AIDC Memoirs

by

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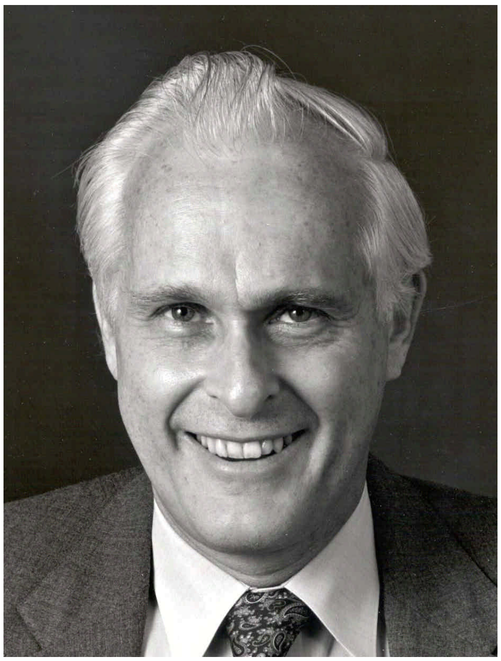

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Chapter I – Introduction

To the extent that I have been able to contribute to the AIDC field, credit belongs to my parents, professors, and mentors. Along the way I have made some choices, but perhaps only two have had lasting significance. The first great choice was 48 years ago when I married my lifetime companion, Gay. The second was ten years later when I left the security of IBM to join a startup company (Interface Mechanisms) as its chief engineer.

For 38 years I have been immersed in and sometimes influenced the development of AIDC. Following are some recollections.

Chapter II – Before AIDC

During freshmen orientation week at the University of Arizona I had planned to sign up for pre-law. As I strolled through campus with two friends I spied the law college and, curious, found my way into a cavernous room lined with leather-bound volumes. I could not imagine four years of captivity in this dungeon. Thus, I joined my friends Tom and Bill as we signed up for mechanical engineering. Little did I suspect that decades later I would interact with attorneys by serving as an expert witness in over a dozen patent litigation cases involving bar code.

My choice of employer was also influenced by chance. Only because of a scheduling conflict did I enroll in a class on digital computers circa 1957 – punched card machines and the IBM 650 drum computer. Inspired by the charismatic professor who taught this course, I applied for a job at IBM in San Jose, CA and was hired the following January. My 10 years with IBM (initially their Research Division then the Advanced Systems Development Division) were an ideal preamble to my later work in AIDC.

My mentor through the IBM years was Norm Vogel, who exuded boundless enthusiasm, positive guidance, and always had an open door. Norm was influential in my getting an IBM scholarship to Stanford for 3 years of study leading to a Ph.D in electrical engineering with emphasis on information theory and pattern recognition. One of my contemporaries at IBM was Paul McEnroe who later co-authored the influential IBM paper on Delta Distance Bar Codes – the direct antecedent to the UPC symbol.

One of my poor choices was agreeing to move to the IBM facility in Yorktown Heights, NY. Here, close to corporate headquarters, it became clear to me that upper management would continue its pattern of rejecting our division's technically advanced but risky proposals. Although the content of my work was interesting, it was discouraging to contemplate that it would ultimately be discarded and thus provide no value to society. Furthermore, my wife, four kids, and cat didn't prefer New York, having come from Arizona and California. After less than a year I decided it was time to return to the West and escape the constraints of a giant corporation. Incidentally, IBM closed down its Advanced Systems Development Division within a year of my departure.

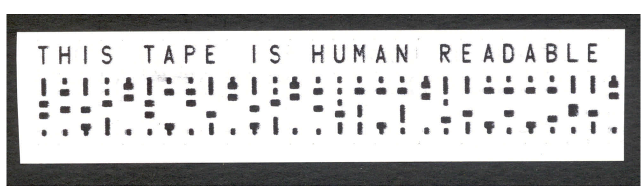
Chapter III – Joining Interface Mechanisms

While on an IBM business trip in the summer of 1968, I arranged some free time to visit my stockbroker, Dale Crow in Palo Alto, CA. I explained my frustration with IBM and my desire to move to a smaller company based somewhere in the West. Dale, noting that the stock market was closed for the day, offered to introduce me to a client who might be helpful. Two blocks down the street we entered an office labeled Dilling and Rawlins – Consulting Engineers. Thus, I met Bob Rawlins, one of the pioneering venture capitalists.

Of the several companies described by Mr. Rawlins, the one which most appealed to me was Interface Mechanisms located near Seattle, WA. That evening Gay and I had dinner with its managing partner, Ray Dilling, who subsequently hired me to be the company's chief engineer.

This infant company, later named Intermec, had no product, no customers, and no revenue. Its only asset, other than startup capital, was a plan to develop a better paper tape for data storage and communication. In 1968, computers were costly, data communications were primitive, and punched paper tape was widely used to record and store information. Ray Dilling conceived the idea of printing a paper tape rather than punching holes in it. Ray named his invention "Dual Image" because it contained both text and data. Dual Image Tape as shown in Figure 1 is one of the earliest examples of bar code being implemented on a commercial scale.

Fig 1 - Ray Dilling and a Sample of Dual Image Tape



Over 1000 Dual Image printers and perhaps 300 readers were sold to Compugraphic Corporation for use in composing printed text, primarily columns for newspapers and magazines. Unfortunately, the rapid advance of technology soon made all paper tape obsolete and we could find no lasting market for Dual Image. Three years had passed, we still had no viable products, and our funding was nearly exhausted. The company faced liquidation, and I would be unemployed.

Chapter IV – Plessey – The First Linear Bar Code Printer

In England, the Plessey Company was marketing a library circulation system based on unique bar coded labels in every book (see AIDC Memoirs by Paul Bergé – Chapter 2). Plessey had altered IBM electric typewriters so they could be used to print their bar code on book labels, but the machines were slow and broke down frequently. The Company had approached a dozen established manufacturers of printing equipment to interest them in developing a bar code label printer that would meet Plessey's specifications. None were interested, however, when they learned that only a few hundred such machines would be needed. In October 1971 Plessey inquired through Harvey Ulijohn, our distributor in the UK, whether the Dual Image printer might be adapted to produce their bar code labels.

Plessey needed a reliable device to print proprietary bar code labels to exacting tolerances. Intermec needed a product with a future. Exchanging letters over the Atlantic to get technical specifications for the Plessey symbology consumed about a month. I then embarked on an intensive six-week project to re-engineer the Dual Image printer.

In Plessey bar code, the narrow bar is toleranced to plus or minus one mil (0.001 inch), so the printed bars had to be precise with crisp edges. The Dual Image print wheel turning at 1790 rpm caused a pronounced shadow at the right edge. Because there was no time to construct pulleys and bearing mounts, I obtained a variable frequency AC power source and connected it to the drive motor. Reducing the usual 60 Hz frequency to about 14 HZ slowed the print wheel down to the ideal 400 rpm. Aided by Todd Glover, Intermec's skilled machinist who planted precision steel bars in the Dual Image wheel, I developed a primitive bench model that produced near-perfect Plessey bar code symbols. These symbols were printed on the paper tape normally used for Dual Image. My breadboard device and the Plessey Code symbol it produced are shown in Figures 2 and 3.

Figure 2 –Bread Board Plessey Code Printer

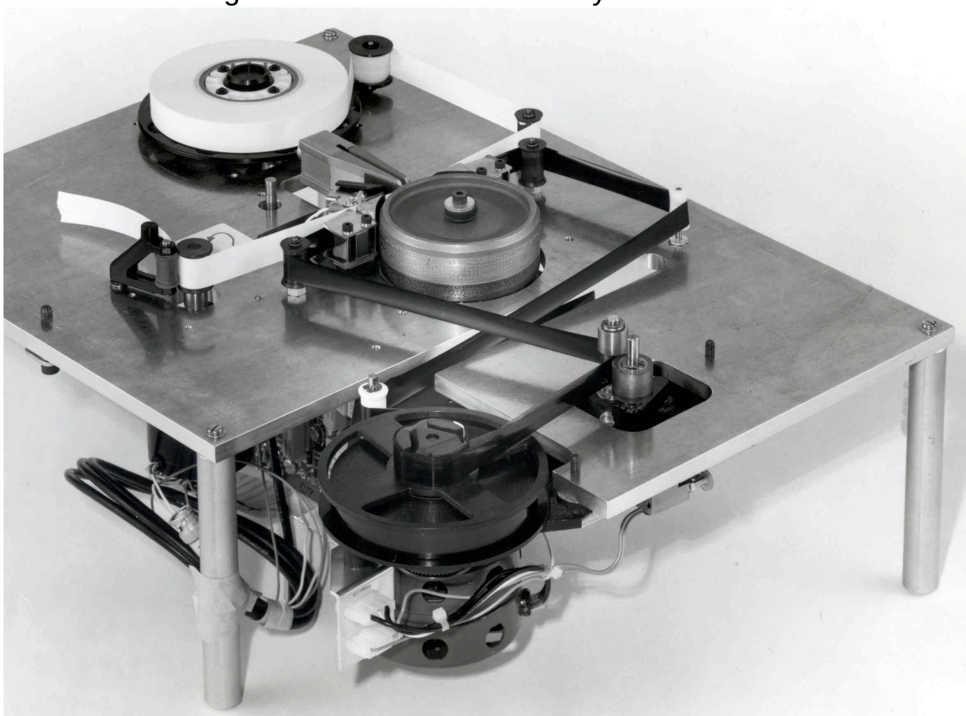


Figure 3 – Plessey Code Printed on Paper Tape, 1971

I journeyed to Poole, England with a proposal and print samples in hand. A Plessey technician took my printed samples into the lab and emerged shouting, "These really scan!" No other potential supplier had done this.

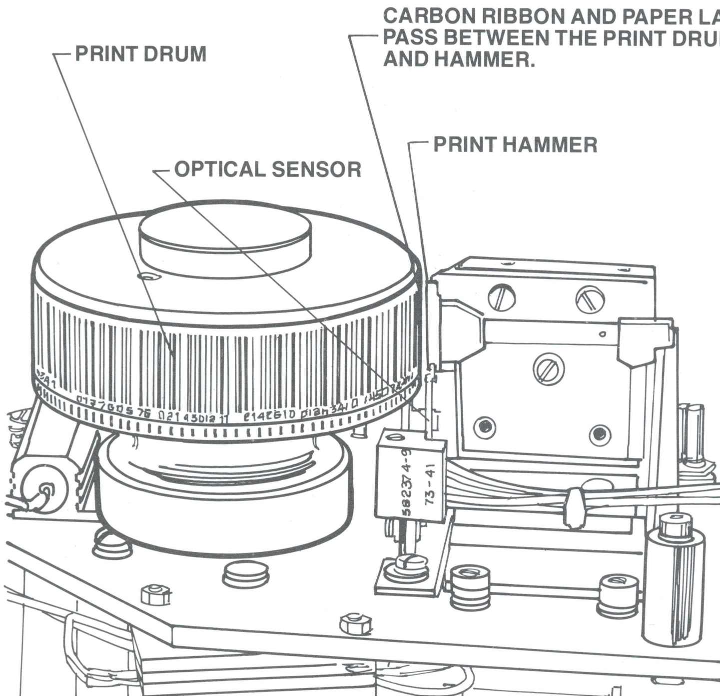
Based on its Plessey contract, Intermec raised new capital, completed development of the Plessey bar code label printer, and the company was reborn.

Prior to signing a development contract with Intermec, Plessey required that we provide a financial statement. Some years later, Plessey's project manager, Frank Cook, confessed that our finances were so scary (red ink and negative net worth) that he "lost" it in his desk rather than forwarding it to company headquarters. He knew that Plessey's executives would never approve the project if they knew we were technically bankrupt. Frank Cook believed in us, and his company was rewarded with a good product solution.

Today, high-quality bar code symbols are produced on demand by laser printers, thermal printers, and ink jet. However, until about 1984, none of these technologies had been commercialized. The bar code label printers developed by Intermec were electromechanical devices wherein bars and text were engraved on a rotating metal drum.

A powerful electro magnet drove a shaped hammer against the label backing, forcing the face of the label against a carbon coated ribbon backed by the rotating print drum (Figure 4). Timing of the hammer impact was critical to assure accurate bar code printing. From 1972 through the mid 1980s over 15,000 Intermec impact printers were delivered and installed in customer sites.

Figure 4 Intermec Printing Mechanism, 1972 to 1985



Chapter V – Other Early Bar Codes

Codabar. Shortly after the Plessey printers went into production, a local Seattle company CX Systems asked Intermec to develop a printing mechanism for Codabar labels. CX manufactured film-processing machinery and wished to automatically place a bar code label on each envelope containing finished photographs. The CX project positioned Intermec to provide Codabar printers to others including Dupont, Markem, Matsushita in Japan, and directly to Monarch Marking Systems, the inventor and primary sponsor of Codabar. Intermec maintained a long supplier relationship with Monarch whereby Intermec provided Monarch branded Codabar printers. We always had a good relationship with the engineering staff at Monarch and particularly with Monarch VP Bud Klein.

Nixdorf. The Nixdorf Computer Company of Germany sent Dr. Hartmut Fetzer to visit Intermec in May 1973 to negotiate the purchase of two prototype printers for Nixdorf code. These were to be used in Europe for generating retail price labels. Over the next several years, Intermec produced several hundred of these Nixdorf code printers. Nixdorf was always a demanding customer. Their stringent requirements forced Intermec to a higher standard of quality. After the EAN standard was adopted in late 1976, Nixdorf code gradually faded away.

Chapter VI – Computer Identics and Interleaved 2 of 5

In October 1972, I traveled to Boston to meet with Dave Collins, John Hill, and Chuck Mara of Computer Identics, which company at the time was about four times the size of Intermec. Computer Identics needed to label corrugated cartons that would be scanned as they moved along a conveyor. Each bar code symbol containing four to six digits of data would be affixed to the carton in a ladder orientation for scanning by a fixed vertical laser beam. Traditional 2 of 5 was the symbology of choice. Achieving a sufficient aspect ratio for reliable scanning would require the bars to be 1½ inches tall. At the time, Intermec printers were limited to ¾ inch tall bars and increasing this height would have entailed a significant engineering and tooling investment.

After some discussion, we agreed that if I could come up with an alternate symbology that was more compact than 2 of 5, they would be receptive to purchasing several of our printers. Their systems would require a fixed length in each application, thus eliminating the need for robust start and stop characters. While flying back to Seattle, I sketched out the specifications for Interleaved 2 of 5. My motivation was simply to sell a few printers. Little did I suspect that this primitive symbology was destined to be standardized and widely adopted for many applications including shipping containers, multi-packs, and casino coupons.

Over the years Intermec sold a modest number of printers to Computer Identics. More importantly, we got to know Dave Collins, John Hill, Ed Anderson, and Ted Williams, each a pioneer in the AIDC world. The late Ted Williams would subsequently create Code 128, Code 1, Code 16K, and more recently the RSS family of space-efficient linear symbologies.

The move to establish a standard format and bar code for shipping containers began in 1977 with the formation of the Distribution Symbology Study Group (DSSG) led by Bill Maginnis of Hunt-Wesson Foods. Their first attempt to specify a shipping container symbol structured in a similar fashion to UPC was unsuccessful. Testing over the next several years suggested the need for a more robust symbology that could stand up to the uneven surface of corrugated linerboard. I suggested interleaved 2 of 5 for their application and recommended an aspect ratio of 2.5 to 1.

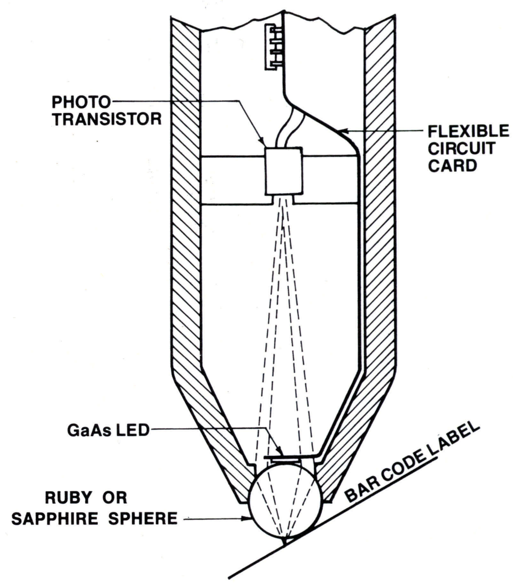
I recall one intensive day's meeting where Chuck Mara, Bill McGinnis, and I drafted the specification for Interleaved 2 of 5 on shipping containers published by AIM as "UCS-TCS Recommended Practices for Uniform Container Symbols & Transport Case Symbols". In 1982 the Uniform Code Council endorsed Interleaved 2 of 5 for shipping containers in retail logistics, revised some details of the DSSG publication, and republished the specification as the UPC Shipping Container Symbol Specification Manual.

Chapter VII – Bar Code Readers

When we first exhibited the Intermec label printer at trade shows, we found that most attendees were ignorant of bar code, so our product held no interest. At subsequent shows, we showed a Monarch bar code reader plugged into a CRT terminal. Visitors could wand a bar code symbol and the characters would magically appear on the screen. We soon realized that Intermec needed to sell bar code readers to stimulate the market for our printers. This need inspired my invention of the Ruby Wand.

Wand Readers. In the fall of 1972, we recognized that a bar code reading wand needed to be simple and durable. A wand with a hole in the end (such as the original Plessey device) could permit the buildup of paper dust. A flat glass tip could be scratched by abrasive paper and unless rounded at the edges would abrade the bar code being scanned. After some days of pondering and sketching, I came up with the solution. The wand tip would be an industrial ruby or sapphire ball acting both as a lens and a contact surface. Initial modeling showed promise and a patent application was filed resulting in US patent 3,784,794 (see Figure 5).

Figure 5 – Ruby Wand Cross Section



Schematic of Intermec's RUBY WAND Scanner

The ruby wand design refined for production used an infrared light emitting diode (LED) chip mounted on a flexible printed circuit. Over time this basic design remained, but later wands also used visible red LEDs. Aluminum bodied wands gave way to stainless steel for harsh industrial applications.

Intermec's first decoder was an ugly breadboard with components, wires, and power supply in a makeshift box. I recall a trip to Southern California with this device and several ruby wands to be demonstrated to MSI Corporation. The inspection of carry on baggage had just begun. The security officer pointed to the breadboard reader and asked, "What is that? My companion Rudy Host answered, "It's a sophisticated electronic device". "Oh, that's ok then", replied the inspector.

Intermec's first production decoder resembled a black breadbox with a chrome handle. Inside, three of its four circuit boards were the same as those used in our label printers. The next generation readers were half that size and the third generation was the size of a small book as shown in Figure 6. By the 1990s, decoders would be built on circuit boards smaller that one square inch.

Figure 6 – Intermec Model 9300 Reader, 1980 - 1983

Hand Held Laser Scanners. In 1981, Symbol Technologies began promoting hand held laser scanners to the US Department of Defense and others. Soon the market for Symbol's invention showed great promise, so Intermec needed its own hand held laser scanner. In early 1982, discussions began with both Symbol Technologies and Spectra Physics. From May until September 1982, a purchase contract for Symbol's emerging LS 7000 was discussed with Symbol's president Jerry Swartz. At the time, Symbol was a small struggling entity with minimal manufacturing capability. For this and other reasons, Intermec decided to partner with Spectra Physics to develop an appropriate scanner. At the time Spectra Physics was the leader in laser based products and the dominant producer of counter-top, omni-directional retail point of sale scanners.

At a June 4, 1982 meeting with Spectra Physics' Steve Bissell, Mike Hodges and others, it was determined that Spectra physics would develop and manufacture the units. Intermec would co-fund the product development in exchange for pre-negotiated and stable pricing. The initial meeting laid out technical guidelines and a preliminary schedule.

At a subsequent design meeting, three wooden industrial design models were presented by Roger Palmer, Intermec's VP Engineering. Roger named our favorite the "Duck" because its profile resembling a duck head. Spectra chose to mount the scanning mirror using a commercial component that supported the oscillating member on captive flexure springs rather than using a conventional stepping motor. Pilot production began in July

1983. The Duck, now called the Intermec 1600 Laser Scanner (Figure 7), was featured in Intermec's 1983 annual report.

Figure 7 – The Duck, 1983

The pilot scanners worked well as long as no one dropped them. Unfortunately, when dropped the fragile component used to mount the scanning mirror broke, rendering the scanner inoperable. This problem delayed the production rollout while limit stops were incorporated into the design. Subsequently, the 1600 became a good product with many units sold.

Over time, the management changed at Spectra Physics' Eugene, OR facility and development of the next generation hand held scanners languished. Meanwhile, the Symbol 7000 was improved to provide substantially greater depth of field. Consequently, I negotiated a purchase contract (May 1985) with Symbol Technologies' Ray Martino for their LS-7000-II, and Symbol became Intermec's primary supplier of laser scanners.

Chapter VIII – UPC

Opportunity and Challenge. In January 1973, we became aware of the grocery industry ad hoc committee's project to develop a standard bar code symbol for all products sold in supermarkets. Anticipating the opportunity of selling printers, we obtained and read the requirements and the specifications for the proposed symbols. The six companies proposing symbols were IBM, Litton, Pitney Bowes (Monarch Marking Systems), RCA, Scanner, Inc., and Singer. The candidate symbols included three bar codes, a bull's eye, a half bull's eye, and an ORC font. As I studied the specifications, it became clear that the Intermec impact printer could easily be adapted to produce the Pitney Bowes symbol (modified Codabar). It would be much more difficult for our printer to produce the IBM symbol.

The committee's symbol selection was announced in April 3, 1973. From the wording of the announcement, the choice could be either the IBM symbol or Pitney Bowes "Food Codabar". A phone call to Larry Russell at McKinsey & Co. confirmed, however that

UPC would be much more like the IBM symbol and that written specifications would be available May 1.

Ray Stevens (Intermec's eastern region sales representative) happened to be visiting Toledo Scale shortly after the UPC symbol selection was announced. Toledo Scale wanted to have a UPC printer interfaced with one of their meat scales in the big Food Marketing Institute (FMI) show in Dallas the week of May 5. Ray initiated a phone conversation between Don Hall (Toledo's VP Engineering) and me to decide how we could support Toledo in this big show. After some discussion we agreed to build a printer for Food Codabar because time did not permit the engineering required to print the IBM symbol. We would rent this printer to Toledo Scale and ship it to them in two weeks so that they could develop the scale interface in time for the show. When I first talked to Don Hall he came across as somewhat abrasive and doubtful that we could deliver as promised. However, as soon as Don came to appreciate Intermec's integrity, we became fast friends.

On April 6 I called my former IBM colleague and friend Paul McEnroe to let him know that Intermec would be developing impact printers to produce UPC labels. Paul agreed to pass along the information to IBM management and to meet me at the upcoming FMI show.

For Intermec, the excitement surrounding UPC at the FMI show was a huge boost to our optimism about the future of bar code and hence the survival and growth prospects for the company. On the evening of May 8, Ray Stevens and I sat with Lou Kohler (Toledo Scale marketing) as we hammered out the requirements for a keyboard driven UPC label printer to be branded and sold by Toledo. This was the beginning of a 12 year relationship between Toledo Scale and Intermec whereby we provided them with many thousands of impact printers.

Hobart, Toledo's principal competitor for supermarket meat scale systems, contacted me at the FMI show and a purchase agreement for Intermec printers followed within a few months. Hobart would also purchase thousands of our printers in the coming years.

Sales opportunities for UPC printers abounded but we had yet to figure out how to print the symbol. When printing other symbologies (excluding low density Interleaved 2 of 5 printed one bar at a time), the bar height was only 0.3 inch. The hammer blow could produce good coverage of black carbon pigment within the bars so long as the total area to be printed in a single impact was modest. The UPC specification required a minimum bar height of 0.72 inch, more than twice that of other symbols. Moreover, stringent tolerances required that each symbol character be printed with a single impact. Finally, the character-to-character spacing including the irregular spacing for the center guard pattern had to be maintained to an exacting tolerance.

Solving these problems and producing a working prototype took nearly four months, with our first UPC symbols printed on August 29, 1973. We cheated a little. Our symbol was only 0.73 magnification (x = 9. 5 mils) compared with the specified minimum 0.8

magnification (x = 10.4 mils). Our bars were only 0.65 inch tall but should have been 0.72 inch. However, our undersized symbols performed well when scanned by omni-directional POS laser scanners. Within several months we enlarged the symbol to the required 0.8 magnification.

My solution to the problem of printing the larger area UPC symbol characters was to print all of the five and four module characters (left 3,6,7,8 and right 0,1,2,4,5,9) in two impacts. The first impact outlined the bars and the second impact filled in the outline. After each symbol character was printed, the label stock was moved forward to the next character position by a polyurethane capstan driven by a stepping motor. This technique had worked well printing Codabar and other discrete symbologies. Our prototype UPC printer appeared to run ok in the moderate humidity and temperature of Seattle but we had no time for extensive testing.

The first public showing of Intermec's UPC printer was at the NRMA retail show in southern California on October 8, 1973. Here we were, nascent Intermec, with an untested prototype to be presented as a product ready for sale to large company representatives. As Dick Dilling and I demonstrated our new baby, we began to notice the printed symbol deteriorating. The leading spaces on the left hand characters and the trailing spaces on the right hand characters shrank and the overall symbol length diminished. Clearly the polyurethane capstan was either slipping or had grown smaller in the dry California air. We solved this problem at the show with a short-term chemical fix. Just before each program break when prospects would be gathering around, one of us would wet the capstan with methyl ethyl ketone. This powerful, flammable solvent activated the polyurethane causing it to expand and develop an abnormally high coefficient of friction. For perhaps the next half hour our prototype printer could produce pretty good UPC symbols. Later back at Intermec, a lot of engineering went into developing stable capstans that advanced the label reliably over a range of temperature and humidity.

As Intermec sold its UPC printer prototypes to major companies with exacting quality requirements (IBM, NCR, Toledo Scale, and Hobart) we got a lot of feedback and motivation to refine our design. Of all symbologies, UPC was the most difficult to print but represented by far the largest market opportunity. All of the early scanning supermarkets that were testing the UPC business model used Intermec printers to label the merchandise in the store. In July 1974, I first met Tom Brady of NCR, at the Marsh store in Troy, Ohio. I recall advising the NCR and Marsh people how to keep their Intermec printers pounding away reliably for hours on end.

STAC Committee. On October 4, 1973, I joined the newly formed Symbol Technical Advisory Committee (STAC) in Dayton, Ohio with Dick Mindlin presiding. Dick had retired from NCR to manage the newborn Uniform Code Council UCC). Dick provided just the right leadership to the STAC committee of strong willed engineers from competing companies. After initial arguments pro and con, with Dick's guidance the group always arrived at consensus solutions to important industry problems.

Six STAC subcommittees were formed included one on scanning headed by Fran Beck, and one on in-store printing headed by Mark Zivan. A little later, Mark departed from STAC and I became chairman of the in-store printing group. The real work, forming the technical underpinnings of the UPC system, occurred in these subcommittees. After several years as separate committees, the scanning and printing groups were merged and Fran Beck and I were appointed co-chairmen.

An important early project of the STAC in-store printer subcommittee was to resolve the printing tolerances for UPC. As initially conceived by IBM, the printing tolerances were very exacting and could never be achieved by Intermec impact printers. The problem was that there was no space between characters, so that every one of the 30 bars and 29 spaces in the UPC symbol were subject to the same tight tolerance. Our solution was a compromise between the scanner manufacturers and Intermec, which became Appendix A to the UPC Symbol Specification. In Appendix A, the “inter-character” space and character-to-character pitch carried more liberal tolerances, thus enabling the use of Intermec drum printers.

At one STAC meeting we were privileged to have Joe Woodland of IBM address the group. Joe held the first patent filed in 1949 for a point of sale scanner reading a bull’s eye shaped bar code. In 1971 he had joined IBM to nurture the project that became UPC. In 1993 President George Bush awarded Joe Woodland the national medal of technology for his pioneering invention and contribution to the commercialization of bar code technology.

One of my long time colleagues at STAC was George Laurer, the true inventor of the IBM symbol and its refinement into the UPC symbol. George always had a fine sense of humor. During President Carter’s years of energy shortages and high unemployment George suggested that the simultaneous solution to both problems was public treadmills!

After some years, Dick Mindlin retired from UCC and Hal Juckett was appointed to replace him. STAC continued under Hal but the subcommittees were merged into a single group. In time, Hal Juckett was succeeded by Tom Rittenhouse as head of UCC and Dennis Epley took over the leadership of STAC which was renamed GSC (Global Symbology Committee). During this era, I was privileged to serve on GSC with many outstanding contributors to the UCC standards process. Particularly significant were the contributions of Craig Maddox (NCR), Andy Longacre (HHP), Ted Williams, Sprague Ackley (Intermec), and Clive Hoeberger (Zebra). I would also like to mention the dedication of Fran Beck and Rudy Faller, who continued to actively participate in STAC/UCC long after they retired from their respective companies.

Recently UCC merged into EAN and the whole organization was renamed GS1. At this writing GSC committee meetings have resumed under GS1 after a two year hiatus.

Verification of the UPC Symbol Throughout the early years the official position of the Uniform Code Council was that verification was unnecessary. The party line was that a procedure had been specified for creating accurate film masters and printing plates.

Correctly following this recommended procedure would assure that the resulting symbols would be acceptable. Unfortunately, the film master technique did not apply to in-store printed labels. Notwithstanding this exception, the council simply wanted the issue of verification to go away quietly.

Meanwhile thousands of Intermec impact printers were churning out UPC symbols which scanned well at the retail checkout counter. However, Mathews and other companies had developed verifiers that they claimed could measure the accuracy of printed bar codes and judge them against the published tolerances. End users who purchased these verifiers would use them on UPC symbols printed with Intermec equipment and complain to us when they were "out of tolerance" even though the symbols scanned well.

From time to time, a salesman would bring his verifier to Intermec and try to sell it. These verifiers were tabletop devices positioned over the symbol to be measured. I would present each salesman with a sample bar code and ask him to demonstrate his machine. The device would measure the width of every bar and space, print the dimensions, and highlight elements that were out of tolerance. I would then request a repeat measurement without moving anything. Inevitably, the two measurements would differ by more than a mil on some elements. Since the bar and space width tolerances were approximately 1½ mils, I would send the salesman on his way, inviting him to return when his product could be repeatable within one or two tenths of a mil. This type of verification device never produced credible measurements.

Later, Symbol Technologies came out with their "Laser Check" which Intermec and Toledo Scale found useful for ranking the quality of symbols produced by Intermec printers. As I recall, a 75% scanability rating was considered acceptable. Much later, we finally solved the enigma of verification (see Chapter XIII).

Chapter IX – Code 39

Background All of the early bar codes were numeric except Codabar, which represented 6 punctuation characters (- $: / . +) and four start/stop characters in addition to the ten digits. During 1973 and 1974 there were some low level inquiries about representing alphabetic characters in bar code. Ray Stevens had suggested a four-bar three-space code similar to Codabar but with shift characters enabling the full alphabet. However, Intermec had not yet developed this concept. It is important to remember that during this era, Intermec promoted those symbologies that were most compatible with its drum printers. Codabar, for example, could be printed faster than UPC and with less exacting printer adjustments.

The Beginning On December 19, 1974 several representatives of the Boeing Company were seated around Intermec's secondhand conference table in Mountlake Terrace, WA. I was at the blackboard (yes, a real black board with dusty chalk) explaining bar code using Codabar and Interleaved 2 of 5 as examples. One of the Boeing team explained that they would not be able to use bar code because their part numbers contained both letters and numbers. Being an impulsive young man, I said that's no problem; we'll develop a new bar code for you. I proceeded to illustrate a symbol character using the side of the chalk to draw the wide bars. The structure of five bars and four spaces including two wide bars and one wide space came to me in flash. The two of five coding in the bars afforded ten combinations and the wide space provided for four separate groups. Setting aside one of the 40 possible characters as a start and stop pattern left 39 characters; hence the name Code 39. My impulsive invention simply combined ideas from Gerry Wolfe's 2 of 5 Code with those of Bruce Dobras' Codabar.

After the Boeing people departed, I explained my insight to Ray Stevens, who responded, "I thought we could only print up to four bars". I replied that five should be ok if we kept the printed character width under one tenth inch. That evening in his motel room, Ray took a quad-rule pad and sketched a logical code chart for code 39. Intermec immediately began developing a Code 39 printer and decoder. In choosing dimensions for the bars and spaces, we were mindful of the characteristics of our drum printers and of the Ruby Wand. We settled on 7.5 mil narrow bars, an aspect ratio of 2.24, and an inter-character gap of 11 mils. A nominal ten characters per inch would have been nice, but we settled for 9.4 in the interest of performance. Within a couple of weeks, we had an operating Code 39 printer and a functioning decoder.

One of our first customers was Mitre Corporation under contract to the US Air Force. This early sale and having Ray Stevens work directly with the Mitre people sowed the seeds for having the LOGMARS program choose Code 39. Many manufacturing companies recognized the utility in Code 39 and began buying sample quantities of printers and readers. And yes, in time Boeing became one of Intermec's largest customers.

US Department of Defense Chapter 10 of Ben Nelson's excellent book tells the story of the LOGMARS program and the adoption of Code 39 by the US Department of Defense.

While this DOD committee was evaluating alternative bar codes, they invited Intermec to make a presentation about Code 39. We had short notice of this critical meeting and the large Marriott near the Pentagon was oversold. Ray Stevens recalled that he had seen a nondescript motel nearby and persuaded the Marriott operator to look up its phone number for him. As I recall we arrived in Washington, DC late at night, Ray from Boston and I from Seattle. Our presentation was to be at 8:00 the next morning. We were assigned the last two rooms in this sleazy motel. When I crawled into bed it rolled like a ship at sea. Indeed, it was an early waterbed. What was worse, the water was unheated, so it was really cold. My solution for the remainder of the short night was to sleep on the floor.

We arrived at the big meeting a few minutes early to set up our equipment. The room was swarming with captains, majors, colonels, and navy commanders, together with guys like Mike Noll in suits. Alas, Ray and I had communicated imperfectly. I had brought a couple of ruby wands and expected Ray to bring an Intermec decoder. Ray thought I was bringing both wands and decoder. He had brought an early prototype battery powered reader made by a small New England company, but its performance was flaky.

My slide show explaining the strong, self-checking properties of Code 39 went well. Ray demonstrated one swipe of the Ruby Wand, which luckily produced a satisfying beep. We skipped our plan to encourage the audience to try their hand at wanding Code 39. I guess we did ok because LOGMARS in its comprehensive report published 1 September 1981 selected Code 39.

The Automobile Industry Code 39 rapidly gained acceptance for tracking components through the car assembly process. I recall several visits to General Motors and Delco operations to observe Intermec products in action and understand problems. These visits were always educational. While visiting the Oldsmobile assembly plant in Lansing, MI with Bob LaMoreaux I noticed a cascade of two bar code readers each from a different manufacturer. I asked why just one of these readers wouldn't work as well or better. Bob answered, "Technically you are right, but the obsolete reader was not fully depreciated so we could not get funding to replace it." However, it was easy to get approval for adding onto the older device. Thus I learned that in the large corporate world, finance dominates both engineering and common sense.

Through the work of the Automotive Industry Action Group (AIAG) bar code standards were extended through their supply chain as explained in Chapter 11 of Ben Nelson's book. Code 39 was the chosen symbology. I recall several meetings with Don Dubuc at the General Motors Technical Center to discuss the emerging AIAG standards and assure compatibility with Intermec's product plans.

Copyright The symbology of Code 39 was always in the public domain, but I made the mistake of having Intermec copyright the name "Code 39". This had the unintended consequence of promoting the alternate name "3 of 9 Bar Code". Intermec quickly and publicly abandoned its copyright but the damage was done. The DOD specifications called for 3 of 9 Bar Code and the user community became confused.

Chapter X – OCR

Personally, I never liked OCR as a data capture technology because I believed it to be an inferior competitor to bar code and bar code was at the core of Intermec's business. However, in the 1970s department stores through their trade association NRMA selected OCR-A as the standard for merchandise labeling. They considered the UPC bar code to be ugly and inappropriate for fashion merchandise. My, how times have changed!

In 1975, Dick Meyers of NCR contacted me to inquire about printing OCR-A. This and subsequent conversations stimulated Intermec to develop a feasibility model OCR drum printer which was provided to NCR for evaluation. At a meeting on September 24, 1976 chaired by Dick Meyers detailed specifications and price targets were discussed. There followed a long delay while NCR corporate generated the thickest contract Intermec had ever seen. It took more time to sort through the contract language and negotiate changes. Eventually, both parties signed and we began development.

The prototypes sent to NCR for approval failed their electrostatic and electromagnetic interference testing, thus requiring some circuit design changes. When it came time to ship production units, an NCR quality inspector arrived and nitpicked various details such as connector integrity. At last our quality was approved and in 1979 about 400 production units were shipped. We thought all of the quality issues were behind us.

Nine months later, we received a call from NCR systems test. When connected to the in-store computer, the printers failed electrostatic testing. It seems in previous tests at NCR no communication cable had been attached to the printer. This presented a serious problem for both parties. Intermec engineering modified the interface card until it passed the NCR systems test. Then we undertook the arduous retrofitting of 400 finished units packaged in their shipping cartons on racks in the NCR warehouse.

Some years later, we were informed that NCR had not sold as many printers as they had forecast and they still had about 200 surplus units. Would Intermec like to buy them back? No, thank you.

The final chapter came when Intermec received a purchase order from NCR South Africa for 100 OCR-A printers. Evidently, the 200 surplus units had been scrapped.

Over time the outstanding success of bar code scanning and UPC in particular contrasted with poor results with OCR at the point of sale. When the NRMA abandoned their support for OCR in favor of UPC the curtain fell on widespread use of OCR for point of sale data collection.

Chapter XI – Code 11 and Code 93

Code 11 In 1977 Intermec's printing and reading technology limited the density of Code 39 to 9.4 characters per inch. For numeric applications, Codabar provided somewhat higher density (12 characters per inch). However, at the time, Intermec was contractually obligated to sell Codabar printers only to Monarch Marking Systems. Interleaved 2 of 5 was not a discrete symbology and thus could not be printed at a high enough density by our drum printers.

I solved this problem with Code 11, which we could print and read at a density of 15 characters per inch. Code 11 was picked up as the standard for telecommunication equipment.

Code 93 When Computer Identics introduced Ted Williams' Code 128 in late 1981, Intermec viewed it as a competitive threat. Clearly, higher printing densities could be achieved with continuous (n, k) codes than with discrete symbologies like Code 39.

My response was Code 93. At 9 modules per character it was clearly denser than Code 128's 11 modules per character. In the long run, however, Code 128 won out because of its ability to compress numeric data.

Chapter XII – Code 49

In 1987, I began to think about the next evolution in bar code symbology. The prevailing linear bar codes were very effective for encoding moderate amounts of data on most types of objects. However, small objects and larger data requirements presented a challenge. When I became Chief Scientist (and not CEO) of Intermec, I had time to concentrate on the challenge of bar coding small objects. My solution was Code 49, a prototype of which was exhibited by Intermec at Scan Tech 1987.

Although the practical uses of Code 49 would be limited, it set the stage for the later development of PDF 417, which extended the stacked concept to the next level of density. Over time, PDF 417 and its variants have enjoyed wide acceptance.

Chapter XIII – Verification

Developing the measurement machine. In 1985 when Sprague Ackley became my technical assistant I challenged him to develop a technique for accurately measuring printed bar code. The optics of the measuring device should resemble those of a bar code scanner and measurements should be reproducible to a high degree of accuracy.

Over a two-year period Sprague and I conferred frequently to plan and evaluate his progress. His final apparatus was mounted on a heavy steel plate affixed to a 55 gallon drum filled with water, thus minimizing the effects of vibration. A micrometer stage held the printed bar code for accurate positioning in the axis parallel to the bars. The optics borrowed components from an Intermec fixed reader (similar to a wand but with greater depth of field) with a low voltage lamp illuminating the symbol from a 45 degree angle. A motorized drive moved the symbol slowly across the scanning spot while its exact position was measured by a laser interferometer.

The analog signal from reader was sampled, digitized, and fed into an IBM PC together with the instantaneous positions from the interferometer. The sequence of amplitude values was smoothed by linear regression to minimize random noise. We tried 5 different algorithms to locate the bar edges, and selected the one that gave the most consistent measurements for successive scans along the same track. The final result was the ability to reproduce successive measurements within 6 micro inches (152 nM). Best results were obtained on weekend nights free from AC power fluctuations, passing traffic, and airplane over flights.

Sprague and I had solved the problem of accurately and reproducibly measuring printed bar code symbols.

As a corollary, we observed that the signal amplitude in wide spaces exceeded that of narrow spaces even when the scanning spot diameter was considerably less than the X dimension. This had long been observed by bar code scanner people but dismissed by optical scientists as simply due to inferior optics. My explanation for this apparent paradox is that a paper or plastic substrate is partly translucent and the black bars cast shadows down into the spaces. We also learned that when measured correctly, the bars are wider and the spaces are narrower (by about 1 mil on typical samples) than would be measured by a human using an optical comparator.

ANSI X3A1. In 1982, this sub-committee of the American National Standards Institute had begun exploring the issue of bar code print quality. The chairman of this group was Chuck Biss, who welcomed the new information Sprague and I brought to the table. Initially, the sub-committee was concerned only with measuring contrast, but was receptive to expanding their charter to include printing accuracy. I advanced the principle of decodability as an appropriate predictor of scanner performance, superceding the classic plus or minus bar width tolerances. This dynamic group then added defects and modulation to the qualities to be measured. After much voluntary scanning of controlled samples, sharing our data, and vigorous discussion the first bar code print quality guideline was born as ANSI X3.182-1990. Later this was adopted as the international standard ISO/IEC 15416.

UPC. Subsequently, the Uniform Code Council realized the need for a verification standard for their retail symbols. I chaired a working group within STAC to correlate verifier grading with scanner performance, resulting in the published Quality Specifications for the U.P.C. Printed Symbol in 1994. I also co-managed with Fran Beck a subsequent STAC project to develop verification standards for corrugated shipping containers.

Chapter XIV – Teaching and Preaching

I always believed that spreading the word was not only good for the industry but also for Intermec. In 1982 I authored a booklet entitled "Bar Code Symbology – Some Observations on Theory and Practice" published by Intermec and revised in 1984 and 1989. Beginning with the first Scan tech in 1982, I became a frequent speaker explaining bar code and promoting its virtues. In addition to Scan Tech, I lectured at many ID Expos, APICS conferences, and at Ohio University's Auto ID Summer Institute for Professors. I particularly recall sharing these platforms with Ben Nelson, Kathleen Parsons, Dick Meyers, and Paul Bergé.

In preparation for these lectures, I created lots of 35 mm slides featuring the latest products and applications. In order to explain bar coding of variable weight items I purchased a one pound beef roast, affixed a prototype label Intermec had developed for Toledo Scale, and photographed the package (Figure 8).

Figure 8 – Integrated Label for Variable Weight

Shortly thereafter, a burglary occurred at our house in which the missing items included a valuable jade ring and my one pound roast. I presented the investigating officer with evidence including the photo of Figure 8. The thief was apprehended and the ring recovered because the police found the discarded meat wrapper at his campsite in the woods.

Paul Bergé and I were the featured speakers at a memorable conference in New Zealand in 1985. I had brought five carousels fully loaded with slides. Fortunately, on the afternoon before the conference I tested the projector and found that it jammed on every third or fourth slide. My mistake had been to assume that a Kodak carousel intended for domestic use would work properly with their international projectors. My hosts provided some compatible carousels so all went well the following day.

Back at Intermec in the 1985 time frame, we put together a traveling road show to educate customers and prospects about the technology, applications, and benefits of bar code. Steve Burr managed this program which he named "The Winning Edge". In addition to Intermec staff, we invited leading customers to present their own applications at these affairs. Tom Sweeny who later would join me at PathGuide was a regular contributor on the Winning Edge Circuit.

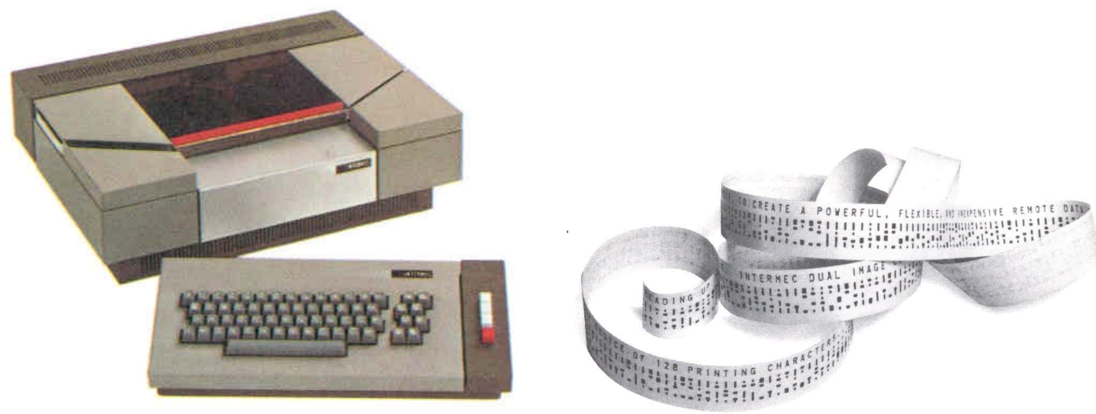
Chapter XV – Intermec , Startup to the Number One Bar Code Company

In October 1968 I left the lifetime security of IBM and joined Interface Mechanisms as its 17th employee and chief engineer. Five years later I would be elected president and CEO. Soon I would confront the three great problems of business; we can't make it, we can't sell it, or our money is gone. Later I would learn about a fourth problem – expectations of the investment community.

<u>The Beginning Years</u> During my first year I immersed myself in development engineering. This was a joy compared to the incessant project reviews and endless meetings at IBM.

Although Interface Mechanisms was two years old, it had yet to implement a functional Dual Image prototype. My first task was to mold the company's engineers and draftspersons (yes, we had a girl "draftsman" Margy Gangl) into an effective development team. I returned them to first principles by analyzing and breadboarding every subsystem and then applying the successful results to a complete redesign. Within a year we had a product, which not only ran reliably, but also received an award of excellence in the 12^{th} Annual WESCON Design competition. Our booth in the 1969 Fall Joint Computer Conference featured three working units in blue, green, and brown (Figure 9).

Figure 9 – Award Winning Dual Image Printer/Reader



This trade show brought a rude awakening. We had implemented better paper tape, but it was only a curiosity. Bankers suggested it might be used in retail. Retailers thought manufacturers might like it. Manufacturers indicated that it could appeal to banks. Although we finally had a solidly working product, our product had no market.

Our sales director, Harvey Ulijohn, tried valiantly to sell Dual Image by signing up manufacturers reps throughout the 48 contiguous states. I pitched in by traveling around the country to demonstrate Dual Image to our new sales team. All this activity resulted in only one sale, but it was big. Compugraphic Corporation of Wilmington, MA was planning to market a keyboard driven paper tape punch as a companion product to its new line of photocomposition machines. Intermec's rep for New England, Ray Stevens, talked Compugraphic into Dual Image instead.

In rapid sequence, we negotiated a contract, redesigned the Dual Image product to Compugraphic's specifications (separate keyboard/printer and rack mounted reader), and began production.

Our joy was short-lived. After shipping about 1000 printers, Compugraphic noticed that their warehouse contained 500 unsold units. The contract was terminated. At this point, Dick Dilling took up the challenge, moved to an apartment in New York City, and sold Dual Image printers to independent typesetters, one at a time and door to door. Over a three-month period, Dick sold 20 devices. It was a heroic sales process, but insufficient to support the company. There was to be no future in paper tape.

Keeping Baby Alive From its founding as a venture partnership on November 10, 1966 the company lost money in every one of eight successive years. How did it stay alive and breathing? The short answer is Ray Dilling's tremendous faith and the dogged persistence of our management team.

The partnership converted to a corporation on April 29, 1969 and I was elected Vice President, Engineering. The company had consumed all of its venture capital with losses totaling $906,000. An initial public stock offering by Hughbanks Incorporated was completed on November 12, 1969. Those were amazing times in which this company with no product and no market could sell stock to the public at $8.00 per share, raising $1.3 million in the process.

On March 31, 1971, with the Compugraphic contract in hand, a secondary offering to its existing shareholders raised an additional $450,000. Expenses exceeded income and all too soon our cash was again consumed. Intermec's common stock, which had climbed to about $12 per share after the initial offering, fell into a range of $0.25 to $1.25. In late 1972, with the Plessey contract (Chapter IV) in hand, Ray Dilling loaned the company $200,000 which he later converted to stock at $5 per share.

In early April 1973, I was elected President and CEO of Intermec, and Ray Dilling became non-executive chairman. A private placement of additional stock was initiated April 23, 1973 but poor market conditions prevented its culmination. However, in anticipation of repayment from the private placement, the company borrowed $175,000 from outside individuals. This was subsequently converted to common stock and two of these lenders joined the board of directors.

In early 1974 we began talking to David Putnam and Joe Baute at Markem, about the possibility of making an investment in Intermec. Markem was already a customer for our impact printers, and they foresaw the market developing with the advent of the UPC standard. On May 13, 1974, Markem purchased 150,000 shares of Intermec stock at $1 each with an option to acquire all the remaining shares of Intermec in any of three future years (1977, 1978, or 1979) for stated multiples of Intermec's pre-tax earnings. The Markem investment brought the cumulative total invested capital to $3,181,000.

Intermec earned a profit in the year ending March 31, 1975 and every fiscal year thereafter. Thus ended our desperate search for investment cash.

Managing Intermec In May 1973 I was elected President and CEO of Interface Mechanisms, Inc. Nine years later, we would change the official company name to Intermec.

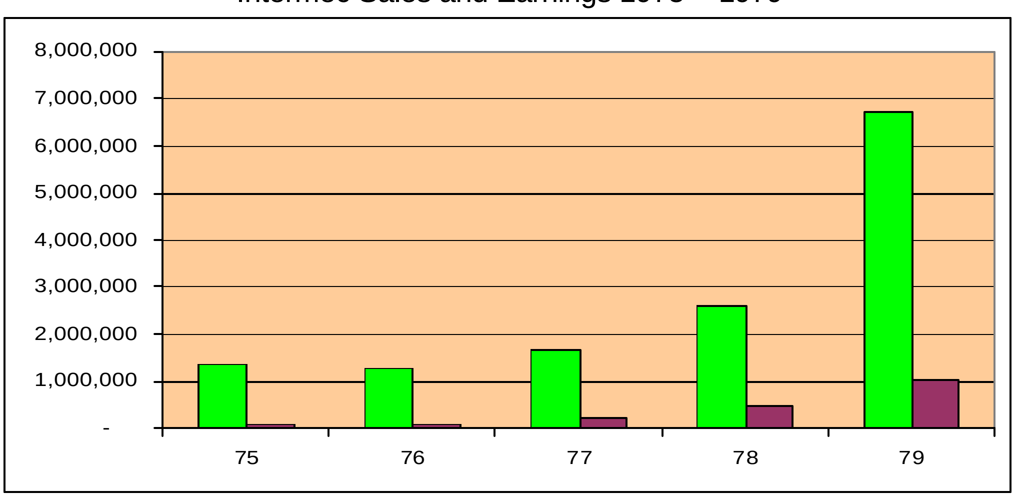
How did I feel about being president? It was exhilarating, fulfilling, and gratifying. In my experience, building a company is the most satisfying of professional experiences. However, I felt personally responsible for hundreds of Intermec employees and their families.

In early 1974, we believed that the company had a strong future. However, cash was still really tight. I gathered the employee team together and announced a voluntary salary deferral program. Each employee could elect to have a portion (up to 100%) of his or her salary deferred – i.e. not paid. If and when the company could afford it, the deferred salary would be repaid together with a 25% premium but there was no time limit specified. I led the way with 100% deferral and several others also agreed to take no pay. A majority of employees participated at some level with rank and file $6.00 per hour assembly workers kicking in 10%. It turned out that all deferrals were paid back in 16 months resulting in an 18% annual return to the participating employees.

Later, in better times, I instituted an unconventional form of profit sharing. Rather than contributing a share of profits to an employee's retirement (with near term tax advantages) Intermec's profit sharing was in the form of immediate cash. The reason for this was that the younger workers were simply not motivated by the concept of saving for retirement. Each fiscal quarter when the books were closed I called a company meeting at which I would announce the quarter's profit share. This was stated as a percentage of full time hours worked during the quarter and was paid immediately. Assembly workers frequently received quarterly bonuses exceeding $100. I believe this program helped all employees identify with company goals and put forth the extra effort needed toward the end of each quarter.

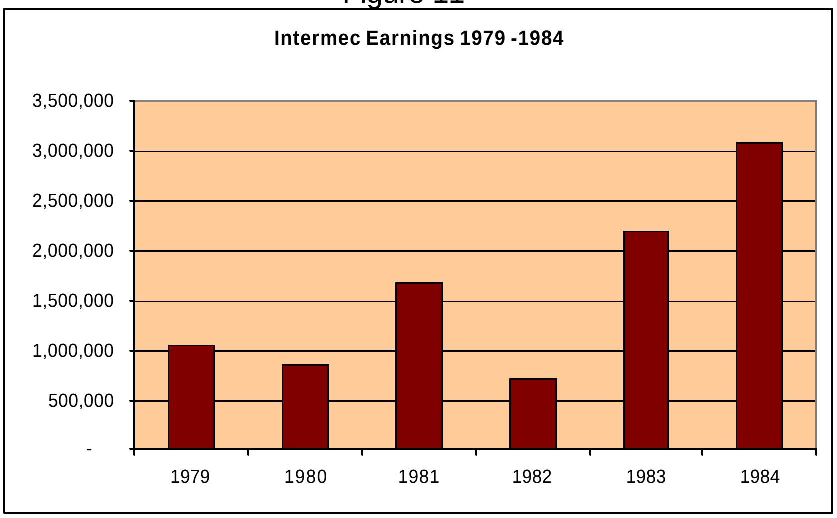
There was only one year (1978) of my 14 years as CEO when sales were not the dominant problem. That year, UPC scanning implementations were ramping up. Hobart and Toledo Scale placed one purchase order after another, each for hundreds of impact label printers. The year ending March 31, 1979 was spectacular for sales and profits as shown in Figure 10. Markem chose not to acquire the company for the high price (based on a multiple of Intermec earnings) required by our agreement, setting Intermec free to pursue its own destiny.

Figure 10
Intermec Sales and Earnings 1975 – 1979



Our small manufacturing operation was overwhelmed. The employee count grew in one year from 77 to 235. We hired warm bodies off the street including a couple of union organizers. It took several years to stabilize operations including the intensive communications needed to shake off the union threat. These problems resulted in the uneven profit over the next three years as shown in Figure 11.

Figure 11



During my years as president of Intermec, it was my privilege to lead a great team of people several of whom distinguished themselves in the wider AIDC community. Dick Dilling became Intermec's representative to AIM in about 1974. In a few years, Dick became Vice President of AIM and chairman of its communications committee. In 1983 Dick managed the successful Aim Scan Tech show in San Diego, but the following year Dick passed away from inoperable cancer. In his honor, AIM established the annual Richard Dilling award for outstanding contributions by an individual within the AIDC supplier industry.

Roger Palmer joined Intermec in 1982 to become Vice President, Engineering. I encouraged Roger to become a speaker at Scan Tech and other conferences and he soon became very effective. Later he authored the first complete textbook on bar coding "The Bar Code Book" published by Helmers. This excellent treatise has been updated every few years and is now in its fourth edition.

Sprague Ackley began his Intermec career as a manufacturing engineer with the challenge to routinize the process for manufacturing print wheels for our impact label printers. In short order, Sprague made this critical process into an engineered procedure with predictably high yield. It had previously been driven by tribal knowledge resulting in expensive over-production to compensate for erratic yield. Building on this success, Sprague became my technical assistant for special projects. In this position, he solved the age-old problem of bar code verification (see Chapter XIII). Subsequently, Sprague became a key contributor to several standards committees (AIM TSC & EAN/UCC GSC) and now heads the ISO/IEC JTC 1/SC31 Committee for bar code related standards development.

By 1983 we had developed the strong management team shown in Figure 12.

Figure 12 – Intermec Officers 1984
Left to right David Allais, Gerry Hastler CFO, Will Rogers VP Marketing, Larry Ellefson VP operations, Roger Palmer VP Engineering, and Charley Anderson Treasurer

After the accidental death of Ray Dilling in November 1981, my relationship with the Intermec board of directors deteriorated. The board was dissatisfied with the uneven progression of year-to-year profit and its effect on the price of Intermec stock. In September 1987, the board named Phillip Arneson CEO of Intermec and I was appointed Chief Scientist. I had learned too late that one of the most important jobs of a CEO is to manage his board.

Within 5 months Arneson resigned and John Paxton became CEO. Intermec was acquired by Litton Industries in 1991 although the company retained the Intermec name. Three more CEOs would pass through the leadership role before the company settled in with its current, stable management. In early 2006 Intermec regained full independence from the last residue of Litton and was listed on the New York stock exchange with symbol IN.

Flogging the Stock and Making the Numbers Prior to fiscal 1978, Intermec stock was obscurely listed in the pink sheets. No analyst followed the stock and few people outside the Seattle area had heard of the company. In 1977 we retained the services of Allen Nelson and Company who helped Intermec achieve NASDAQ listing. Allen introduced us to Seattle area analysts and upgraded our annual and quarterly reports.

After its spectacular growth spurt in 1979, Intermec became a "hot" stock and I briefly basked in the accolades of the investment community. Ever so briefly, I was golden.

For the next five or six years, Allen Nelson and I traveled to investor conferences for emerging growth companies in Monterey, CA where I presented ten minute slide shows promoting Intermec as an investment opportunity.

With the earnings disappointments of 1980, 1982, and 1986 I would instantly transition from hero to dog in the eyes of our investors. I recall numerous rude and uncomplimentary phone calls on those occasions. In time I learned to play the game of guiding analyst expectations and then struggling to exceed these expectations each quarter. The relentless pressure of quarterly earnings expectations dominated my decisions, a nasty problem that privately held companies do not have.

We had a good relationship with our OEM customers which helped us through a number of difficult quarter and year endings. For example, Toledo Scale's parent company was focused on return on assets and graded their subsidiaries accordingly. As a result Toledo wanted minimum inventory on the last day of every month. I recall the end of one fiscal year (March) when it was critical for the year's revenue and profit that we pull their 100 printers scheduled for April into March. The deal I made with Dick Miller (Toledo Scale's purchasing manager) was to ship the printers on a slow truck on the last day of March and to mail the invoice personal and confidential to him. In April we sent another invoice through regular channels. Thus both companies achieved their seemingly opposite financial objectives.

On another year-end occasion, I offered Monarch Marking a special deal. If they would order 40 printers to be invoiced in March, I would give them a large discount from the contract price. We would then hold their inventory in a preconfigured condition until each release at which time it would be configured and shipped. Our outside auditors that year were shown the shelf containing the "finished goods" owned by Monarch.

As Intermec grew, we needed more capital, resulting in public stock offerings in 1980 (Foster & Marshall and Piper, Jaffray and Hopwood) and 1984 (Dean Witter Reynolds and Piper, Jaffray, and Hopwood). For each of these offerings I had the opportunity of presenting the Intermec story to lunch meetings of institutional investors in Seattle, New York (yes, at Windows of the World atop a World Trade Center tower), San Francisco, and Los Angeles. Both offerings were oversubscribed and the new investors who held their stock did well. These public stock offerings increased the number of analysts and large investors following Intermec, bringing even more pressure on management to meet financial expectations.

As Intermec matured, more sales were made through distributors and a lesser percentage to OEMs such as Hobart, Toledo Scale, and Monarch. As the end of each fiscal period approached, we would offer our distributors special discounts and extended payment terms. Using this technique, we usually made the expected financial numbers but at the expense of longer-term profit. In time our distributors learned to wait for the impending end of each quarter before ordering inventory. As a consequence, Intermec's sales for the first two months of each quarter were relatively low.

Manufacturing and MRP. Back in the Dual Image and initial bar code era, sub-assemblies including finished printed circuit boards were stocked in open racks on the assembly floor and consumed when required. A somewhat generous inventory of piece parts was maintained to guard against shortages. If a part ran out, manufacturing screamed at our one purchasing guy to get it quickly. Up to a modest level of production, this casual methodology worked well.

The impact drum printers consisted of many individual parts arranged in seven or more layers of subassemblies. Gerry Hastler (CFO) sat down once a year and went through every engineering drawing and purchase order part by part and assembly by assembly with an adding machine to calculate the cost of a representative printer. He then called me in to estimate (guess at) the cost of other printer models relative to the specific model he had painstakingly costed. In this fashion, the cost of finished goods inventory was determined. In time, Gerry tired of the drudgery of this process, so we set out to obtain a computer program to manage product costing.

The search for costing software led us to MRP and specifically IBM's MAPICS program. The simple examples presented in the IBM seminar were logical and appealing. The timing of purchases would minimize inventory while guarding against shortages. Lead times of procurement and assembly would be managed in software, resulting in a smooth flow through the manufacturing process. How naïve we were.

We hired Bob Taylor and he became our all-knowing "priest" of MAPICS. Purchasing and production were coerced into filling out innumerable forms detailing the time required for procurement of every piece part and the time to fabricate each batch of every assembly. Buyers and supervisors were conservative in their estimates allowing generous time for each event.

In fiscal 1979 when sales soared, manufacturing descended into chaos. I believe that if we had continued the old pre-MRP informality, manufacturing would have run far more smoothly. As it was, when demand exceeded plan the MRP system froze, in that required schedules were impossible due to the accumulation of unrealistically long lead times. The plant was crawling with shortage lists and expediters working around and in spite of the system. In time we learned to co-exist with MAPICS but no one outside the IT department liked or trusted it.

One year in September a customer indicated that his company had an impending budget surplus and would order 100 bar code label printers if and only if we could ship and invoice before year's end. I asked Bob Taylor to determine the feasibility of doing this. Over the weekend, Bob loaded MAPICS with the requirement for 100 additional printers by December 31. The result came back that we would need to order the parts two years ago! With this un-helpful answer, I asked our production manager Bob Metal (a guy from the old school) if he could get the parts and build 100 additional printers by year-end. He replied, "You're damn right I can", and he did.

Years later when I was Chairman and John Paxton was president and COO, John engaged Garwood and associates to train Intermec people from top to bottom in the nuances of MRPII. MRP became a top down religion for running manufacturing. However, as recently as 1990 after I had departed, I asked Kelly Britz (then Intermec's production manager) how it was going with MRP. "Oh", he replied "about the same. For the first two months of each quarter we faithfully follow the MRP process. Then the final three weeks are upon us, the rules are abandoned, and we scramble". Or reflection, I think that MRP could work well if demand could be accurately planned. At Intermec with many products and sub-models we could never accurately forecast sales by product and ultimately manufacturing had to make what was sold, not what was planned.

Sales and Distribution. In the beginning, the preponderance of Intermec's sales were customized products for large corporations (OEMs). These volume customers included Compugraphic, Plessey, Monarch Marking, NCR, Nixdorf, Hobart, and Toledo Scale. However, in the United States Intermec contracted with multi-line manufacturer's representatives to sell our products within defined geographic territories. With the exception of Ray Stevens in New England, sales through this "rep" channel were disappointing.

Our next step was to convert our reps to stocking distributors. This resulted in dividing the US among twelve regional distributors. Although we could not legally constrain our distributors from selling outside their defined boundaries, the group generally respected each other's territories. Sales increased because the distributor's margins were much larger than the previous rep commissions and they had their own money tied up in inventory, which motivated them to sell. Even so, we felt that the distributors spent less time on Intermec's behalf than we wished because they also carried other (non-Intermec) product lines.

The breakthrough concept came from Will Rogers (Intermec VP). Will believed that only distributors dedicated to Intermec would work consistently hard on our behalf. Furthermore, if these dedicated distributors named their companies Intermec-Something, we could build an international presence. These objectives were incorporated into Intermec's strategic plan.

Our challenge was to convince the distributor family to adopt an Intermec name and dedicate a subsidiary (or their entire company) to stocking and selling only Intermec products. To motivate this conversion, I developed a contract which provided for us to acquire the Intermec-named distributor in three to five years. This acquisition was to be a pooling of interest merger. The distributor would receive Intermec stock where the number of shares was based on the audited profit of the distributor and the price to earnings ratio of Intermec stock. For the distributor, there was an opportunity to acquire significant capital. For Intermec, the transactions were structured to boost earnings per share in the year of acquisition.

This initiative resulted in the formation of Intermec New England, Intermec Mid-Atlantic, Intermec West, and nine other domestic entities. These independent, dedicated distributors became Intermec's conscience and primary window to the marketplace. Annual distributor meetings were lively affairs. Product quality was always a key point of discussion and the attendees discussed and voted on proposals for new products.

The 12 distributors elected a three man council to coordinate meetings and help with communication between Intermec and the distributor family. This council consisted of Bob Irish (Intermec Southwest), John Larkin (Intermec South), and Russ McCabe (Intermec Metro). I became quite close to these council members and had periodic meetings with them to forge stronger relationships and communicate mutual concerns.

International Sales. Outside the US Intermec's sales were initially limited to Plessey and Nixdorf. However, in 1975 we hooked up with a free lance European distributor named Ron Hammon. Ron was a multilingual expatriate South African with high energy and many contacts. His network of sub-distributors included several Plessey affiliates selling bar code related products. Eventually, Ron sold his business to Plessey and shortly after that the various Plessey entities went their independent ways, becoming Intermec's distributors in several countries. After Will Rogers became our international marketing director, his philosophy of dedication and Intermec naming was implemented in selected countries. In the long run, some European distributors were acquired by Intermec, while others remained independent.

Intermec's distributor in France was formed in 1980 by Edouard David, a former salesman from Ron Hammon's French distributor, and his engineer Gilbert Warnan. Edouard grew his business to the point where Intermec sales in France were larger than in any country other than the US. Later, however, Edouard's company began purchasing competitive light pens and manufacturing their own decoders copied from the Intermec model 9300 bar code reader. These infractions resulted in their termination and replacement as our French distributor. Despite losing the Intermec franchise, Edouard's business prospered, merged with Swedot (a manufacturer of label printers) and became United Barcode Systems. Many years later Intermec acquired United Barcode Systems with its strong research lab in Toulouse and printer operation in Sweden.

I recall many enjoyable experiences visiting international distributors and customers. Often I would travel with the latest Intermec products to solicit interest and encourage early purchase orders. Crossing international borders with these devices required either paying custom duties or presenting a carnet (a formal document in English and French) which guaranteed payment of duties by a bonding company if the equipment were not re-exported. Normally, we did not write serial numbers on the carnet so that it could be used again with other equipment.

In April 1977 I planned to visit Germany with a newly designed reader and printer. Pilot production units were never available until the last minute, so my departure to Seattle's airport ran late. In order to process the carnet out of the US, I had to take the equipment to the airfreight terminal were the customs agents worked. Here the agent acted out of character by requiring that I fill out the serial numbers. With no time for unpacking and repacking, I telephoned Linda Worland at Intermec. She told me the correct serial number for the printer and said "I think the reader is probably 10005012".

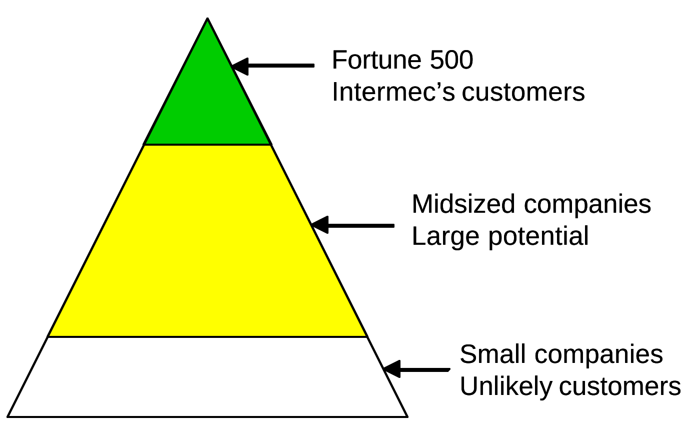
Upon arrival in Frankfurt, I was escorted into a small room by a guard carrying an automatic rifle and asked to remove the reader from its packaging. I visualized being jailed for smuggling or worse. Thank you, Linda and thank you, God, because the serial numbers matched!

System Applications. Intermec, being a hardware manufacturer was totally dependent on application software implemented by others. Without appropriate software, bar code printers and readers delivered no business benefits. I recognized early on that our market (primarily industrial applications for bar code) was inhibited by the lack of software.

In February 1984 a startup software company, DCSI, visited Intermec to negotiate a purchase agreement for printers and bar code reader networks. I was so impressed with their business plan and initial software that we began a three way relationship. They bought our hardware, we bought their software for internal use, and Intermec invested one million dollars in DCSI. I became friends with the three founders John Geiss, Jeff Laurel, and Greg Tweedt and took pride in the growth and success of their enterprise. Renamed High Jump Software, the company was sold to 3M in 2004 and remains a tier one supplier of supply chain systems.

Several of Intermec's distributors also recognized the pivotal role of application software in facilitating the sale of bar code products. Bob Irish, the head of Intermec Southwest, drew the pyramid shown in Figure 13. At the time Intermec sales were limited to major corporations (top of the pyramid) with strong IT staffs. At the bottom are small unsophisticated companies who were poor prospects for bar code enabled applications. Midsized companies offered the greatest potential, but they would require complete solutions including software, services, and hardware.

Figure 13 – Intermec's Opportunity Pyramid



Acting on his own advice, Bob employed software talent to expand the reach of Intermec Southwest. After Intermec acquired his company in 1988, Bob headed an internal software group. Unfortunately, developing and selling software was incompatible with Intermec's hardware culture and the relentless pressure for sales toward the end of every fiscal period.

In a similar fashion, Russ McCabe's company, Intermec Metro, was solutions oriented. After Metro was acquired by Intermec in 1987, Russ formed Applied Tactical Systems. This new, independent company developed complex systems for manufacturing and distribution. After 13 years of growth, Applied Tactical was sold for a good price to Vertex.

Chapter XVI – After Intermec

PathGuide. All in all Intermec had been a great experience. I had even managed to accumulate a little capital thanks to Intermec stock options. Going forward, my primary interest was in business solutions combining bar code with software. With this objective I formed my new company on April 28, 1989 with Intermec veterans Tom Bartlett, Larry Huseby, and Carolyn Loveland. Reflecting on lessons learned at Intermec, this enterprise would be closely held, thus avoiding conflicts with outside investors and directors.

The company was named Applied Tactical Systems of Washington, Inc. We were informally related to Russ McCabe's company Applied Tactical Systems (New Jersey) so that each could share the other's software developments and project a larger image to prospects. We also contemplated a possible future merger. However, as time passed, the companies grew apart and after several years I renamed my company PathGuide Technologies, Inc.

In the beginning, we took on consulting work and any custom software that we could sell. Our first big break came in March 1992 when we convinced Airborne Express that we had a robust time and attendance system. Initially we showed them some skeletal software adapted from ATS (New Jersey). At each meeting the Airborne people revealed another aspect of their complex payroll environment and we set a date for the next meeting. Between meetings, Tom Bartlett would program night and day so that at the subsequent meeting we could demonstrate the required functionality. There was not a lot of bar code involved, but we did use Linx terminals with swipe readers and bar coded badges. The Airborne system we developed on the fly served over 8,000 employees and implemented contract rules for 43 different unions. In time we rewrote the entire package to operate in Windows and web browser environments. Time and Attendance became the first software product that we could step-and-repeat.

Also in 1992, Tom Sweeny came aboard to sell for us. Tom's experience had been managing an industrial distributor and being an early adapter of bar code scanning in the warehouse. Tom and I put on many educational seminars in Seattle and Portland, OR to spread the good word and drum up prospects for PathGuide solutions. We soon came to appreciate that real-time warehouse management systems could generate large benefits for industrial distributors with potential paybacks of one to two years. Our big break on this front was meeting Bill Derville of General Tool and Supply in Portland. Bill had the vision of making his picking operation much more efficient by using a hand held scanning terminal to pick a large batch of orders simultaneously while keeping the items for each order separate.

With our warehouse system working well at his company, Bill Derville arranged for us to present our capabilities to a national association of industrial distributors (IDA). Additional customers followed in short order. Bill introduced us to Chuck Boyle, president of Prophet 21, a leading provider of enterprise software for industrial distributors. Shortly thereafter, PathGuide and Prophet 21 entered into a co-marketing agreement. This agreement facilitated our selling warehouse management systems nationwide plus Canada and Puerto Rico. Nine years later, this agreement is still in place and benefiting both companies although Prophet 21 was acquired by Activant in 2005.

When I founded PathGuide, I made a business plan that proved to be too optimistic. Although it had taken Intermec nine years to become profitable, I thought my enterprise would get there sooner. In reality it took eight years to achieve sustainable profit and more than three times the investment I had initially planned. My advice to would-be entrepreneurs is dogged persistence and determination.

Creating a company has been very satisfying. This is particularly so when customers derive major gains in productivity and can provide better service to their own customers. Today PathGuide has grown to support 18 people and their families. In March my son Eric became president. As PathGuide's Chairman I provide corporate guidance while working on interesting projects.

Honors and Awards. On December 8, 1988, I was presented with the Richard Dilling award which cited that I was a preeminent contributor to the bar code industry. I was the fifth recipient of this prestigious annual award. As of 2006 there have been 23 individuals honored in this fashion. It has been my privilege to personally know all but one of these outstanding individuals.

I was honored in 1997 by being nominated to join the newly formed AIDC 100 as a charter member. Today I am pleased to be serving on its leadership council as this organization becomes more proactive and gains broader recognition.

AIM TSC. In late 1994, Andy Longacre nominated me for membership on the AIM TSC committee. This group is responsible for all of AIM's symbology standards. For the next two years I worked in this capacity with Sprague Ackley, Chuck Biss, Andy Longacre, Rick Schuessler, and Ted Williams. We brought forth specifications for Data Matrix and MaxiCode which embodied major technical improvements over the preceding proprietary symbologies. Serving with this group was intellectually stimulating and satisfying.

Patent Litigation. My first experience as an expert witness happened in 1985 when a lone inventor sued the Uniform Code Council alleging that the UPC symbol infringed his patent. The UPC Symbol Specification manual had by then been in the public domain for

12 years and the symbol was pervasive in retailing. Furthermore, there was no structural similarity between UPC and the symbol claimed by inventor Bilgutay. Although this case eventually settled out of court for minimal cost to the UCC, I learned a lot about the process and became acquainted with Charlie Bradley, a technically astute New York patent attorney.

Subsequently, I served as an expert in thirteen other bar code related litigations wherein I testified in court or by deposition. Most of these cases were commercial disputes between competitors wherein both parties manufactured similar products and the issues came down to claim interpretation vs. the details of how the accused products actually functioned.

A very different case arose in 1992 when Jerome Lemelson sued General Motors, Ford, and Motorola alleging that their use of bar code scanning in manufacturing infringed multiple patents. I was brought in as an expert by Charley Bradley whose firm represented General Motors. Soon I was deep into the nearly inscrutable Lemelson patents. These patents were built on specifications dating from 1956 with claims drafted in the late 1980s and early 1990s to read on bar code scanning and machine vision. The embodiments described in the Lemelson patents were dysfunctional in concept and no attempt had ever been made to construct such devices. Although this case settled before coming to trial, I became acquainted with Jesse Jenner and other attorneys at Fish & Neave.

After the major US auto manufacturers settled, the Lemelson legal machine became a scourge on the bar code industry by sending out thousands of warning letters to end users and filing over 400 law suits. The industry (Symbol Technologies and five other manufacturers of bar code equipment) responded by suing the Lemelson Foundation to invalidate its patents. Thus I came to spend 42 days and nights in Las Vegas preparing for and participating in the trial. Fish and Neave's legal team of a dozen attorneys, their support staff, and witnesses occupied the long wing of the 16th floor of the Venetian hotel. I worked alongside Rick Schuessler and Ed Barkan preparing our testimony and finding flaws in the testimony of Lemelson's experts.

Judge Phillip Pro was attentive and engaged in the details of how scanners worked and why they were different from the asserted patent claims. His decision in January 2004 that Symbol's scanners did not infringe and that the Lemelson patents were invalid and unenforceable freed the whole AIDC community from this predator. Judge Pro's decision was upheld and extended by the Federal Circuit Court on appeal.

Chapter XVII – Looking Forward

I feel very positive about my current activities. The products and processes we promote enable PathGuide's customers to become significantly more productive. While currently free from day to day management, I am pursuing PathGuide related projects with enthusiasm.