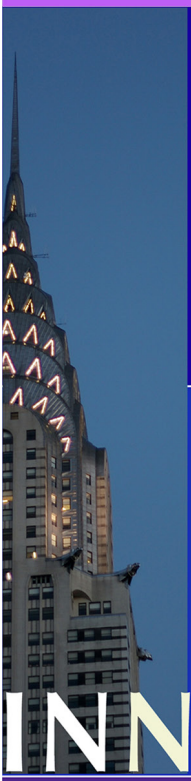
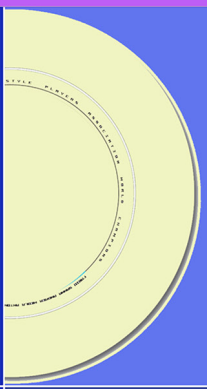
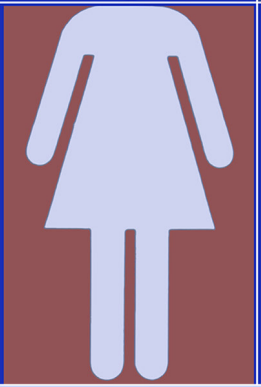




INNOVENTIONS



Breakthrough Designs that Made the World Modern

Alan Robbins

Innoventions

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Design is the way the world of our making gets made. It is the basic process by which we harness our creative energy to make real and tangible things in our everyday lives. The modern world, so familiar to us, is really just the latest moment in the long story of design evolution. In a word mix, each new breakthrough is an innovention that ushers in a new age.

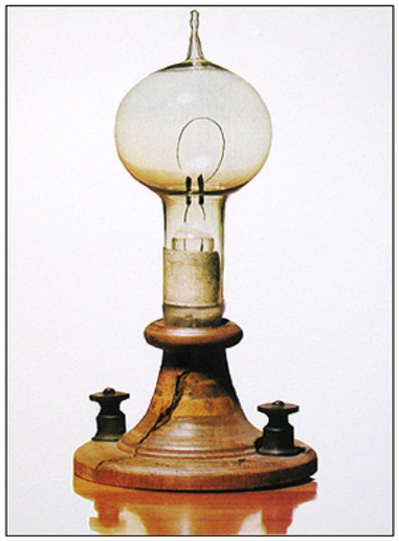
But just which breakthroughs are worth noting is the subject of this book and the list is admittedly incomplete, idiosyncratic, and limited as all such lists tend to be.

For one thing, to make things manageable, the selections are only from roughly the time of the Renaissance until now...one version of the modern world. For the sake of focus, this book looks only at design breakthroughs in the West - in Europe and the New World - since covering the globe would require a much grander project than this modest romp through history and culture. The book is also necessarily dominated by male names; historically they are the ones who recorded history. And finally, the designs are presented in no particular order simply to increase the surprise factor.

Yet in spite of all these limitations, the innoventions explored here should offer a glimpse into the breakthroughs that made the world modern and the ways in which such changes came about.

LIGHT BULB

A Bright Idea



Contrary to myth, Edison did not invent electric light. Scores of inventors all over the world were already trying to "subdivide" electric arc light, that is, reduce its brightness for use in the home. Edison did not even invent the light bulb; inventors such as Joseph Swan and Hiram Maxim were already working on it. What Edison did was to finally make the ideas and designs of all these others work in a practical way, by thinking of the bulb right from the start as one piece in the design of a total electrical system that included dynamos, meters, switches, and fuses.

After months of effort, the final design that Edison and his company came up with for this compatible bulb was based on two key concepts...a coiled filament that would glow brightly (they struggled with everything from platinum to human hair), and a strong vacuum that would prevent the filament from burning up (thousands of hours went into improving their vacuum pumps).

The final, and successful, design change came when they substituted carbon (in fact carbonized thread, and later bristol board) for the filament. By New Year's Eve of 1880, crowds who had gathered at the Menlo Park laboratory were treated to a the first electric lighting display of any millennium. This design for a bulb that would be part of the electrification of a city ushered in a new era of artificial light and indoor life. It also quickly became a symbol for creative insight from that moment on.

BENTWOOD CHAIR

A Gracious Seat

To understand that design is not just about technical problem-solving but about symbolic meaning as well, one need only consider the endless variations on the chair. Chairs are not only for sitting; their designs also present a wide variety of social meanings. That is why thrones look like thrones and not armchairs, and why neither look like stools.

A fascinating mix of sculpture, seating, style, and semiotics, all chairs represent some form of innovention from the fabulous seat of the Sun King to the serene simplicity of the Shaker chair all the way to the innovative fiberglass chair of Charles and Ray Eames.

The representative example here is the famous bentwood chair designed by Michael Thonet. Around 1830, Thonet invented a technique for bending solid beech staves using steam pressure. What he eventually designed and manufactured with this process was a curvy but sleek, light, inexpensive, and very practical chair. Called the No. 14 chair, it quickly became a prototype for modern mass-produced furniture.

By 1990, an estimated 150 million of his classic side chairs had been produced and they, along with many variations, are still in production today. But study it carefully and you will see that the Thonet chair isn't just a place to sit down; it is an icon for an idea...the possibility of a moment of rest, repose, repast, or reflection for ordinary folks. A very modern idea.

BROWN PAPER BAG

Disposable Portage

So familiar, cheap, disposable – and yet so remarkably functional – it is hard to believe that someone somewhere actually invented the brown paper bag. But in 1883, Charles Stilwell not only created it, he also invented a machine to mass produce it. The prolific inventor Margaret Knight also invented such a machine using a slightly different method. Stilwell called his design for a folding bag an S.O.S. or "Self-Opening Sack." Certainly there were paper bags before his, but Stilwell's design included two key innovations. First, the sides of his bag were pleated so that the bag could fold flat and stack neatly. Second, it had a flat bottom when opened so it could stand by itself.

The solution is pure paper engineering. The design really relies on a very simple, but very clever, pattern of folds and is, in its own way, reminiscent of Japanese origami, although applied to more mundane needs.

Stilwell's bag was immediately popular, but it did not really hit big until the birth of the supermarket in the 1930s. As you might expect, there was a slight drop in popularity with the advent of the plastic bag. But environmental concerns and the fact that the paper bag is recyclable, have returned it to its primacy. All of which has made the lowly brown paper bag one of the most familiar and effective package designs of all time.

BRASSIERE

New Means of Support

Is the brassiere a great liberating design innovation or just another politically imposed restraint on the female form? Like most designs directed exclusively at women, the brassiere raises all sorts of questions about social power and cultural manipulation. Either way, though, the bra has had an undeniable impact on fashion and sexuality in the modern world.

The actual inventor of the bra is open to question...images suggesting such a "device" appear variously throughout the world. But the first person to patent the idea and produce the particular design that eventually killed off the corset, was Mary Phelps Jacob. She got the idea as a New York debutante fed up with the corsets of the day which were a kind of boxlike armor made of whalebone and cordage that restricted movement and constricted the organs.

According to her autobiography, one night before a dance she and her maid devised the prototype for the bra from two pocket handkerchiefs, some pink(!) ribbon, and thread. It was such a success that friends persuaded her to make more and Jacobs eventually went into small-scale production. But the brassiere that she eventually patented did not take off until she sold her patent to the Warner Brothers Corset Company. Typically, the design was worth far less than the ultimate product. Jacobs sold her idea for $15,000, but it was Warner that reaped a fortune by manufacturing and marketing it on a grand scale as the new liberation in female undergarments.

STINK TRAP

Banishing the Foul

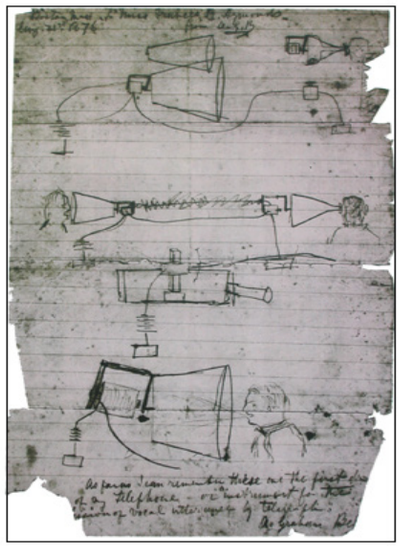
The idea that odors ought to be controlled by design is ancient but also very modern. The flush toilet, for example, had actually been around for thousands of years, dating back to the Minoans. Yet in spite of their advantages over chamber pots and outhouses, they failed to catch on until a flood of designs appeared in Europe throughout the 18th century. From that point on, too many variations make it almost impossible to single out any one for design posterity.

But there was one particular design innovation ~ so utterly simple and so dramatic ~ that it changed the course of toilets for all time. That innovation came in 1775 from a British mathematician and watchmaker named Alexander Cumming. What he added to his toilet design was nothing more than a simple bend in the draining pipe. This was a tiny design change but one with vast implications.

This so-called stink trap was able to "retain a small quantity of water to cut off all communication of smell from below". In other words, the U-shaped bend always kept a small amount of water in it; this effectively separated the toilet from the sewage or septic tank. The stink trap banished forever the odors of the cesspool from going back up the pipe to the toilet. Simple as it seems, this finally secured the triumph of the flush toilet over all other systems and is now the very definition of a modern innovation.

TELEPHONE

Throwing the Voice



Like any great innovention, the telephone has gone through an entire design evolution throughout its history. And few would deny that it is one of the great breakthroughs of the millennium, certainly in its impact on the modern world. But which particular design to select? Unlike radio, which built up by accretion through many decades and the work of many innovators, the basic function of the telephone has not changed that much since the first one ever made.

For that reason, the very first telephone gets special mention as the first device to send a sound, the one that Bell shouted into on that June day of 1875, when his assistant John Watson claimed he could hear "something." Amazingly, although audible speech was not actually transmitted with it, a patent for the telephone was issued to Bell on March 7, 1876.

It was an improved version of this early mechanism that carried Bell's famous "Mr. Watson ~ come here ~ I want to see you," three days later. The pace of evolution in the design of telephones picked up immediately, by Bell and Edison and many others, and has never slackened. Many other phones throughout history have been notable ~ the Slimline, the Cradle, or the classic Model 302 by Henry Dreyfuss, the iPhone ~ but it is the very first design, in this particular case, that seems to best encapsulate the spirit of sending a voice over a wire and achieving that great goal of modern life...collapsing distance.

FORK

A Stab at Civility

Although they were introduced back in the first millennium, forks were exclusively kitchen utensils at first. There is some evidence that they were used at table during the Byzantine Empire in the 12th century, but the first clear illustration of their use at meals is in a manuscript from the monastery of Montecassino in Italy in 1022 A.D. Even so, most of Europe at the time, even the nobility, still ate with their fingers (or the disastrous two-knife method) until well into the 17th century. It was only then that the fork began to appear at dinner tables, and only throughout upper class society at first.

As with the design history of any object, the form of the fork has changed over time, producing countless variations. Tines, for example, increased from the original two to as many as eight, until the optimum amount of four was firmly established by the mid 1700s. At this point the fork came into its own as the primary tool for eating, not to mention the great symbol of foodware, at least in the West.

Chopsticks, while equally innovative and effective (and still favored 2 to 1 throughout the world) date back to 1200 B.C., spoons are even older, and knives far more ancient than that. But it is the fork that has come to represent the great modern design for getting morsels to the mouth carefully and deliberately, and for slowing down meals enough to bring small talk and etiquette to the tables of the world.

FRISBEE

Flight of Fancy

It is a beautifully simple design that takes advantage not only of the utility of plastic injection molding and complex aerodynamics, but of everyone's sense of the romance of flight. To watch a frisbee hover in the air is to see the poetry of physics in action. It helps that it is also great fun to play with.

The original design for a flying disk toy was created by Walter Frederick Morrison in response to the flying saucer craze of the 1950s. By 1957, his invention was being produced in plastic by the Wham-O Company of San Gabriel, California. To expand sales of the toy, company president Richard Knerr went on a promotional tour of Eastern college campuses. But when he arrived at Yale University in Connecticut, he found students already tossing flying metal saucers. These were called Frisbies in honor of a local pie company that made the metal pans.

With a few key design changes ~ notably a ring of ridges around the top and a curled lip around the edge that improved stability ~ the renamed Frisbee was trademarked in 1959. It quickly became and remains an international fad including endless graphical alterations and some pretty serious competitions. Who says that a design cannot be frivolous and still be great? And besides, with its sci-fi echoes and inspiration, the Frisbee can be thought of as a perfectly modern innovention.

SPECTACLES

A New View of Things

The first written reference to eyeglasses occurs in the "Opus majus" of Roger Bacon in 1268. Although it is still hotly debated among historians, the evidence suggests that a glassmaker named Salvino Armato was the first to actually design a pair of eyeglasses in Pisa sometime during the 1280s. No record of the design exists, only accounts of a demonstration. But the description is of a design focusing on the sensible idea of placing two lenses (the word is derived from the Italian for lentil, whose bulbous, round shape early lenses resembled) in a frame that could be worn over the eyes.

Whether by Bacon, Armato, or someone else, the whole idea of using glasses to improve vision was based upon recent translations of the optical theories of the brilliant Islamic scholar Ibn al-Haytham from about 1040 A.D. It is a simple design concept, but one that dramatically altered the opportunities for reading and may well have created the impetus behind the print revolution of the 15th century.

For a century after their first appearance in Italy, the new "disks for the eyes" were convex and aided only the farsighted; concave lenses had to wait for the improved grinding techniques of the 14th century; it is that mass-produced version that allows eyeglasses to slip into the time frame of this book.

It took until the 18th century for the various straps, cords, clips, and clasps for holding them in place were replaced with rigid arms that looped over the ears and led to the one of the most familiar addendums to the modern body.

PLAYING CARDS

Working at Play

Cards, by which we mean cuts of paper with symbols on them, are mentioned as early as the Tang dynasty in China in the 10th century. Subsequent centuries saw a proliferation of this idea throughout the world in money cards, picture cards, alphabet cards, flower cards, and many other applications used for gambling, divination, or education.

But the most popular modern variation on this theme – the conventional deck of 52 number cards divided into four suits – probably made its appearance in the 12th century in Europe. While the distribution of number and picture cards was settled early on, the familiar modern version with hearts, clubs, spades, and diamonds was only established in France by the 16th century.

It is a tribute to the human design impulse that even this very basic scheme has led to endless transformations and interpretations in terms of themes and graphics and imagery. As is true of any designed object, the variety of design possibilities is truly staggering; hobbies, auctions, and obsessions are built around this fact.

Yet as an overall design for a system of play in which 52 numbered cards in four suits can become the basis for countless games of chance and skill, hours of diversion, and fortunes won and lost, playing cards themselves represent an unparalleled design innovation ubiquitous in the modern world.

TIN CAN

The Fine Art of Storage

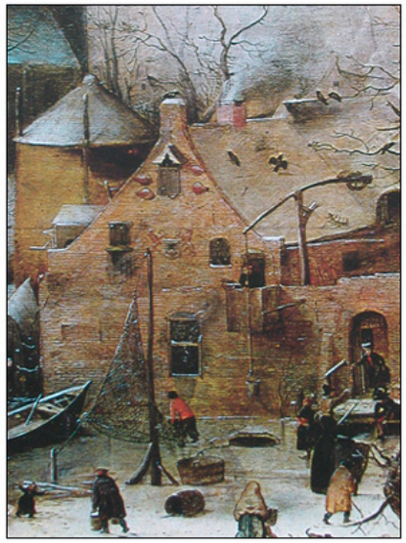
Although ideas for preserving foods in a portable container had been around before the millennium, a total design that also included sealing and preserving had not. The benefits of such an innovation were so obvious in fact, that by 1795 the French government was offering a reward of 12,000 francs to anyone coming up with a workable design.

The original solution by Nicholas Appert was to place the food in a champagne bottle, then seal and boil it. But in 1810 a London merchant named Peter Durand came up with the added idea of fashioning a can made of tin-coated wrought-iron to preserve the food. The patent was bought by Bryan Donkin in 1811, who set up a factory to produce the cans.

Some historians suggest that the tin can may have made the ensuing British Empire possible by allowing the army and navy to venture further afield without increasingly elaborate supply trains, a problem that Napoleon had faced. Naturally, the can also led to an inevitable design explosion as subsequent tinkerers tried to make cans thinner, lighter, stronger, and more easily assembled. Amazingly though, and despite a constant stream of complaints about the difficulty of opening the new device, the first attempts to fashion a decent portable tin can opener did not begin until 1858. And that is a design quest that continues to this day.

CHIMNEY

Up In Smoke



Believe it or not ~ although specific dates are unknown ~ it is fairly certain that the chimney was not invented until the second millennium, and was not in widespread use until the 14th century. Until that time, the only way to allow smoke from an indoor fire to escape was through a hole in the middle of the roof. This of course was drafty, leaky, and could not be used in the rain or snow.

The new design at first was simply an extension of the roof hole that allowed smoke to escape higher than the roof itself. This created a slight updraft that made rooms less smoky, and a narrower opening less vulnerable to the weather. The addition of a flue and a mantle then made it possible to move the fire to the side of the room.

As simple as it sounds, the new design revolutionized dwellings and therefore lifestyles as well. By moving the fire from the center to the wall of a house, the new chimney changed the function of interior space towards more diverse use of the main area. With less smoke to contend with, interior decoration blossomed into an art. And by allowing for smaller and more controllable fires, it led to the notion of private rooms within a home. All these changes supported the new indoor activities that were emerging from other technological innovations and that would profoundly change the work and life habits of Europe...paperwork, leisure, reading.

PAPER CLIP

Gem of an Idea

Before the clip, sheets of paper were held together by a variety of pins or clamps designed for the purpose. But by the time spring-wire was being manufactured at the end of the 19th century, the search was on for a clip that would not damage or make holes in the paper. Typically for the history of design, there were hundreds of variations proposed and patented by the turn of the century.

The classic modern paper clip shape - what has come to be known as the Gem paper clip - was first recorded in the United States in an 1899 patent, but the application was actually for a machine to produce the clip and not for the design of the clip itself. It is likely that the familiar double-looped configuration was produced a bit earlier in England by a company called Gem Limited. And this is the design that we all know so well today.

As everyone knows, the Gem-style paper clip shape is not perfect...it slips, snags, and catches. New designs are constantly being produced using new materials as well as a seemingly endless array of patterns and configurations. But for whatever reason, it is the Gem design that has evolved not simply as the classic form of the paper clip, but as a cultural icon that will not easily be superseded. It has come to represent the modern world of printouts and documents. Form does not necessarily follow function, but occasionally they become inextricably entwined to create an iconic design.

SANDWICH

The Layering Principle

Lest you think that all design is the result of a high-minded process of rational planning, let us consider one of the great eating innovations of all time. The sandwich was named for a notorious 18th century gambler and rake named John Montagu. Montagu was the fourth Earl of Sandwich and first lord of the British Admiralty during the American Revolution.

An inveterate gamester, history records that in the year 1762, Montagu engaged in a 24-hour non-stop gambling spree during which he refused to get up for meals. Instead he ordered sliced meats and cheeses served to him between slices of bread. This arrangement – design, if you will – allowed him to eat with one hand while playing his cards with the other. His contrivance immediately became referred to as a sandwich, and both the name and the strategy have come down to us and stayed there.

Although Romans in the pre-Christian era were known to eat a light snack of food between slices of bread called an *offula*, it was the Earl of Sandwich's design alteration using cold cuts that establishes it as a modern innovention. Admittedly the principle at work – layering of materials – seems pretty rudimentary. But that is only because it is so powerful. It has, after all, been used effectively in many great designs like sheetrock, plywood, and even the microchip.

PANTS

A Leg Up

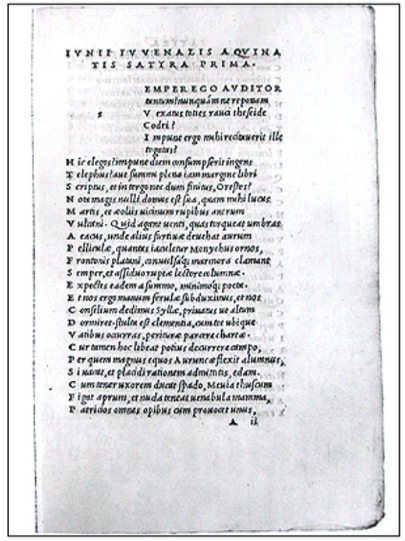
Until pants, men covered their legs with a wide variety of stockings or tights and women tended to be completely covered by any number of fabric wraps, tunics, dresses, etc. But a clothing design that loosely covered the entire lower body and held the legs separately did not appear in Europe until just before the Renaissance and was still rather rare.

The term pants came from the character Pantaleone in the Italian *commedia dell'arte* of the 15th century, who wore an exaggerated version that was tight from ankle to knee but flared out at the thighs. From that point on, knickers and breeches that stopped at the calf began to replace tights, but it was not until the early 1800s that pants became the standard style for men around the world. As an alternative for women, slacks – the word comes from the Roman *laxus*, referring to a loose form of breeches – did not become popular until the 20th century.

By far the most popular type of pants worldwide today are blue jeans. They were designed during the 1850s gold rush in California, by a 17-year old immigrant selling tent canvas named Levi Strauss. His canvas overalls proving too stiff for comfort, Strauss began to use demin which was softer. Besides designing a successful shape for the new pants, Strauss also devised a practical pattern for their cutting and sewing, added rivets to the pocket seams to prevent them from tearing, and used a blue dye to hide stains.

ITALIC TYPE

Brave New Slant



Type design is one of the most complex and challenging of all the design arts; it attempts to balance artistry and expressiveness with clarity and precision. This is not as easy as it might seem. One of the best solutions, and most enduring innovations, in this arena is certainly the creation of italic type.

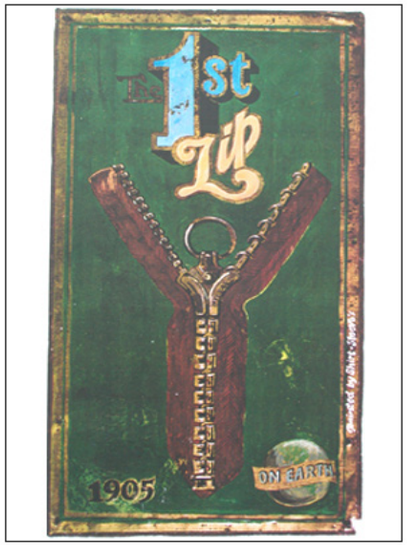
It was a Venetian printer named Aldus Manutius (1450 -1515) who first used italic type. He based this slanted letterform on a chancery cursive style of handwriting that was popular at the time. The idea was to create a new typeface that would mimic, suggest, or at least echo the intimacy and personal appeal of handwriting for the new era of the printed book. Most scholars agree that the first book set entirely in italic type was an edition of the works of the Roman poet Virgil in 1501.

In our time, the graceful curves of italic are seen as a bit too tiring to read for an entire book; italic type these days is generally used to set words or phrases off from the rest of the text for emphasis, for titles, or for foreign words. And for this it works quite well.

Despite this limited usage, though, italic type gets a vote for one of the millennium's classic graphic innoventions; it introduced a simple and elegant gracefulness into printed text that helps to capture the nuances of vocal expression.

ZIPPER

A Design with Teeth



The lowly zipper is so familiar and commonplace that it takes a moment of reflection to understand its true impact. The methods of the past -- buttons, laces, ties, hooks, pins, sashes -- all have their fans, but they were cumbersome, complicated, and often unreliable. The design that is the zipper is the modern era's great attempt at true closure.

The original device, called the clasp locker, was exhibited at the World's Colombian Exposition in 1893 by Whitcomb L. Judson. This was the first device in which a series of metal teeth with tiny hooks engaged with the spaces under adjoining hooks on an opposing row. But his design was so clumsy and snagged so easily that scores of inventors, many of them women, immediately tried to improve on it. Finally, in 1913, a Swedish immigrant and employee of the Universal Fastener Company in Chicago named Gideon Sundback, redesigned and streamlined a version that was patented in 1917. One of Sundback's most brilliant changes was attaching the metal locks of the zipper to a flexible cloth backing.

When the B.F. Goodrich company used the device on its rubber galoshes in the 1920s, the name "zipper" was used as a marketing device. And the rest is modern history. In fact, the design of the zipper is so compelling that it even nudged its fascinating rival - Velcro - right off this list.

CRYSTAL PALACE

Enshrining Newness

Like most grand buildings, The Crystal Palace was not just a structure. It was an entire aesthetic movement as well. It was designed by Joseph Paxton -- an architect and greenhouse builder -- who won a competition for the Great Exhibition in London in 1851. With slight contempt, it was nicknamed the Crystal Palace by Punch magazine and the name stuck.

The design was a conscious attempt to break with traditional architecture up to that time. Relying heavily on new engineering techniques and new materials, the massive 1,800-foot long structure with its extensive use of glass and iron created a new kind of public space, vast and light and open. It was also the first building of its size to be factory built and prefabricated for its erection in Hyde Park.

It was designed to support the goals of the Great Exhibition itself...to showcase the industrial products of the leading economic nations and to create a sense of awe for the visitor. In this, it became the inspiration for any number of world exhibitions of that century, as well as the World's Fairs of a later era.

Naturally, the building was not without its critics, who saw in it not the romance of the future but a confused mix of ornament, pattern, historical reference, and various other sins against good coherent taste. Based on that kind of critique, The Crystal Palace could be seen as the first post-modern building... challenging, confusing, and controversial. Another reason to include it here.

TOP HAT

Heads and Tails

Hats of all kinds and shapes are everywhere in the world, so how to pick one out for special mention? The answer is by sheer whimsy. After all, hats represent an oddity in the world of clothing design, not exactly necessity mothering invention. True, they keep the head warm (sort of) and deflect the rain (so do umbrellas) while, on the other hand, flattening the hair, snagging on doorways, and in some cases causing massive storage problems.

Can you think of a single hat design ~ whether the conical henin of the 16th century, the stiff bonnet of the 18th century, the absurd stetson of 19th, or the daft bowler of the 20th ~ that has any rational purpose other than as advertisement for itself? Of course not and on that basis it makes perfect sense to single out for posterity the most ridiculous, least practical, and best example of a "hat for hat's sake."

Even its debut captures the proper absurdity of the top hat. It first appeared on the head of John Etherington, a London haberdasher who emerged on the Strand on January 15, 1797 with a new black stovepipe hat of his own design. Critics immediately pointed out its impracticality; the hat caused such an uproar that Etherington was arrested for disturbing the peace. On his return from custody, three orders for the new hat awaited him. Now that is a great hat design and a true innovention.

TALKING MACHINE

Music in a Groove

The phonograph ~ ancestor of all sound systems ~ made its debut on December 22, 1877, when its inventor Thomas Edison first shouted "Mary had a little lamb" into the sound tube and heard those words repeated back, though almost unintelligibly. In fact Edison thought little of the device at first. He dismissed its application for recorded music, and instead envisioned it in graveyards playing the voices of lost loved ones.

Still, as other inventors such as Alexander Graham Bell and Emile Berliner improved his original design for better sound quality, the idea of recorded music began to catch on.

By 1888 a series of devices of different designs called gramophones caught the public imagination. With elaborate sound tubes, simple wind-up mechanisms, and shellac disks turning at 78 revolutions per minute, the gramophone became so popular that by 1903 opera star Enrico Caruso could make a million-selling recording of "Vesti la giubba" from *I Pagliacci.*

Other improvements quickly followed of course...motor drives, electronic amplification, balanced needles, and so on. But it was a quintessential gramophone like the Victor Talking Machine ~ with its delicate crank, swiveling needle, black grooved platter, and brassy sound tube ~ that revolutionized communications and created the pop music industry. And due to the accessible elegance of its design, it stands as the classic modern sound machine.

RESTROOM SYMBOLS

A Fine Distinction

Like music and mathematics, graphic symbols are the closest thing we have to a universal language, even being used to communicate with other species. Graphic symbols are also among the oldest known human images ~ appearing in the caves of the Ice Age. Just think of the overwhelming emotional power packed into that infamous symbol of modern evil...the swastika. Or contrarily, the sappy but instantaneous impact of the ubiquitous happy face.

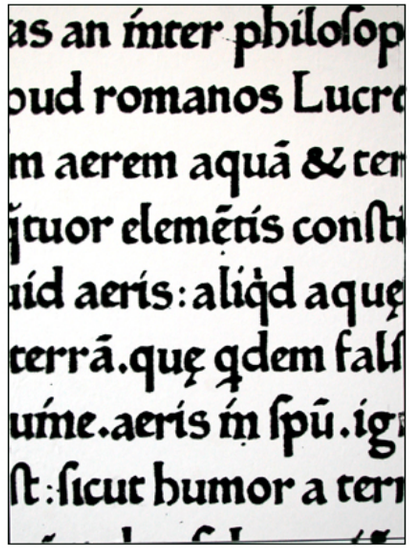
But of all these, perhaps the ones that best express the modern world are the familiar restroom symbols.

The idea of international pictograms emerged in Vienna in 1924 in a system eventually called Isotype (International System Of Typographic Picture Education). By the mid-1960s, the British railways were using a standard design style and The American Institute of Graphic Arts was commissioned to develop a set of pictograms for a wide range of public access uses.

Many countries and localities use their own – sometimes highly unique and confusing – bathroom symbols but the familiar bubble-headed figures from the AIGA set have taken on an iconic significance. Like all graphic symbols and logos, their power is in their simplicity and recognizability. Through this, they not only help preserve a widespread cultural practice, they also strike us as so basic and essential that they have come to represent a way that we think about our human condition as binary, distinct, and gendered.

ROMAN TYPE

From Pen to Metal



Roman typefaces are the ones with letters made of thick and thin strokes, and with those small cross streaks at the ends of the letters known as serifs. You are reading one style right now. They are the most popular typefaces in use throughout the world and include thousands of different variations. But all of these are descendants of the original design by Conrad Sweynheym and Arnold Pannartz, two German printers who were hired by a Benedictine monastery to set up the first practical printing press in Italy in the 15th century.

Until that time, all printing was done in the gothic textura, or blackletter, style. This heavy, compressed, angular letterform had been the most common writing style in medieval Europe; it was even copied by Gutenberg for the first books printed by his new cast-metal technique.

But to offer a more readable, graceful texture in their printed text, Sweynheym and Pannartz made their design consistent with the Renaissance passion for everything classical. Their new typeface design combined classic Roman capitals with the humanist small letters favored by Italian scribes. They added serifs to the small letters to match the capitals for a consistent look. The result was an open, flowing typeface ~ with letters that were easy to distinguish even in smaller sizes ~ that became the basis for all the serif typefaces we see today.

SISTINE CEILING

Heavenly Designs

It is popular these days to distinguish art from design by suggesting that the former is concerned with self-expression and the latter only with problem-solving. This is a weak distinction, however, since artists are always solving problems just as designers certainly express themselves through their work.

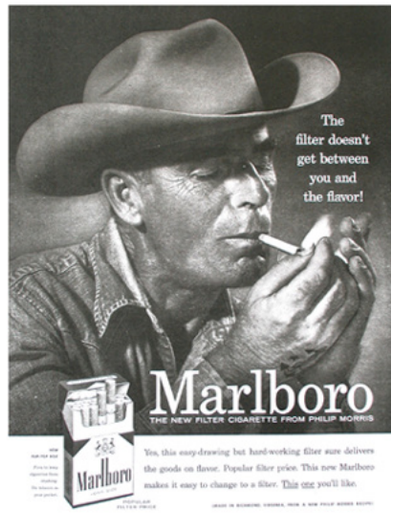
To prove the point, take one of the most famous works of art of all time ~ the Sistine Ceiling ~ and consider it as the ultimate design assignment. There was a demanding client (Pope Julius II), a heavy deadline (before the aging Pope passed on), a daily rate of pay (Michelangelo constantly complained about it), a struggle with the technology (the challenges of horizontal fresco painting), written copy (the Bible), and a given format (the limitations of the chapel ceiling itself).

In other words, the Sistine Ceiling assignment had all the earmarks of a basic design challenge from the design brief to the conception, the sketches, the production techniques, the final unveiling. Add to that all the pure design decisions that were involved in planning, organizing, and composing such a complex work in such a challenging space, and you have nothing less than a wonderful example of communication design at its most successful and most famous. It also happens to be one of the greatest works of art of the millennium as well.

All modern environmental and public art of all kinds can be linked back to this grand innovention.

THE MARLBORO MAN

Icon Making



Great is not always good and not all great design is benign. Since design is what we humans do, it necessarily reflects our dual nature...both in our dreams and our nightmares. The images we create as part of our design obsession have a unique power to encapsulate social fantasies, to focus cultural mores like a lens. Through this, every age develops its symbols of beauty, power, and propaganda.

One of the best examples of this in modern times is the classic Marlboro Man, an advertising image usually considered to be one of the most influential graphic images ever created. The Marlboro Man was invented by legendary adman Leo Burnett in the 1950s for the Philip Morris cigarette brand and it was so popular that it was featured for thirty years in its advertising campaigns as photograph, illustration, or graphic rendering.

The image did precisely what advertising icons do best...it compressed reality into a nugget of fiction. In this case, by representing a certain classic American dream of rugged individualism, tough sensuality, cowboy power and using this to imply that smoking is healthy for your body and soul. That this virtual reality helped to hook an entire generation on the drug nicotine only underscores its manipulative power. Tragically, and ironically, the original model for the Marlboro Man died of lung cancer in the 1990s. Even so, it is the awesome manipulative power of the Marlboro Man imag, for better or worse, that puts it on our list of modern innoventions.

PERIOD

Getting to the Point

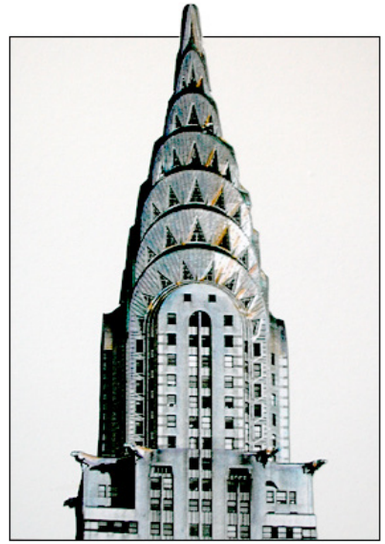
It doesn't look like much design-wise. Just a round black dot. But design is not just about the look of things; it is about their function too. The secret of this particular dot's greatness is not in the visual form (which is not terribly innovative) but rather in applying it in a new and dramatic way (which is).

Believe it or not, the period as a sentence ender was not set down until the Renaissance. Up to that time, the methods for separating written ideas on a page were a hodgepodge of blanks, slashes, dits, and dashes. Then in 1566, Aldus Manutius the Younger (whose grandfather is cited elsewhere for his role in creating italic type), defined the use of the period as a full stop in his book, *Interpungendi ratio*. Although he wrote this treatise as a style manual for printers, what Manutius really did was set down a basic rule for the musicality of prose. His design for the dot called for a way to separate ideas into visual phrases that influenced all written prose thereafter, whether in the long symphonic paragraphs of 19th century fiction, or the snappy jingles of modern ad copy.

In a 1680 book entitled "Treatise of Stops, Points or Pauses," an anonymous English teacher wrote that a full stop, or period, was "a Note of perfect Sense, and of a perfect Sentence." Surely perfect is a reasonable measure for any great design innovention.

CHRYSLER BUILDING

Scraping the Sky



Any collection of great designs since the Renaissance would have to include that quintessentially modern innovention...the skyscraper. Part hubris, part romance, and with a dash of flashy engineering magic thrown in, the skyscraper has come to symbolize the city, which itself has become an emblem for modern civilization. For better or worse.

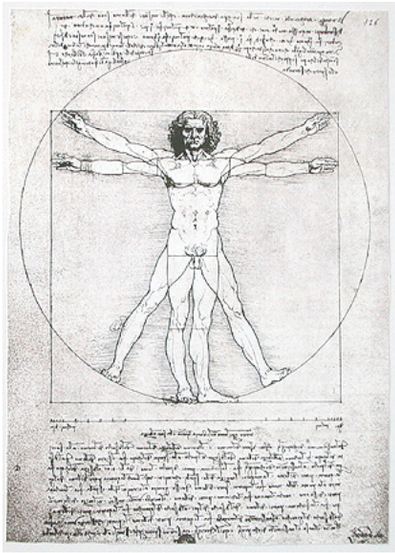
But to pick a representative of the form one cannot rely simply on height, which is engineering without poetry. Luckily there is an example that can be called one of the most beautiful skyscrapers in the world, a building that is not simply tall but statuesque.

The Chrysler building was, in fact, the tallest building in the world when it was completed. But that distinction only lasted nine months until the Empire State Building was finished in 1931. And it is now dwarfed by buildings in almost every major city that have carried the ideal of the skyscraper to inhuman proportions.

But the vision realized in 1930 by the Chyrsler building's designer, William Van Alen, was of a tower that would stand as the classy, jazzy side of New York. Dramatic but somehow also on a human scale. It is also a perfect example of the Art Deco style and a unique mix of brick and light, angles and curves. This is the skyscraper as a monument to soaring dreams.

DA VINCI NOTEBOOKS

Ultimate Design Book



Most of what we know of the creative output of Leonardo DaVinci comes from the notebooks that he kept throughout his life. The roughly 7,000 pages of these codices that have survived to our time stand as a fascinating example of the creative mind at work and play. They offer a catalog of images, sketches, outlines, words, studies, codes, and plans for all manner of projects and explorations. Here we find designs for buildings, statues, paintings, war machines, gearworks, flying devices, and monuments, alongside diagrams showing the flow of water, the orbits of the planets, the structure of the human body and much much more.

Even the pages of the codices themselves (most of them at least) have been designed with a focused intent...carefully laid out for clear presentation with columns and inset images. This fact, along with the strange reverse writing throughout the notebooks has led to speculation that they were planned to be printed (copies made directly from the pages would print in reverse, making the writing legible) by some method DaVinci devised but never developed.

To DaVinci, the notebooks were a library of creative ideas. But they have come down to us as something more...the ultimate book on the expression of design. The pages of the codices exemplify the design process...the urge to view the world ~ all of it, in every field and form ~ as a mechanism open to study, analysis, understanding, and, of course, fixing

COKE BRANDING

A Classic Package

The familiar Coca-Cola script is probably one of the most recognizable product logos in the world, yet it was designed by an amateur named Frank Robinson, the company's first bookkeeper. Besides the Spenserian calligraphy, which has been smoothed out and refined over the years, Robinson also came up with the first ad slogan for the product: "Delicious and Refreshing."

But the immediate success of the logo depended heavily on its appearance on the distinctive Coke bottle. Naturally, there have been many variations in the design of the bottle throughout the century. But the enduring classic ~ and the one most people visualize when they think of Coca-Cola ~ is the curvy vessel designed by Alexander Samuelson for the Root Glass Company of Terre Haute, Indiana. That design ~ intended to be grippable when wet and to vaguely echo the shape of the cola nut ~ first appeared in 1915 and versions of it are still marketed to this day.

It is the combination of the two that recommends them for distinction. Taken together, the original script and bottle are an example of near perfect packaging design. They are appealing to the eye and the touch, graphically distinctive, representative of the Art Nouveau aesthetic of its time and place, yet timeless as well. And all without any expertise to guide them which in the world of social media, seems like a very modern notion.

VOLKSWAGEN AD

Smaller Is Better

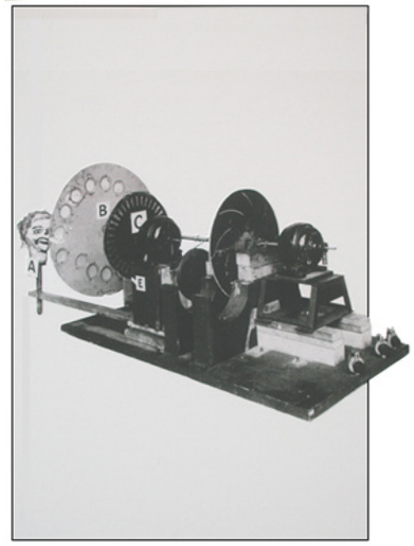
It may seem that an advertisement for a car has no place on a list that includes the light bulb and the Periodic Table, not to mention the car itself. But consider that modern advertising reaches out to and touches on the lives of as many people as any product or device. In addition, effective advertising has the opportunity to directly influence the attitudes and behaviors of ordinary folks as much as any other innovention.

The Volkswagen ad campaign created by Doyle Dane Bernbach in the 1960s is a case in point. What copywriter Julian Koenig and art director Helmut Krone accomplished here was nothing less than a revolution in the public attitude towards excess, in both automobiles and advertising. The campaign positioned Volkswagen as a protest against Detroit, both its massive cars and its overheated ads. It defined a new attitude of defiance, consumer revolt, and even contempt for corporate browbeating. It also managed to turn the car into a cult and quickly boosted sales of it up to half a million a year.

The Volkswagen ad campaign not only changed attitudes towards cars, it also had an effect on advertising itself. In fact, it initiated a new era in marketing campaigns that were more direct and visual, less talky, less snooty, and directed unapologetically towards the spending potential of a new and vast market base... the average consumer.

TELEVISION

Breaking up the Image



Although it is one of our most sophisticated technologies, television is based fundamentally on a very simple design principle...that of breaking up an image into dots or lines of varying luminescence, converting these into signals that can be transmitted, then re-creating the same pattern at the other end.

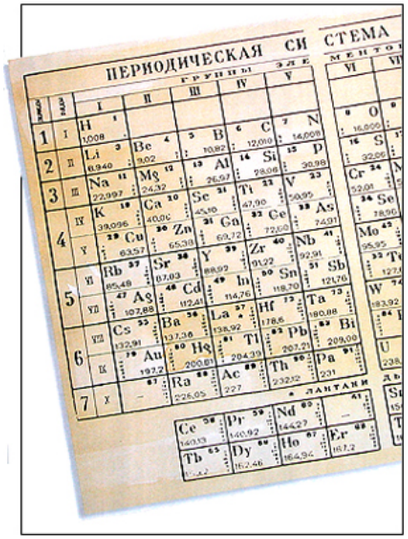
Modern television relies on a series of complex improvements, but the basic idea was present -- minus the fancy electronics -- back in 1925 when a Scotsman named John Logie Baird made the first mechanical television in an attic in Hastings, England.

This contraption used an old tea chest as a base, a tin biscuit box to house the lamp, a puppet head for a subject, spinning disks made of cardboard that held lenses from used bicycle lamps, and power from an old storage battery. It was the spinning lenses that broke the image up into lines, and with this absurd gizmo Baird was actually able to transmit a tiny, shaky image a distance of six feet.

By 1929, Baird had improved his mechanical system to the degree that the British Broadcasting Corporation could transmit short programs over an experimental network. Within a few years Baird was out of business, overtaken by the electronics of Philo Farnsworth and the cathode-ray tube of Vladymir Zworykin, which along with other contributions formed the future of television. But in Baird's mechanical TV we have a home-made design that any decent tinkerer could grasp and that manages to demonstrate a process that would soon become hopelessly complicated to the average person.

PERIODIC TABLE

Charting Nature



Design is not only about the look of things, but the structure as well. A well designed map, for instance, not only looks good (attractive and readable) but tells you something about the shape of the world that you would not otherwise see. And this is precisely what the Periodic Table does for chemistry. It is a map of the geography of the elements.

In 1868, Dmitri Ivanovich Mendeleev, inspired by more accurate methods for determining atomic weights, began to design small, two-dimensional grids that juxtaposed related groups of elements. Using both logic and hunch, he created a variety of charts that represented the strange periodic nature of the elements. Three years later, he settled on the version that became the basic plan for the table so familiar to students and chemists today.

The Periodic Table provided nothing less than a new comprehensive view of chemistry that allowed one to visualize the organization of chemicals by atomic weight, the hidden structure of the elements, and the orderly procession of atomic properties. The fact that his design even allowed Mendeleev to predict the existence of elements "as yet unknown," based on gaps in the table, proved that he had come up with an arrangement that did not just provide a neat visual order, but that actually captured truths about the hidden structure of nature itself. Now that is great design in action, not to mention an innovention that changed the world.

PERSPECTIVE

An Imposing Angle

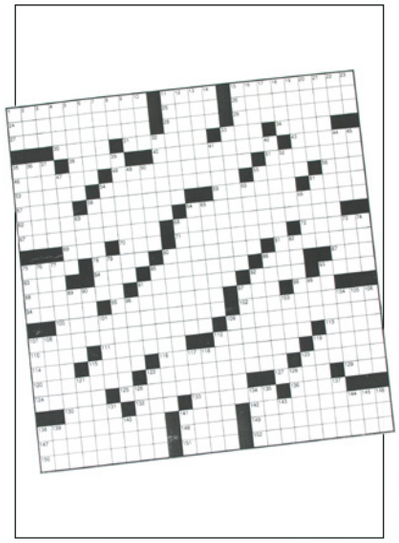
Make no mistake about it, perspective is an invention, pure and simple. Although it is so common in Western art that we often think of it as a scientific discovery, it is really a convention. Perspective offers a set of geometric principles or rules for foreshortening and convergence that gives two-dimensional designs an illusion of space.

These rules for making flat images appear to have depth that are used so precisely in Western culture were designed during the Renaissance by the architects Filippo Brunelleschi and Leone Battista Alberti, and the painter Masaccio. Others artists including Leonardo DaVinci and Fra Angelico perfected their mathematical rules for creating the illusion of perspective.

While there are other methods for creating a sense of depth in an image -- the overlapping that appears in Egyptian art, for example, or the visual hierarchies in Persian work -- perspective is unique in its systematic analysis of visual space and in its ability to seem to place the viewer very powerfully in the depicted space. This is just the kind of design innovation that would appeal to the rationalistic, analytic side of the Western mind which perhaps accounts for its extraordinary popularity until well into the 20th century until more modern art - like cubism for example - began to challenge these notions of depicted space.

CROSSWORD PUZZLE

A Playful Grid



One astounding aspect of design is that it is rich enough to apply to all levels of human needs from the necessity of shelter to the inconsequence of play. In the latter category, there have been a great many design innovations from alphabet blocks to Legos but among these, the crossword puzzle stands out for the elegant simplicity of its design.

Word puzzles have, of course, been around for millennia; they have even been discovered in Egyptian tombs. But the crossword puzzle is unique; a format not seen until the 20th century.

The crossword puzzle is nothing more than a simple grid to be filled in with the letters of words, separated by black boxes, that provide answers to a list of across and down clues. Who could imagine that so many hours of intelligent amusement could be supplied by such a straight-forward and self-contained design?

The first crossword puzzle was published in 1913 in the New York World. It had been created rather innocently by a journalist named Arthur Wynne. Yet by 1924, when a little known start-up named Simon & Schuster published the first book of crossword puzzles, the fad was established (so was the publisher.)

Aside from its pure triviality (which alone is appealing), the crossword puzzle stands as a nice example of the way that a simple design based on a formal structure can lead to a complex activity.

HELVETICA TYPE

Letter Imperfect

Of the thousands of typefaces that have been created, Helvetica is perhaps the most familiar in the modern world. Naming if after the Latin word for "Swiss", Edouard Hoffman and Max Miedinger designed it for the Haas type foundry in the 1950s with clear open forms and solid lines that would be easily readable in public settings. They succeeded beyond their wildest dreams as Helvetica came to be the most popular typeface, especially as used for signage all around the English-speaking world. Versions of it have also been adapted for languages using different alphabets and writing systems.

As a sans-serif typeface ~ it lacks the crossbar serifs at the end of Roman letters ~ Helvetica is very much a modern typeface. It presents a strong, solid appearance, and the simplicity of its design also lends itself to a wide family of variations that are all equally readable such as light, condensed, bold, extra bold and so on.

In fact, the typeface is so ubiquitous in public signage that it has also come, according to some critics, to represent bureaucracy itself and perhaps even the cold, calculated manipulation of individuals by corporations and governments. Design being so much a part of our ambiguous lives, this kind of paradox should not be too surprising. The innoventions of the modern world have their strengths and weaknessness, just as we do.

IVORY AD

The Personal Touch

Soap itself is an innovention of course, initially made from lye, cooking grease, and table salt. What Proctor & Gamble did was not only produce the first decent commercial version, but begin the empire of advertising and promotion that continues to this day. This was largely the work of one of the founder's sons, Harley Proctor, who began the whole idea of brand marketing. And his very first advertisement for the product contains all the elements that have become standard advertising ploys since.

The ad takes a generic product and gives it suggestive name; Proctor got the name Ivory during the reading of a psalm at a Sunday sermon. The fact that the soap floated resulted from a mistake in manufacturing which Proctor instinctively knew gave the soap a unique selling point. This was also the first ad to make a claim (99 and 44-100 per cent pure) that suggested a benefit to the customer. And it speaks directly to the consumer, a completely new idea at a time when ads were thought of as public pronouncements. The first Ivory ad was also designed right from the start to be part of an ongoing campaign that would emphasize a continuing theme...quality.

The idea of brand advertising was so new that there were hardly any venues for it and so this ground-breaking ad first appeared in a small religious weekly called *The Independent*. Brand marketing has gone a bit beyond that now.

MUSICAL NOTATION

Plotting Tones

Musical notation may very well be the most elegant and manageable design for a written code ever created. Its ability to record something as evanescent as music borders on the miraculous.

While there had been many systems devised to write down songs and tunes, the one designed in the 11th century by Guido D'Arezzo, a Benedictine monk, was certainly the most flexible and formed the basis of our familiar staff notation. In lieu of the fifteen letters of the Roman alphabet that had been applied to the notes used in music to that time, D'Arezzo designed a system of "neumes", shorthand symbols written above the words of each piece to indicate melody. In an attempt to make his system intuitive, he hit upon the idea of making the relative highness or lowness of each note depend on its respective distance from the text. D'Arezzo also introduced the notion of lines or staffs parallel to the text, so that intervals between the notes could be more accurately determined by comparing their position to the lines. All these innovations are still with us today.

As a corollary to this groundbreaking plan, D'Arezzo also created the idea of a basic six-note set ~ like an octave ~ and named the notes in it after the words in a famous Latin hymn, thus also inventing the familiar do-re-mi convention.

Of course the 11th century is not the Renaissance by anyone's measure, so by what logic is such an early innovention included here? A simple answer...cheating. It was impossible to resist the imaginative and practical power of musical notation as an important breakthrough.

RADIO

Voices in the Air

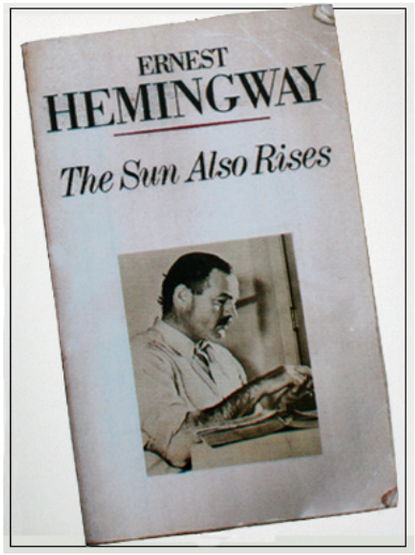
Some designs, especially modern inventions, are so complex and evolutionary that they cannot be attributed to a single individual's creative effort. Nor, because the design is in flux for such a long period of time, to any particular variation on the basic theme.

This is design, not by committee, but by succession. The story of radio is a good example of innovention as a generational endeavor, slowly and inexorably evolving to fit the needs of the time. Contributors to the march of radio included Heinrich Hertz and his copper transmitter, Guglielmo Marconi and his wireless telegraph, Reginald Fessenden's high-frequency alternator, John Ambrose Fleming's diode, Lee De Forest and his amplifier, Edwin Armstrong's superheterodyne circuit, and many many others. Each one added to, improved upon, or refined the basic idea with new designs that would eventually congeal into one of the most powerful mediums of communications in the world.

Each technological change ushered in a change in style, making radio one of most varied inventions on this list in terms of design. But one sample that can stand for all is the so-called seashell design that became popular during the 1930s. Unlike so many radios that were designed to look like other things, this one is purely and proudly representative of the feel of voices in the air, the grandeur of the airwaves. It suggests a sturdy cathedral but in another sense it looks the quintessential radio of the imagination.

PAPERBACK BOOK

Publishing for All



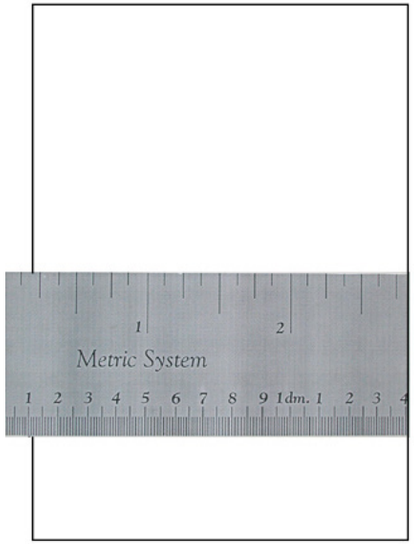
You know there has been a design innovation when people start to rail about the demise of good taste. Almost every breakthrough that affects art or literature is met with such opposition at first. And this was precisely the reaction to the paperback book when it was introduced in the 1920s, in spite of its immediate success.

The new design for a book resembled the old standard in many ways but two crucial changes made it a revolution in publishing. First, it was a smaller size and designed to be portable. This was perfect for the increasingly mobile workers of the new century. Second, it was printed on cheaper paper and had a soft cover, also made of paper. This brought the price way down, while also implying that it was more disposable and not simply meant for the libraries of the rich.

What the paperback did was to democratize publishing and create an enormous new market for writing aimed at the average person and the growing middle class. In this way, it also changed the nature, style, and subject of popular writing itself. While the old guard naturally assumed that it would cheapen literature and destroy standards, the new book design is now by far the most common format for publishing. So much so that it is being defended ~ in exactly the same way ~ against the onslaught of a newer threat to good taste...the ebook.

METRIC SYSTEM

Measure of Importance



The metric system was designed by a series of governmental commissions during the French Revolution to address the fact that every province had a different standard unit of length and each trade had a different method of measurement.

The idea of a system with a uniform scale of relation all based on the decimal was hotly debated at first, but eventually proposed by the commission and accepted by the National Assembly. The bigger problem was in deciding what a standard unit of length ~ the first measurement to be proposed ~ would be. The commission eventually adopted an idea proposed back in 1670 that the basic unit of length would be one ten-millionth of the distance from the Equator to the North Pole (as measured via Paris, naturally). This unit ~ which works out to just over what we call a yard ~ would be called a metre, from the Greek word for measure. Other basic units for surface, volume, capacity, and weight were similarly negotiated.

The new system took a while to finish. These were, after all, revolutionary times; the chief surveyors were even arrested for a time until the motives for their measuring could be proved. When the measurements for the new unit were finally completed and reported to Napoleon in 1810, he remarked, "Conquests pass, but such works remain." Napoleon may have had designs over Europe, but the metric system proved a more lasting innovention.

NEWSPAPER

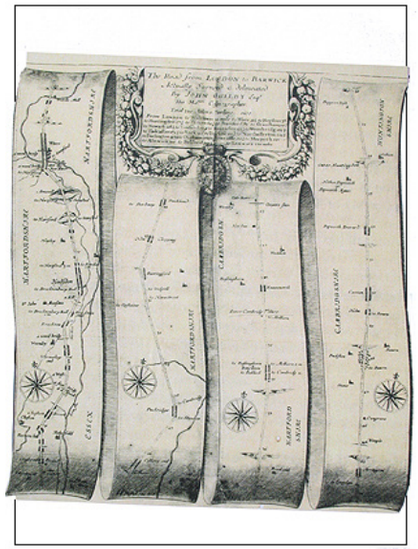
Making the News

The history of the newspaper is a long and varied story running throughout the millennium, through every country, and covering a wide diversity of formats. One of the most interesting things about this particular design for information ~ from both a historical and cultural perspective ~ is the amazing variety of forms it has taken that can still all be called newspapers. From the bellmen and proclamations of the Middle Ages, to the pamphlets, broadsides, newsbooks and Messrelationen of the 1500s, to the English corantos of the 1600s, and all the other versions in every society...the only unifying principle seems to be the idea of communicating to the general public a collection of printed reports about events of the day.

Due to this diversity, it is virtually impossible to determine what the first true newspaper was or what the greatest breakthrough might have been; but any modern representative example demonstrates the power of the idea. To design a newspaper is to take a collection of stories unrelated in size, significance, and style, and combine them into one format that will make them at once varied but readable, distinct yet coherent, exciting but accessible. The *New York Times*, for instance, achieves this with an oversize six-column page, standard Roman typefaces, lean headlines, and carefully cropped photos. This is newspaper design as the ultimate in information management.

ROAD MAP

Finding One's Way

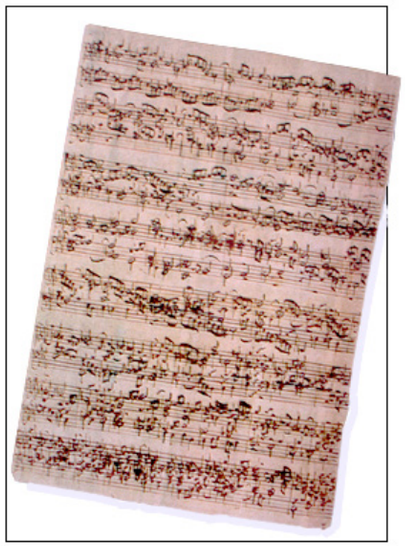


The first local maps began to appear in England towards the end of the 16th century. The impulse to create them was the result of better surveying techniques and more precise printing technology. But in the 1660s, John Ogilby ~ probably the most famous map-maker of the century ~ added a new design twist to his massive atlas, *Britannia*. This was a complete set of road maps, the first comprehensive accounting of roads throughout England. Although Ogilby died in 1676 before completing the book, the road maps themselves stand as a great design breakthrough.

For the first time, the major roads in each county were displayed graphically so that anyone could follow them. In fact, a number of graphic devices were included to aid this usage...compass points were indicated, distances were measured in statute miles, buildings were represented to give some idea of the size of towns, local features were listed to guide the traveler. In other words, Ogilby had invented the modern idea of the public road map, useable by the average traveler rather than officials and royalty. Not simply a handy guide, this was the introduction of a radical idea...that the country was there for individual citizens and open for their personal travel and use, rather than simply the exclusive property of the landed gentry. It was part of the opening up of the modern world for access by ordinary people.

FUGUE

A Musical Plan



Musical forms are also designed...in the sense of being structured, planned, and organized. But an entire book would have to be devoted to this topic in order to do justice to the extraordinary variety and creativity of world music over such a long expanse of time.

With apologies to the complex musical forms that have emerged from cultures all over the world, the fugue was chosen as a sample design innovention. And for this, Johann Sebastian Bach's C Minor Fugue, composed in 1722, can be singled out as a perfect example. The choice was made not because this was seen as the greatest piece of music, but as a great example of design in music. More than almost any other form, the fugue can be seen as a planned structure of sounds, similar to the way architecture is constructed and appears to the viewer as a complex organization of parts and pieces that achieve a cohesive overall effect.

The Bach fugue involves in its design a systematic exploitation of repetition and alteration, and it uses extravagant melodic complexity controlled by procedural guidelines, polyphonic rules, and harmonic progressions.

It has been said that architecture is frozen music; but the fugue stands as a corollary example...music as liquid architecture. Structure creating freedom. For this reason it is included as an innovention for the modern world.

GLOBE

A Well-Rounded View

Surprisingly, when globes were first introduced they did not have an especially dramatic effect on the mapping of the world that resulted from the Age of Discovery. The reason for this is that their size and shape made them necessarily less accurate and detailed than their flat alternatives, and harder to store. The first recorded design for a spherical map came in 1492 in Nuremberg from a man named Martin Behaim, and for the next fifty years many variations were produced. But these round maps never achieved the popularity of the flat map as a scientific tool. Advances in cartography, geometry, surveying, longitude and other measures, had a much greater impact via flat representations where the details could be reproduced at varying scales. Even though Magellan was known to have carried one on his explorations, globes were more commonly used in university lectures at the time.

Then why is the globe singled out as a great design innovention? Simply because it offers a completely different world view. The advance of the flat map is an evolution of detail and accuracy resulting from more precise technology. But the globe is a change of mind. The globe offers a view of the earth not as a landscape of endless details, but as a world unto itself, contained and isolated. To generations of students, only the design of the globe has given a sense of what it is like to live on the skin of a ball drifting through the cosmos. Not a bad legacy for any design breakthrough.

CALCULUS

Code of the Cosmos

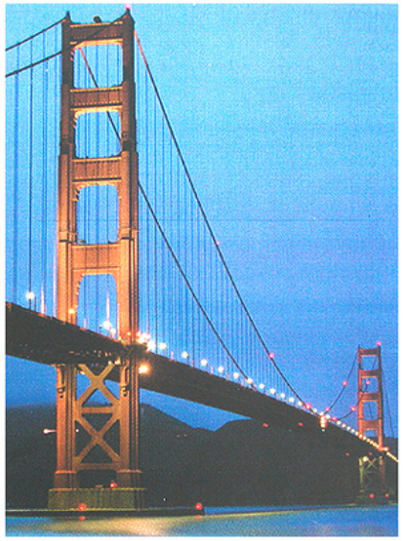
Of all the developments in mathematics throughout the centuries, there is one innovention that calls out for special mention. This is the system of calculation we now know as calculus. Calculus was invented during the 17th century – simultaneously, it appears – by both Isaac Newton (who was 24 and relatively unknown at the time) and Gottfried Wilhelm von Leibnitz (who was older and already world famous). With slight differences, they separately worked out (designed, that is) the general rules for using mathematics to find the tangent to a curve (differentiation) and the area enclosed by a curve (integration).

Newton, unsure of its significance and the effect it might have on his career, deliberately hid his "method of fluxions" in obscure language; his papers on it were only released over time as he became more famous. It therefore fell to Leibnitz, and later Bernoulli, to popularize and extend the new field.

Calculus took math from static descriptions of the world to dynamic interpretations that allowed things to change; this eventually had a profound effect on modern science and especially physics. The invention of the calculus also demonstrates one of the most fascinating aspects of design...the ability of a sketch, a plan, a scattering of marks on a blackboard – whether for a building, an engine, or a code of calculation – to reach out into the world and change it for all time.

SUSPENSION BRIDGE

Connecting Distant Shores



All of the bridges of the world, and throughout history for that matter, have been based on a handful of design strategies for supporting a road over water. Pier bridges are supported by columns set into the river bed, truss bridges by a framework of beams, arch bridges distribute their weight across the span of the arch, cantilever bridges extend over their piers. These ideas, plus a handful of others, enhanced by new materials or combined for added effectiveness, represent the story of bridge engineering.

But the suspension bridge is unique and very modern in its concept. In this arrangement, the roadway hangs from cables suspended from towers on the shore or from piers at the riverbank. This design allows for longer and thinner bridges and, in fact, it has resulted in the majestic, sweeping lines that we associate with the most impressive of bridges. From the first one built in 1826 at Menai Strait in England, to the most recognizable example ~ the Brooklyn Bridge in New York, finished in 1883 ~ suspension bridges have become the most common plan for spanning wide rivers.

The most dramatic example is the Golden Gate Bridge in San Francisco. Built in 1937 and with a 4,200-foot span, it is still one of the longest and certainly one of the most impressive suspension bridges in the world. A fine example of a minimum of structure to create a maximum impact. It is beautiful too; an example of the way in which design addresses both visual appeal and function.

UNIVERSITY

Design for Learning

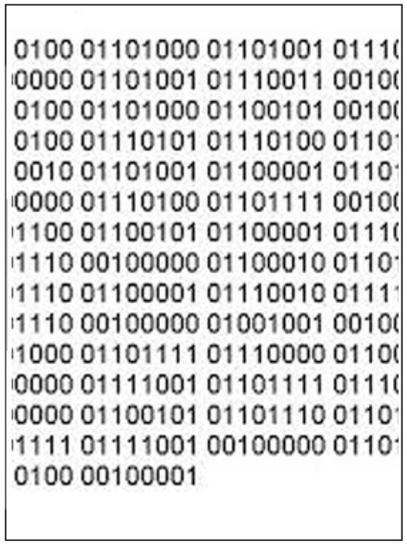
The university system is based on a simple idea...that individual learners might come together in one place to pursue academic interests. Although schools with similar goals were known in the Arab world in the first millennium, what we have come to think of as the modern university did not emerge until the turn of the millennium throughout Europe. This was a new academic design based on a course structure in which scholars instructed students about specific topics of their expertise.

The Latin term *universitas* originally meant any community or corporation and only came to refer to a collection of teachers and scholars by the 14th century. Such communities began as scholastic guilds, similar to trade guilds, formed as a kind of union to protect students. These guilds grew and broadened into *studium generale*, meaning centers of instruction beyond those offered by the church, and eventually into the universities that sprang up throughout Europe by the 12th century.

Early universities were based either on the scheme at Bologna, where the university was a corporation of the students who hired (and fired!) their own teachers and controlled school policies, or the structure at Paris, which was a corporation of teachers who collected fees from the students and managed the school. Overall, the revival of interest in Greek and Roman culture and learning during the 1400s was facilitated by the structure of the new universities, and this is the basis of the concept of liberal arts higher education to this day.

DIGITAL BIT

Binary Basics



Binary systems of notation, in which there are only two elements for representation, are common; they appear in the I Ching, in Mayan calendars, in Morse Code. Francis Bacon created one as a code for diplomatic messages in the 1600s. Binary arithmetic, however, is a system in which all numbers can be represented by only two symbols and manipulated in mathematical operations. This innovation is usually credited to Gottfried Wilhelm von Leibnitz, who wrote about it in 1679; but it was developed into a full algebra by George Boole in the 19th century.

By the 1940s, such a system was suggested by John von Neumann as the basis for a digital computing machine. Neumann felt that a binary language would be far more efficient for an electronic device than the bulkier decimal system that was under consideration, and of course his logic prevailed.

A bit is simply the name given to one of the elements in a binary code ~ 1 or 0, on or off, flow or no-flow ~ and as part of a digital, electronic system, it is a true innovention. The design breakthrough is not in the look or form of it, but in the way it functions. Today, all forms of communication including text, images, sounds, etc. are translated into bits that can be used and traded and manipulated by computers. It is the idea of the bit ~ as a pure component of information ~ that has made computer networks so central to the modern world.

WOOD SCREW

One Good Turn

The design of a screw is so simple and so obvious as to appear timeless. Certainly the idea of a shaft with a spiraling ridge had been used for centuries to raise water, to press clothes, even to torture infidels. But it was not until the 16th century that the familiar design with a slotted head at one end and a tapering point at the other was used as a fastening device for wood.

Wood screws were originally hand-fashioned out of iron and were, therefore, expensive enough to be used only by the wealthy. They were only machined cheaply after 1850, at which point they helped to usher in the post-Civil War housing boom.

More durable than nails, pegs, or staples ~ which can all loosen and pull out ~ the screw design actually squeezes the pieces of wood tighter the more it is turned. It is also efficient to use, requiring only a simple screwdriver to install and uninstall. Although slot shapes, materials, thread styles, and sizes have evolved over time, the basic design for the wood screw has remain unchanged in 500 years.

Cheap, effective, simple to use...it is easy to see why the wood screw has become such a basic component of the builder's trade and a practical symbol of construction in the modern world.

DAKOTA

Airborne Dreams

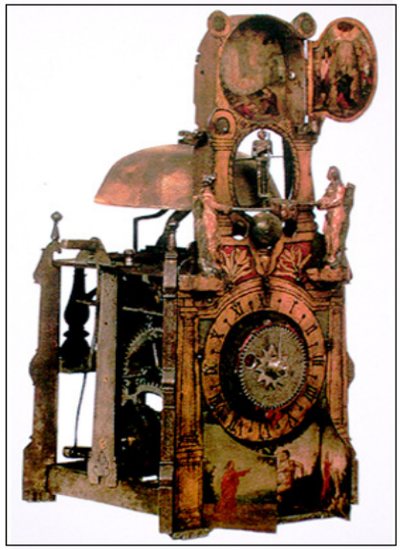
Airplanes may provide the best example of the idea that while form and function may go hand in hand, they are not identical. The new aircraft designs that emerge in each era all take to the air, but they always seem to reflect current aesthetic styles. The Wright flyer of 1906 for example ~ the first powered heavier-than-air craft ~ resembled a Victorian finch with its double canvas wings, wire struts, and narrow wooden propeller. The Concorde, on the other hand, with its swept back wing and angled nose, seems straight out of a Cold War space fantasy.

While the Wright flyer is rightly an iconic breakthrough, another aircraft was so successful in its day ~ so perfect in its merging of form and function ~ that it virtually started the entire industry of flight. This was the sleek and gleaming, all- metal DC -3. The plane was designed by a team of 400 engineers and draftsmen led by Arthur Raymond at Douglas Aircraft. It was created to be an improvement over the earlier planes in response to the growing market for transcontinental travel. Nicknamed the Dakota, the DC-3 so caught on in the popular imagination that it energized the entire airline business. As the Model T did for auto travel, the DC-3 suddenly made flying available to everyone.

The Dakota was the first to use a curved aluminum skin that added to its strength and rigidity, and to its lightness. The fuselage and wings merged smoothly reducing wind resistance. These innovations, along with its very 1930s streamlined shape, made it an instant classic and inspiration for all that followed.

MECHANICAL CLOCK

Parsing Time



For much of the first millennium, and even into the second, clocks were run by water. Typically, a vessel was either emptied or filled with water over a set period of time. But the obvious problems of evaporation, spillage, freezing, and erosion, were not answered until the 13th century with the design of the verge and foliot escapement. In Europe, that is; there is evidence of a mechanical clock in China as early as 725 A.D.

The verge was a vertical rod with two small metal flags called foliots. Suspended on a length of cord or sinew, the verge could twist in one direction and then the other; as it did the foliots alternately engaged and released the teeth of a gear. With a weight pulling on the gear, this system controlled the speed without relying on dripping water and thus was the first truly mechanical clock. Like the earlier water clocks though, it had no clockface and was used largely to sound the hours of the day.

The use of the pendulum by the 1600s led to more accurate clocks and was an equally innovative development. But the verge and foliot system was really the first to initiate our obsession with the precision of clocks, with increasingly minute divisions of time, and with the entire notion that time is a second-by-second phenomenon. This notion helped pave the way for an objective science by converting our idea of time from a subjective experience into a construct independent of perception; it is the reason the mechanical clock was called by historian Lewis Mumford "the key machine of the modern industrial age."

EIFFEL TOWER

Engineering a Fantasy

The Eiffel Tower is singled out as an innovention because, like the airplane, it combined engineering with romance. The structure is part metal fantasy and part industrial cathedral, and this unique concoction makes it one of the most recognizable landmarks in the world.

It was designed by Gustave Eiffel for a Paris exposition in 1889. Following the examples of earlier expositions, the tower was intended to show off the latest in technological marvels. Eiffel's skinless wrought-iron skeleton was a 98-foot spire that was the tallest human-made structure on earth at the time. It was designed right from the start to be a major tourist attraction and succeeded immediately; its construction cost of $1,000,000 was covered in the first year of visits. It is still one of the most popular tourist sites in any country in the world.

Yet the design was also immediately controversial with many artists and planners who expressed outrage at its scale and ugliness. Eiffel responded to these criticisms by comparing his tower to the Egyptian pyramids: "My tower will be the tallest edifice ever erected by man. Will it not also be grandiose in its way? And why would something admirable in Egypt become hideous and ridiculous in Paris?"

More than a century later, the Eiffel Tower seems so unique, definitive, and so perfectly designed for its function that it strikes the visitor as the only possible solution to the problem of mixing art and science in a majestic structure.

MICROSCOPE

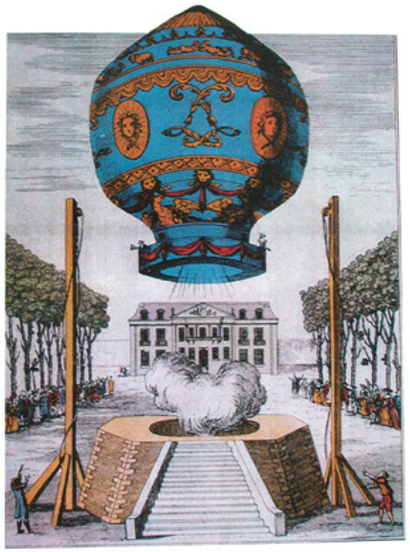
The Small Picture

The first microscope was rather unimpressive. The one in use by 1600 ~ probably designed by the Janssen brothers of Holland ~ was simply a tube 18 inches long and 2 inches in diameter, with a single convex lens at each end. Yet by the middle of that century an improved design with a supporting base and finer lenses was used by Robert Hooke for his book *Micrographia*. It was the book even more than the device itself that spurred interest in the world the microscope could explore and largely for that reason, microscope design began in earnest. Over the centuries this led to larger and more complex devices using more and better lenses, fancier focusing mechanisms, and new and more precise lighting sources...all the way up to the electron beam microscopes of our day.

For innovention though, special mention must be given to the device designed in 1673 by Anton von Leeuwenhoek. It was a comparatively primitive instrument, magnifying only 500 times. Yet there is something delicate and charming about it. It used a simple and intuitive screw thread specimen holder (user-friendly, in modern terms) and an unusually effective double-convex lens (small but functional). With this rudimentary device Leeuwenhoek was able to view ~ for the very first time ~ bacteria, plant cells, and other denizens of the world too small to see. Great designs are often great less for their engineering than their power to fire the imagination.

HOT AIR BALLOON

Flight of Fancy



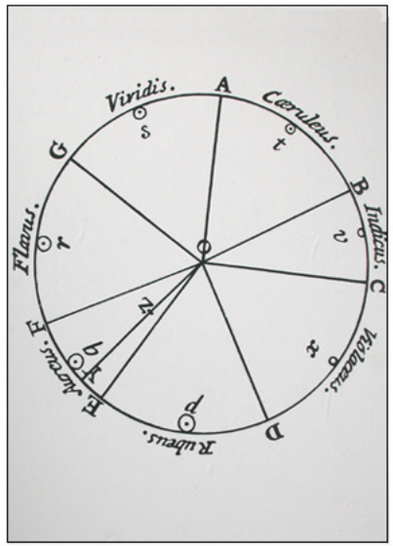
Some genius of the 14th century, noting that morning dew rose off the grass when the sun's rays warmed it, suggested a flotation device using dew filled egg shells. It was a lovely thought but a lousy design idea. It was not until the 18th century that two prosperous French papermakers – Joseph and Etienne Montgolfier – actually came up with a practical plan for floating in the air.

After months of experiments, including sending some terrified animals into the air, their most famous design went aloft in November of 1783. This was a huge 74-foot high balloon made of linen lined with paper, and filled with the hot air from a large fire carried at the base of the bag. The "aerostat" as they called it, carried two passengers...a young physician named Jean-Francois Pilatre de Rozier and the Marquis d'Arlandes. These first aeronauts floated aloft for some 25 minutes. Can you imagine the sensation this must have caused as the fancifully painted balloon (another key reason it stands as a design innovention) floated five miles over Paris, its passengers waving their cocked hats and scrambling to put out small fires caused by cinders?

It is not often that romance, art, and engineering meet so perfectly as they did on that day, when the Montgolfier balloon initiated the age of lighter than air flight.

COLOR WHEEL

Bending the Rainbow



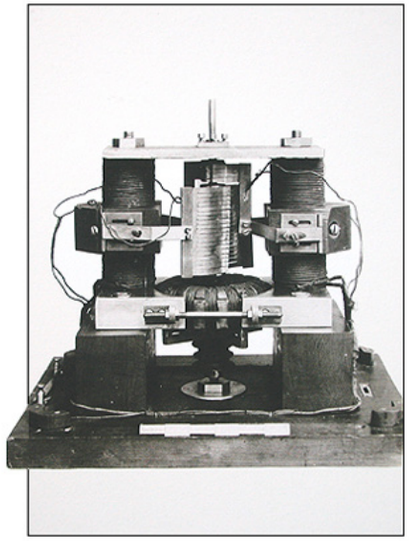
Like many designs, the color wheel seems so familiar, and obvious to anyone who attended second grade, that it is hard to believe that it was invented. Hard to believe, in other words, that it really is a design...a particular arrangement of things created by someone for a particular use. The someone in question here was none other than Isaac Newton, who created his Spectrum Wheel while in his early twenties, around the same time that he invented the science of optics and described the theory of gravity.

Noticing that the colors at the far ends of the spectrum created by his prism were similar, Newton got the idea of placing these rainbow hues into a circular pattern. Being a bit of a mystic, he settled on seven key colors because that number related to the proverbial seven spheres of the heavens and to the seven notes on a diatonic scale. As with other designs that rely on circular arrangements (the circle of fifths in music, for example, or the rings of organic chemisry), the wheel pattern itself led to new insights about the relationships of the colors.

Over the centuries, other systems have competed with or amended the original color wheel including Goethe's Color Triangle, the color circles of Chevreul and Blanc, the color spheres of Munsell and Ostwald, and many others. But it is Newton's first design for a color wheel that has been the basis for modern color theory, color printing, and all industrial paint and ink production.

ELECTRIC MOTOR

Empowering Life



The electric motor that is found in almost everything that plugs in these days began, like many innoventions, not with a complex apparatus but rather with the design of a very simple experiment.

In 1821, Michael Faraday suspended a 6-inch long piece of copper wire from a hook with its lower end dipping into a bowl of mercury. In the center of the bowl was a bar magnet. When Faraday passed a current from his battery through the hook and down through the wire to the mercury, the wire rotated as long as the current flowed. This simple setup with its "electrical rotations" was the first electric motor. Later motors, of course, grew increasingly more elaborate with spools of wire, more powerful magnets, and far more complex mechanisms to convert the electricity into circular motion. And it was these devices in myriad shapes and sizes that essentially brought the Industrial Revolution into the home.

But Faraday's first simple demonstration of the principle proves that design relies as much on the key concept behind an innovation as it is about all the elaborations that follow. Oddly, in spite of his exploration of the basic principle at work, the reverse idea of the dynamo -- that a revolving magnet might produce electrical current -- was not seen by Faraday or anyone else for over a decade.

ENIAC

A Big Calculation

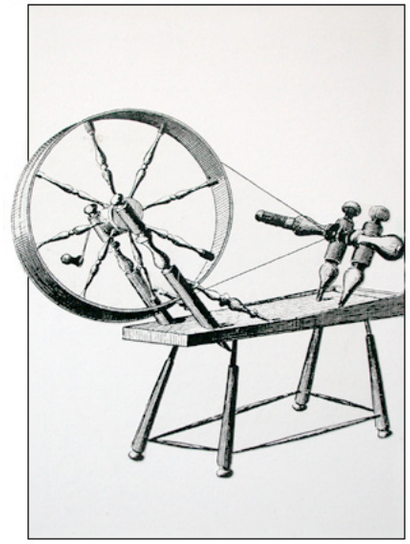
The idea for an automatic calculating machine was a fine design challenge, met by numerous machinists of the 17th and 18th centuries and culminating in the plan for a steam -powered "analytical engine" of Charles Babbage and Lady Lovelace in the 19th. But their design was never built. Other plans for the addition of electricity to such a machine were also explored into the next century.

It was a secret Army-sponsored project at the University of Pennsylvania called ENIAC (Electronic Numerical Integrator and Computer) that first successfully combined electronics and calculation into one design. Not so much a device as an environment, ENIAC was an air-conditioned room containing 3,000 cubic feet of electronic circuitry, 17,468 vacuum tubes, and weighing in at thirty tons. It could take up to two days to set up the wiring for a particular calculation problem and had to be constantly monitored throughout its computations. This made the basic design of the ENIAC really more of a human/machine calculating system.

Faster and smaller versions followed including EDVAC and UNIVAC. But ENIAC was the first general-purpose computer to use binary logic and electronics for general computation and is therefore the grandmother of all computers to come. Including, by the way, that microchip in every cell phone that is far more powerful than the original behemoth.

SPINNING WHEEL

A Big Revolution



Ancient systems for making thread from wool relied on two devices....a distaff and a spindle. The distaff was a cleft stick on which wool was loosely wound. As a continuous lock of wool was drawn from it, it was spun by the fingers and deposited on the spindle, a thin wooden rod with an incision at the top for attaching the forming thread. The spindle revolved by a variety of devices, usually a wooden disc that whirled and kept the spindle turning at a uniform pace as the thread gathered on it. The idea of using a wheel to make the process more efficient did not occur until the second millennium.

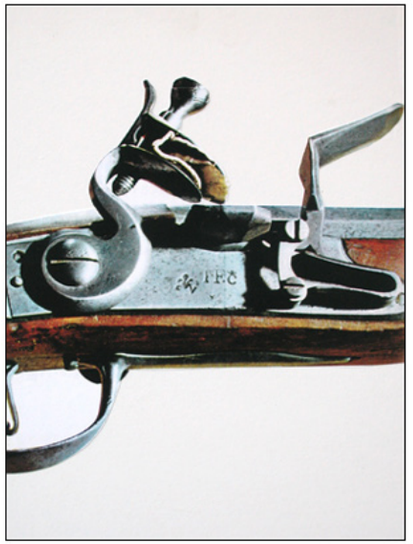
It emerged in India as the *charkha* and arrived in Europe by the 1200s, although there is some evidence that it was invented in China at around the same time.

At first the spindle was set into a frame and turned by a belt looped around it and around a large wheel, itself turned by hand. The teased wool was pulled through the spindle and pulled taut as it turned. Eventually a bobbin was added to gather the thread.

The familiar spinning wheel turned by a foot pedal did not appear until the 18th century, which is how it sneaks into the time frame of this book. This design for a spinning wheel allowed a far greater quantity of useable thread to be produced much faster, thereby supplying the raw materials for a weaving revolution that not only created new industries, but finer fabrics that influenced the style and fashion of the rest of the modern age.

FLINTLOCK

Automatic Firing



To see how design can refer to both the visual appearance and the mechanical workings of a made object, one need only consider the history of the firearm with its endless varieties of styles, decorations, shapes, sizes, and mechanisms. Yet one particular innovention in the 16th century made such an enormous difference in firearms that it changed the course of war from that point on.

This was the flintlock, a simpler and more reliable firing mechanism than previously known. In this arrangement, a piece of flint is struck against a hardened steel plate. This creates a shower of sparks which fall onto a pan below and ignite the gunpowder prime. The flash that this creates passes through a small hole in the barrel where it ignites the main charge that propels the projectile.

Although based on the firing mechanism of the earlier musket, the flintlock was designed as a self-contained unit to be smaller, lighter, and more consistent. The earliest record of such a device occurs in Sweden in 1539 and the mechanism was used for 200 years thereafter along with dozens of design changes including the addition of sears, cocks, notches, tumblers, hammers, batteries, frizzens, not to mention endless variations on the decorative side.

All weapons change both hunting and warfare, but it was the adoption and widespread military use of the flintlock by the French during the 17th century that changed the whole notion of battle from a melee of swords and pikes into an organized shooting gallery.

GOOSE QUILL PEN

Of Words and Feathers

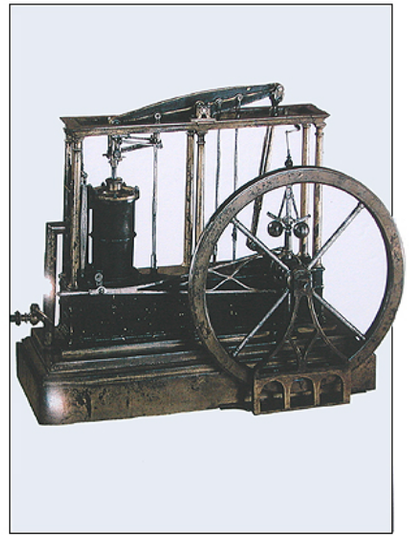
The Latin word for quill is *penna*, and it is from this that we get our word pen. Although there are some references to quill pens before the second millennium, there is no doubt that they did not come into common use until after 1000 A.D. Inexpensive, renewable, recyclable, the quill pen was a vast improvement over earlier and clumsier writing tools for the average person. The quill pen also created a lovely symbolic connection between writing and flying.

As usual throughout design history, its success also depended in the ease of its manufacture and early in the millennium an industry developed around the production of quill pens. This included raising flocks of geese just for their quills and an elaborate process of plucking the quills, then drying, heating, and boiling them in alum and nitric acid to produce an improved quill that would last longer and sharpen better. Crow quills came into fashion by the Renaissance and other species of birds have contributed their wings to the art of writing.

In their day, the design of steel-tipped pens, fountain pens, ballpoint pens, and felt-tipped pens have left their mark. But there is something about the quill pen that made it special, perhaps in the way it enforced a more reflective, gentler, ornate yet delicate style of writing. And because it was also cheap, portable, and easy to sharpen, it changed writing habits for hundreds of years.

STEAM ENGINE

The Power of Vapor



Steam used as a form of power had been around for thousands of years. Its expanding pressure had been used to move simple mechanisms in both Greece and China. But it was not until the 18th century that steam was harnessed for industrial uses. Ideas for engines that would run on steam power were widespread during the 1700s, with each new version improving on some problem with a previous design. But of all the engines that used steam to move a piston in a cylinder ~ by Papin, Savery, Newcomen, and others ~ it was the design by James Watt that had the most substantial influence on the modern world.

Watt's final design had a number of improvements over earlier versions, including the governor, a spinning device that was the first to provide feedback for regulating machines. But above all, the Watt engine relied on one fundamental improvement...the cylinder in which the volume of steam was suddenly condensed by a jet of cold water was a separate unit. This separate "condenser" prevented the piston from cooling down with each stroke of the engine. This change alone made the entire engine far more efficient.

Watt struggled for years to realize his vision, in part due to the primitive industries of his age which could barely produce good enough components. Yet by 1800, many of the problems were solved and there were already 500 Watt engines at work in England. This was the design that proved to be the true engine of change for the Industrial Revolution.

TELESCOPE

Distant Visions

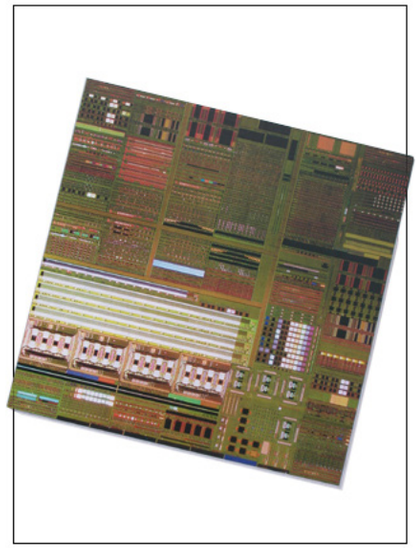
Although certainly invented earlier, the first claim for a patent for a telescope came in 1608 in the Netherlands. It was essentially a tube with two lenses. Two years later, the improved instrument that Galileo designed allowed him to make the stunning observations and drawings of the heavens that began modern astronomy. With his rudimentary device, Galileo was also able to see the rings of Saturn, the satellites of Jupiter, and mountains and craters on the moon... all with a telescope that magnified only 30 times, less than standard binoculars!

A famous legend has it that he was able to get money to work on his telescopes when he proved to the merchants of Venice that he could use the device to see ships at sea days before they pulled into port, thus allowing for more efficient schedules.

These early telescopes were refractors, with a front lens to collect and focus the light, and an eyepiece at the rear for examining the image. As in the evolution of the microscope, better technologies such as finer and compound lenses, more precise adjustment mechanisms, and better reflecting schemes, eventually led to more powerful instruments. Once again, the biggest long-term effect of the design is via the process of revising, reworking, and tinkering with the original idea that spans decades. On the other hand, the profound inspiration of designing a device that might bring the wide world closer to the eye was right there in the very first telescope.

MICROCHIP

Diminishing Circuits



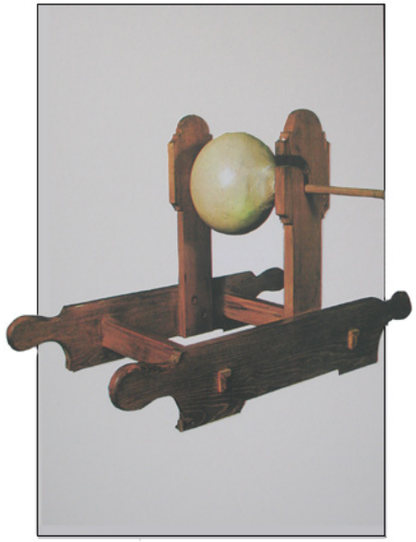
The transistor designed by a team at Bell Labs in 1948, and for which they won the Nobel Prize, was a great invention. Their transistor was a miniature valve based on the semiconductor principle, with no moving parts and no warm-up time. It replaced the clunky vacuum tube that was being used in TV's and early computers, and which was constantly overheating and had to be replaced. Since every new invention, besides addressing old problems, inspires a new round of innovation, the transistor also paved the way for the electronics revolution.

The first transistor could be the choice here but it has now been incorporated into an extension of the basic principle that has even more radically changed our world. That extension of semiconductor design is the microchip. A microchip is a microscopic collection of millions of transistors and other electronic components, created by etching complex patterns of circuitry in layers onto a tiny chip of silicon. The connections in the average microchip are 900 times thinner than a human hai and the chip itself is the size of a quarter.

Chip design ~ that is, the organization and arrangement of the components and circuits for maximum efficiency and minimum heat ~ is a design art all its own, perhaps most closely related to urban planning, but on a far vaster and more minuscule scale.

ELECTROSTATIC GENERATOR

Hints of Power



Admittedly, the design does not seem like much. It is simply a ball of sulfur on a hand crank set in a frame with some gears so that it can be turned quickly. Yet this plain little device, designed by Otto von Guericke and described in his book called *Experimenta Nova Magdeburgica* in 1672, set off a century of discovery with repercussions still being felt in the modern world.

Rubbing the ball with his hand as it turned, Guericke found that it could attract feathers, linen threads, water. In the dark he could see a glow extending from his hand back to the globe. To Guericke these were both attributes of the strange force called magnetism then being explored, and which he believed to be the very same force that pulled objects towards the Earth.

In fact what Guericke had designed was the first machine to actually produce electricity. Other and better designs would follow...the Voltaic pile, the acid battery, the dynamo. But in spite of the fact that Guericke's device generated only a very weak form of static electricity, it still marks an earth-shaking breakthrough. It was the beginning of the idea that such a mysterious force could be produced or even harnessed. The invisible becomes useable.

Guericke's generator is therefore the ancestor of all the devices, gizmos, machines, and designs that ~ throughout the rest of the millennium ~ have led to the generation of one of our most basic energy sources.

GUNPOWDER

An Explosive Recipe

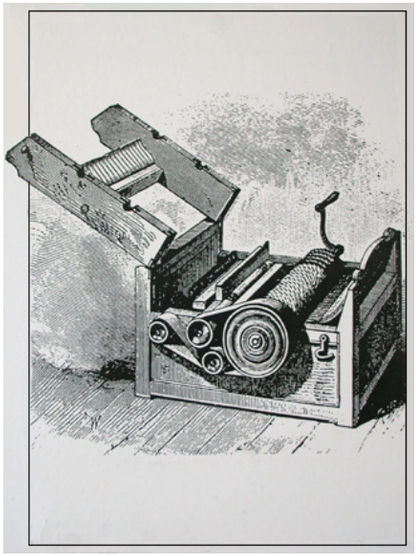
It is one of the most dramatic innoventions of the modern world but can it be said to have been designed at all since it is a mixture rather than a device. It can, if you consider the elaborate process of filtering, boiling, reducing, and crystallizing that was involved in producing just one of its components...saltpeter. This substance mixed in the right amounts with sulfur and charcoal ~ themselves the result of manufacturing procedures ~ will explode if ignited. This is surely no simple discovery and if a recipe can be designed, then gunpowder certainly can too.

Although known earlier in the millennium, it was not until the end of the 13th century that a book by a man called Mark the Greek offered, for the first time, a useable recipe for gunpowder based on information from China via the Arab traveler Ibn al Baitar. Factories were quickly established throughout Europe. Even so, the choice ingredients, proper proportions, and best methods of production were not fixed until the mid 1600s.

The true challenge about including gunpowder here concerns its problematic use mostly for destructive purposes. China being an older and more stable civilization, its invention had less explosive effects on that society; gunpowder was used in the East as a propellant for arrows and firecrackers. In the West it destroyed cities and maimed civilians. And yet, if design is central to our need to remake the world, we have to accept this as a major innovention for both its noble and ignominious effects.

COTTON GIN

Uncertain Legacy



Eli Whitney only spent a few months during one winter designing his cotton gin. It was not a very complicated device. The problem he was addressing was that the Industrial Revolution had opened up a huge new market for cotton across the Atlantic. But the type of cotton being grown in the South, due to its short fibers and tightly clinging green seeds, was very hard to clean. The cleaning then being done, by the slaves of the plantations, was by hand. And this was far too slow to meet the enormous need.

Whitney's "engine" was simply a box with two rollers. One was covered with wire spikes that tore the cotton away from the seeds, and the other was covered with bristles that brushed the cotton off the first to prevent clogging. Rudimentary as it was, a slave who could formerly clean only 1 lb of cotton a day by hand could now clean 50 lbs with the new device.

The cotton gin therefore was one of the major influences in the transformation of the region from farming communities to prosperous plantations with plenty of slave labor to efficiently pick and clean the cotton. Not exactly a machine made in heaven. On the other hand this transformation, in turn, paved the way for the Civil War, which precipitated the abolition of slavery. So if you want an example of an important and innovative design with totally ambiguous consequences, look no further than the cotton gin.

CARAVEL

Innovation on the Seas

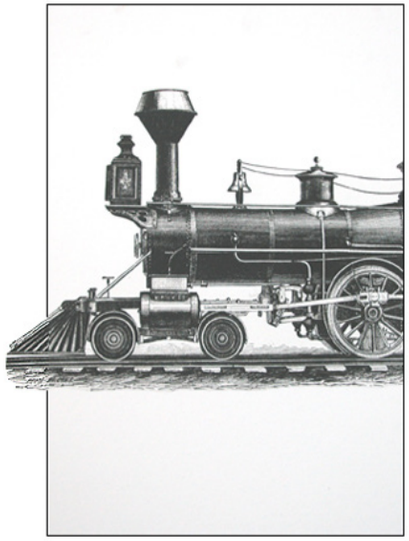
The caravel was the basic design for the first great ocean-going vessel. The Nina and the Pinta were both caravels. Like many great designs, the caravel was not so much a new invention as a great combination of existing ideas. In this case, a new ship was created that included the square-rigged sail, the Lateen sail, and the sternpost rudder. While all of these devices had been invented hundreds of years earlier, probably in China, the caravel designers of the 14th and 15th centuries had the foresight to add them to the bulky, wooden ships of the day.

The new design proved revolutionary. The Lateen or triangular sail made it possible for the caravel to sail diagonally to the wind, rather than simply being pushed in the direction of wind by its square sails. This allowed it to sail more efficiently before the wind and to cover greater distances faster. The sternpost rudder allowed for greater maneuverability and for a wider ship with a more generous hold. All of which made the caravel perfect for ocean navigation and for trading. This was the design that led to the great explorations of the 15th century, to the opening of the first global trading routes, and as you might expect on the murkier side, to the age of colonial expansion.

In other words, there would be no moderm world, for better or worse, without this innovention.

LOCOMOTIVE

Engine of Change



The idea of pulling cars along rails originated as early as the 1500s in Europe. Although made of wood, these wagonways allowed loaded carts to be pulled more easily by horses or oxen than on rutted dirt roads.

The locomotive ~ a machine used for the same purpose ~ came much later, starting with the advent of the steam engine in the late 18th century. Since then, almost every source of power ~ with the exception of nuclear energy ~ has been applied to the locomotive.

There have been any number of famous locomotive designs in the past 200 years. The first was Richard Trevithick's marvelously stumpy design from 1804 which he called the Catch Me Who Can. By 1829, George Stephenson's slightly streamlined Rocket had reached a dizzying speed of 29 miles an hour. The first diesel locomotive was the Zephyr in 1934, a gleaming stainless steel design out of a Buck Rogers comic that inspired the look of diners. Raymond Loewy's designs in the 1930s introduced streamlining to the style of trains.

But the most familiar exemplary locomotive design is the so-called General, a style that emerged in the 1850s. This is the one seen in so many American Westerns, with its separate engineer's cabin, outside oilers, wheel linkages, and funnel-shaped steamstack. The design remained popular almost until the end of the century and has pretty much come to represent steam locomotion in the popular imagination.

SEWING MACHINE

A New Stitch in Time

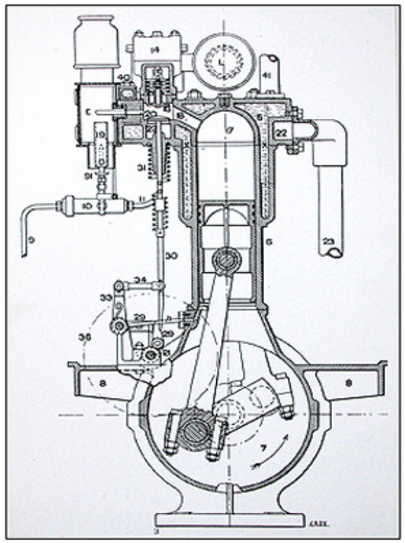
Needles with holes for thread made of mammoth ivory, reindeer bone, and walrus tusk have been found in Paleolithic caves. They are significant because they made possible a completely new method of assembling clothes, far beyond the possibilities provided by tying skins or felting fur.

But in the modern world, that same innovation is the basis for the breakthrough device we call the sewing machine. A number of people during the 18th century toyed with the idea of combining the eyed needle with some sort of wheel to automate the sewing process, but none of these seemed to work very well. Then in the 1840s, a French tailor named Barthelemy Thimmonier designed the first working device. He used it to make army clothing until his workshop was wrecked by a mob and he narrowly escaped with his life. This was not unusual given that almost every single machine designed to automate garment production has historically met with violent confrontation by workers. Despite improvements on his device and patents in both England and America, resistance proved too great and Thimmonier died in poverty in 1857.

Others advanced the idea...Elias Howe improved the design of the machine, and Isaac Merritt Singer created a better manufacturing process. But it was Thimmonier's design that first proved the possibility of automated sewing...to his detriment, to our benefit.

COMBUSTION ENGINE

Explosive Rotation



Although an engine using the explosion caused by igniting a gas was built in France in 1860, it was the design by Gottlieb Daimler that would eventually revolutionize transportation. Daimler's series of designs in the 1870s and 1880s became increasingly smaller, lighter, and more powerful as he continued to improve on the ignition mechanism, compression power, air-fuel mixing device, and lubrication system of his engine. Daimler's contribution was not in inventing the internal combustion principle or even in constructing its first application. What he accomplished was the refining and redesigning of the engine to produce a workable model that could be commercially manufactured.

While others struggled to devise self-propelled vehicles using engines of all kinds, Daimler's primary goal was to design an internal combustion engine that could power factory equipment. Only after some convincing in 1886 did he install one of his engines in a horse-carriage. The vehicle attained 10 miles per hour from his single-cylinder, 1.5 hp engine. Not very impressive by today's standards, but this was the demonstration needed (by onlookers, the press, investors) to usher in the age of the motorcar.

As with most revolutionary designs, this one too had an ambiguous outcome. While it transformed mobility, travel, and lifestyles on the one hand, it also created environmental consequences and oil dependency that we are still coping with today. Design revolutions are never pure.

KEYBOARD

Banquet of Tones

No one knows exactly when the keyboard was invented, but the earliest surviving example dates from the 14th century. That sample is a chunky set of keys ~ almost two octaves worth ~ that are part of a Swedish organ. This is the first known attempt to relate individual notes to keys that could be pressed singly or in combination. It is not quite the dramatic carpet of black and whites that we know now, yet the basic idea of whole and half notes arranged horizontally in two offset rows is there.

What changed most dramatically after the introduction of the keyboard was the method by which the depressed key would elicit a sound...whether by releasing air as in an organ, plucking a string as in the harpsichord, hitting one as in the pianoforte and then the piano, or completing a circuit as in the electronic keyboard.

It is easy to make the case that all musical instruments exemplify great design. Yet there is something beautifully simple, elegant, and instantly appealing about the design of the keyboard. In modern parlance, it has been called the most intuitive interface ever created, with the sequence of notes and their intervals clearly displayed. So comprehensible and usable, in fact, that it can be played by both a child to make a singsong and a genius to create a sonata.

VELOCIPEDE

Rolling Ingenuity

Can it be that no one thought of designing a vehicle with two wheels in a line before the 18th century? In spite of some ancient Babylonian and Pompeiian bas-reliefs that show devices resembling this arrangement, the forerunner of the bicycle apparently did not make its debut until 1791. That was the year in which the Comte de Sivrac rode a small wooden horse set on two wheels through the gardens of the Palais Royale in Paris, creating quite a stir.

The device had no steering and no pedals; the rider moved it by pushing along the ground with his feet and coasting. It was stopped by the heels on the ground or the object it ran into. Yet it proved so captivating that by 1804, races for such velocipedes were already being held on the Champs-Elysees.

In time, of course, steerable front wheels, saddles, braking devices, and a wide variety of mechanisms for pedaling and gearing led to an explosion of variations on the theme. Streets of the 19th century were soon filled with Draisiennes, hobby-horses, tricycles, penny-farthings, and later on with racers, dirt bikes and all the rest.

But it is the original design in its utter simplicity, for a device on which a rider can sit astride two aligned wheels and move forward, that make the bicycle, to this day, the most common form of transport in the modern world.

SEAGRAM BUILDING

The Modernist Style

The 38-story office tower designed by Ludwig Mies van der Rohe in 1958 has come to represent the ultimate modernist building. Modernism was the design movement that sought to eliminate the ornament and detail of industrial production and pare things down to their functional essentials. "Less is more," was one of van der Rohe's dictums, and he pursued this notion in all his designs from buildings to tumblers.

The Seagram building, like so many others that followed, is essentially a glass box. Gone is the elaborate facade, the ornate detail, the rich front to the world. This is building compressed to its most minimal impression. Modernism is a quest for basic truths, grand narratives, one answer for all...and this building has come to represent its ultimate architectural statement.

The Seagram building is not all cold calculation, however. Their is art within the design. The steel framed structure is wrapped in a curtain wall of pink-gray glass; spandrels, mullions, and I-beams are used to modulate the outer surface; the elevator banks are lined with travertine. This is really a Gothic dream realized with classic formality, but its ultimate impact is still uncertain. It is open to question whether the building will, in time, come to represent the triumph of the technological aesthetic over the excesses of romanticism or the final defeat of style at the hands of industrial man.

QUADRANT

Sighting the Stars

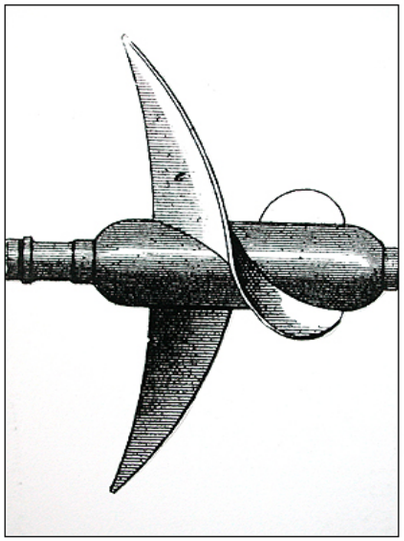
The idea of using a device to measure angles is a long story in the history of technology. Medieval scientists used an astrolabe ~ a complex device made of brass and covered with scales and symbols ~ for measurements of many kinds both astronomical and astrological.

The quadrant was a much simpler design, and it was this simplicity that made it such an innovative mechanism. The early quadrant was a quarter of a circle made of metal and inscribed with a gauge that measured the angle between a line of sight set along one straight edge and a plumb line suspended from the apex. Separated from the complexities of the astrolabe, the quadrant became a tool that could be more cheaply produced and more easily used to measure angles for surveying, gunnery, time telling, and most relevant to the modern world... navigation.

Increasing precision of the mechanism and gauges by the 16th century, eventually led to a device so accurate that Tyco Brahe could make the exacting measurements of celestial phenomena that initiated modern astronomy. The quadrant is a case in which a simplified design proved to have a much wider application and greater impact than a more complex alternative. The story of design includes both a desire for simplicity and a dream of complexity.

SCREW PROPELLER

Pushing Water

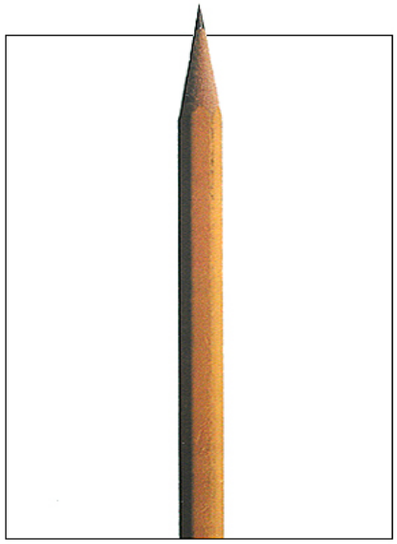


By the end of the 18th century, two different designs for using steam power to move boats were being proposed...paddles and jet propulsion. Neither was particularly efficient. Then in 1837, Sir Francis Pettit Smith built the first screw-propelled steam launch. The propeller he designed was really a screw drive, a long horizontal shaft around which the screw thread curved like a spiral stairway. It was cumbersome and awkward as a design. And because it was made of wood, half of it broke off during a trial run. But to everyone's astonishment ~ Smith's above all ~ this actually increased the speed of the boat. Taking advantage of this serendipity, as good designers always do, Smith quickly realized that it was the propeller's shape not its length that was pushing the water. Thus began a long series of redesigns to find the most efficient screw shape for this purpose.

By 1838, Smith had built the Archimedes, named for the Greek scientist who had been an early fan of the screw for other uses. For this he used a flattened screw design resembling the modern version. The success of the boat convinced other designers to scrap their plans for giant paddle-engines and to concentrate instead on propellers. The Age of the Steamship had arrived and it was the design of the propeller that got it moving.

LEAD PENCIL

Greatest of All?



No collection of great innoventions can be rated because every breakthrough is important in its own way. But if you absolutely *had* to chose the top breakthrough for the modern world, you would find ample support for the pencil. In fact, it has changed so little from its original form and is so timeless in its appeal that the pencil may very well be the perfect design.

The first description of a writing instrument consisting of a piece of lead held in a wooden casing appears in a treatise by Konrad von Gesner in 1565. However, the pencil took a long time to rise to prominence. It never, for example, replaced the quill pen in that time period.

The breakthrough came in 1795 when Nicholas Jacques Conte first designed a pencil made of graphite which had been ground, formed into sticks, and baked in a kiln, then inserted into a wooden shaft, all of which made mass production possible. This is an example of why the power of design is not limited to planning and creating, but includes fashioning as well. The success of the pencil, like many of the designs selected here, depended equally on how effectively it could be produced.

The pencil is not only useful, it has a wide range of appeals...it smells good, is chewable and portable, feels good in the fingers, makes a delicate scratching sound that mimics the brain thinking, is largely recyclable, will not roll off a tilted desk, and can be sharpened. It also happens to contain what many consider to be the second most important design innovation of all time...the eraser.

MODEL T

Mobility for All

Introduced in 1908, the Model T automobile marked the beginning of modern mass production and also served to "Put the country on wheels", as an early advertising slogan promised. In fact, the combination of an affordable and mass-produced car became the impetus for a transportation revolution that still affects us to this day.

When the Model T was introduced, just five years after Henry Ford founded his motor company, there were only 200,000 cars on the road. They ranged in price from $2,000 to $7,500, making them pleasure vehicles for the wealthy. The Model T cost $850 and was engineered specifically for poor country roads; it should not be surprising that 15 million of these "Tin Lizzies" were sold until the style made way for the Model A in 1928.

The car was designed for the factory, not for the showroom. Much of the style was based on the goal of getting it through Ford's new assembly line in one hour, rather than on any particular aesthetic concerns. As the company boasted, you could buy one in any color you liked as long as it was black. Yet the Model T is graceful and dramatic and manages in its gentle curves to somehow capture the romance of the road with dignity. For all these reasons ~ historic as well as aesthetic ~ it has come to represent the archetypal car, devoid of excessive flourishes, but fulfilling its purpose with quiet style.

VIOLIN

Making Wood Sing

Stringed instruments are quite ancient and diverse. The notion of stretching gut or string from one end of a stick across a hollow form that would resonate the sound seems to have occurred all over the world at various times. In Europe, the violin is generally traced back to the *rebec*, a bowed instrument of the early Middle Ages with two or three strings and a pear-shaped body.

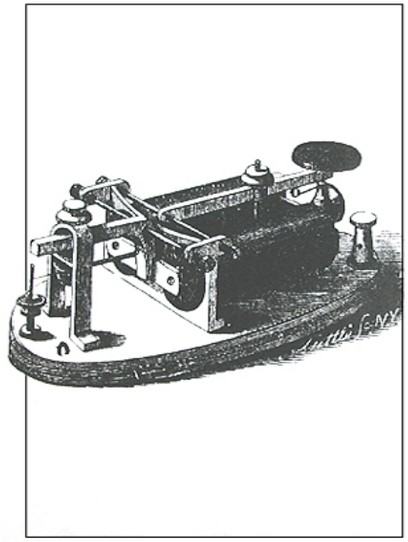
But the familiar sensual shape of the modern violin only began to appear in Italy in the 1500s as the larger Viola d'Amore. In the 17th century, Nicolo Amati produced instruments considered to be of astonishing sweetness and inimitable tone. In the next generation, this distinction fell to one of his pupils, Antonio Stradavari, who made a larger, flatter model with greater volume and roundness of tone.

In the modern world, the violin has become the quintessential stringed instrument, the ultimate application of design in the service of beauty, and the best example of form and function in perfect harmony. A violinmaker is no journeyman, but a designer struggling to make wood sing.

Flutists, guitarists, saxophonists, and others who love the design of their instruments will, no doubt, understand if in the limited space of this list, the violin is proposed as one of the greatest of all designs.

TELEGRAPH

Talking Wires



To prove how fickle success can be – whether via design or any other avenue – one need only look at the case of Samuel F. B. Morse. A mediocre painter and failed Daguerreotypist, with virtually no understanding of electricity or mechanics, it is Morse nonetheless who is remembered as the inventor of the telegraph.

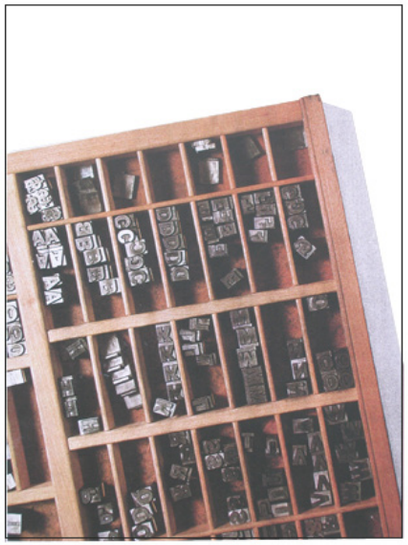
The idea of sending messages over wires using electricity goes back at least to the 1750s and includes hundreds of designs for different devices; even in Morse's own time there were numerous competing and equally effective devices. Yet Morse eventually won out when he was able to use his pro-slavery politics to influence key politicians who helped sway the Congress in his favor so that his telegraphic machine would be financed.

The first design he came up with was an impossibly crude device that relied on a moving stick bouncing over metal ridges for a transmitter, and a swinging pendulum scratching paper for the receiver. By the time of his first public success in 1844, the device had been refined considerably, and there is no denying that the telegraph is one of those innoventions that radically changed the world.

Still, the iconic telegraph key is not the Morse version, but a more effective design that evolved by the time of the Civil War. This is the simple and efficient tap-key device, so familiar from movies. It was the ease with which this design could be mass-produced that allowed the telegraph to become the first true system of electrical communication.

MOVABLE TYPE

A Lasting Impression



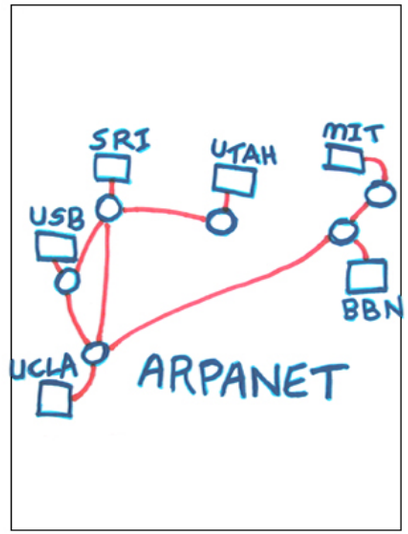
Printing, one of the greatest of all innoventions, is ancient. It was known in Minoan Crete around 1700 B.C., as demonstrated on a clay disk from Phiastos that was created using hand-punched letters. By the second century A.D. the Chinese were masters of printing using wooden blocks, even to produce books. In 1041, the Chinese alchemist Pi Sheng developed movable type...individual letters made of clay that could be composed into texts, then disassembled and reused. Wooden letters appeared in China by the 13th century and within the next two hundred years other advances appeared in Korea, Holland, and elsewhere.

But in the 1400s, a design innovation appeared in both Korea and Germany that revolutionized printing. This was the invention of cast metal type. In Korea it developed at the Royal Type Foundry and resulted in a book printed in the thousands of characters of the Hangul alphabet in 1403. In Germany, it was the work of Johannes Gutenberg. Besides using an olive press mechanism for repeated impressions, Gutenberg designed a clever, reusable mold for casting letters that also standardized the cast type. This made mass production of printing press letters possible for the first time in the West.

All combined, the various innovations that led to movable type became the first salvo in the great printing revolution that resulted in over a million books printed by the end of the 15th century, in countless books reflecting on its implications, and that continues up to this morning's newspaper.

ARPANET

Online Steps



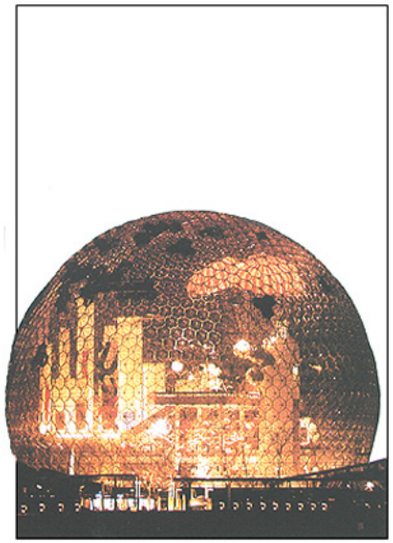
While no one actually sat down to design the online universe that has become so central to modern life, its precursor was a limited online system that can logically be called the key innovention. Arpanet was the name of a small-scale computer communications system created for ARPA ~ the Department of Defense's Advanced Research Project Agency ~ in 1969. The innovation of the system was that it allowed separate computers at different locations to transfer information electronically. This was a new idea at the time, when computers were seen as isolated machines.

To make it work, a computer company called Bolt Baranek and Newman, Inc. worked with researchers at UCLA, the University of California at Santa Barbara, the Stanford Research Institute, and the University of Utah to set up the first online computer network. Software applications, transfer methods, hardwiring plans, and computer stations all had to be designed to accomplish this. Even so, by 1971 there were two dozen sites in the system, and by 1981 more than 200.

The switchover to a new form of information transfer called Transport Control Protocols (TCP) in 1983, allowed the system to expand far beyond its original design. Arpanet itself went out of commission in 1990, but its influence remains as the grandparent of the global online network we have today, the one it would be impossible to imagine the modern world without.

GEODESIC DOME

Geometry of Shape



The name associated with the geodesic dome is Buckminster Fuller. The structure was part of what Fuller called at the time his "dymaxion approach to design." He created the word dymaxion from a combination of dynamic and maximum. Alone among designers in the 1950s, Fuller was looking into building designs that used tension and compression to create light-weight but high strength structures. He found the perfect solution to this problem in the geometric arrangement of triangular supports holding an external skin.

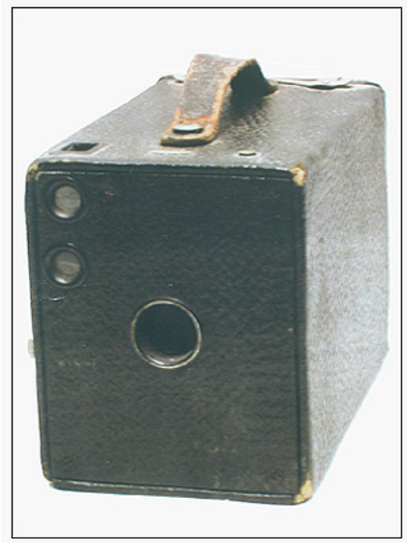
Fuller did not invent the geodesic pattern; this is a common structure found throughout nature. Nor did he create the idea of the dome, which is as antique as the igloo. What he did do, however, was to get the first patent for a building framework based on polyhedron shapes forming a spherical overall shape. This idea led to a structure that enclosed a maximum volume with a minimum weight and amount of material, fulfilling his "dymaxion"goal.

The geodesic dome failed to catch on as a basic building structure as Fuller hoped it would. But because it allows for a large open space with no obstructions, it has chiefly been used in exhibition settings. And because its strength comes from its geodesic structure and not its skin, the dome can be lit to create a beautiful translucence.

These properties make it a unique architectural design that perfectly mixes structural integrity with visual beauty and challenges the idea that human beings must live and work in boxes.

BROWNIE CAMERA

Photos for Everyone



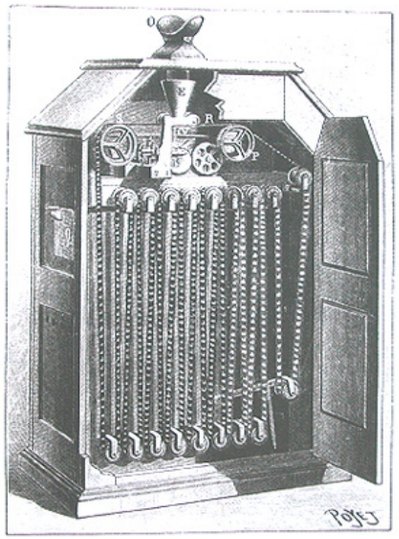
The raw materials for photography ~ lenses to focus an image and light-changing chemicals ~ had been around for a thousand years. The *camera obscura* (literally a dark room that allowed an image to be projected onto one wall) was used as a drawing tool during the Renaissance. But it was not until the 19th century that Joseph Niepce and Louis Daguerre in France, and Fox Talbot in England, combined these with a method for fixing the image on a surface so that it would not fade in the light, that the camera was invented.

Handsome as those early examples are ~ not to mention all the Leicas, Nikons, and Polaroids thereafter ~ the Kodak Brownie Camera has its own place in design history. It was the apotheosis of George Eastman's desire to "make a camera as easy to use as a pencil." The Kodak Brownie was essentially a black cardboard box with a film strip (another Eastman invention) at one end and a simple lens and shutter at the other. It sold for $25. Once the 100 pictures on the roll were taken, the entire camera was mailed to Kodak which developed the film, then sent back prints and a reloaded camera...all for $10. "You press the button, we do the rest," was the ad slogan.

This was the design innovation that turned the formerly cumbersome profession of photography into a hobby. A fine example of design in the service of democracy, making a complex technology ~ and an art form ~ available to all.

KINETOSCOPE

A Moving Image



There had been many devices for creating the illusion of movement throughout the 19th century. Perhaps to compensate for their reception as mere toys, they were given fancy names: spinning disks called thaumaturges, flip books called filoscopes, spinning wheels called phenakistascopes, whirling disks with mirrors called praxinoscopes. All of them worked on the principle that if individual images are presented quickly enough, the eye and brain merge them into a continuous moving image. By the time photography was invented in the first half of the 19th century, the search for a means of adding movement was on in earnest.

The first commercial motion picture device, however, took this so-called "study of chronophotography" out of the parlor and kicked it into the world of communications media. This device was the kinetoscope, first constructed by William Kennedy Laurie Dickson, who was one of the engineers working in Thomas Edison's lab. This cinematic peep-show was a cabinet that held fifty feet of film in an endless loop. A penny placed in the slot started an electric motor that pulled the film under a revolving shutter, and turned a light on as each frame went by the magnifying eyepiece. This was the first design to use photographic film and it became the precursor for the first movie theater -- The Electric Theater in Los Angeles -- a few years later. And of course, the entire movie industry of today.

VERSAILLES

Royal Grandeur

There have, of course, been countless palaces and castles throughout history but among these, Versailles is unique in its grandeur and excess. When the 3-year old King Louis XIV took over Versailles in 1661, it was still a comparatively modest building and grounds. Over the next half century, Louis and a series of architects expanded Versailles into the archetypal vision of state power. In fact, the design of Versailles reflects both the ambitions of King Louis XIV and of the French empire itself. This was the monarch, after all, who famously said "L'etat c'est moi" ("I am the state").

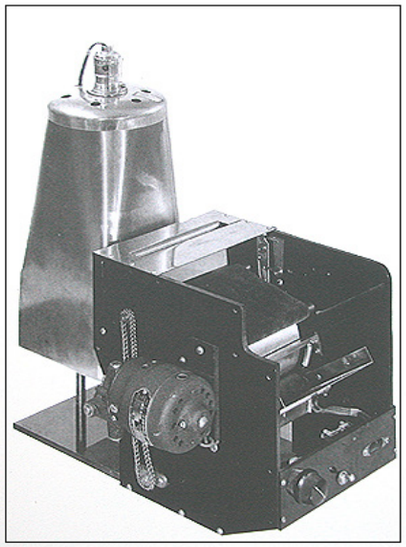
By the end of the century, Versailles had become one of the most elaborate palaces on earth with its gilded balconies, 200-foot long Hall of Mirrors, courts, stables, squares, offices and lodgings, grottos, canals, waterworks (over 1400 fountains). The spectacular formal gardens alone represent one of the most complex landscaping designs in the world and seem to suggest that while a man of wealth can build a palace only a king can reform nature.

Versailles is also an example of grand design as a personal statement of power and wealth. It was intended and used right from the start to feed into the cult of personality surrounding the King, who not only moved the seat of government there, but lived there on very public view...eating, dressing, attending to state matters, and even undressing, for his courtly audience.

In Versailles we have an illustration not of the power of design to change the world, but of the powerful to change design.

PHOTOCOPIER

Reproductive Work



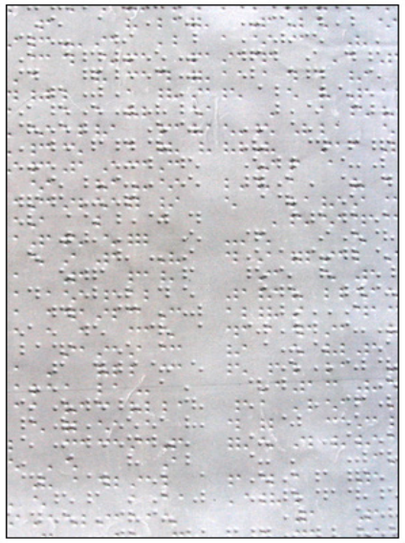
Most inventions are the result of a process of accretion; individuals adding to the evolving design in pieces over generations. Not so the photocopier. In fact, its creator was so alone in his enthusiasm for it that it took him many years to convince anyone else that it had any value at all.

What Chester Carlson did in creating the photocopier was to design a practical process even more than a mechanical device. Working in his makeshift lab over a bar in Astoria, Queens, Carlson ~ a chemist by training ~ tinkered with the idea of using electrical charges to control powdered ink. Because it was dry ~ requiring no photographic chemicals ~ the process could be used to make instant "electrophotographic" copies of documents. His very first copy was made entirely by hand using a lab slide, a lamp, and the proper chemicals; with this he managed to produce a smudgy piece of wax paper that said "10-22-38 Astoria."

Having proved that the process could work, Carlson then labored for years over the mechanics of a machine that would apply it in an efficient way. For a long time no one was remotely interested in his invention, until the president of the little known Haloid Company in New York took an interest. By 1949 their engineers had transformed Carlson's homemade machine into The Model A, the world's first office copier. The name of the company was eventually changed to Xerox, which meant dry in Greek. And the rest is, as they say, design history.

BRAILLE

Points of Understanding



It is not only the objects of the world, but also systems of communication and information that must be designed. Perhaps the best example of this, because it is the most familiar, is the system of raised dots on paper that allows the visually challenged to read text. Relying on a disarmingly simple plan for the representation of letters, Braille is surely one of the most elegant and versatile designs for a method of printed communication.

According to his biographers, the idea for such a system first came to Louis Braille when he was a 15-year-old student at the National Institute for the Blind in Paris. He based the idea on a dot-dash code that was punched into cardboard, and used by a certain Captain Charles Barbier to send messages to his soldiers at night.

Braille's system, first published in 1829, was much simpler. It used a cell of six dots, just large enough to be distinguished by the sensitive tips of the fingers. From the 63 possible arrangements of those dots, Braille designed a code for the letters of the alphabet, punctuation marks, numerals and, later, even musical notation.

Braille is compact and effective, and can even be printed on both sides of a page since the raised dots on one side do not interfere with those on the other. It is a clever design for a language code, and one that has improved the lives of millions of people

TYPEWRITER

Making Words Work

The design for the modern typewriter included two innovations over the ideas for "transcribing machines" that emerged in the 18th century. One was an inked ribbon for continuous impressions, the other was simplified parts that could be manufactured and mass-produced. Credit for the first such design usually goes to Christopher Latham Sholes for a rather clunky device that he eventually sold to Remington, the arms company.

A commercial version made its first appearance at the 1876 Centennial Exposition, but it failed to find a market for years because it was largely viewed as an outright offense to the fine art of letter writing. Once it did catch on, however, the typewriter succeeded in creating a new role for the new working woman of the 20th century. Leading to the employment of millions of women, it can be seen as a key instrument in their slow emancipation from the home...or in their enslavement as secretaries, depending on one's viewpoint.

Representing this innovention is the IBM Selectric introduced in 1961. The sleek design by Eliot Noyes was created to "feel like a complete single shape" in spite of the complex technology inside, and to be easy to clean. The typebars and moving carriage were replaced with that amazing feat of engineering...the spinning type ball.

Sholes, by the way, designed the QWERTY keyboard arrangement based on the frequency of letters used, specifically to avoid jamming. With typewriters now extinct, QWERTY may remain as his greatest legacy.

SPECIAL MENTION

Other Designs that Mattered

No list of great designs or major breakthroughs is complete. The process is biased, the method imperfect, the space limited. Many other innoventions since the early Renaissance have had their impact on the modern world. Here are just a few of them:

Les Demoiselles D'Avignon
This painting by Pable Picasso in 1907, ushered in one of the most significant looks of the century, not to mention the era of abstraction in modern art.

Knitting Machine
Designed by Englishman William Lee in 1589, the machine knotted threads into fabric and introduced the entire industry of knitware to the modern world.

Jacquard pattern
This unique pattern, popularized in France in the 1600s, was significant as the result of a mechanized process using punch cards that could be considered the forerunner of the computer.

Opera
The 17th century in Italy saw the evolution of opera from other performance forms as a major new art form designed to appeal to all the senses and that still thrives today.

Paper Cup
Created in 1908, this innovention quickly became a ubiquitous industrial object and a symbol of modern disposability.

Bessemer Steel
Developed in the USA in about 1856, this was a significant, and carefully designed, process for creating a new material that changed the industrial world forever.

Fallingwater
Possibly the most familiar design for a private residence and the one the best representations of a "Modern" design aesthetic, as created by Frank Lloyd Wright in 1936.

Left and Right Shoes
A unique innovention that was developed only around the time of the Civil War with obvious resonance today; earlier soldiers alternated their shoes every other day.

Bar Code
The most ubiquitous tracking system of all time, and a clever design using a visual code. Created in 1952, the bar code can also claim to be the most viewed type of image in history....by computers not humans.

London Underground
The first subway system in the world, built in the 1860s, was the standard for all urban transport systems to follow.

Sonata
Just listen to Beethoven's String Quartet in C-sharp Minor, Op. 131 to understand the revolutionary impact of this form.

Central Park
The beautiful design for an urban greensward by Frederick Law Olmstead brought nature back into the city. A great example of design that disappears into its function.

What innoventions would you add?