The Evolution of the Grocery Bag

HENRY PETROSKI

That much-reviled bottleneck known as the American supermarket checkout lane would be an even greater exercise in frustration were it not for several technological advances. The Universal Product Code and the decoding laser scanner, introduced in 1974, tally a shopper's groceries far more quickly and accurately than the old method of inputting each purchase manually into a cash register. But beeping a large order past the scanner would have led only to a faster pileup of cans and boxes down the line, where the bagger works, had it not been for the introduction, more than a century earlier, of an even greater technological masterpiece: the square-bottomed paper bag.

The geometry of paper bags continues to hold a magical appeal for those of us who are fascinated by how ordinary things are designed and made. Originally, grocery bags were created on demand by storekeepers, who cut, folded, and pasted sheets of paper, making versatile containers into which purchases could be loaded for carrying home. The first paper bags manufactured commercially are said to have been made in Bristol, England, in the 1840s. In 1852, a "Machine for Making Bags of Paper" was patented in America by Francis Wolle, of Bethlehem, Pennsylvania. According to Wolle's own description of the machine's operation, "pieces of paper of suitable length are given out from a roll of the required width, cut off from the roll and otherwise suitably cut to the required shape, folded, their edges pasted and lapped, and formed into complete and perfect bags." The "perfect bags" produced at the rate of eighteen hundred per hour by Wolle's machine were, of course, not perfect, nor was his machine.

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The history of design has yet to see the development of a perfect object, though it has seen many satisfactory ones and many substantially improved ones. The concept of comparative improvement is embedded in the paradigm for invention, the better mousetrap. No one is ever likely to lay claim to a "best" mousetrap, for that would preclude the inventor himself from coming up with a still better mousetrap without suffering the embarrassment of having previously declared the search complete. As with the mousetrap, so with the bag.

Wolle patented a more elaborate, and presumably improved, "Machine for Making Paper Bags" in 1855. However, the operation of both machines must have been plagued with jams by the loose pieces of paper left over when each fresh sheet was "cut to the required shape," for Wolle patented a third machine in 1858, among whose "novel arrangements" was a provision "for preventing the loss of the strips of paper usually cut off in order to make the bottom lap or seam of the bag." In other words, his new, improved bag maker left an extra flap of paper at the bottom of the bag, out of sight and out of the mind and guts of the machine.

Early paper bags, including those made by Wolle's machines, had what is known as an envelope bottom, so called because of what their shape resembled and how they were formed. Indeed, the drawing sheets of his second patent are headed "Paper Bag & Envelope Mach." Though the envelope-bottom bags that all of Wolle's machines produced had the advantage of relatively simple assembly, they also had severe limitations. They could not stand upright by themselves and so had to be held open with one hand while being filled. Furthermore, because they were flat, they could not easily accommodate bulky items like hardware goods and groceries. There was thus plenty of room for improvement in the design of paper bags.

The way Wolle's machines formed an envelope bag was akin to but not quite as elaborate or complete as the way an aerogram is prepared for mailing, with its several tablike edges folded over and pasted down to make a compact package. There is never a single way to design anything, however, and just as there are alternative ways to fold a piece of paper into an envelope, so there are alternate ways to make paper bags. One method is to overlap and paste together two opposite edges of a rectangular sheet of paper, thus forming a tube open at both ends. When flattened, one end of the tube can be folded over and pasted to the side, thus forming the bag. The bottoms of padded, manila, and other large mailing envelopes are essentially made in this way, and envelope-bottom paper bags are commonly used to this day by stationery and other stores that sell flat goods. However, the bags for the kinds of goods sold in hardware and grocery stores are formed by closing off the end of a paper tube in an entirely different way.

The invention of the familiar square- or flat-bottomed paper bag—the "grocery bag"—is commonly but incorrectly attributed to Luther Childs

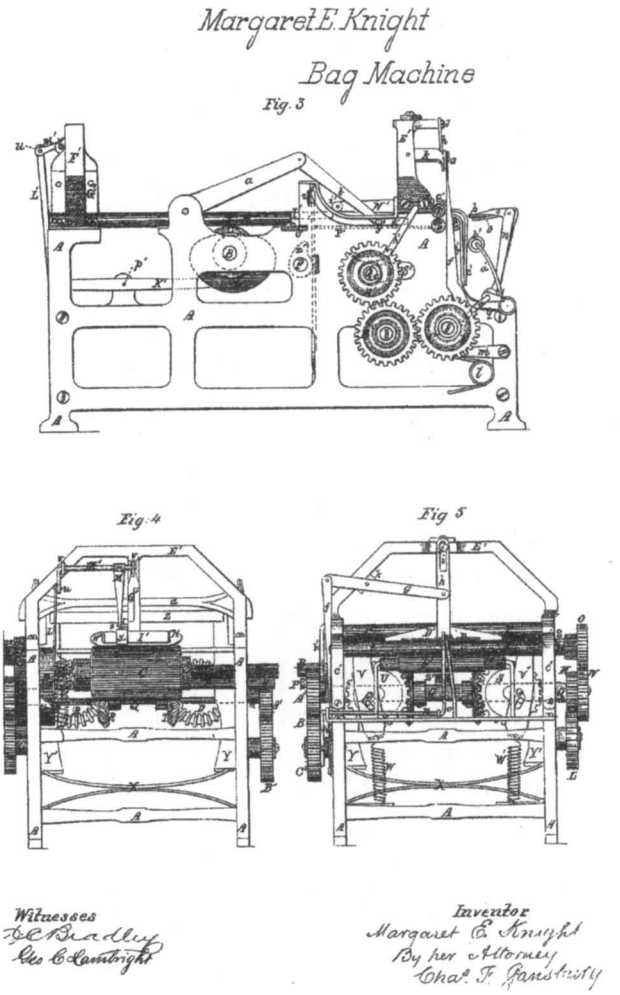
Crowell, of Boston, Massachusetts, who in 1872 received a United States patent for an "Improvement in Paper-Bags." The word "improvement"—encountered as frequently in the titles of patents as "mystery" is in those of thrillers—is, in fact, a clear giveaway that Crowell's bag represented an evolutionary rather than a revolutionary invention. Nevertheless, this obvious clue is all too frequently overlooked in the literature of technological whodunits. In fact, because the page of drawings accompanying Crowell's patent is headed simply "Paper Bag," a quick reading of the evidence might lead one to jump to the erroneous conclusion that he was the inventor of the paper bag itself.

Luther Crowell certainly did invent a "new, improved" way of making paper bags, so he rightly earned a patent for his advancement of the state of the art, but he did not invent the original square-bottomed bag. Indeed, by his own admission, he was "aware that paper-bags have been made which will assume a quadrangular shape when filled." He claimed only that his method of making them was "the most simple and practical," and, given "the proper machinery," that such bags could be made "as economically and as rapidly as the common bags." Indeed, manufacturing paper bags of all kinds had become a competitive business, and more than one inventor had been working on new ways to produce them more quickly, more efficiently, and more reliably.

One was a creative woman. Margaret E. Knight, who has been called "the most famous nineteenth-century American woman inventor," was born in York, Maine, in 1838; she grew up and was educated in Manchester, New Hampshire. As a child, she preferred "a jack-knife, a gimlet, and pieces of wood" to dolls. She made playthings for her brothers and became "famous for her kites." Her sleds were the envy of the town's boys. Like many a young girl of her times, Margaret went to work in a cotton mill, where one day she saw a steel-tipped shuttle shoot out of its loom and injure a worker. At twelve years of age, she devised a loom-shuttle restraining device, thus demonstrating the talent for mechanical invention that she would draw on throughout her life.

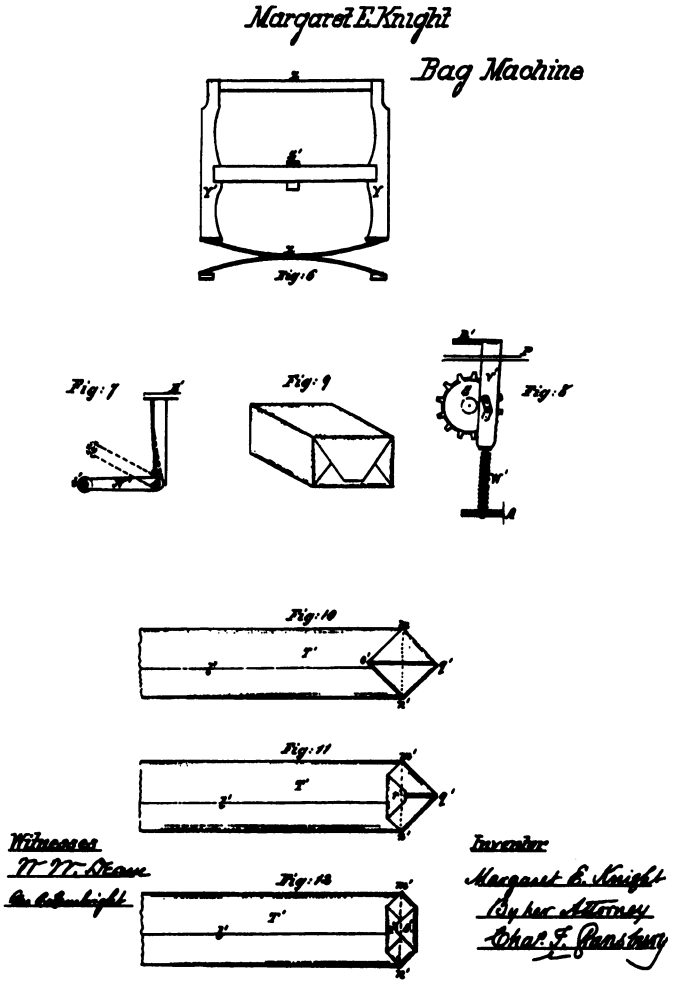
Knight left the mills in her late teens and engaged in a number of temporary jobs and activities that introduced her to a wide range of technologies, including those associated with upholstering, home repair, daguerreotypy, and engraving. After the Civil War, she worked for the Columbia Paper Bag Company in Springfield, Massachusetts, where she became acquainted with the process of making bags from flat sheets of paper. After a while, she began to experiment with a machine that could feed, cut, and fold the paper automatically and, most important, form the squared bottom of the bag.

Margaret Knight's machine started making this square-bottomed bag—one that could be opened to a wide, flat base—around 1870. After



Drawings from an 1871 patent show views of Margaret Knight's paper bag-making machine.

testing and refining a wooden prototype of her ingenious invention by making thousands of paper bags with it, she contracted a Boston machinist to fashion an iron model for submission with a patent application. While that model was being produced, it was seen by an unscrupulous would-be inventor, Charles F. Annan, who applied for a patent in his own name but based on Knight's idea. When Knight learned of Annan's action, she took him to court. Annan apparently was counting on the court to assume that a woman could not be a credible inventor; he argued that



The folding and pasting steps used to form Margaret Knight's rectangular, square-bottomed paper bag.

Knight "could not possibly understand the mechanical complexities of the machine" that made paper bags. But Knight's "drawings, paper patterns," and more, including relevant entries in her personal diary, convinced the court of her mechanical aptitude and priority of invention, and it ruled in her favor.

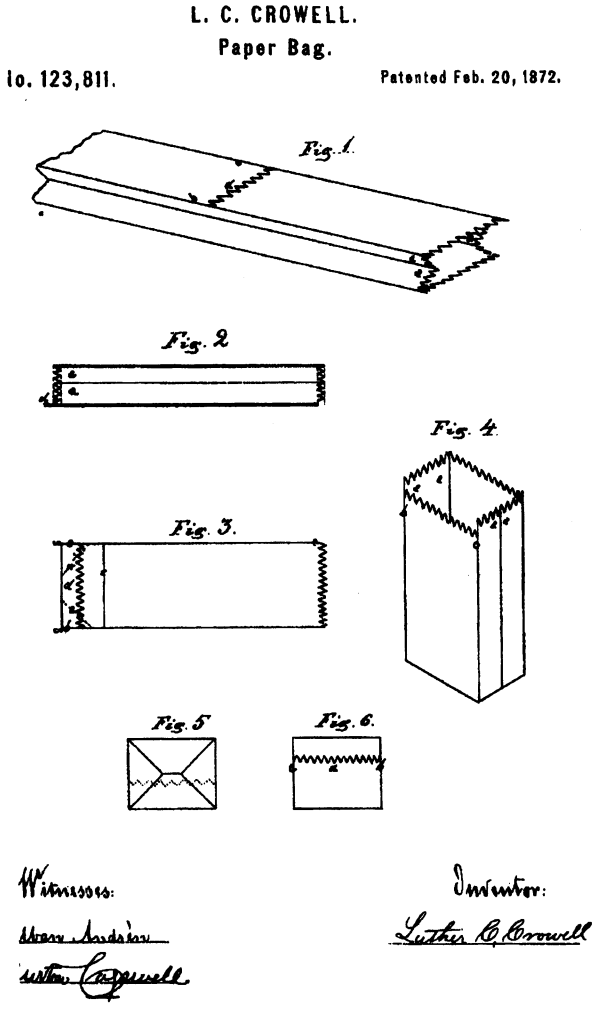
Unlike many a contemporary female inventor and writer, Margaret Knight did not conceal her gender by employing only the initials of her given names. She had used her full name on her very first patent, issued in

1870, which was for an "improvement in paper-feeding machines." This "pneumatic paper-feeder" had applications to printing presses and paper-folding machines, which must have been her principal objective. While the inventor's name on the heading of the five sheets of patent drawings is given in the androgynous form of M. E. Knight, the bottoms of these same sheets clearly identify the inventor as Margaret E. Knight, as do the front page and continuation sheets.

It was her second patent, issued in 1871 for an "improvement in paper-bag machines," that dealt with the satchel-bottom grocery bag. Among the patent drawings is one that clearly shows the rectangular shape and flat bottom of the opened bag to be essentially the same as those of brown paper grocery bags today. Knight's machine worked by pulling from a roll of paper stock a sheet that it immediately started to form into a tube. Paste was applied where one side of the paper overlapped the other, thus completing the tube. Knight's machine performed its greatest magic by shaping the end of the tube into a flat bottom by means of a series of three folds, and the drawings that delineate the three-step mechanical folding process look like instructions for "industrial origami": the first fold formed the end of the tube into a slit diamond, the second creased one tip of the diamond over to make a pentagon, and the third creased the other tip over to form an elongated hexagon. With the proper pasting taking place simultaneously with the folding, the closed bottom was formed quickly. The bag was completed by being severed from the continuously forming tube, at which point the cycle was repeated.

To highlight the key feature of her invention, but perhaps also to underscore her legal victory over Charles Annan, Knight declared in her patent that she believed herself "to be the first to invent a device to hold back or push back a point or portion of one side of the paper tube while the blade or tucking-knife forms the first fold," making no claim to the invention of the paper bag itself. She referred to the patent drawings and, in the legal language of a savvy inventor, emphasized that they did not represent the only way her ideas could be embodied in a machine that accomplished the essential folding step, "the basis of the flat-bottomed bag."

With her patent in hand, Knight found a partner, a Massachusetts businessman with whom she established the Eastern Paper Bag Company in Hartford, Connecticut. Her financial arrangements with Eastern gave her $2,500 outright, plus royalties and company stock. Another of her patents, for an improvement in paper-bag machines, was issued in 1879 and assigned to Eastern. Knight's financial arrangements with the company brought her a comfortable income for the time, but since the royalties were capped at $25,000, they did not continue indefinitely. Like many inventors driven by the challenge of the new, Knight went on to other things. She eventually received patents for a shoe-sole-cutting machine and for improvements in automobile engines.


L. C. CROWELL.
Paper Bag.
No. 123,811. Patented Feb. 20, 1872.
Fig. 1.
Fig. 2
Fig. 3.
Fig. 4.
Fig. 5
Fig. 6.
Witnesses:
Inventor:
Luther C. Crowell

Luther Crowell's 1872 patent illustrated a new way to form a square-bottomed paper bag with accordion-pleated sides.

Though Margaret Knight's flat-bottomed bag could be opened into a boxlike quadrangular shape, it did differ from today's grocery bag in one important way: it lacked the now-familiar accordion-folded sides. This feature not only makes for more compact storage but also defines the corners of the bag by creasing them as part of the forming process. It also enables the bottom of the bag to be shaped in a manner that does not require Knight's ingenious but somewhat difficult-to-manage slit-diamond folding step. Indeed, it was an accordion-pleated bag, with its necessarily different

forming folds, that was patented by Luther Crowell in 1872, the year after Knight's first patent for a bag-making machine was issued. Unlike Knight, Crowell did not patent a machine for making bags, but his bags could be made more easily by either hand or machine than hers—hence his claim for his method as "the most simple and practical." However, like Knight's, Crowell's bag did not unfold easily into a square-bottomed shape. Rather, it had to be coaxed by the packer's hand or by the force of the contents being stuffed into it.

Both Knight's and Crowell's patents understandably focus on forming the bottom of the bag. However, a bag has two ends, and after it is formed, it is not the closed bottom but the open top that first commands the user's attention. Opening a paper bag that has perfectly congruent top edges, as Knight's appears to have had, can be as frustrating as turning the pages of an unread newspaper. Sides cut to the same length tend to stick together and hide their seams, like the sides of a plastic garbage bag taken fresh from the box.

Crowell's patent drawings also call attention to the top of his bag, but only because of its irregularity. One drawing clearly shows a bag-length section of a pleated paper tube terminating in the now-familiar and characteristic zigzag pattern, no doubt made by a serrated knife edge but looking as if it had been made with pinking shears. More important, though, the drawing shows one side cut a bit shorter than the other, a necessary feature for making the bags according to his improved design. Indeed, after the inward-pointing folds had been made in a tube of paper, Crowell's bottom-forming process involved only a single folding and pasting, a definite improvement over Knight's.

Designs of all kinds often have interesting little features unintended by their inventors. In the manufacture of Crowell's bag, the tube of paper could not have been simply severed with a single straight knife cut, as Knight's was, for that would have left no tab to fold over and paste to form the bottom. The tube thus had to be cut to two different lengths. This process left, as an artifact of the manufacturing process, a bag top with unequal front and back sides. Rather than being a blemish, the detail proved to be a boon, for the bag could be opened with ease.

Today's paper grocery bags do tend to be formed with both sides of the bag top cut off at the same length, of course, but with a thumbnail or rectangular notch cut into one of them to achieve the same effect as Crowell's perhaps accidental device. (The mating tab on the bottom of the next bag to come down the tube is often folded under in the manufacturing process and so leaves no hint of its presence. Occasionally, however, the tab remains exposed, thus providing a clue to anyone trying to figure out how to reverse-engineer the darn thing.)

As older shoppers will remember, when a new paper bag was picked up

off the pile under the counter in the grocery store, the notch permitted the bagger's thumb and fingers to grasp only one side of the bag. This enabled the bagger to snap it open in one sweeping motion, with the flair of a waiter opening a napkin before placing it on a diner's lap. The experienced and flamboyant bagger could open the grocery bag with a loud report as sharp as the crack of a whip or the sound of a home-run ball leaving a baseball bat. No matter how it's opened, however, the modern flat-bottomed bag stands upright by itself, freeing both the bagger's hands to stuff groceries into it with the deftness of a professional juggler. Packing a paper grocery bag quickly and efficiently became a source of pride. It also became the object of competitions that required significant skill, given the wide variety of sizes, weights, fragilities, and temperatures of cans, jars, boxes, and other assorted containers that the checkout person passed down the counter. The practiced bagger was ready for them all, though not always for the likes of David Letterman, who in the 1990s often spoke of packing groceries in his youth. His *Late Show* was the venue for annual head-to-head bagging competitions, though hardly serious ones, between Dave and the current year's championship grocery bagger.

The brown paper grocery bag was not the butt of the jokes, however. The square-bottomed bag itself is a tribute to man and woman's creativity, as manifested in a series of ingenious folds made on a tube shaped from a roll of paper. Inventors and designers like Knight and Crowell fashioned their bags as much with their minds as with their hands. Though their creations were worthy of praise even in the nineteenth century, the use to which the bag is put represents a recurring problem in design. How do you bag items on a conveyor belt full of ever-changing merchandise? Naturally, harder and heavier things, such as cans of vegetables and soup, are properly put in first, providing a solid base that will also give the full bag a low center of gravity. Boxes of macaroni, cake mix, and the like also provide solid foundations on which to pack smaller, lighter, and flimsier items, like packages of Jell-O and plastic bags of beans. Bread and eggs belong on the very top, but not so far up that they can tumble out when the bag is grasped and lifted. As obvious as such protocols might be, they have often been violated by inexperienced, careless, distracted, or mischievous baggers.

The material out of which the familiar grocery bag is made is known as kraft paper, after the German word denoting power, force, and strength. The name thus connotes the familiar toughness of the bag. Kraft paper is made from a pulping process employing a long-fibered softwood like southern pine. When the paper is unbleached, the familiar brown paper bag results. Bleached kraft paper is usually used in making bakery bags, the white paper suggesting a cleaner container, one suitable for holding unpackaged rolls, bread, and pastries. Kraft paper bags are also produced in different sizes and weights, with the largest and coarsest usually designated as grocery bags.

The strength of a lightweight white bakery bag is seldom tested. It is not intended to hold much weight, and its contents do not have hard, pointed edges that might puncture or tear through the sack. Brown grocery bags, however, can be packed too full and with items that are too heavy, and their contents can have numerous sharp corners that can poke through the paper. The overzealous bagger who tries to squeeze a box of cat food beside the other boxes already in the bag can easily tear a gash along the side. But this is usually a benign failure, one that prevents the bag's reuse but does not undermine its essential structure. The grocery bag that is overly heavy because of a jumble of cans and jars and bottles inside poses a more serious risk. It is tempting to pick up a bag by its edges—a perilous move unless the load is light. The overly heavy bag is likely to rip at the stress-concentration points beneath one's grasping fingers, a situation that, in accordance with Murphy's Law, inevitably occurs as the bag is being lifted out of the shopping cart beside one's car. The result can be a mess of glass and jelly on the pavement of the parking lot. Like any design, the supposedly perfected grocery bag is only as good as the care with which it is used.

However, it is not the paper bag's susceptibility to failure under extreme conditions that has been its downfall. As every shopper knows, it has become increasingly scarce in supermarkets for reasons other than strength. Brown paper bags have been largely replaced by plastic bags, whose propensity to develop, but also to tolerate, holes and rips is well known to anyone who has ever brought a large load home from the supermarket. The plastic grocery bag also has a smaller capacity than the paper bag, and its thin film suggests flimsiness and ephemerality, as compared with the kraft paper bag's strength and substance. So why by 1996 were more than four out of five grocery bags made of plastic?

The plastic bag was introduced into American supermarkets in the mid-1970s. In 1982, only 5 percent of grocery bags were plastic, but every year more shoppers were asked, "Paper or plastic?" By 1990, plastic bags accounted for 60 percent of the market, or about 23 billion bags per year, and some stores were no longer giving shoppers a choice. The plastic bag, with its lighter weight and more compact form, was the clear preference of the merchant and eventually, in spite of its shortcomings, of the customer as well.

Plastic bags begin as long seamless tubes extruded from various kinds of polyethylene, a form of plastic that in sufficient thickness can have considerable resistance to stretching, a desirable property for a grocery bag. Their bottoms, however, are formed not from the folding and gluing operations that produce paper bags, but by the application of a line of heat across the flattened tube of plastic film. This accomplishes three things: it fuses the polyethylene into an almost-seamless bag bottom; it separates that bag from the next in line on the tube; and it fuses the top of the bag,

thus forming the basis for its handles. After the (still-closed) bags have been stacked, they can be cut through to form an opening between a pair of handles.

Because their handles are suggestive of shoulder straps, plastic grocery bags are known within the industry as T-shirt bags. This is a misnomer, however, because when new and as yet unopened, the handles are suggestive not of a short-sleeved polo shirt but of the shoulder straps of an even more casual muscle shirt. Nevertheless, the bags do have great advantages for the customer. They are easier to wad up and store at home, and, as long as they remain intact, their waterproof properties make them excellent for reuse, especially for the disposal of wet refuse. (Taking out the garbage in an old brown paper grocery bag often results in a trail of drippings that Hansel and Gretel could have followed back to their house.) Plastic grocery bags can also be reused to transport soggy laundry, damp swimming suits, and other potentially messy loads.

It should come as no surprise that the principal reason plastic has displaced paper in the grocery store is economics, aided and abetted by promotion. Not only were costly paper bags given away free with each grocery order, but they also took up a great deal of space that consequently could not be used to stock things that people might buy. So it was not just to save trees that some stores began to offer customers a cash credit, albeit usually only a nickel, for bringing their own bags to the store.

In order to have the necessary strength, paper bags cannot be made entirely of recycled material. This is one reason that recycling them has never been widely promoted. By contrast, the upstart plastic bag has become the object of very visible recycling programs. In 1990, more than ten thousand supermarkets, representing about one third of the total in the United States at the time, were promoting the recycling effort to recover some portion of the almost 400 million pounds of polyethylene then used in the manufacture of plastic bags. As many as one out of every four plastic grocery bags used were returned to some stores, and the recycled material was reportedly made into new grocery bags, trash bags, bottles, and other useful things. But a manufacturer of reusable cloth shopping bags claims that the "average consumer uses 500 disposable paper and plastic bags a year" from grocery stores alone and that "very few plastic bags are actually recycled."

Whether recycled or not, the filmy plastic bag, unlike the square-bottomed paper bag, cannot stand by itself and so needs a supporting technology—an infrastructure. At the supermarket checkout counter, plastic bags are kept at the ready on a wire rack as clever in design as a clothes hanger. It is on this walker-like frame that the bags are hung in multitudes, opened, and packed in place. As frail as it may at first have seemed, the familiar plastic bag has gained our confidence, convincing us that it is less likely to rip than an overloaded paper bag lifted by its edges.

When I was a graduate student without a car, I lived in a small apartment almost a mile from the nearest supermarket. The first time I went there, I filled the shopping basket with staples: cans of soup and beans; jars of peanut butter and jelly; boxes of rice and cereal; eggs, bread, and milk. Everything seemed so necessary to get on this first trip that I forgot it would all have to be transferred into grocery bags. This was before the plastic bag had made its debut, so there was no question that all the groceries I bought would have to be packed into paper sacks or cardboard boxes. I instructed the bagger to pack everything into two sacks, expecting to carry them by wrapping an arm around each one. I was warned that because I had bought a lot of cans and jars, the bags would be very heavy, but I insisted. The bags were filled to the brim, and the eggs and milk and bulky boxes of cereal had to be put in a third bag. I figured that I could manage to carry this third, light sack like a lunch bag by grasping its rolled-top edge with the fingers of one hand.

This was also before the time when people thought of appropriating a store's shopping cart and removing it from the premises. It did not occur to me that I might hijack a cart for the half hour or so it would take to wheel it to my apartment, remove the groceries, and wheel it back where it belonged. The two stuffed bags were indeed heavy, but I was young and proud, and I wrapped my arms around them as if they were long-lost friends. With the third bag dangling from my right hand, I walked out of the supermarket and headed toward my place. After a few blocks, and out of sight of the clerk who followed me out the door, I had to put the bags down. Luckily, there was a waist-high wall beside the sidewalk on which I could stand the heavy square-bottomed bags. Had I put them on the ground, I might not have been able to pick them up again without ripping them or spilling their contents. After three more blocks, I took another break by setting the bags down on the trunk of a parked car. When I reached my apartment, I set the two heavy bags down on the porch and carried the light one inside. Half an hour elapsed before I could bring myself to retrieve the others, one at a time. Except when I had access to a car, I never purchased such a large order again.

Almost a century ago, Walter H. Deubner, the operator of a small grocery store in St. Paul, Minnesota, saw his customers struggle as I did, and found himself wishing they could carry more items out of his store. He devised a shopping bag by reinforcing a paper bag with cord, which also formed handles. The "Deubner Shopping Bag" sold for five cents (a practice long continued by department stores), and by 1915, more than a million were bought each year. Deubner's bags are said to have been "strong enough to carry up to seventy-five pounds worth of groceries." That is a remarkable capacity, but beyond the weight that most shoppers would want to or be able to carry very far.

The handles of plastic grocery bags, which enable shoppers to carry

more bags at one time than they could if the bags were paper, are among their most competitive features. The paper-bag industry has therefore tried to take away this advantage by introducing handles on its grocery bags, essentially making them into shopping bags not unlike the ones Deubner devised almost a century ago. But, unlike the classic paper shopping bag with its thick string or rolled-paper handles, the new bags have flat handles. These work fine as long as they are pulled parallel to the side of the bag to which they are glued. But they have very little holding strength when pulled away from the bag, as is likely when a shopper tries to tote a bag by only one handle. It is no wonder that the commandment "Please hold both handles" is printed on the bottoms or sides of many of these "handle-bags." (Interestingly, such bags have a vestigial notch cut into one side of the top edge. It is not very useful for snapping the bag open, however, since the handles shield it from easy access by the bagger's fingers.)

The Paper Bag Council advertises the handle-bag's "strength, durability, and capacity," a clear comparative reference to the plastic grocery bag's apparent flimsiness, its susceptibility to puncture, and its smaller capacity. But the cause is likely to be a losing one for the paper-bag industry, given the perceived benefits of the plastic grocery bag—benefits that appear to outweigh its outright failures.

For all its advantages when full, there is no way to pack a plastic bag with attention to the same geometrical aesthetic as can be achieved in a square-bottomed paper bag. The best the bagger can do is segregate like products and refrain from placing the eggs between the two-liter bottles of soda. Putting plastic bags full of jars and cans in a car trunk not designed to keep them in place is an invitation for the contents to roll into distant corners. The lightly loaded plastic bag containing boxes is likely to end up with pinholes in its bottom. The heavily loaded plastic bag occasions an anxious journey from checkout counter to car. Who has not worried that the bag with the jar of pickles and the special bottle of wine will give out as he steps off the curb? Yet the plastic bag has clearly become the container of choice, shoppers adjusting to its limitations the way people adjust to those of all designs. The once near-perfect upstanding paper grocery bag has been largely displaced by something that is at the same time superior and inferior: an evolution that, in microcosm, recapitulates much of the history of design.