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Paper Clips and Design

A paper clip appears to be among the simplest of objects. In its most common form, it consists of a four-inch-long piece of wire shaped by three bends into a thing that is both pleasing to look at and easy to use. It comes fully assembled, and no batteries are required for its operation. No one expects instructions to come with a box of paper clips, and we tend not to think very much about how they are made and used. We take paper clips, as we do a lot of familiar artifacts, for granted, and seldom give them a second thought. They seem to be just too simple and ubiquitous to be very interesting or instructive. However, sometimes the simplest of things can hold as much mystery and provide as many lessons about the nature of engineering as the most complex.

When an object is simple and small enough to hold in our hand and turn about at will, we can inspect it to our heart's content to see for ourselves how it is made and how it works. If the artifact is inexpensive enough, we can each have an adequate supply to break open or test or experiment with in any way that might help us understand how the object is made and how it works. If the principles on which the object functions are conceptually simple and clearly visible, then we can explore questions of how we ourselves might engineer an improved version. Finally, the artifact can serve as a gripping metaphor for engineering itself.

Pick up a box of paper clips and examine it. The box is likely to have a minimum of information printed on it: The brand name (perhaps ACCO, which seems to be just another anonymous acronym, or Noesting, which seems to be an unpronounceable nonsense word); a name describing the kind of paper clips (perhaps Gem or Perfect Gem or Nifty or Peerless or Ideal—certainly something positive-sounding); the quantity in the package (usually a nice round number, like 100, but does anyone ever really count the number of paper clips in the box?); a catalog or stock number (so the supply can be replenished); possibly the address of the manufacturer (so the purchasing department knows where to reorder or locate a supplier, or complain about the product); most likely that ubiquitous UPC (universal product code) barcode that enables checkout counters to be automated; and, more likely a factor in selling the box than almost anything else printed on it, a picture of the kind of paper clips inside.

One thing that is *not* likely to be on a box of paper clips is instructions for use. We are all expected to know how to use these clever little objects, as readily as we know how to open the box and remove a clip, but we might be hard pressed to explain in words alone how to attach a single paper clip to a group of papers.

Let's open a box of paper clips and take one out, an action we are likely to perform without looking, letting our fingers select a clip from the top of the pile. We seldom, if ever, stop to admire or marvel at the paper clip. If our other hand holds the papers to be fastened, we may glance at the paper clip to see if it is oriented properly to slide onto the papers; if it is not, we will manipulate it around in our fingers without a thought. As we bring the clip to the papers, we will unconsciously notice the loops that must be slid one on each side of the papers. Experience will have taught us that a standard paper clip will not just slide automatically onto the papers, however; we must open the clip, most commonly by a rather subtle action of pressing the end of the longer loop against one side of the paper (which one of our fingers backs up and stiffens), while at the same time flexing the clip just enough so that it can be slid down on the papers with its smaller loop on the other side. This all takes place so quickly and automatically that the complex small motor skills required are usually overlooked, yet this action of applying the paper clip is central to its use—and to our appreciation of it as a piece of engineering.

THE SPRINGINESS OF MATERIALS

The paper clip works because its loops can be spread apart just enough to get it around some papers and, when released, can spring back to grab the papers and hold them. This springing action, more than its shape per se, is what makes the paper clip work. Springiness, and its limits, are also critical for paper clips to be made in the first place. To appreciate this, open a paper clip a bit wider than needed to get the loops around some papers. There will be a point at which the clip will be bent out of shape and will not return to the flat pattern that it had when fresh out of the box. When this happens, the clip's elastic limit is said to have been exceeded (or the wire is said to have been plastically deformed), and it is extremely difficult to restore the clip to the shape it had in the box. Needless to say, the clip is also no longer as effective in holding papers or in lying flat upon them.

Every material that engineers work with, whether it be timber, iron, concrete, or the steel wire of paper clips, has a characteristic springiness to it (not unlike the springiness of a rubber band), and the spring manifests itself in everything made of these materials. This behavior of materials was no doubt observed long before Aristotle's time, but it was a particular topic of discussion in that Greek philosopher's circle. In a collection of "mechanical problems" compiled in the fourth century B.C., the question was asked, "Why are pieces of timber weaker the longer they are, and why do they bend more easily when raised?" We have certainly all observed this behavior of long pieces of most everything: two by fours, spaghetti, pencil leads, plastic rulers, yardsticks, and so on. Anything slender can be bowed easily, and the longer the easier, yet if not broken or plastically deformed it will regain its straightness when put down. This is spring action, and it was not fully understood until about 2000 years after Aristotle's time.

Even the great Galileo did not fully recognize that all bodies have a certain springiness, and, as we shall see in Chapter 3, this led him to make some fundamental errors in his seminal work on strength of materials, published in 1638. It remained for Robert Hooke, a contemporary of Newton, to articulate the essential elements of elasticity. Hooke was an early advocate of the microscope and so was inclined to look closely at natural and artificial objects and to see things that other scientists overlooked. (Among the first observations Hooke reported in his *Micrographia*, published in 1665, related to the details of simple objects, such as the point of a needle or the edge of a razor.)

There was fierce competition among seventeenth-century scientists over priority of discovery of everything from calculus and natural laws to clever new devices, and so publishing a discovery in a cryptic manner established that one had made the discovery without having to reveal the details of it until the busy scientist or inventor had the time or inclination to do so in the way one would now, in the form of a scientific paper or a patent application. Although Hooke discovered the nature of spring force as early as 1660, he did not publish his observation about the elasticity or springiness of materials until 1678, and then in the form of an anagram.

The customary language of the time was Latin, and anagrams then did not have to spell out something apposite as they are expected to today (for example, THEY SEE is an good modern anagram of THE EYES). Thus, Hooke's anagram was presented with the letters in alphabetical order, as follows: *ceiiinosssttuv*. When he was ready to articulate his principle, he rearranged the letters to spell out, *Ut tensio sic vis*, which is commonly translated by the phrase, "As the extension so the force."

What Hooke had discovered was that, up to a limit, each object stretches in proportion to the force applied to it. Conversely, the more we stretch something elastic, the more resistance it offers to being further stretched. Thus if we pull a rubber band with twice as much force, it stretches twice as far. If we hold a very long piece of spaghetti by one end, it sags in a gentle but barely perceptible curve. Here the weight of the spaghetti itself is the force doing the pulling, and the stretching results from the bending that occurs. If the piece of spaghetti were too long, it could break, as it will if we cause it to vibrate, which adds the force of inertia to that of gravity and causes curving and bending beyond the Hookean, or elastic, limit. When the spaghetti or its broken parts are put back on the table, they are straight again, with the table providing support.

These springing phenomena are manifestations of Hooke's Law, and they (along with many other phenomena of materials and structures) affect the behavior of airplane wings and bridges and skyscrapers and paper clips and virtually everything mechanical and structural that engineers design. Heavy wire cables that support elevators in skyscrapers have a springiness that is exaggerated by the extreme length of the cable, and the bounce it produces can be unsettling to passengers if not properly taken into account in designing the elevator system.

A degree of elasticity can be very helpful in the operation of even the simplest of objects. If a straight pin, for example, did not have sufficient flexibility to allow it to bend a bit as it was threaded through a piece of fabric, the pin would tend to be more difficult to use and would not work as well. Furthermore, if it did not have enough spring and tended to stay crooked or plastically deformed whenever so slightly bent, it would not be so easily reusable. Although primarily intended to hold clothing together before buttons were commonplace, straight pins, like all technological artifacts, also came to be cleverly adapted for other uses. One important use was to attach papers together, long before anything like a modern paper clip was developed. To this day one can find pins used in this manner in third-world countries and in banking and brokerage businesses that cannot tolerate the risk of a paper clip slipping off documents

FIGURE 2.1 A mid-nineteenth century portrait of the British engineer Isambard Kingdom Brunel, holding a pencil, with a wooden paper clip in the foreground

or the extra time it would take to remove staples. Before the metal paper clip, clothespins and other wooden clamplike devices were also used to fasten larger piles of papers together (as in Fig. 2.1), and in the mid-nineteenth century the term "paper clip" more often than not meant a rather large metal clamp much like the kind that is found on clipboards today. But well into the twentieth century the straight pin remained a most common means of keeping a few sheets of paper together.

FORMING WIRE INTO PAPER CLIPS

The kinds of wire used for centuries for making pins was also suitable for making paper clips, but the idea of a bent wire paper clip is more obvious in retrospect than in prospect. Bending wire into clever shapes is a very old concept, and even the Romans had such devices as safety pins. But before the advent of wire-working machinery in the mid- to late-nineteenth century, the process for making even a single pin or needle was rather long and tedious. In his famous book on the wealth of nations, the eighteenth-century Scottish economist Adam Smith used pin making as a prime example of division of labor and its economic benefits. Each step in the process was performed by a separate individual, and collectively they could make 4800 pins per day. Smith estimated that if an individual uninitiated to the techniques did all the steps on a single pin, the output might not even approach 20 pins per day. The famous French encyclopedia edited by Denis Diderot described pin and needle making in the late eighteenth century and illustrated parts of the process (Fig. 2.2). It was not hard to see the advantages of designing machinery to perform automatically all the tedious steps of pin making, but it was not until the 1830s that the American inventor John Howe succeeded in developing an effective pin-making machine (Fig. 2.3). Such a machine has been on

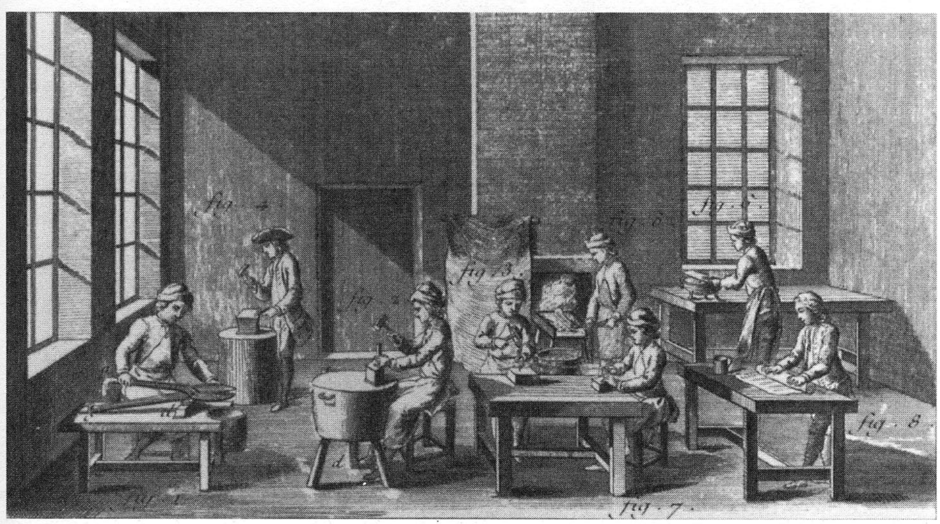


FIGURE 2.2 The very labor-intensive activity of needle making in the eighteenth century, suggesting also the division of labor involved in pin making at the time

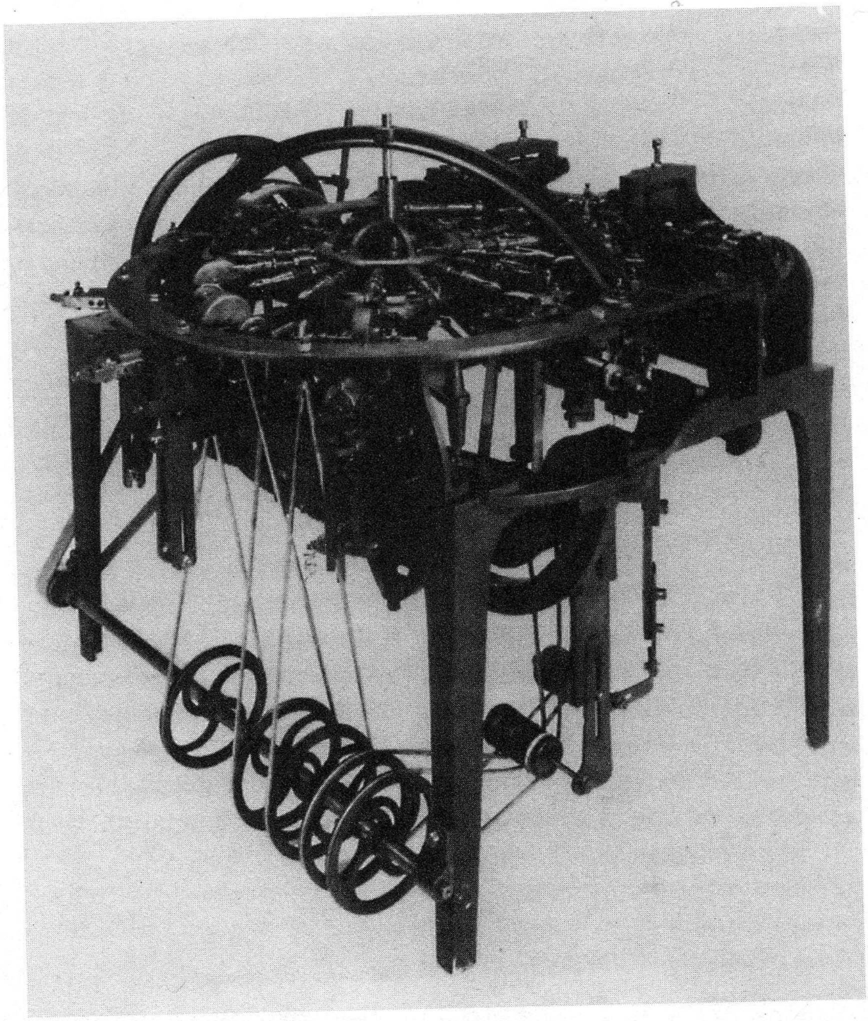


FIGURE 2.3 A pin-making machine, patented by John Howe in the mid-nineteenth century

display in the National Museum of American History of the Smithsonian Institution, along with a videotape showing pins being made by it.

Paper clips could certainly be made by hand, just as pins had been for so long, but since pins served the purpose there was no pressing need to make such specialized objects as paper clips. With the development of the Industrial Revolution and the concomitant need to handle more and more volumes of paper as businesses expanded first nationally and then internationally, extremely specialized devices such as paper clips could be sold in such quantities as to make their manufacture worthwhile, if it could be done effectively.

Imagine how paper clips might be made by hand. They would most likely start much as a pin did, with a piece of wire pulled off a spool and straightened and cut to the appropriate length, say about four inches. This wire would have its spring, of course, but the fact that there was a limit to the spring would make the forming of a paper clip possible. As the wire was bent beyond the elastic limit, it would retain the bent shape. With the experience gained of trial and error, one could learn how to bend the wire, perhaps with the help of some pointed pliers, just far enough beyond the limit so that when the wire was released it would spring back to just the right shape. One could, after a while, develop a facility in doing this bending, and one could devise arrangements of pegs or jigs around which or in which to work the wire. In this way more paper clips could be made and, incidentally, made more quickly, and one might be able to make them inexpensively enough to sell for prices competitive with the pins they would displace in the office. Since pin making had become automated by the time wire paper clips were conceived, it essentially meant that paper clip making also had to be automated to produce a competitive product.

But paper clips could not have replaced straight pins on the basis of competitive price alone, and this brings us to one of the central technological ideas of invention and innovation and the roles that engineers play. A new artifact will displace an existing one only if there is a clear advantage that the new holds over the old. The most direct and successful means of establishing an advantage is to point out the shortcomings and failings of existing technology and to show how the new device serves to remove objections to the old. Nothing is perfect, and even the most traditional and established ways of doing things leave something to be desired. If a new artifact can be shown to overcome one or more incontrovertible disadvantages of an old, then there is likely to be some artifactual succession or evolutionary displacement. Generally speaking, however, the very fact that long-existing artifacts have become so familiar also means that people have adapted to any inconveniences or problems associated with their use. In fact, it is at first often only the inventor or engineer, effectively acting as technological critic, who even sees anything wrong with things as they are. But, once articulated, the problems that just one critic clearly points out will be immediately obvious to everyone.

If a new invention removes those problems, then it has a chance of succeeding.

The problems that late-nineteenth-century inventors found with the straight pin as paper fastener were several. It was difficult to thread through more than a few sheets of paper; it left holes in the paper; its point could prick one's finger; it could catch extraneous papers; it bulked up piles of paper. A flat paper clip that slid on and off a group of papers could be readily seen to do the job better by removing, or at least reducing, many if not all of these objections. Thus it was that early paper clips could displace pins in office use. But, as with many new products, early versions of the paper clip themselves soon came under criticism by other inventors. Early paper clips were generally not as easy to attach as subsequently conceived versions; early paper clips slipped off too easily; early paper clips got tangled together; etc., etc.

Whenever an inventor got an idea for a "new, improved" paper clip, its advantages were argued in contrast to the relative disadvantages of the old. A plethora of paper clip patents was issued around the turn of the century, but very few of the designs touted so successfully in the patent applications have survived. This is not surprising, since as each new artifact comes on the scene it becomes an object of criticism, especially by inventors who can imagine how this or that shortcoming (which, at first, only they see) can be removed, perhaps just by giving this or that leg of a paper clip a slightly different bend, turn, or twist. Not every inventor would choose to patent a new paper clip design, however, for various reasons. Some chose not to patent because the cost of the patent application seemed too high, others did not believe that the patent system was the best way to encourage invention, others felt they could maintain a better competitive advantage by keeping a trade secret than by revealing a new process in a patent application in exchange for the right to sue infringers.

THE GEM PAPER CLIP

For whatever reason, the most successful paper clip design, and the one that has become virtually synonymous with "paper clip," was never patented. Indeed, the concept of what has come to be known as the Gem clip clearly existed in the late nineteenth century because a patent was issued to William Middlebrook, of Waterbury, Connecticut, for a machine (Fig. 2.4) for *making* paper clips, and the patent drawings clearly show a fully formed Gem as the raison d'etre of the machine. Middlebrook's 1899

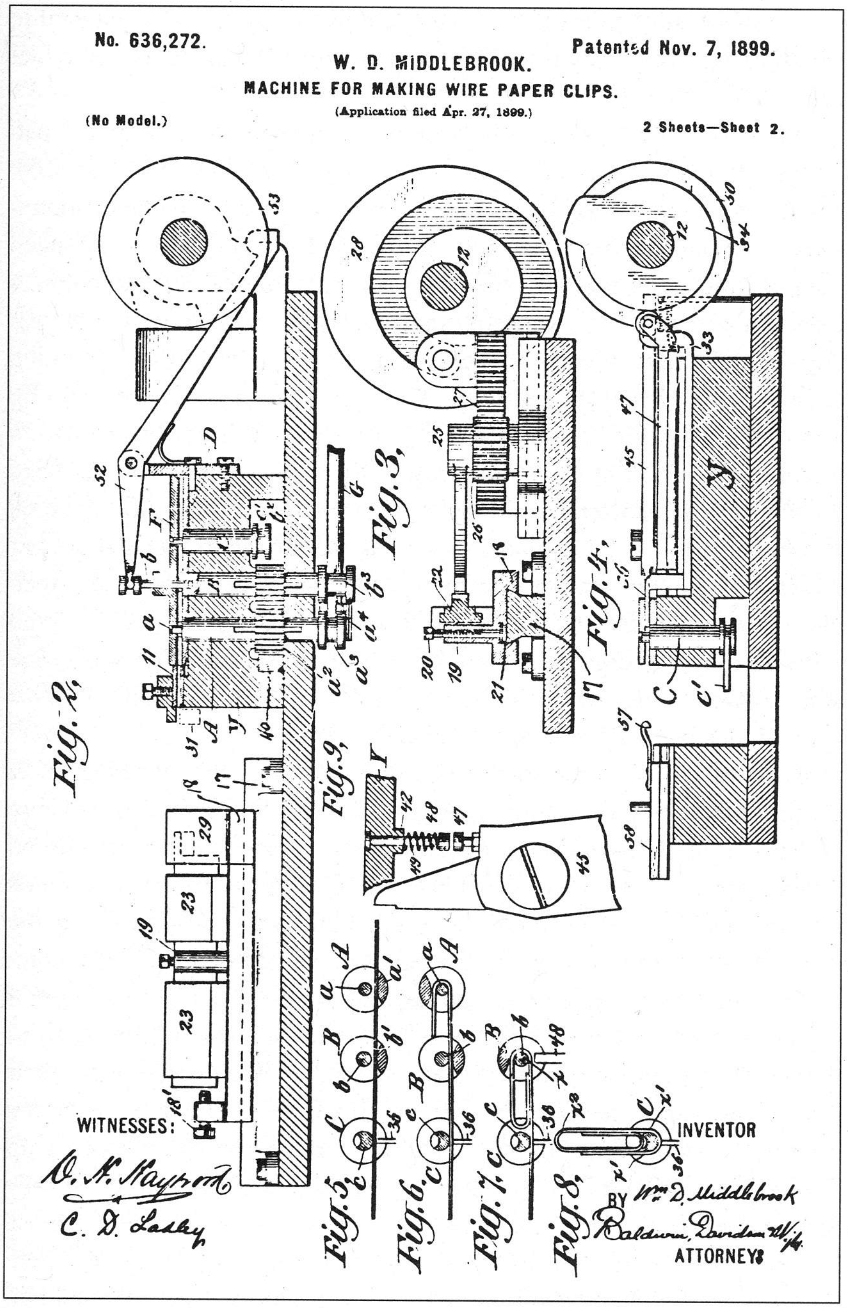


FIGURE 2.4 William Middlebrook's patent for a machine for making paper clips

patent incidentally shows that the standard history of the Gem paper clip, which credits its invention to a Norwegian named Johan Vaaler, is in fact not correct.

While Vaaler and other turn-of-the-century inventors were in fact patenting all manner of shapes and sizes of paper clips (see Fig. 2.5), Middlebrook was patenting the means for forming the Gem clip economically. Without machines like his, no paper clip could have challenged the machine-made pins very effectively. The complexity of Middlebrook's machine is clear from his patent drawings, and it is apparent that he was engaged in serious mechanical engineering as opposed to just doodling to find a new shape of paper clip. There could be many shapes of clip that can hold a pile of papers just about as well as, if not better than, a Gem, but the ability to manufacture the clips reliably and in large quantities is what would make or break a company. Why Middlebrook chose the Gem design to manufacture may be subject to speculation, but it clearly is the clip that the machine was designed to shape. The principles upon which the machine works, bending wire around pegs, are well suited to the Gem design and it to them. In short, Middlebrook's machine and the Gem were made for each other. But if not from Vaaler and his contemporaries, from where did the Gem come?

Believed to have been introduced in England in the late nineteenth century by a company known as Gem, Limited, the now-familiar paper clip that took its manufacturer's name soon became firmly established as *the* paper clip to which all others were compared. Patents continued to be issued for improvements in paper clips, but none displaced the Gem. Today, when an icon for the paper clip is needed to label a computer's desktop organizer or to warn against jamming copier machines, it is the Gem that seems invariably to be employed. Newer clips, such as the plastic-coated wire variety, are shaped like Gems, although their proportions never seem to be quite right. One of the latest genuine improvements in (Gem) paper clips is the introduction of a turned-up lip on the end of the inner loop. This enables the unopened clip to be truly slid on the papers, and there is no need for the user to spread the loops of the clip apart manually. But, as with just about all improvements, there is a trade off. This new clip is not flat, and so it adds further bulk to a pile of papers.

In fact, this new improvement is not even all that new, for it was clearly present in at least one version of paper clip patented in 1903 by George McGill of Riverdale-on-Hudson, New York. Several versions of his clip, as illustrated in the patent drawings (Fig. 2.6), show clearly that McGill also sought to improve the Gem by turning up or putting an eye or bulb on the ends of the wire, which tended to catch and rip the paper upon removal, as well as to introduce a turned-up end on the inner loop to make application easier.

IMPROVEMENTS IN PAPER CLIPS

Inventors are always looking for things to improve, and for about a century the Gem has been the main target of criticism in patents for new and improved paper clips. For example, one clear challenge to the Gem was patented in 1934 and has come to be known as the Gothic clip (Fig. 2.7), because its loops are pointed more to resemble Gothic arches than the rounded Romanesque ones of the Gem. Henry Lankenau's patent application for the "perfect Gem" also listed ease of applying to papers as one of the invention's advantages. More importantly, the Gothic clip has longer legs that extend almost to its squared end, thus reducing the possibility that their sharp ends would catch and tear paper. Since the danger of tearing papers or the pages of books is minimized with this clip, it can typically be made of heavier wire to give it better gripping power. While it is also more expensive, the Gothic clip is favored by some users, such as librarians, because of its distinct advantages.

There are other ways to improve the paper clip, and among the most often tried is economizing on raw materials, a common object of engineering design and manufacturing. After the capital investment that goes into the machinery to make paper clips, the wire that is used is the single most controllable factor in determining cost and hence price. Because invention, design, engineering, and manufacturing are always bound by the laws of nature, only so much savings can be effected by reducing the quality of the wire used. There must be just the right spring to the paper-clip wire, and to try to make clips with too stiff or too soft a wire is tantamount to trying to break Hooke's Law. Material economies can be realized in another way, however, and that is in the amount of wire used in each paper clip. Starting with a piece of wire just ten percent shorter that what the competition uses to fashion its Gems can translate into an advantage in the office products catalog, especially if saving pennies on every box of paper clips is more important than how the clips look to a supply manager who orders them by the millions.

The classic Gem paper clip has certain proportions, as shown in Fig. 2.8, which are principally manifested in the distance between the inner

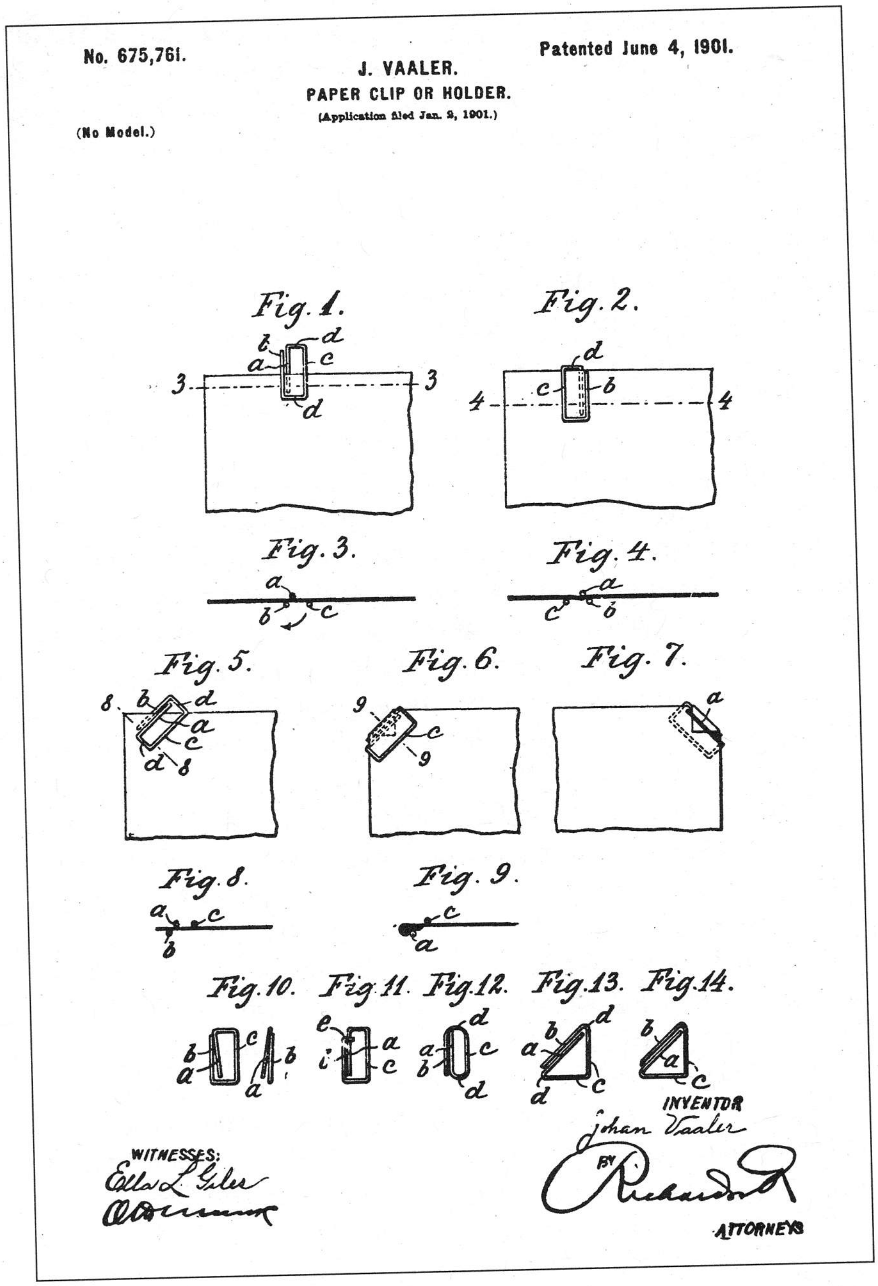


FIGURE 2.5 Two of the many early twentieth-century patents granted for paper clips

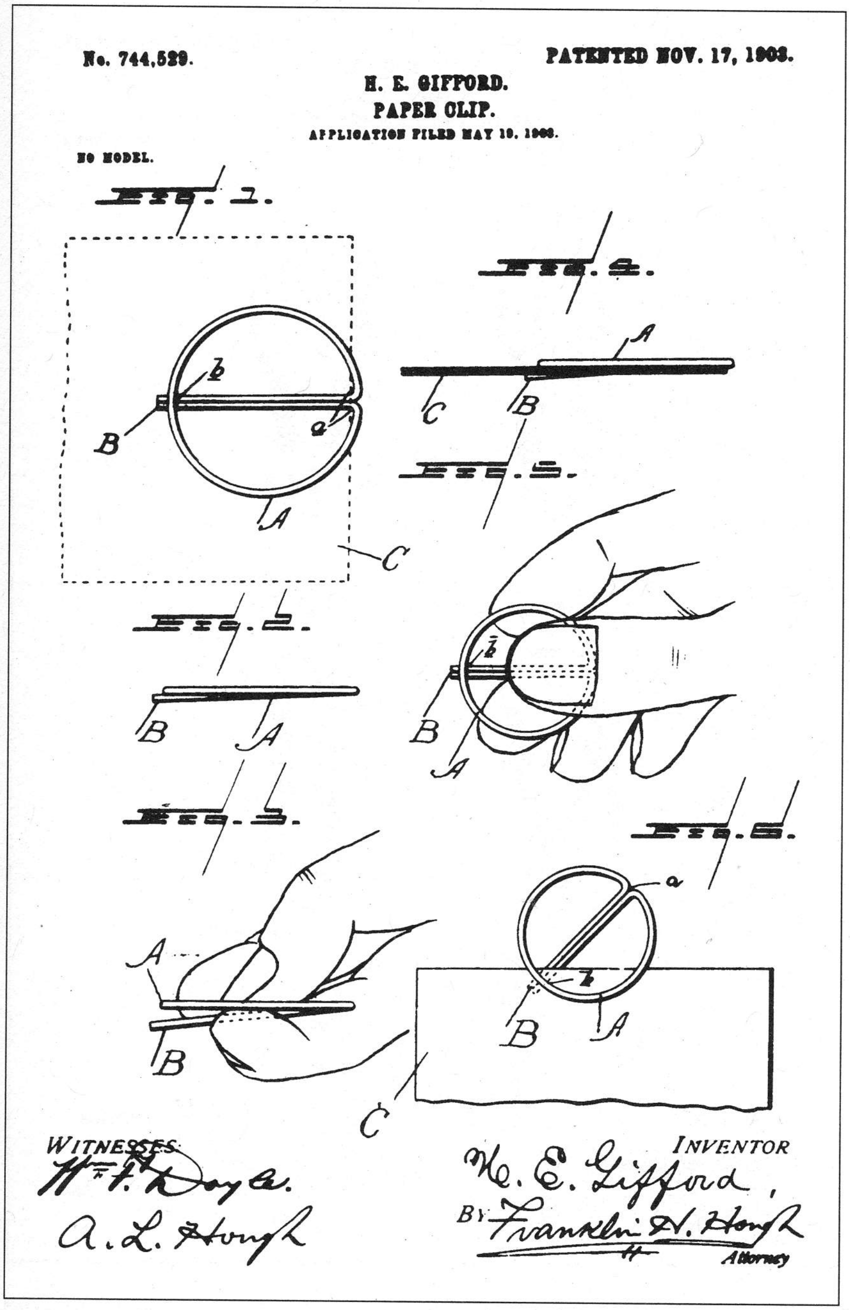


FIGURE 2.5 *(Continued)*

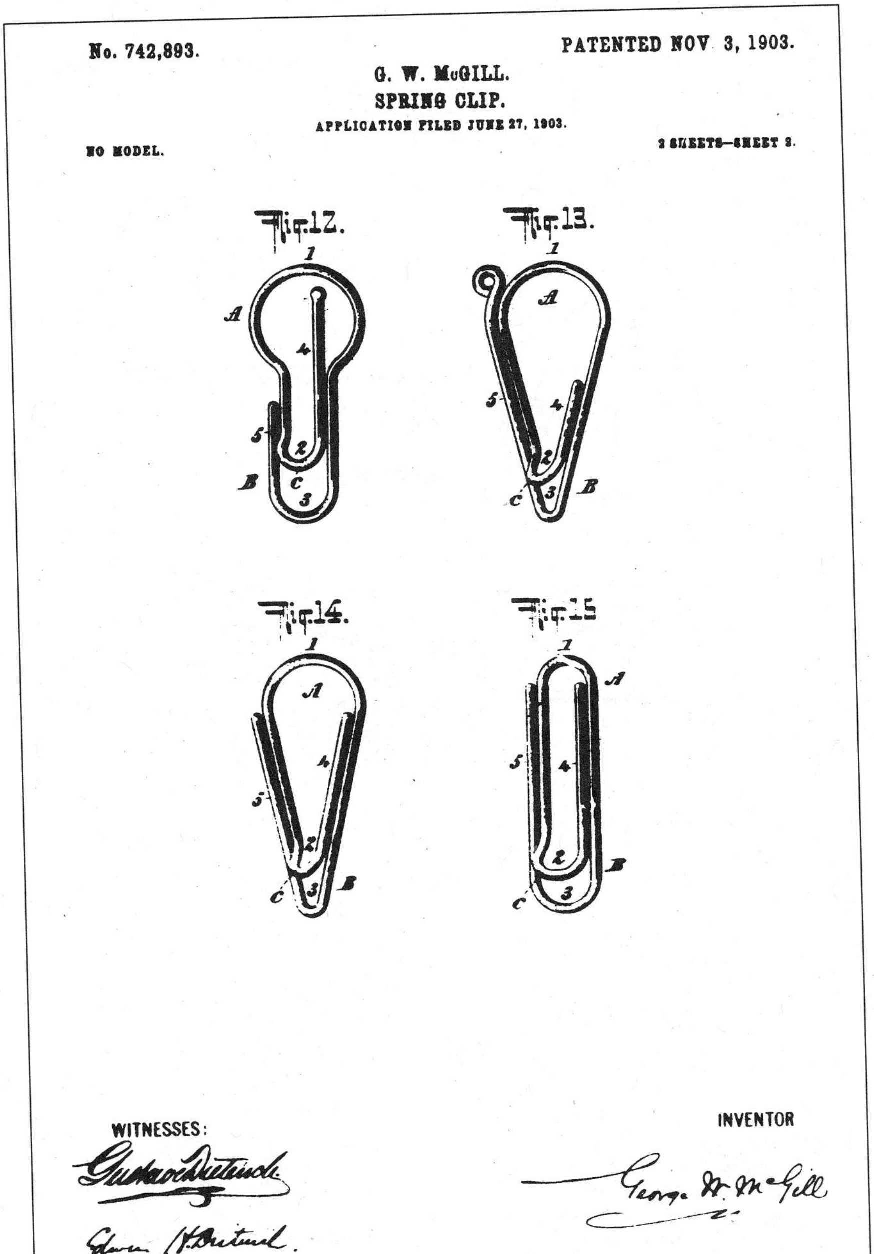


FIGURE 2.6 An early twentieth-century patent for a wide-lipped paper clip

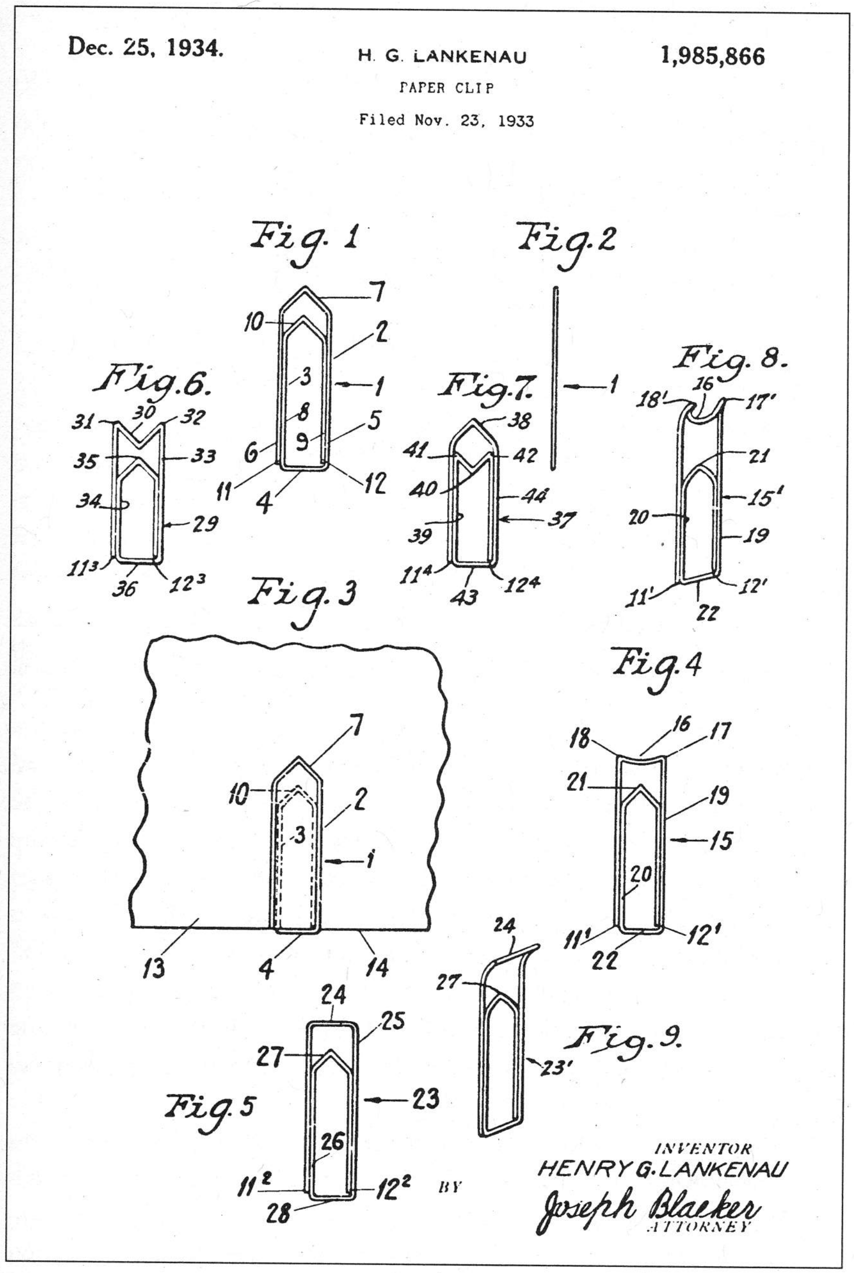


FIGURE 2.7 Patent for a Gothic-style paper clip, issued in 1934

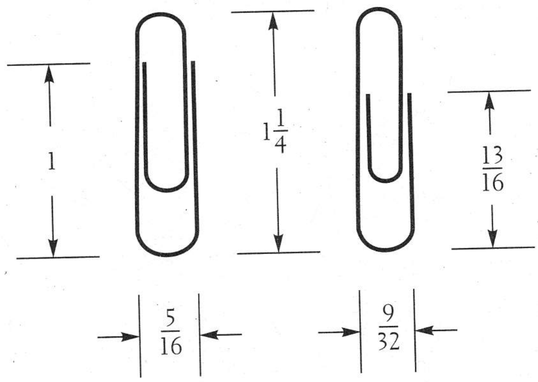


FIGURE 2.8 Dimensions (in inches) of a classic Gem paper clip (left) and a recent imitator

and outer loops and the length of the legs in which the wire terminates. The longer the inner loop, and thus the closer it is to the outer loop, the harder it is to attach a standard Gem, but the longer the loops and the legs, it has been generally believed by inventors, the better the gripping action of the clip. Like many a problem in engineering design, there is a tradeoff no matter what proportions are chosen, and the "best" solution is the one that balances ease of application with gripping power. The compromise might be further complicated if the designer wishes to choose balanced proportions that make the clip also aesthetically pleasing to the eye.

The proportions of the Gem illustrated in Middlebrook's 1899 patent for his machine seem to have struck the happy medium that gave an all-around successful paper clip. Like all artifacts, the Gem had its shortcomings, but for almost a century its proportions remained unchanged. When old companies wanted to make a less expensive Gem or newer manufacturers wanted to break into the market, one of their most obvious strategies was to use less wire per clip, which necessitated making judgments about how to reshape the classic lines of the Gem. A proportionately smaller clip would be one solution, but the overall length of the clip would then change, and that would make the clip seem not quite comparable to the standard Gem. Alternatively, the loops could be moved further apart or the end legs could be shortened, or thinner wire could be used, or all of the above could be incorporated in a very inexpensive paper clip. Many of the newer manufacturers of "Gems" being sold today have taken this last course, making the clips look, feel, and behave differently. Each such alteration also leads to functional problems, of course, such as reduced gripping power, more easily deformed clips, and more easily torn papers.

CHANGE AND COMPETITION

The box of "No. 1 Gem Clips" that I took most recently from our office supply cabinet displays a drawing of several Gems on the cover. These are classically proportioned, with close (but not too close) loops and long straight ends. The clips inside the box are different, however, as can easily be seen by placing one of them over the cover drawing. The actual clips, formed of less wire, have more distant loops and shorter legs. This gives a design that appears to be distinctly less well proportioned. In examining the box more carefully, I discovered that the clips are imported from an emerging industrialized country, and it is very possible that they were made on reclaimed old machinery that is not too dissimilar from Middlebrook's but that has been adjusted to cut off a shorter piece of wire before forming it into an almost but not quite classically proportioned paper clip.

Besides the poor proportions of the clips in this box, there is an amazing lack of uniformity from clip to clip, contrary to all the conventional wisdom about mass produced items. Although the side of the box reads "Finest Quality, Bright Finish, and Smooth Style," the contents proved to be a mixture of bright and dull finish clips, smooth and ridged designs, and, most strikingly, a collection of clips that looks almost hand-formed, with some so distinctly malformed that they could hardly be called paper clips. (In one box, I even found a straight pin, recalling the origins of the paper clip and the similarity of the roots of the manufacturing process.) Few of the clips lay flat, many are bent out of their plane and look almost pre-used. Clearly, there was little attempt to control the quality of what goes into the box. Since so few of the clips in the box are flat or have close-set legs, they tend to get tangled together and thus it is difficult to pick out one without several others dangling from it. This problem was described in some of the earliest patents for paper clips, and it was considered such a distinct disadvantage almost a century ago that many a new paper clip design argued for its superiority by claiming that the clips did not become interlocked in the box. Once the faults are pointed out, it is easy to see that the "new, improved" paper clips in the supply cabinet are in fact inferior to the old, established brands! So how did the new brand of paper clips end up in the supply cabinet? Why do manufacturers risk producing products inferior to what already exists?

A book on "successful product design" provides some insight. Written by a former director of design in a manufacturing company and by a lecturer on technical management, the book outlines a concept of "total design," whereby technical issues of design and production are balanced by economic and marketing considerations. As an illustration of the system that the authors have devised, they present a detailed case study of the hypothetical British company, Omega Wire Forming, a large firm that had long prospered by supplying the automotive industry with springs and wire clips. With that industry depressed, however, Omega wished to broaden its product line so that it could move into new markets. The Board of Directors ordered the firm's design manager to form a group consisting of members of the market research, production, sales, and design departments and to look into what new product could be made utilizing the company's experience in wire forming. There were naturally guidelines on how much capital might be invested in new machinery and how much return on investment was expected, but otherwise the research group was unconstrained.

Within two weeks, the group identified wire paper clips as a viable new product. The decision was justified in part by data showing that in recent years the price of paper clips had risen almost three times as fast as the price of wire, that demand for the product was up, and that there appeared to be little customer loyalty to any particular brand. According to the group's analysis, if Omega could manufacture paper clips at three for a penny, it might expect to capture 10 percent of the domestic market, which was estimated to be 500 million paper clips per year. Furthermore, if the price could be lowered to four for a penny, Omega might expect to sell 80 million paper clips domestically and export another 20 million each year. Among the main anticipated costs was that of distribution.

Omega Wire Forming decided to get into the business of making paper clips, and the company's designers and engineers were instructed to focus their attention on improving the Gem paper clip and its method of manufacture. Since the standard-size Gem accounts for 90 percent of the market, its overall dimensions were believed to be fixed. However, if the legs could be cut off shorter, up to 10 percent less total wire would be needed for each paper clip, thus reducing the cost of raw materials, which represents over half the manufacturing cost. A lighter paper clip would result, which would also reflect savings in shipping costs. A test engineer's determination that a paper clip with shorter legs resulted in only a 2 percent decrease in springiness or gripping strength clinched the decision.

Finally, at virtually no additional manufacturing cost, the inner loop of the paper clip could be given a slight bend out of its plane, a competitive feature that had recently begun to appear on most competing British paper clips, thus reviving a feature that the inventor McGill had introduced almost a century earlier (see Fig. 2.6). Within a year of studying the problem, Omega Wire Forming was manufacturing modified Gem paper clips and was expecting to recover its investment costs in eighteen months. Thus are the economics of saving fractions of a penny on items that have potential sales in the hundreds of millions, if not billions worldwide.

Whether the Far East manufacturers of the new paper clips found lately in our stationery catalogs and supply cabinets followed so structured a total design process as that of Omega Wire Forming, the imported clips do embody some very similar cost reduction features to give them an edge over more traditional domestic designs. It behooves those older manufacturers who do not wish to lose very much more of their accustomed market share to the newcomers on the shelf to look at the traditional designs with a critical eye to improving their usability and to educating paper clip users about the aesthetic, strength, and quality advantages that might be had for pennies more a box. The engineer, often acting as an inventor or designer, plays a central role in such considerations, whether the product be paper clips or computer chips. Indeed, the engineer is often the most severe critic of existing technology, and that is why things change over time. Curiously, however, where engineers find fault and see a need for improvement, others can sometimes find perfection.

FORM AND FUNCTION

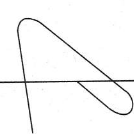
The classic Gem paper clip is often held up by product designers as the epitome of modern manufactured articles. One design critic, praising elegant design solutions, has written:

> If all that survives of our fatally flawed civilization is the humble paper clip, archaeologists from some galaxy far, far away may give us more credit

DESIGNING A BETTER PAPER CLIP

A favorite pastime of some office workers is to doodle in wire by reshaping paper clips into all sorts of fanciful, and sometimes grotesque, new forms.

Try your hand at deconstructing a Gem and designing a new paper clip. How is your design an improvement on the Gem? Does it have any less desirable qualities, such as reduced gripping power? Inventors often claim their improved designs for paper clips have superior gripping power to that of the prior art. How could you determine in an objective way which of two paper clips has the greater gripping force under comparable conditions?

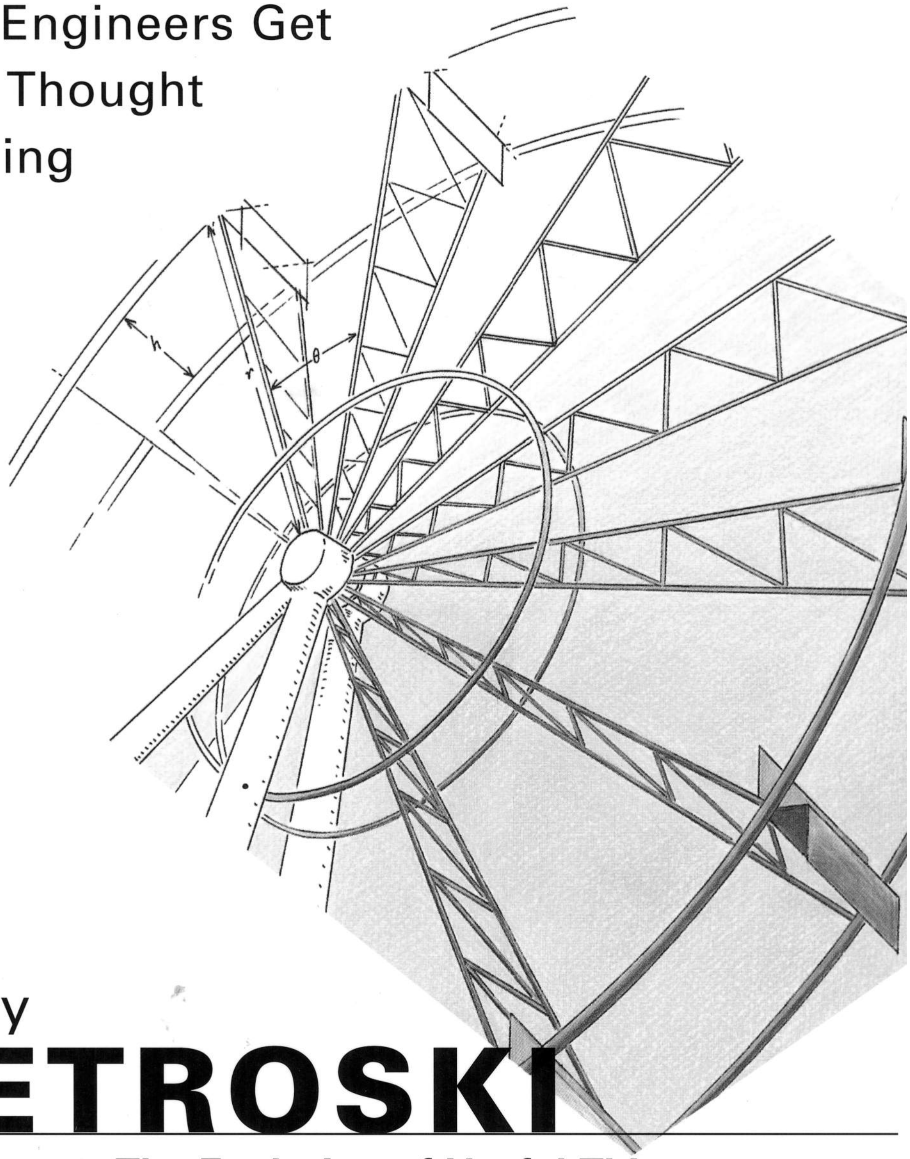


Printed in the United States of America

Library of Congress Cataloging-in-Publication Data
Petroski, Henry.
Invention by design : how engineers
get from thought to thing / p. cm.
Includes bibliographical references and index.
ISBN 0-674-46367-6 (cloth: alk. paper)
ISBN 0-674-46368-4 (pbk.: alk. paper)
1. Engineering design—Social aspects.
2. Engineering design—Political aspects.
3. Engineering design—Case studies.
I. Title.
TA174.P4735 1996
620'.0042—dc20
96-19227

INVENTION by DESIGN

How Engineers Get from Thought to Thing



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