes, will remain in the running. The determiner will not be the glamor of their offerings, though, but the quality of their demonstrated service.

INDUSTRY OVERVIEW: MINICOMPUTERS

1. Industry Structure & Key Trends

In the less than 25 years since its inception, the computer industry has experienced tremendous growth, until, with $30 billion in revenues in 1975, it has become one of the most important segments of the world economy. One of the primary contributors to this high rate of growth has been the minicomputer segment, which in the last decade has become an industry in its own right. The minicomputer industry can be viewed as consisting of three levels of participants: (1) primary minicomputer participants; (2) secondary minicomputer related participants, and (3) general purpose minicomputer competitive participants. Primary minicomputer dependent participants include:

- o General purpose minicomputer manufacturers.

- o Hardware-oriented third party participants, i.e.

  - OEM's, systems integrators, systems software house.

  - End users of equipment.

Minicomputer related secondary participants include:

- o The suppliers of semiconductors, memories, power supplies.

- Independent peripheral equipment suppliers.

- Service related firms such as software, maintenance and consulting concerns serving the primary market structure.

General purpose minicomputer competitive participants include a wide variety of firms competing for the minicomputer end-user market:

- Suppliers of programmable controllers, microprocessors, small and medium-sized EDP computers, accounting machines, remote terminals, intelligent and batch terminals, programmable calculator manufacturers, etc.

- Computational services such as timesharing, remote batch services and interactive remote batch service suppliers.

Where minicomputers once filled a need left unanswered by mainframe suppliers, higher power/price ratios are blurring the traditional product application distinctions between minicomputers and other computational products such as microprocessors and large mainframe computers. The result of this trend is that the industry will experience continuing change as minicomputer manufacturers attempt to maintain their historically high growth rates.

Thus, the 1975-1980 period is expected to be distinguished by an increasing emphasis on software and end-user support, more powerful systems, and direct competition with medium--and large scale--EDP computer suppliers.

Recent announcements have shown an increasing emphasis on 32-bit word length machines and sophisticated software systems. The distributed processing concept is allowing networks of minicomputers to perform tasks previously accomplished only by large mainframes when possible at all. This concept clearly thrusts the minicomputer suppliers into direct competition with IBM and other large and relatively well capitalized mainframe suppliers. The success of the minicomputer suppliers will be related closely to their ability to finance the software required to implement the distributed processing concept. The eventual outcome of the impending confrontation is by no means clear. The one clear conclusion is that the worlds of large mainframes, microprocessors, and minicomputers are merging and eventually will be one and the same.

2. Products: Types and Trends

Like the computer industry in general, the product offerings in the minicomputer industry fall into four general categories: mainframes, peripherals, software, and support. Several product trends within the minicomputer industry are becoming increasingly important:

- Minicomputers in networks now rival mainframe computers in power.

- The declining value of semiconductors increases the value of software in the final system, so software becomes a crucial selling element in the systems. (General purpose minicomputer CPU and memory costs as a percent of minicomputer direct costs: 1977--42 percent, 1982--20 percent).

- 32-bit word lengths allow direct data base management.

- A full-line of products is increasingly important in order to allow customers to migrate upward.

3. Markets: Segments, Distribution Patterns

The market for minicomputers can be segmented by customers, geographical patterns and end-user applications.

The overwhelming preponderance of mini-computers are being shipped to business. Potential customers within the business sector can be separated into three categories:

- Very small companies (annual sales of $100,000 to $1 million with 4 to 25 employees)--over 13 million potential users.

- Small companies (annual sales of $1 million to $25 million, 25 to 100 employees)--about 285,000 potential users.

- Large companies (over $25 million in annual sales, more than 1,000 employees)--about 25,000 potential users.

These three different business sectors have very different equipment requirements. The very small businessman will need low priced systems, with packaged software and low maintenance and training costs. The small businessman will require somewhat more mass storage, typically more than one terminal, a fairly fast low cost printer, and more customized software. Large companies are likely to be using several computers, dispersed geographically. They will have a sophisticated data processing department that can make knowledgeable price comparisons. More and more, they will require communications capabilities and software networking packages. They will be uninterested in applications software, but will require service at all geographic locations.

Geographical Segmentation

The need for a wide geographical dispersion of manufacturers' customer service organizations stems from the fact that the minicomputer marketplace is becoming increasingly international in scope. Indeed, one of the most striking statistics pertaining to the industry is that over 40 percent of the revenues of U.S. minicomputer suppliers result from export shipments. This figure includes both the systems that are exported directly and those that are eventually exported by the Third party participants (TPP's) such as hardware OEM's and software houses.

End-User Application Segmentation

Perhaps the most critical market segmentation for analyzing the minicomputer market is end-user application. Minicomputer applications can be separated into ten major segments:

- Business Data Processing: Most rapidly growing application (34 percent in value annually) with high end minicomputers playing the largest tole. Value of this segment in 1980: $509.5 million.

- Communications: applications include both data and telephone communications. Minicomputer manufacturers here encounter AT&T and IBM occupying positions of strength. Probably room for aggressive minicomputer companies: sales 1975--$84.5 million: 1980--$152.4 million.

- Design and Drafting (CAD) Multiple applications including Computer Aided Design Sales 1975--$27 million; 1980--$277 million for a growth rate of 59 percent annually.

- EDP support: remote patch terminals, processing terminals, shared processor data entry, and peripheral control accounted for $100 million in 1975, $334.7 million in 1980.

- Industrial Automation: Many applications reaching maturity and being displaced by microprocessors: growth expected at 10.5 percent annually; 1975--$195.4 million to $332.1 million in 1980.

- Instruction: fund constraints will promote timesharing applications: 1975--$27.4 million to grow to $69.2 million by 1980.

- Laboratory and Computational: subsegments are (1) instrument automation, (2) laboratory automation, (3) experiment monitoring, and (4) scientific computation. Growth 11.1 percent to $310 million in 1980.

- Specialized Data Acquisition and Control: transportation, environmental monitoring, simulators, and military and weapons control. 18.5 percent growth annually from $80.3 in 1975 to $187.6 million in 1980.

- Specialized Data and Word Processing: major applications include point of sale systems, banking terminals and word processing. First two applications dominated by large mainframes (IBM). Word processing appears best minicomputer opportunity. 20 percent annual growth to $56.8 million in 1980.

- Other: Wide variety of applications including an increasing personal/consumer market. Estimated market size by 1980--$239 million.

Distribution

Distribution of minicomputers, both in the U.S. and Internationally, is being accomplished increasingly by means of a direct sales effort on the part ofthe manufacturer. However, in the earlier phases of industry development, the third party participant (TTP) was the primary distribution channel used, and TTP's still play a major role in the industry. This role has been decreasing because of the growing sophistication of minicomputer manufacturer marketing capabilities and because of the rising importance of general EDP minicomputer applications (1970--64 percent of minicomputer sales were through TTPs, 1975--39 percent of sales were through TTPs with other 61 percent sold directly to end-users).

In summary, the minicomputer market will grow overall but will experience most of its growth at the expense of the larger mainframe companies while losing some low level applications to microprocessors. The role of third parties in securing general purpose minicomputer sales is decreasing (although not for dedicated application); thus the efforts of minicomputer manufacturers to develop general minicomputer system applications that meet end user requirements are becoming increasingly important.

4. Competitors, and Market Shares

The major minicomputer manufacturers are, to the extent of their resources, putting increased emphasis on software and broad product-line offerings to meet end-user requirements. A recent event that may have a substantial impact on the industry is IBM's 1978 entry into the minicomputer market. Exhibit #1 shows that IBM's system 1 should capture a 4 percent market share in 1978. Digital Equipment Corporation remains the dominant firm in the industry with a 33.8 percent market share, followed by Data General (17.5 percent), H.P. (6.7 percent) and Interdata (4.1 percent). The top five firms should account for 66.1 percent of minicomputer system shipments in 1978.

5. Finance and Conclusion

Like the rest of U.S. Industry, the minicomputer suppliers are faced with a severe shortage of capital for future expansion. Most are too small to obtain favorable treatment from the investment community. The continued growth of the industry combined with increased competitive pressures will exert severe demands on suppliers in terms of working capital and capital expenditures, with few having sufficient earning to generate the necessary capital internally. Thus, the major uncertainty associated with the industry may well relate to the source of capital. Unless stock market conditions change drastically, or the OTC market once again becomes the haven for the small investor, or unless the capital gains tax is reduced, merger and acquisition may be the only route open for some suppliers.

EXHIBIT #1

MINICOMPUTERS TO BE ACQUIRED IN 1978
BY SURVEY RESPONDENTS*

COMPANY	QUANTITY	1978 PERCENT SHARE
Digital	10,063	33.8
Data General	5,193	17.5
H-P	1,979	6.7
Interdata	1,217	4.1
IBM	1,200	4.0
Computer Auto.	1,045	3.5
Gen. Auto	768	2.6
Texas Instr.	692	2.3
Honeywell	543	1.8
Microdata	438	1.5
Modcomp	403	1.4
Varian	385	1.3

Total Units--29,734

Total Dollar Value--867,630

*Dataquest/Mini-Microsystems Annual Survey Data Based on 11,915 Responses.

INDUSTRY OVERVIEW: INSTRUMENTS

INTROOUCTION

Following is a brief review of a significant trends in the instruments industry. Volumes 2 and 3 of this series provide a more definitive analysis.

PRODUCT TRENDS

1. Lower cost LSI/VLSI and increasingly scarce engineering resources are driving product developments in several directions:

   o Small, low cost, low margin, high volume products like handheld DMMs. These products are expanding the vista for T & M products by virtue of their small size and lower price.

   o Equipment that does repetitive measurements without operator assistance. More and more, this category of equipment gives answers to the user rather than just a series of symptoms of measuremments. This allows engineers and other scarce labor to work in more productive areas.

   o Stand-alone instruments with gradually improving price/ performance ratios that are designed for a service or laboratory environment. Information supplied by the equipment is used directly by the operator rather than by another electronic device. Instruments are designed for a fairly narrow category of measurements, although the measurement breadth may be increasing.

2. GPIB is another potent driving force (due to both customer needs and aggressive HP promotion). GPIB underlies a trend toward "systems" which grab and process data and then display data in uniform and usable forms. This equipment is also enlarging the market for instruments by enabling "unsophisticated" users to perform technical tasks.

3. Increasing numbers of users are finding "low-cost" instruments suitable for R & D and service applications.

4. There is a vast audience that feels comfortable with a computer terminal or a hand held calculator and BASIC or FORTRAN. Over time, such users may gradually begin to make measurements in new ways, perhaps using "instruments" more as signal acquisition devices than as stand-alone devices.

5. The fastest rates of industry growth will be in the "low-cost" and systems categories. General purpose test equipment sales overall will grow at a 9 percent rate. Although the growth rates are higher in the "low-cost" and systems segments, the magnitudes of these segments are still small compared to GPTE.

- "Low-cost" instruments increasingly are marketed by wide retail-like distribution networks. There are more price sensitive buyers compared to upper-end purchasers for these products. Manufacturing cost is a primary profit leverage tool. The importance of manufacturing and retailing may spread upwards into the higher price products as the industry and its product mature.

- "Systems" means the connecting of possibly disparate units. So, integration, turnkey support, and service take on more importance to the buyer and the user--who may be different people. Debate surrounds where the integration should occur: Should it be designed and built into the products "at the factory" (Tek), or should integration take place in the field (HP)?

- Although direct selling is now economical for stand-alone lab equipment (due both to the prices and volumes involved), in general, instruments are coming up in complexity and down in price, with many instruments gravitating toward the $1,000 to $4,000 price range. Products in this range are too complex to sell through catalogs and too cheap to sell through F.E.s. As a result there are some distribution problems to face. . .walk-in showrooms? Retail outlets? Radio and TV ads? More sophisticated distributors?

INDUSTRY OVERVIEW: OSCILLOSCOPES

INTRODUCTION

Since Tektronix is a primary force in the oscilloscopes industry, to describe the industry would cover material in Volumes following. Accordingly, the following represents a basic situation overview.

SITUATION

The oscilloscope industry may be nearing the end of its second long period of stability and quiet (although rapid) growth. The first such period started after World War II and continued into the 1960's. The second long period occurred with Tektronix' decisive turning back of a challenge by HP in 1967-1970, and an industry shakeout in 1970-71 due to a severe recession in electronics.

The driving force for a new period is semiconductors, both as devices to be measured and as devices to do the measuring.

DEVICES TO BE MEASURED

Semiconductors are becoming the primary device of interest in the electronics industry. They are different from preceeding devices in that they operate digitally and more slowly. While they will continue to operate digitally, their speed is picking up to the point that optimization around higher performance levels may gradually become necessary.

Another key feature of semiconductors is their operating voltages. Up to now operation at five volts has been common, but new devices will operate at much lower voltages, which creates a need for ever better probes operating with greater sensitivities and higher impedances.

Semiconductors are also getting more complex, truly systems on a chip. Not only are physical probe connections important, but also sorting out the data will become an increasingly crucial task.

Finally, semiconductors are basically a different type of device to measure as compared to analog devices because of the relatively greater importance of timing issues rather than waveform or signal amplitude issues.

DEVICES WITH WHICH TO MEASURE

Advances in A-D converters alter the economics and performance of oscilloscopes by making possible new and digitally oriented techniques for signal acquisition. With a signal acquired in digital form, use of semiconductors for processing and storing the signal becomes relatively easy and desirable from a user's standpoint. In fact, at lower speeds, signal processing features made possible by semiconductors already seem to be selling factors in some products.

Advances in displays also has implications for oscilloscopes. Although it seems impossible to conceive of a faster or "better" display than a CRT, use of fast A-D converters and storage of a signal in digital form means that cheap, television-like monitors are all that are needed to display the signal in a pseudo-analog or digital format. Alternately, flat panel displays, while not expected until 1980 in significant quantities (in televisions), may impact oscilloscope packaging and perhaps measurement approaches for field applications.

HOW OTHERS SEE OSCILLOSCOPES:

<u>HP's View</u>: "For most of their existence oscilloscopes have been used to study those waveform parameters that can be determined from the shape of the traces displayed, like noise on analog control lines, ramp linearity, and amplifier response. But with the tremendous growth of digital systems and techniques, the emphasis has shifted to time related parameters."

(The 9800 desk top calculators, the 1000 series minicomputers, and a planned line of hand-held calculator/controllers are seen as the control nuclei of systems in which "instruments" are distributed processing devices.)

HP is reported to have centered its oscilloscope R & D efforts on the achievement of high speed A-D conversion.

<u>Intel's View</u>: "We (have) recognized that the design of electronic equipment was changing and introduced what could be the equivalent of the oscilloscope for digital systems, namely the Intellec design aid."

<u>Minicomputer Manufacturers' View</u>: (Once the signal is acquired, use a device coupler and have a minicomputer analyze, format, and display the signal.)

Prime Data's View: "Oscilloscopes are a basic instrument and will grow and mature into a replacement market despite alternate measurement methods" (computer self-diagnostics, logic analyzers, digital service instruments).

Gould's View: (The key is signal acquisition, so we will use our waveform digitizing expertise to capture and then analyze and display signals. Over time we will get better and faster at it.)

Philip's View: (The key is understanding what customers want, namely reliability. So we will provide me-too products with crisp traces, solid switches, metal frames, sober colors, and then dominate Germany, then Europe, then U.S., focus on large accounts, and avoid Tektronix expertise in lab areas.)

Hameg's View: (The proportion of proprietary components in low-end oscilloscopes is low, and the associated electrical engineering issues are well defined. So we will focus on assembly, tight control of costs, and me-too engineering.)

INDUSTRY OVERVIEW: TELECOMMUNICATIONS TEST EQUIPMENT

INTRODUCTION

The Telecommunications Test Equipment industry is a $1.2 billion (1977 world-wide) industry related to the larger $60 billion telecommunications equipment industry.

U.S. sales account for about one-half of the total market, but this percentage will decline to about 44 percent by 1987 due to more rapid growth in the international markets. Overall, the industry will grow slowly and steadily at a rate of about 8.8 percent per year.

In more normal times this industry would not be discussed in a report such as this because the natural assumption would be that in the U.S., at least, Western Electric would have this business entirely for its own. But maybe not.

PRODUCTS

The products of the telecommunications test equipment industry include centralized test consoles, analog line impairment instruments, digital bit error rate testers, spectrum analyzers, pattern/function generators, microwave test equipment, and transmission test sets. These products are similar in nature to general purpose test equipment except dedicated to and optimized for particular applications. The products are used in the maintenance and installation of telephone and data communication networks.

INDUSTRY STRUCTURE AND KEY TRENDS

It is necessary to understand the intense battle being waged in the telecommunications equipment industry to understand the situation in the related telecommunications test equipment industry.

The main thing that is happening to the telecommunications equipment industry is technology: fiber optics and satellites are jostling to obsolete conventional wire links; computers are replacing mechanical and electromechanical switches; digital transmission of signals is replacing analog transmissions; and new consumer and banking services, such as electronic funds transfer, are being tied in with conventional communications networks. Of special interest to the telecommunications test industry is the equation computer equals switches, for computer service is a mainstay of the General Purpose Test Equipment industry.

Fueling this technology turmoil are large sums of money: IBM is spending $900 million on R&D in 1977 and AT&T is spending $600 million. Sums being spent outside these two companies by other computer, minicomputer, and semiconductor firms and by foreign government consortiums on technology related to this field must be of a similar size.

Both AT&T and IBM are giant firms with a high competence in technology. AT&T and Western Electric are about 2.4 times the size of IBM, but that advantage is overweighed by another critical variable; cash. Although AT&T earns from 27 to 30 percent pretax on its revenues, it is still not enough, because earnings are not the same thing as cash, and cash is what AT&T needs to replace its equipment quickly enough to head off competition from IBM in the form of satellite-based communications networks. AT&T depreciates its equipment on a 40-year schedule, while IBM depreciates its equipment over five years. Since AT&T earns "only" 8 percent on its capital, it is constrained from installing advanced equipment as fast as is necessary. IBM may show lower profits with its faster depreciation, but it then has much more cash to spend on capital equipment.

The result of all this turmoil is some unique market openings and even some thinking of the unthinkable: AT&T forced to sell Western Electric for the cash necessary to bring it into the new era? Unbundling of AT&T costs and charges due to regulatory issues raised by IBM?

Meanwhile, the structure of the telecommunications test equipment, in the light of the above developments, seems increasingly open. Basically, the competitors consist of Western Electric (with sales of $260M in 1977 and a market share of 44 percent) and a large assortment of small and specialized firms. The next largest competitor is HP with sales in this industry of $47 million and an 8 percent market share, followed by Scientific Atlanta with a 3 percent market share, and more than 100 other firms sharing $246 million and 45 percent of the market.

This fragmented market structure did not happen by accident but is the result of the influence of Western Electric. The small firms involved are typically vulnerable with low levels of sales support and specialized areas of technological competence. As the influence of Western Electric becomes less decisive, the telecommunications test equipment may be due for restructuring.

COMPETITOR OVERVIEW: AMERICAN TELEPHONE & TELEGRAPH (WESTERN ELECTRIC)

INTRODUCTION

AT&T, with $40 billion in revenues and over $5 billion in profits for 1978, dominates one of the largest industries in America, telecommunications. Highly integrated, most equipment is developed by Bell Laboratories (with a yearly budget of $666 million) and manufactured by Western Electric. The $8 billion in captive sales to AT&T revenue comes from common carrier (voice) (communication) operations, but AT&T faces a loss of revenue to:

- FCC actions allowing increased competition in specialized common carrier services and business and consumer telephone interconnect equipment. Competitors have, for the most part, been aiming at "cream-skimming" by offering only selected, high margin services.

- Anti-trust action threatening to force divestiture of Western Electric. This could also be a major threat to Bell Labs.

- A leveling of growth in telephone common carrier operations.

About 10 percent of AT&T's revenues come from data communications, which is a rapidly expanding market. Bell is seeking a monopoly position in the market for transfer of information (without transformation), and is also pushing into data manipulation (imaging and computing) which places it in direct competition with the large computer mainframe companies.

AT&T faces a major hurdle if it is forced to apply accounting practices designed for the utility industry to its new competitive ventures.

AT&T's management is dedicated to a 'religion' of the best possible service to the public. It is conservative and hardworking, with a high reliance upon management controls and standards. Recently there has been a shift from an engineering/service orientation to a market-oriented perspective forced by new competition:

- Major accounts are individually managed and are being centralized.

- Marketing/planning is being organized around major market segments.

DIGITAL EQUIPMENT CORPORATION

Introduction & Strategic Overview

Digital Equipment Corporation (DEC) is the leading world supplier of small computers. From modest beginnings as a logic module supplier, revenue has grown to $1,059 million in fiscal 1977 and should approach $1.5 billion in fiscal 1978. Approximately 80 percent of the company's revenue is estimated to be derived from small computer-related products.

DEC has established a worldwide manufacturing, sales, and service capability which has allowed it to achieve a leading position in nearly all countries where it sells its products. Products range from the 12-bit PDP-811, through the 16 bit PDP-11, 18-bit XVM, 32-bit VAX, and 36-bit DEC 20, to the large-scale DEC 10. In addition to DEC's dominance of the small computer market, the DEC 10 and its predecessor, the PDP-10 are widely used in the time-sharing business as well as by engineering and commercial DP end-users.

DEC has developed substantial in-house manufacturing capabilities which include semiconductor production facilities, manufacture of a wide variety of peripheral devices, and, of course, its computer mainframes. Research and development expenditures have been maintained at a high level, approximately 8 to 10 percent of total revenue over the past five fiscal years. A significant portion of these R&D expenditures is for software products such as the DECNET computer network operating system.

Originally concentrating on the OEM market for its small computers, today DEC is placing increasing emphasis on meeting the product, service, and support requirements of end-users. Particular emphasis is being placed on commercial EDP users who are actively implementing stand-alone and distributed computer systems to augment or replace large central DP facilities. In 1976 and 1977, DEC undertook a major facilities expansion and appears currently well-positioned to maintain its leadership position in the small computer market.

DEC's product and marketing strategies for the future can be summarized as follows:

- DEC's future revenue growth will come more from its "mainframe" lines, VAX and DECSYSTEM-20, services and peripherals.

- Their future product startegy will attempt to improve DEC's "commercial image" via three main lines:

    1. VAX-11/780;

    2. DECSYSTEM-20; and

    3. an LSI version of the 11/34.

- The first-time end-user market will continue to be penetrated through distributors and retail outlets (the first opened July 31, 1978, at the Mall of New Hampshire near Boston).

- The corporation is changing from its earlier product oriented groups to an industry specialized structure, and its targeted markets will include:

  1. manufacturing

  2. services (e.g., ADP, etc.)

  3. insurance, and

  4. distribution

- In order to succeed in distributed processing, Digital must correct the software incompatibilities between its many product lines. DNA/DECnet, common command languages and data types are the primary techniques being implemented to improve this situation.

- DEC will gradually unbundle its software and services over the next five years.

- DEC's chief challenge is: how to hire, train, and make productive the thousands of new professionals required to support its 40 percent annual growth rate.

Industry Trends That Affect DEC's Strategies

DEC is operating against a background of rapid industry-wide change. Differentiation between the microcomputer, minicomputer, mainframe, and data communication industries is becoming increasingly more difficult:

- Minicomputer firms are horizontally migrating into traditional mainframe markets.

- Minicomputer and semiconductor firms alike are entering IBM plug-compatible mainframe markets.

- Mainframe firms, in turn, are developing and marketing minicomputers to protect their markets from trends toward distributed processing, and to reduce the cost of mainframes. IBM poses a formidable challenge to Digital's leadership in minicomputer markets.

- Mainframe and minicomputer firms alike are vertically integrating into semiconductor development and manufacture to gain critical microcomputer expertise, and to protect themselves from the onslaught of semiconductor firms that choose to build computers. (National Semiconductor claims that a full IBM 370/158 processor could be confined to a single chip by 1985.

- IBM and AT&T will have a major confrontation in the future when both offer new data communications services and when computer and communications technologies become inseparable. Cheap communications will alter in some way not yet definable the market for minicomputers in distributed processing networks.

Product Strategies

In response to these changes, Digital has embarked on three major product developments to support its competitiveness and growth: (1) a 32-bit minicomputer called the VAX-11/780, (2) a computer networking approach called Digital Network Architecture (DNA), and (3) a family of medium-scale mainframes called DECSYSTEM-20.

VAX-11/780

The VAX-11/780 is DEC's first 32-bit supermini system and represents a commitment that will provide substantial impetus to the marketability of 32-bit superminis. It offers substantially more processing potential that the PDP-11/70 (presently Digital's largest 16-bit minicomputer) at prices ranging from only 30 percent at the low end to 15 percent more at the high end for comparably configured PDP-11/70's. The VAX-11/780 offers Fortran processing capabilities competitive with those offered by vastly higher-priced systems, such as the IBM3031, Honeywell level 66/DPS-1, etc. However, due to an intentional slowdown on developing software (to avoid impacting its PDP-11 and DECsystem-20 lines of computers), the business processing potential of the VAX-11/780 remains underdeveloped. However, as hardware prices erode and the Japanese threat to the established U.S. EDP industry intensifies, software will become vital to Digital's future. These trends will force DEC to spend substantial amounts to develop software functionality for the VAX-11/780 and to pursue direct marketing to end-users.

DNA

Digital introduced Digital Network Architecture (DNA) in April 1975, as an approach to computer networking. It comprises:

- Digital Data Communications Message Protocol (DDCMP), a bit oriented message format with transmission recovery and packet switching provisions.

- DECnet, a collection of modular operating system extensions that are easily installed to facilitate information exchanges between Digital's minicomputers and mainframes arranged in complex communications networks.

DECnet software can be employed to coordinate message traffic and control functions with a wide range of network types, including host-independent distributed computing networks and host-dependent terminal and resource sharing networks.

DECSYSTEM-20

Although mainframe sales and services constitute only about 20 to 25 percent of Digital's total revenues, they could contribute substantially more in the future, especially as a result of the DECsystem-20 announcement in February 1978. The 2020, a low-end member of the DECsystem-20 family, is acclaimed by Digital to be the "World's Lowest Cost Mainframe," competing head-on with small-scale mainframes, such as the IBM 370/115, the Honeywell L66/DPS, and the Burroughs B17/1800. Capable of supporting two mature operating systems and a broad range of application software already in existence, the 2020 could open vast new markets for Digital.

Higher levels of processing power are offered by the other members of DEC's 20 family: the 2040, the 2050, and the 2060. DEC's product strategy, therefore, has been to meet its competition head-on with often uniquely designed hardware and software offered at extremely competitive prices.

Marketing Strategies

In 1977, Digital commanded a 41 percent share of the minicomputer market and was mounting a substantial challenge in mainframes. Several marketing elements have contributed to this success. One of the keystones of Digital's marketing strategy is offering products with among the best price/performance ratios available.

Using IBM products as an example, Digital offers:

- The 2020 at IBM System/3 and 370/115 prices but with 370/125 and 138 performance.

- The 2040 at IBM 370/115 and 125 prices but with 370/138 and 148 performance.

- The 2050/60 at IBM 370/138 and 148 prices but with 370/158 and 3031 performance.

Thus, with mainframe product offerings ranging in (full system) price from $150,000 to $1,000,000, DEC has become a thorn in the side of mainframe suppliers.

Another factor that DEC management considers central to their marketing strategy is their effort to provide extensive field support. To support this policy DEC pays its salesmen salaries with the result that they go after small customers and sell the most appropriate product, rather than the product that generates the best commission. Perhaps as a result of this salary arrangement, one major DEC customer has commented that "DEC's salesmen are very aggressive and stop by once or twice a week to make sure equipment is working all right and fill any sudden requests".

The needs of the very small businessman have traditionally been ignored by minicomputer suppliers. However, DEC opened a small business system retail outlet near Boston in July 1978, with the intention of making inexpensive packaged systems and extensive support readily available to this customer segment. This latest development underlies some of the reasons for DEC's 40 percent annual growth rate: superior price/performance offerings and extensive efforts to address the needs of a broad array of customers.

Management Styles & Capabilities

Some industry experts and DEC customers worry that the company has grown so fast that it will be hard-pressed to keep up with changing demands. One facit of this potential problem is that DEC has a decentralized management organization that encourages competition among its 13 product and marketing groups for sales and internal resources. This had led to inefficiencies such as two new computer products occasionally priced about the same. This can cause some customer confusion, and may mean there were duplicate development efforts, as scientists design computers for a certain price range. DEC's recent growth spurt also has brought it some less sophisticated customers who expect additional technical assistance and service. Citicorp's Citibank subsidiary, which has about $20 million of DEC equipment, is pleased with DEC's "very reliable" computers but complains that DEC seems to employ only technically oriented types who are unable to get "involved in our strategy"; they "want a little more handholding". DEC has reacted to these pressures to the extent of reorganizing for centralized long-term planning. However, it remains to be seen whether DEC can hire, train, and employ productively sufficient numbers of new employees to service its rapidly growing customer base and thereby insure its continued growth at historical levels.

COMPETITOR OVERVIEW: JOHN FLUKE MANUFACTURING COMPANY

INTRODUCION

Fluke designs and manufactures electronic test and measurement instruments and systems.

PRODUCT STRATEGIES

Fluke enters T & M areas through the engineering of a lower-cost alternative. An exception to this strategy is data loggers where they performed a technological leap-frog to become the market leader. Fluke is the leader now in DMMs, number two in frequency synthesizers, and strong in counters and in programmable, high voltage power supplies. HP has countered Fluke moves strongly with mixed results so far.

Fluke has recently been advertising for CRT engineers and is expected to go into the manufacture of controllers.

MARKETING/MANAGEMENT STRATEGIES

Fluke has just completed purchasing its U.S. distributors, more than a year in advance of its own schedule. Fluke is internally organized into business units whose definitions seem cumbersome to outsiders but which seem to be effective in practice.

MANUFACTURING STRATEGIES

A key skill of Fluke so far has been choosing their projects well and sticking to a low cost approach. Fluke buys a fair amount of components, most importantly ICs from Intersil and Siliconix (the designs for which were developed jointly on a non-exclusive basis). Fluke is building an IC facility. The new Fluke manufacturing facility has been successful in increasing productivity significantly, and their business unit structure, although cumbersome appearing to outsiders, appears to be working out.

PERFORMANCE

Recent performance has been startling:

Year:	1974	1975	1976	1977	1978
Sales:	33.4M	41.9M	49.2M	60.0M	74M

COMPETITOR OVERVIEW: GOULD, including ADVANCE, BIOMATION, STATHAM

"The Product Development Company"

INTRODUCTION

Gould is a $1.2 billion (1977) company which makes electrical products (motors, generators, torpedoes), electronic products (principally thin metal foils for circuit boards and digital instruments including waveform digitizers, oscilloscopes, recorders, DVMs, counters, pulse generators, and medical products), battery products (principally auto batteries), and industrial products (battery answered industrial trucks) that are based on key and related technologies in electronics, electrochemistry, electromechanics, and metallurgy.

As an acquisitions minded company (acquisitions supply half of its growth) Gould may be interested in acquiring instrument firms (six in the last seven years) only as a way of improving its price/earnings ratio.

But Gould is not a conglomerate, and so closely reasoned and decisive have been its other acquisitions (15 plus three mergers since 1967), numerous internal resource allocations (resulting in an internal 12 percent compound annual growth rate over the last ten years. . . .for an overall growth rate of 23 percent per year for ten years to a present size of $1.2 billion), and firm insistence on continued growth of any business it holds (six have been sold since 1967) that Gould deserves a second look.

There is room for reasoned debate, and Gould only threatens Tek now in a few areas (logic analyzers), but their actions do seem to suggest a coherent strategy to become a leading manufacturer of instruments. If so, factors such as their command of some key technologies, their cash sources invulnerable to easy counterattack (i.e., auto batteries), and their able management make them a worthy competitor.

PRODUCT STRATEGY

Gould's slogan, "the product development company", seems apt. Gould is product oriented in the sense of a relative emphasis on innovative design to lead the company into new areas and maintain growth in sales and earnings.

Gould's instrument products are clustered around low frequency measurement needs, particularly in the mechanical and medical market segments. Gould has a history of producing excellent analog oscilloscopic chart recorders, and signal conditioners, and, in the U.K., sells low frequency oscilloscopes with some success.

Recently, principally through acquisitions, Gould has gained control of over half of the small ($17 million in 1977) but rapidly growing (42 percent per year since 1972) waveform digitizer market. This digital expertise is also related to its benchtop IC tester and logic analyzer products.

These various strengths in low frequency measurements and digital products recently combined in an innovative logic analyzer product. This "Digital Testing Oscilloscope" can operate as a go/no-go comparison tester, as a logic analyzer, and, by constructing a psuedo-analog waveform from its digital memory, as a storage oscilloscope. The DTO-1 is billed as "the first oscilloscope-like instrument designed to test and troubleshoot digital systems. It performs automatic tests, as well as manual trouble-shooting procedures, not only on digital but also on related analog circuitry."

Some observers feel that with oscilloscopic recorders (basically oscilloscopes without CRTs), some basic offerings of oscilloscopes in the U.K., and a new logic analyzer, Gould is in a good position for a major effort in the low frequency oscilloscope market in the U.S.

Gould's overall product strategy may have a fatal flaw, however, in the form of its strong commitment to electric vehicles. Gould has overwhelming battery exepertise, but long-term success means overcoming the combined forces of the auto industry, the oil companies, and alternate forms of fuel, including alcohol.

MARKETING STRATEGY

Published statements and corporate actions suggest that Gould sees the instrument industry as a relatively fragmented one where small firms can thrive while growing strong by carefully defining their niches and positioning in areas of rapid growth.

These published statements conflict somewhat with insider statements that Gould has virtually no market research function at the corporate level and only a small effort in the Divisions. The resolution, perhaps, of an apparent inconsistency of market niche strategy with a truncated marketing staff, lies in Gould's practice of bringing innovative but sometimes flawed products quickly to market. Gould then learns from its customers in a direct way and modifies its products accordingly.

MANAGEMENT STRATEGY

Gould's management approach stresses thorough planning, quarterly reviews with decisive action following, annual education in industry trends as well as company procedures, and dramatic "pay for performance" (35 recent millionaires). High priorities are placed on meeting targets for earnings, developing new products, and reducing manufacturing costs steadily. The emphasis on setting and meeting goals in financial terms has allowed an organization that is both "tight" in terms of accountability and decentralized in organizational form.

Gould is not a relaxed place to work. The top managers are financial types, and they do run the firm by the numbers. Gould's public relations efforts strongly assert that they are more than a holding company, but the primary interest in the financial numbers suggest otherwise.

Just below the top levels many of the key managers seem to be engineers, according to available information. This suggests that in the Divisions the current product orientation will continue. The marketing expertise that does exist is apparently concentrated in the Gould Labs.

MANUFACTURING STRATEGY

In relative terms, Gould sees itself less as a manufacturer than as a product and financially oriented firm. Accordingly, Gould often buys components used for assembling its products rather than emphasizing a vertically integrated approach.

ENGINEERING/TECHNOLOGY STRATEGIES

Product development takes place in the various Gould divisions, while basic research takes place in a central facility, Gould Labs. Gould Labs is in the process of doubling in size during 1978 to a size of perhaps 350 or more people. It is divided into two separate groups, an Energy Lab (batteries) and an Electronics Lab.

Gould Labs are oriented toward new products, not improvements in existing products. It seems the one area with Gould that can be said to be market driven, in that it looks for good markets and asks itself what can be produced for that market using the basic technology available.

Published statements about Gould's engineering approach to instruments suggest that Gould sees special possibilities in microprocessors. To Gould, microprocessors make possible and desirable a strategy of developing standardized products which can then be targeted to specific applications through use of software.

Specific areas of Gould strengths are A-D conversion at 100 MHz, digital storage, use of IEEE interfaces, digital and analog displays, and use of microprocessors for internal controls.

COMPETITOR OVERVIEW: HEWLETT-PACKARD

INTRODUCTION

HP designs, manufactures, and sells signal and data processing computers and instruments of advanced design and high quality. Areas of focus include commercial data processing, manufacturing applications of instruments and computers, and "traditional" test and measurement task. 1978 is the year when computers become larger than instruments for HP.

Hewlett-Packard is the largest test equipment supplier in the world and leads in most instrument markets. HP dominates instruments, but over half of HP's overall sales come from areas where they are not the leader. Strengths include finances, vertical integration, technology, distribution, worldwide scope, and extraordinary management. Weaknesses include strains due to fast growth, geographical dispersion, and the sheer pace of VLSI events which affect them directly. HP has lined up against three especially strong competitors: Digital Equipment Corporation, Texas Instruments, and Tektronix; and HP is in the path of at least two others: IBM and Intel.

HP is exceptionally strong in a financial sense, so their ability to fund high growth rates is excellent. They rarely compete on a price setting basis, except to achieve specific objectives such as a particular military contract. HP prefers instead to compete with a flood of quality, high-performance products often utilizing state-of-the-art technology.

HP is a truly international company with important design and manufacturing sites in Germany, France, and the U.K.

PRODUCT STRATEGY

HP product strategy includes emphasis on networks centered around a controller or mainframe with instruments and terminals viewed as distributed processors and peripherals.

While HP has extensive software capabilities, customized point-of-use applications of HP computers usually depend upon outsiders: OEMS and software houses. By contrast, HP performs its own point-of-use applications of instruments in networks using a special force applications engineers in the field.

With request to tying together instruments into networks, HP seems strongly adverse to solving all application problems in the factory. HP prefers its factory types to optimize their hardware in terms of quality and performance while meeting specified interface requirements. Because there is no "grand scheme" of integration at the factory, the field applications of instruments often take in a "messy" appearance, but their salesmen can sell the bits and pieces of equipment in virtually any configuration to almost any manager or engineer at any level in practically any business, engineering group, or educational establishment in the world.

To make this field applications approach work in instruments, HP is well along in appointing applications specialists in every sales office and has implemented a four level pricing scheme based upon the differing levels of support that a customer might need.

In general, Hewlett-Packard products may be described as broad in range, deep in performance, innovative in nature, and excellent in quality.

MARKETING STRATEGY

HP sells its products, with some exceptions, directly to users through its own world-wide sales force, with the exception of Japan where it has a 50 percent joint-owned venture (YHP). It's worldwide sales subsidiaries are not autonomous, but rather they report back directly to the Product Divisions. Although HP conducts aggressive price campaigns in specific countries (such as the U.K.) in order to achieve specific objectives, in general HP is a price leader that prefers to keep prices high. Rather than pioneering new areas (although calculators are an exception) HP prefers to go after other people's markets with innovative products (minicomputers are typical).

Major competitors are: DEC (minis, IBM (business oriented computers), GE (medical), TI (calculators), Wavetek (fcn. gen.), Tek (scopes), Perken-Elmer (analytical), Fluke (DMMs), Gould (osc. recorders).

MANAGEMENT

Current corporate concerns per President John Young, EVP Bob Boniface, VP & GM Instruments Bill Terry, Instrument Engineering Manager Al Bagley (source: Measure, an HP employee communication, F/March 1978):

1a. Top priority is reorganization to reflect the effects of digital technology on all lines and to move from a divisional to a strategic orientation. (Young)

1b. "Our businesses are different, but not fundamentally different." (Terry)

1c. Corporate Marketing is to work with product groups to develop strategies. (Boniface)

1d. Processing of data is 'where the action is' in instruments, and it is hard to imagine an instrument that couldn't use a microprocessor. (Bagley)

2. Add and manage people, particularly at the supervisory level. (Young)

3. Better control of spending. . .meeting profit targets. (Young)

4. Greater use of VLSI in Products. (Young)

5. Reducing IC costs. (Young)

6. Government regulations. (Boniface)

7. Better management information systems. (Boniface)

8. Quality control. (Boniface)

9. New manufacturing sites overseas. (Boniface)

Special instrument group concerns:

1. Generating new products is seen as the key to success.

2. More interdependence of products, ICs, R&D, sales force.

3. Keep the bureaucracy from becoming inward looking.

HP is a geographically decentralized company with plants spread from Corvallis to Malaysia, New Jersey to Grenoble. HP is organized into four product groups (Instruments, Computers, Medical, and Analytical Instruments). Each product group is further subdivided into product divisions (40 division of which 11 are Instrument Group divisions).

MANUFACTURING STRATEGY

Manufacturing is divisionalized, with an important emphasis placed on reducing costs. Divisions can build their own components or order common parts from central manufacturing. An effort is made to use common parts where possible.

ENGINEERING/R&D STRATEGY

HP is technology driven, and they invest heavily into new and innovative technologies.

FINANCIAL STRATEGY

HP funds growth internally and carries no debt. HP places a great emphasis on selling stock to employees.

COMPETITOR OVERVIEW: INTEL

INTRODUCTION

Intel manufactures semiconductor memories, microprocessors, and electronic equipment with a high semiconductor content. Sales and profits in 1977 were up 25 percent to $383 million and $32 million.

Intel in many ways is still an entrepreneurial firm with extremely capable managers at the helm. Intel is aggressive, usually first to market with advanced products, operated at a fast pace, and determined to broaden its business base "to serve new markets for integrated electronics created through technology."

PRODUCT STRATEGY

Intel is now trailing T.I. and Mostek in semiconductor memory devices due to pricing pressures, delivery problems with 16K RAMs, and entry of EPROM competitors. Intel is unlikely to try to regain memory leadership but rather will pursue microprocessors and mircoprocessor related products (where they dominate with perhaps a 70 percent market share) and memory boards (where there is a greater vertical value-added). High priority products are single board computers (14 new types in 1977), MDAs (where profits are higher than microprocessors and Intel enjoys a commanding market share), memory systems, and control devices. A multiprocessor architecture is being emphasized for the single board computers, which minimizes the helpfulness of ICE devices.

Meanwhile MDA people are reportedly becoming closely involved in microprocessor design, in order to improve ease of single chip applications.

Intel recently signed a $52 million agreement to supply IBM with add-on memory to help IBM work down a three year backlog for 303X computers. Intel and IBM are negotiating a follow-on contract. Intel will probably maintain this link for three to five years and then move on when margins begin to decline.

A strong emphasis in the product development effort is placed on ease of use in the forms of advanced software, thorough documentation, and provision of supporting products, such as design aides.

Intel seems to be avoiding the auto market for fear that the products will almost instantly become commodities. Intel does seem to be expanding into telecommunication peripherals and bubble memories.

MARKETING STRATEGIES

Intel sells both directly and through distributors. Direct sales of semiconductors are to OEM customers, such as IBM, and in target areas in Europe and Japan. A portion of the direct sales force works closely with distributors, who perform well for Intel in order to maintain contact with the technology leader and because of the ancillary product sales that go with semiconductors (resistors, capacitors, power supplies and the like).

Intel avoids price competition, relying instead on technological advances. Intel will withdraw from a market as soon as margins suffer.

Europe is a target of a current special marketing effort.

MANAGEMENT

Intel faces strong competition on all fronts, strains due to growth and geographic dispersion, and some morale problems. Intel management is tough and performance oriented, but there is no reason to believe that they have any magic answers to the inevitable problems caused by size and diversity.

Management skills include instrumentation--some key managers have previously worked at Hewlett-Packard. Intel has made few mistakes in entering the instruments market with their Microprocessor Development Systems.

MANUFACTURING

Intel does not have the virtually total manufacturing orientation of Mosek and T.I., but it still relies on high volumes and scale economics as crucial elements of its strategies. Products are assembled in Southeast Asia. Basic manufacturing (as well as engineering and marketing) facilities are being established in the Portland area to supplement its Bay Area plants.

Current technological interests include CMOS and SOS (acquired from RCA) and bubble memories. There is also a strong emphasis on developing in-house software expertise (apparently Intel is beginning to develop software before hardware on advanced projects; the chief architect for the 8086 has a software background). There seems to be a relaxation of interest in GaAs with Intel feeling that its new high speed HMOS process introduced in 1977 has a lot of growth left.

ENGINEERING/TECHNOLOGY STRATEGIES

Intel employs high technology, principally silicon-based, in state-of-the-art products.

FINANCIAL STRATEGIES

Microprocessors now represent more than a third of corporate revenues. Corporate sales may rise 20 percent a year through the early 1980's with industry growth at a faster rate (perhaps 30 percent for microprocessors and 25 percent for memories). Intel invested $4.5 million in plant and equipment in 1977 while maintaining no debt. Intel plans on self-financing its growth and maintaining its strong cash position. Pretax margins in 1977 were maintained at close to 1976 levels despite rapid price declines in many product areas. Intel has 8,100 employees, and 38 percent of sales are overseas.

COMPETITOR OVERVIEW: PHILIPS N.V. AND NORTH AMERICAN PHILIPS

INTRODUCTION

Philips N.V. is a #13.7 billion (1977) firm based in the Netherlands which manufactures nearly a million different products ranging from light bulbs to toasters to computers.

North American Philips is a $1.9 billion (1977) company operating primarily in the U.S. and is 60 percent owned by the U.S. Philips Trust. North American Philips produces products ranging from mobile homes to integrated circuits.

After acquiring Phy Unicam, Philips N.V. could and does claim that it is the oldest test and measurement instrument company in the world. . . .founded in 1896, which is one year before Marconi invented the wireless telegraph. Philips has been strong in specifically oscilloscopes since before World War II, although immediately after the war they gave other areas higher priorities.

Philips N.V. is an international company, not a Dutch company. They are noted for their staying power: they think in terms of the broad sweep of decades and how to remain viable in the midst of wars and world calamities. In general, Philips is slow to market but persistent and powerful once they are there. They have a consumer products focus. They are much more than a holding company, for they can conceive and execute coherent strategies on a worldwide basis.

PRODUCT STRATEGY

Recently Philips announced for delivery in 1980 a flat panel television set with a picture in three-dimensions. Despite this announcement and other similarly startling products, in general Philips, particularly in the Test and Measurement areas, is more known for its reliable, me-too, and easy to use products than for high technology products. Their product lines are pruned with a carefully controlled breadth and depth.

Philips test equipment is oriented towards high volume, medium to low price areas. Philips usually meets competition head-on rather than resorting to product or application niches.

MARKETING STRATEGY

As a company, Philips is long-term oriented and persistent. In the few product areas, such as mainframe computers in Europe, where they have retreated, they have done so only after substantial losses far beyond what most companies would have tolerated.

Perhaps because they are at heart a consumer goods firm, and perhaps because of its orientation to decades of time, Philips shows no hesitation about purchasing world market share with slim margins, high volumes, me-too products, aggressive marketing, and manufacturing economies. They seem willing to pursue this strategy even in industries, such as instruments, that seem far removed from consumer goods.

Philips tailors their marketing strategies to each country and prices products selectively by country to achieve local goals. They prefer to pick off new countries one at a time. In the U.S. in instruments they are currently engaged in trying to buy market share on a price basis.

Philips uses both distributors and direct sales forces to sell Test and Measurement equipment. They have a major account focus, particularly in the U.S., and are capable of aggressive discounting to achieve targets in a particular country are area.

Test and Measurement sales of Philips N.V. are estimated at $70 to 75 million internally (1977) and $70 to 75 million externally (of which perhaps 10 percent was in the U.S.). Oscilloscope sales in 1977 may have been about $23 to 26 million in 1977 of which perhaps $6 million represented sales in the U.S. In 1976 Philips may have had a 17 percent share in portables in Europe and a 25 percent market share in low cost scopes.

Philips' oscilloscopes are designed with an apparently sophisticated regard for customer purchase behavior, almost as if scopes were another consumer good to Philips. Selling strategies in the U.S. are executed by North American Philips.

Philip's world efforts in instruments are aided by the overall company sales organization which operates in 60 countries. About 63 percent of Philip's sales are in Europe, and 17 percent are in North America (1977).

MANAGEMENT

Philips N.V. is organized into five major divisions (until 1977 there were 13 divisions): Lighting and Battery (9 percent of sales), Home Electronics for Sound and Vision (30 percent), Domestic Appliances and Personal Care Products (10 percent), Products and Systems for Professional Applications (24 percent), Industrial Supplies (17 percent). (In its Annual Report Philips also reports revenues from Miscellaneous Activities (10 percent). Philips also has (records and tapes).

Philips has a consensus form of governance which outsiders often have a difficult time understanding. For example, a typical organization will have chains of command along finance, engineering, and marketing lines; but it is unclear who is responsible for the general management of what we would call a business unit.

In any case, Philips employees are generally hired for life, so there is apparently time for its managers to learn its complex but effective management culture.

Although turnover at the very top appears to be low (and key senior positions seem held mostly by Dutch), young managers get tested early and effectively and find their careers dependent upon the results they achieve. This managerial testing against results depends upon the presence of goals, and the Central Group of Philips seems as able to provide strong strategic directions as they are able to act decisively to see that the middle managers work successfully for the goals that have been set.

Although Philips can develop strategies that lead to internally generated growth, Philip's appears to prefer to grow through acquisitions. These acquisitions are often bold and imaginative, and acquired companies such as Signetics and Magnavox often do much better under their new owners.

Although management strength is characteristic of Philips, their return on sales in 1977 was only 2.2 percent and return on equity was 6.1 percent. These returns need to be seen in the light of Philips long-term orientation, the effect of their growth through acquisitions policy, and the fact that their accounting conventions seem to understate earnings.

North American Philips is organized into four principal product groups: electrical/electronic (lighting, electronic controls, components); professional (communications, data, medical); consumer (Magnavox TV, Norelco personal care and home applications); and drugs and chemicals. Philips Test and Measuring Instruments is a subsidiary of North American Philips.

North American Philips grows principally by acquisitions and joint ventures (Magnavox and Signetics). North American Philips executives the Philips sales strategy in the U.S. by targeting on major accounts and stressing reliability, lower prices, advertising, and human engineering. They are perhaps best known for their mobile teams of experienced salespeople and their willingness to negotiate prices.

MANUFACTURING STRATEGIES

Wherever possible Philips manufactures in the countries in which they sell. By manufacturing at least some of their line locally, they can act as a national in each country, which is often to their distinct advantage. Overall, Philips manufacturing strategies are oriented towards high volumes and vertical integration.

TECHNOLOGY STRATEGIES

Although Philips Labs conducts research in advanced areas, in practice Philips products tend to employ medium or well-proven technology. One exception is in the area of human engineering, which is a large and well-funded function and which allows Philips to offer products, including instruments, which are state-of-the-art in terms of ease of use.

FINANCIAL STRATEGY

In general Philips is a conservative company whose enormous size creates an awesome financial potential. This potential is reduced in practice by the facts that its consensus of governance at the top makes it very hard for its managers to treat one area as a cash cow in order to fund opportunities in another area.