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BAR CODES SWEEP THE WORLD

by Tony Seideman

Supermarkets are a perilous business. They must stock thousands of products in scores of brands and sizes to sell at painfully small markups. Keeping close track of them all, and maintaining inventories neither too large nor too small, is critical. Yet for most of this century, as stores got bigger and the profusion on their shelves multiplied, the only way to find out what was on hand was by shutting the place down and counting every can, bag, and parcel. This expensive and cumbersome job was usually done no more than once a month. Store managers had to base most of their decisions on hunches or crude estimates.

Long before bar codes and scanners were actually invented, grocers knew they desperately needed something like them. Punch cards, first developed for the 1890 U.S. Census, seemed to offer some early hope. In 1932 a business student named Wallace Flint wrote a master's thesis in which he envisioned a supermarket where customers would perforate cards to mark their selections; at the checkout counter they would insert them into a reader, which would activate machinery to bring the purchases to them on conveyor belts. Store management would have a record of what was being bought.

The problem was, of course, that the card-reading equipment of the day was bulky, utterly unwieldy, and hopelessly expensive. Even if the country had not been in the middle of the Great Depression, Flint's scheme would have been unrealistic for all but the most distant future. Still, it foreshadowed what was to come.

The first step toward today's bar codes came in 1948, when Bernard Silver, a graduate student, overheard a conversation in the halls of Philadelphia's Drexel Institute of Technology. The president of a food chain was pleading with one of the deans to undertake research on capturing product information automatically at checkout. The dean turned down the request, but Bob Silver mentioned the conversation to his friend Norman Joseph Woodland, a twenty-seven-year-old graduate student and teacher at Drexel. The problem fascinated Woodland.

His first idea was to use patterns of ink that would glow under ultraviolet light, and the two men built a device to test the concept. It worked, but they encountered problems ranging from ink instability to printing costs. Nonetheless, Woodland was convinced he had a workable idea. He took some stock-market earnings, quit Drexel, and moved to his grandfather's Florida apartment to seek solutions. After several months of work he came up with the linear bar code, using elements from two established technologies: movie soundtracks and Morse code.

Woodland, now retired, remembers that after starting with Morse code, "I just extended the dots and dashes downwards and made narrow lines and wide lines out of them." To read the data, he made use of Lee de Forest's movie sound system from the 1920s. De Forest had printed a pattern with varying degrees of transparency on the edge of the film, then shone a light through it as the picture ran. A sensitive tube on the other side translated the shifts in brightness into electric waveforms, which were in turn converted to sound by loudspeakers. Woodland planned to adapt this system by reflecting light off his wide and narrow lines and using a similar tube to interpret the results.

Woodland took his idea back to Drexel, where he began putting together a patent application. He decided to replace his wide and narrow vertical lines with concentric circles, so that they could be scanned from any direction. This became known as the bull's-eye code. Meanwhile, Silver investigated what form the codes should ultimately take. The two filed a patent application on October 20, 1949.

In 1951 Woodland got a job at IBM, where he hoped his scheme would flourish. The following year he and Silver set out to build the first actual bar-code reader—in the living room of Woodland's house in Binghamton, New York. The device was the size of a desk and had to be wrapped in black oilcloth to keep out ambient light. It relied on two key elements: a five-hundred-watt incandescent bulb as the light source and an RCA 935 photo-multiplier tube, designed for movie sound systems, as the reader.

Woodland hooked the 935 tube up to an oscilloscope. Then he moved a piece of paper marked with lines across a thin beam emanating from the light source. The reflected beam was aimed at the tube. At one point the heat from the powerful bulb set the paper smoldering. Nonetheless, Woodland got what he wanted. As the paper moved, the signal on the oscilloscope jumped. He and Silver had created a device that could electronically read printed material.

It was not immediately clear how to transform this crude electronic response into a useful form. The primitive computers of the day were cumbersome to operate, could only perform simple calculations, and in any case were the size of a typical frozen-food section. The idea of installing thousands of them in supermarkets from coast to coast would have been pure fantasy. Yet without a cheap and convenient way to record data from Woodland and Silver's codes, their idea would be no more than a curiosity.

Then there was that five-hundred-watt bulb. It created an enormous amount of light, only a tiny fraction of which was read by the 935 tube. The rest was released as expensive, uncomfortable waste heat. "That bulb was an awful thing to look at," Woodland recalls. "It could cause eye damage." The inventors needed a source that could focus a large amount of light into a small space. Today that sounds like a prescription for a laser, but in 1952 lasers did not exist. In retrospect, bar codes were clearly a technology whose time had nowhere near come.

But Woodland and Silver, sensing the potential, pressed on. In October 1952 their patent was granted. Woodland stayed with IBM and in the late 1950s persuaded the company to hire a consultant to evaluate bar codes. The consultant agreed that they had great possibilities but said they would require technology that lay at least five years off. By now almost half the seventeen-year life of Woodland and Silver's patent had expired.

IBM offered a couple of times to buy the patent, but for much less than the inventors thought it was worth. In 1962 Philco met their price, and they sold. (The following year Silver died at age thirty-eight.) Philco later sold the patent to RCA. In 1971 RCA would jolt several industries into action; before then, the next advances in information handling would come out of the railroad industry.

Freight cars are nomads, wandering all across the country and often being lent from one line to another. Keeping track of them is one of the most complex tasks the railroad industry faces, and in the early 1960s it attracted the attention of David J. Collins. Collins got his master's degree from MIT in 1959 and immediately went to work for the Sylvania Corporation, which was trying to find military applications for a computer it had built. During his undergraduate days Collins had worked for the Pennsylvania Railroad, and he knew that the railroads needed a way to identify cars automatically and then to handle the information gathered. Sylvania's computer could do the latter; all Collins needed was a means to retrieve the former. Some sort of coded label seemed to be the easiest and cheapest approach.

Strictly speaking, the labels Collins came up with were not bar codes. Instead of relying on black bars or rings, they used groups of orange and blue stripes made of a reflective material, which could be arranged to represent the digits O through 9. Each car was given a four-digit number to , identify the railroad that owned it and a six-digit number to identify the car itself. When cars went into a yard, readers would flash a beam of colored light onto the codes and interpret the reflections. The Boston & Maine conducted the first test of the system on its gravel cars in 1961. By 1967 most of the kinks had been worked out, and a nationwide standard for a coding system was adopted. All that remained was for railroads to buy and install the equipment.

Collins foresaw applications for automatic coding far beyond the railroads, and in 1967 he pitched the idea to his bosses at Sylvania. "I said what we'd like to do now is develop the little black-and-white-line equivalent for conveyor control and for everything else that moves," he remembers. In a classic case of corporate shortsightedness, the company refused to fund him. "They said, 'We don't want to invest further. We've got this big market, and let's go and make money out of it.'" Collins quit and cofounded Computer Identics Corporation.

Sylvania never even saw profits from serving the railroad industry. Carriers started installing scanners in 1970, and the system worked as expected, but it was simply too expensive. Although computers had been getting a lot smaller, faster, and cheaper, they still cost too much to be economical in the quantities required. The recession of the mid-1970s killed the system as a flurry of railroad bankruptcies gutted industry budgets. Sylvania was left with a white elephant.

Meanwhile, Computer Identics prospered. Its system used lasers, which in the late 1960s were just becoming affordable. A milliwatt helium-neon laser beam could easily match the job done by Woodland's unwieldy five-hundred-watt bulb. A thin stripe moving over a bar code would be absorbed by the black stripes and reflected by the white ones, giving scanner sensors a clear on/off signal. Lasers could read bar codes anywhere from three inches to several feet away, and they could sweep back and forth like a searchlight hundreds of times a second, giving the reader many looks at a single code from many different angles. That would prove to be a great help in deciphering scratched or torn labels.

In the spring of 1969 Computer Identics quietly installed its first two systems—probably the first true bar-code systems anywhere. One went into a General Motors plant in Pontiac, Michigan, where it was used to monitor the production and distribution of automobile axle units. The other went into a distribution facility run by the General Trading Company in Carlsbad. New Jersey, to help direct shipments to the proper loading-bay doors. At this point the components were still being built by hand; Collins made the enclosures for the scanners by turning a wastebasket upside down and molding fiberglass around it. Both systems relied on extremely simple bar codes bearing only two digits' worth of information. But that was all they needed; the Pontiac plant made only eighteen types of axle, and the General Trading facility had fewer than a hundred doors.

Computer Identics's triumph proved the potential for bar codes in industrial settings, but it was the grocery industry that would once again provide the impetus to push the technology forward. In the early 1970s the industry set out to propel to full commercial maturity the technology that Woodland and Silver had dreamed up and Computer Identics had proved feasible.

Already RCA was moving to assist the industry. RCA executives had attended a 1966 grocery-industry meeting where bar-code development had been urged, and they smelled new business. A special group went to work at an RCA laboratory in Princeton, New Jersey, and the Kroger grocery chain volunteered itself as a guinea pig. Then, in mid-1970, an industry consortium established an ad hoc committee to look into bar codes. The committee set guidelines for bar-code development and created a symbol-selection subcommittee to help standardize the approach.

This would be the grocery industry's Manhattan Project, and Alan Haberman, who headed the subcommittee as president of First National Stores, recalls proudly, "We showed that it could be done on a massive scale, that cooperation without antitrust implications was possible for the common good, and that business didn't need the government to shove it in the right direction."

At the heart of the guidelines were a few basic principles. To make life easier for the cashier, not harder, bar codes would have to be readable from almost any angle and at a wide range of distances. Because they would be reproduced by the millions, the labels would have to be cheap and easy to print. And to be affordable, automated checkout systems would have to pay for themselves in two and a half years. This last goal turned out to be quite plausible; a 1970 study by McKinsey & Company predicted that the industry would save $150 million a year by adopting the systems.

"It turns out there were massive savings that we called hard savings—out-of-pocket savings in labor and other areas," Haberman says. "And there were gigantic savings available in the use of the information and the ability to deal with it more easily than we had before, but we never quantified that." Hard, quantifiable savings were what would draw retailers. These included checking out items at twice the speed of cashiers using traditional equipment, which would mean shorter lines without staff increases.

Still, while early bar-code systems would automate the checkout, they would not be useful for monitoring inventory, because at first too few items would come labeled with codes. Savings from using the collected information, instead of simply from cutting labor costs, would have to wait until most items bore codes. After that happened, management at every level would have to transform the way it operated.

In the spring of 1971 RCA demonstrated a bull's-eye bar-code system at a grocery-industry meeting. Visitors got a round piece of tin; if the code on top contained the right number, they won a prize. IBM executives at that meeting noticed the crowds RCA was drawing and worried that they were losing out on a huge potential market. Then Alec Jablonover, a marketing specialist at IBM, remembered that his company had the bar code's inventor on staff. Soon Woodland—whose patent had expired in 1969—was transferred to IBM's facilities in North Carolina, where he played a prominent role in developing the most popular and important version of the technology: the Universal Product Code (UPC).

RCA continued to push its bull's-eye code. In July 1972 it began an eighteen-month test in a Kroger store in Cincinnati. It turned out that printing problems and scanning difficulties limited the bull's-eye's usefulness. Printing presses sometimes smear ink in the direction the paper is running. When this happened to bull's-eye symbols, they did not scan properly. With the UPC, on the other hand, any extra ink simply flows out the top or bottom and no information is lost.

For a time such exotica as starburst-shaped codes and computer-readable optical characters were considered, but eventually the technically elegant IBM-born UPC won the battle to be chosen by the industry. No event in the history of modern logistics was more important. The adoption of the Universal Product Code, on April 3, 1973, transformed bar codes from a technological curiosity into a business juggernaut.

Before the UPC, various systems had begun to come into use around the world in stores, libraries, factories, and the like, each with its own proprietary code. Afterward any bar code on any product could be read and understood in every suitably equipped store in the country. Standardization made it worth the expense for manufacturers to put the symbol on their packages and for printers to develop the new types of ink, plates, and other technology to reproduce the code with the exact tolerances it requires.

Budgets for the bar-code revolution were on a scale to make the Pentagon blanch. Each of the nation's tens of thousands of grocery outlets would have to spend at least $200,000 on new equipment. Chains would have to install new data-processing centers and retrain their employees. Manufacturers would potentially spend $200 million a year on the labels. Yet tests showed that the system would pay for itself in a few years.

Standardization of the code meant the need for a standardized system of numbers to go on it. "Before we had bar codes, every company had its own way of designating its products," Haberman says. Some used letters, some used numbers, some used both, and a few had no codes at all. When the UPC took over, these companies had to give up their individual methods and register with a new Uniform Code Council (UCC).

The code is split into two halves of six digits each. The first one is always zero, except for products like meat and produce that have variable weight, and a few other special types of items. The next five are the manufacturer's code; the next five are the product code; and the last is a "check digit" used to verify that the preceding digits have been scanned properly. Hidden cues in the structure of the code tell the scanner which end is which, so it can be scanned in any direction. Manufacturers register with the UCC to get an identifier code for their company, then register each of their products. Thus each package that passes over a checkout stand has its own unique identification number.

Two technological developments of the 1960s finally made scanners simple and affordable enough. Cheap lasers were one. The other was integrated circuits. When Woodland and Silver first came up with their idea, they would have needed a wall full of switches and relays to handle the information a scanner picked up; now it's all done by a microchip.

On June 26,1974, all the tests were done, all the proposals were complete, all the standards were set, and at a Marsh supermarket in Troy, Ohio, a single pack of chewing gum became the first retail product sold with the help of a scanner. Decades of schemes and billions of dollars in investment now became a practical reality. The use of scanners grew slowly at first. A minimum of 85 percent of all products would have to carry the codes before the system could pay off, and when suppliers reached that level, in the late 1970s, sales of the systems started to take off. In 1978 less than one percent of grocery stores nationwide had scanners. By mid-1981 the figure was 10 percent, three years later it was 33 percent, and today more than 60 percent are so equipped.

Meanwhile, the technology has been creeping into other industries and organizations. Researchers have mounted tiny bar codes on bees to track the insects' mating habits. The U.S. Army uses two-foot-long bar codes to label fifty-foot boats in storage at West Point. Hospital patients wear bar-code ID bracelets. The codes appear on truck parts, business documents, shipping cartons, marathon runners, and even logs in lumberyards. Federal Express, the package-shipping giant, is probably the world's biggest single user of the technology; its shipping labels bear a code called Codabar. Along the way refinements of the basic UPC have been developed, including the European Article Numbering system (EAN), developed by Joe Woodland, which has an extra pair of digits and is on its way to becoming the world's most widely used system. Other codes, which are given such fanciful names as Code 39, Code 16K, and Interleaved 2 of 5, can sometimes contain letters as well as numbers.

Woodland never got rich from bar codes, though he was awarded the 1992 National Medal of Technology by President Bush. But all those involved in the early days speak of the rewards of having brought a new way of doing business to the world. "This thing is a success story on the American way of doing things," Haberman says. "Our own initiative—take it on ourselves, inviting the world to join in. It has something to say about little guys with lots of vision."

Tony Seideman is a freelance writer who lives in New York City