AIDC Memoirs

by

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My Recollections About the Design of the U.P.C.

About 1970, I was given the assignment to study item and personal identification. Subsequently I was given the specifications distributed by the Grocery Industries group studying automated checkout systems. The specifications made several things clear with regard to the code and symbol:

1. Space on the label was very limited. A maximum of 1.5 sq. in. was to be allotted for both the machine and human readable portions of a symbol.
2. The symbol must be capable of being printed with the same technologies then employed for printing standard labels, some of which dated back to WWI. This requirement was imposed since the additional cost of the labeling had to be zero.
3. Only ten digits were required, based on a study by a well known consulting firm.
4. The label had to be able to be read omni directionally with the label passing the scanner at speeds up to 100 in/sec.
5. System undetected errors must be less than 1 in 20,000 items.

There were many other specifications but the above were the most technically important to the design of a code and symbol.

IBM did not have an optical bar code or equipment to read optical bar codes on the market at that time. We had no proprietary equipment to sell or protect or make fit the requirements. These facts gave me a chance to start from scratch. I reviewed all the literature I could find and also copies of proposals submitted by competing companies circulated by the symbol selection committee. Of all the proposals only Litton's and RCA's offered true omni-directional scanning. The problem with both of these was that they were both circular codes which were impractical to print to the required tolerances.

In the fall of 1971, Paul McEnroe (my manager at the time) gave me a letter and an assignment. The letter was from our division headquarters directing him to prepare a presentation for the division dignitaries and the head of our laboratory, supporting RCA's bull's-eye code[1] and symbol. He handed it to me and said do it because he was leaving on vacation and would not be back until the day before the scheduled presentation. – GOODBYE!

I struggled a day or two but my nature and training would not allow me to support something I did not believe in. It was obvious to me that that approach would never satisfy all the requirements over the long run, even though RCA was demonstrating their system at the time. I simply went against my manager's instruction and set out to design a better system.

I realized early on that the code and symbol had to be treated as an entity. The first break came with the realization that if one simply deflected a single scanning line with a "corner" mirror – two mirrors at right angles – an "X" would be formed on the scanning window. With a simple "X" linear bars could be read no matter how they were oriented in the scan window. I devised a six module code and incorporated a rudimentary parity check in the start and stop bars of the symbol. I thought it would work, it was not great – but it certainly had a better chance of success than the bull's-eye. I prepared a presentation, which explained why the bull's-eye was not the correct choice and offered my solution instead.

I finished the presentation and charts, with the help of my 15 year old son Craig on a Sunday, the day before the scheduled presentation. My manager lived across the street from me so when I saw him arrive home from his vacation, I went over to his place with the charts and explained what I had done. He had no choice but to agree but he also made it clear that if I was wrong or if I could not sell the idea to the brass it would end my career, not his. I was truly playing "bet your job" by designing a new code and symbol rather than supporting what the brass wanted. My arguments must have been persuasive since I was allowed to continue with my approach in lieu of supporting the bull's-eye.

This code met with objections from others in IBM due its lack of redundancy. Also the specifications were amended about that time to require the addition of least five categories. Adding a seventh bit to each character (to provide character parity), making the category character a full digit (to allow ten categories), and expanding the check digit to a full character (providing more over all redundancy) required that one either make the symbol larger or make each character smaller. The latter would reduce the printing tolerance allowed. Each reduction in printing tolerance made the chances of using existing label making technologies remote and the loosening the area specification was not an option, thus presenting quite a dilemma. It was at this time I conceived the idea of dividing the label into two equal parts and using the parity of the characters to allow the
scanner to read the halves as independent symbols and then reassemble them into a complete symbol. The technique allowed even greater printing tolerances than the six bit code and gave the added bonus of allowing me to design a "zero-suppressed" label. The result was IBM's proposal.

The Ad Hoc Committee required that each proposal be demonstrated. By this time we realized that the head of our division, Mr. B. O. Evans would have to be convinced of the workability of such a scanner before he would agree to commit IBM to build and ship equipment to the industry. A group under the direction of Art Hamburgan in Rochester, MN was given the task of building the first prototype scanner. There were many skeptics in IBM, not the least of whom was B. O. Evans himself. However, at the end of a flawless demonstration for Mr. Evans, we had our ace softball pitcher, pitch bean bag ash trays, with symbols on the bottom, as fast as he could over the scanner. When each one read correctly, Mr. Evans was convinced.

In March of 1973 my code and symbol was accepted as the Grocery Industry Standard and became known as the U.P.C. I believe the first public announcement was *Business Week*, April 7, 1973.

It is interesting to note how the undetected detected error rate was originally established. Men were sent to the grocery stores using manual checkout systems and stood outside. When a person with a large order would emerge, they offered $10 to be allowed to check the order against the cash register slip. The findings showed there was an error rate of around 1%. The Ad Hoc Committee reasoned that an error rate of 1 in 1000 would be an improvement of such magnitude as to in itself justify the system. They put a target error rate of less than 1 in 20,000, just to be safe, in the original specification. Our (IBM) scanning system had a predicted undetected error rate of less than 1 in 200,000 when it was first released. It wasn't long before we all got a rude awakening.

Not long after the installation of the first machine, we became aware of the "Golden Chicken" and "Platinum Pork". When the price was imbedded in the symbol as is common in the meat

department, there was no secondary checking such as looking at a file list of allowable numbers or rational price checking. Also, since a machine is just as likely to overcharge by a million dollars as it is to overcharge by a few cents, any errors would attract country wide attention. Another fact we learned had to do with human nature. Most people were willing to forgive the sweet young checkout girl for charging $1.98 for a $1.89 item, but would not forgive a machine for charging $99.99 for a pound of chicken even though such a gross error would never go undetected. People just do not forgive machines for making errors. Frantic meetings of the Symbol Technical Advisory Committee[2] resulted in using one of the descriptor code digits as a check digit on just the price. This along with rational checking, improved printing and better scanners has just about eliminated the problem today.

Another interesting point was that in deference to McKinsey & Co. (who researched the original requirements and came to the conclusion that 10 digits were all that were needed) the twelve digit symbol was always referred to as a ten digit code. The original symbol was released with the "category" number printed half way up in the left margin and the modulo ten check digit was not printed at all. These changes helped to make the symbol look like a ten digit symbol. Only in the past several years has the category character and the check character been printed in line with the rest of the numbers.

A year or two later I was asked to extend the symbol one more digit to accommodate foreign countries (i.e. the country flag). I devised a method and this symbol became known as the EAN-13 symbol. Many countries using the code simply translated the specifications into their language and named them as if they were proprietary to their country, the JAN code used by Japan is but one example. Next I designed a two digit trailer and five digit trailer for the publishing industry. These trailers were specifically designed so that they would NOT be read by U.P.C. scanners.

My decision to "bet my job" and design a symbol and code which best suited the requirements of the grocery industry turned out to be a good one for me. IBM made no attempt to patent or otherwise protect the symbol and code because we wanted nothing to deter the use, or slow the implementation, of the U.P.C. symbol. We gave it to the industry. However, I received several division awards and one prestigious cooperate "Technical & Innovation" award. Our North Carolina state fair had a display about the U.P.C. which acknowledged my invention. The honors I am most proud of are my induction into the Engineering Innovation Hall of Fame by the College of Engineering in 1991 and my induction into the Alumni Hall of Fame in 2000 both of the University of Maryland, my alma mater, for creating the Universal Product Code. I was also honored by being asked to deliver the commencement address to the School of Engineering at the University in 1991.

My book, ***Engineering was Fun,*** which is available from www.Lulu.com, includes an appendix detailing the technical background and the development of the U.P.C. code and symbol.

1 The bull's-eye code was the one patented by my coworker N. J. Woodland and was being proposed by the RCA/Sperry Rand Corp.

2 I was a member of STAC-3, the committee responsible for a solution. David Savir, a coworker of mine, devised the algorithm for the added check digit.