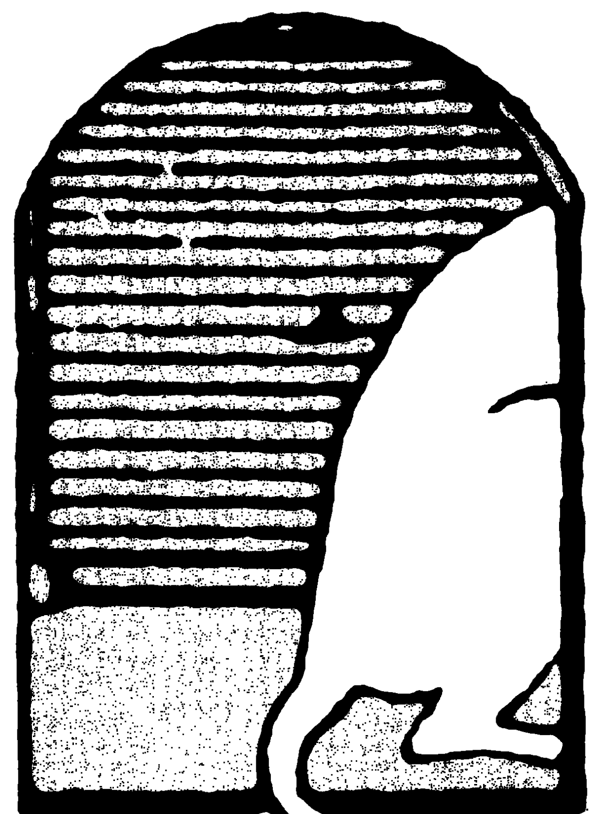
The Cooper Union *for the* Advancement *of* Science *and* Art

A BETTER MOUSETRAP



PATENTS & THE PROCESS OF INVENTION

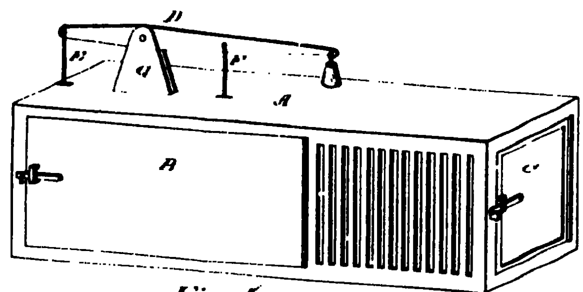


Fig. 1.

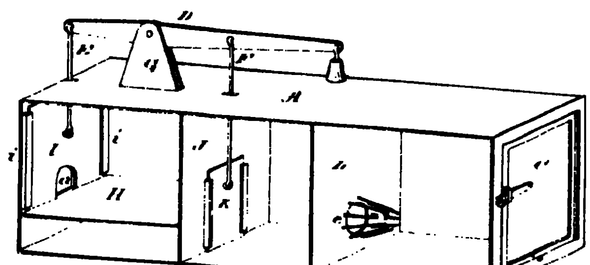


Fig. 2.

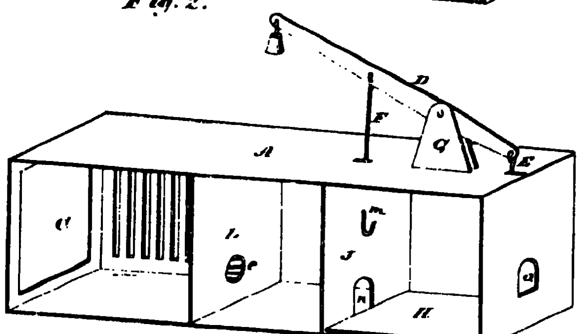


Fig. 3.

Patent No. 214,013, 1878
Presley E. Willford, Inventor
Improvement in Animal-Traps

"The trap consists of a regular oblong box, the size depending upon the class of animals it is desired to capture, divided by suitable partitions into three apartments, with openings in the partitions for the animal to pass, the first apartment being provided with a false bottom, suspended above the floor thereof by a balance-weight, so arranged that the animal entering from the outside upon the false bottom causes, by its weight, said false bottom to descend, closing the outer entrance and opening the entrance into the second apartment, through which the animal passes, when the false bottom again rises, opening the outer entrance and closing the entrance of the second apartment; and the entrance to the third apartment is guarded by inwardly-projecting wires, which prevent a return therefrom when the animal has once entered."

THE COOPER UNION *for the* ADVANCEMENT *of* SCIENCE *and* ART

A BETTER MOUSETRAP
PATENTS &
THE PROCESS OF INVENTION

Sponsored by GENERAL MOTORS CORPORATION and
American Heritage of Invention and Technology MAGAZINE

1791  1991

in CELEBRATION *of*
PETER COOPER'S
200*th* BIRTHDAY

EXHIBITION

17 January - 15 February 1991

The Cooper Union
The Houghton Gallery
The Lubalin Center

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The history of technological innovation offers
valuable lessons about the nature of progress
and the roots of problems facing this great nation.
As the pace of change grows more rapid,
the process of change becomes more important.
To understand that process,
we need to appreciate the past.
Such is the purpose of this exhibition.
Such is General Motors' purpose
in supporting it.
GENERAL MOTORS CORPORATION

ENCOMIUM TO MODELS AND THEIR MAKERS

Jean Le Meé, Albert Nerken School of Engineering
The Cooper Union

"[The American] is no more attached to a particular system of operations than to another.
He doesn't feel himself more tied to an old method than to a new one...
The idea of the new is intimately connected in his mind with the idea of the better...
The American [is], above all, an innovator.
That spirit is to be found, in fact, in all his works...
He carries it everywhere,
to the deep of the woods as to the bosom of cities."
ALEXIS DE TOCQUEVILLE, 1832

Our good fortune in being able to open this exhibition and present this monograph to the public is first and foremost due to the foresight and persistence of Mr. Cliff Petersen, an aerospace engineer and a Cooper Union graduate (CE '43). Since 1979, when he acquired the largest collection of patent models in the nation, Mr. Petersen spared neither time nor effort in ensuring the preservation of these most valuable witnesses to one of America's most productive eras in the domain of invention and economic growth and indeed, to one of the world's great shift in paradigm from the traditional to the industrial type of society.

This collection groups the survivors of a once honored and famous collection that was the pride of a young Washington, displayed in showcases in the halls of the National Gallery, "a Museum of the Mechanic's Art," listed in guide books for tourists and visitors, claiming in 1856 "more than 25,000 specimens of ingenuity and skill... judiciously arranged by subjects."

The collection has its origin in the first patent act passed by Congress in 1790, requiring patentees to submit a model along with drawing(s) and a description with each application. The model requirement was rescinded in 1793 but reinstated in 1836, when the patent system was overhauled. It remained in force until 1880, when, under the effect of a malthusian competition between the growth of space available to store the models and the near exponential growth of their number, the model requirement was definitively abolished. Except for a few thousand models selected at the time by the Smithsonian Institution, there began a sad odyssey of neglect and abandonment for the more than 200,000 models then extant.

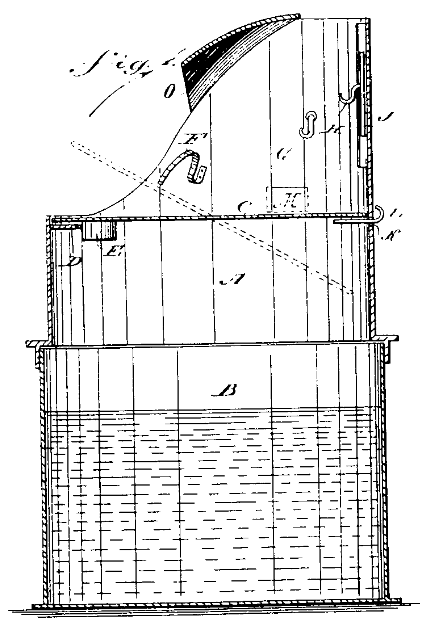
In various fires, floods, and other calamities, more than 100,000 models were destroyed, while thousands of others were dispersed in auctions. The bulk of the some 60,000 which survived have been in the Petersen Collection since 1979. Most of the models in this exhibition come from that collection. This exhibition is not premised on the idea of an encyclopedic survey of nineteenth-century patent models, a task already expertly performed by the Cooper-Hewitt Museum in 1984 in an exhibition by that title, and by other exhibitions last year in Washington and across the land celebrating the 200th anniversary of the Patent office. Our purpose here has been to show something of the variety, ingenuity, playfulness, and indeed, quirkiness of the inventive mind at work in the matrix of the times. No area of life, or even of death, seems to have been preserved from "a better idea." From a hat-box shaped like a hat to chaotic swings and coffin torpedos, from pessaries and corsets to steam engines and boilers, the whole spectrum of human activities lay open to Yankee ingenuity.

PATENT
No. 530
M. Steiner,
Inventor
1837
A hatbox
shaped
like a hat
Cliff Petersen Collection
Photography, Joanne Savio

One driving, overwhelming impresssion given by the models is their practicality: not necessarily in the sense of their usefulness, mind you—who needs one of these break-neck swings, or one of these washing machines that, no doubt, required more effort to run than doing the wash by hand—but in the sense of their concreteness. They address concrete, practical ends: swing a child, wash the clothes, blow out the brains of whomever is in the line of sight of your "Colt." They do not appear, in themselves, to raise or answer fundamental questions of science or philosophy. They are of the moment and for the moment. They fit the traditional American frontier ethos. Hence, probably, their appeal then and their appeal now. But one also detects through their constant striving to "be different," even in trite details, more in the line of fashion than science, in the sheer accumulation of trivia, a quantum effect that leaves a mark on a national scale, a monument to the restless spirit of change where all is relentlessly brought into question, modified, adapted, improved, expanded, made better, in a permanent flux whose only constancy is its law of change.

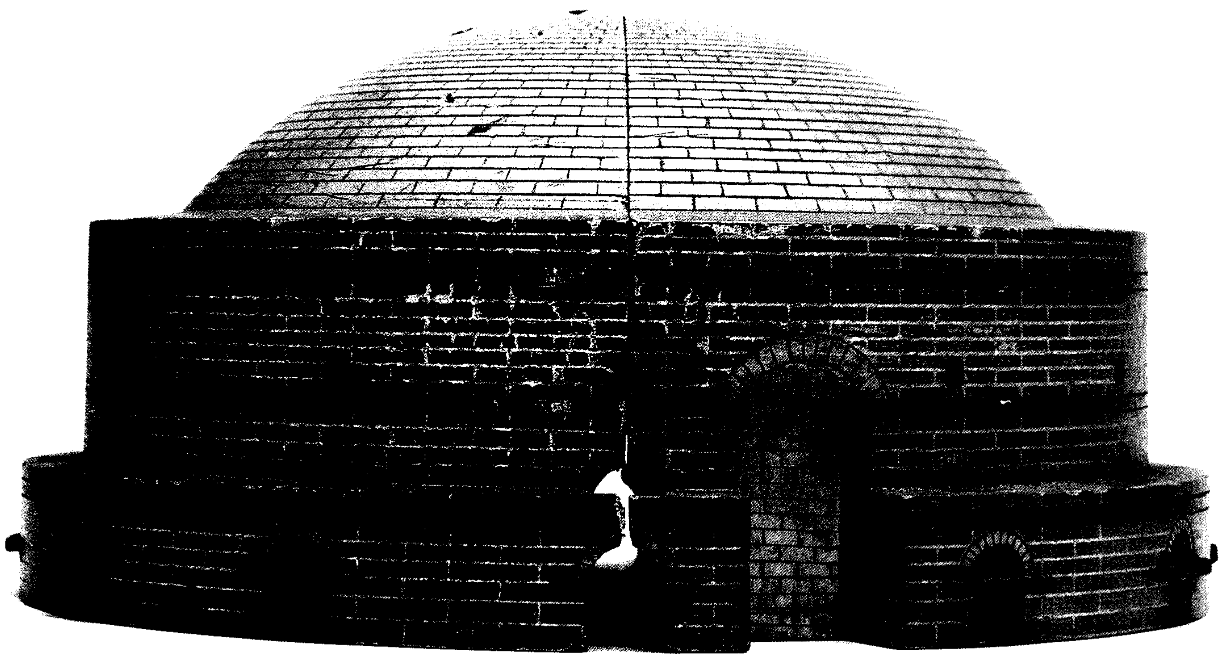
PATENT NO. 271,952
T. B. Turley, Inventor 1883
"I claim as new and desire to secure by Letters Patent—The combination, with the open-bottomed trap-body A, placed over a vessel of water, B, of the tilting platform C and the vertically-sliding bait hook H J, as and for the purpose specified."

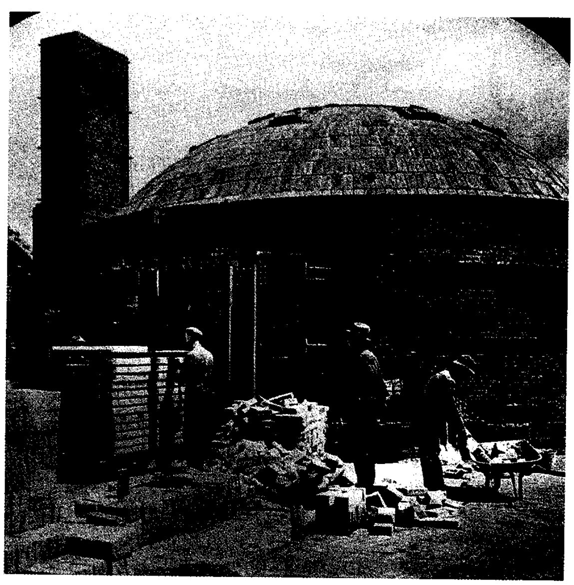
It is, it seems, that very mass of inventive activity, that need to reach a critical level for igniting the chain reaction of "progress," to provide the ground where the significant emerges from the commonplace. The parallel with the Italian Renaissance is striking, when great art was sustained and nourished by an extraordinary level of competence among a large mass of artisans and people of *"métier."*



Looking at these models—so many swings, so many washing machines, so many steam engines, mousetraps, and artifical limbs, all variations on a theme—we catch a glimpse of the utter delight of the inventors' minds in coming up with their own versions: "useful," though to whom and for what may not be any of our business, novel," yes, but above all, "different." That spirit of invention, crystalized in a state of mind, may not be due to the patent system itself, but the patent system miraculously helped preserve it by inducing inventors to record their inventions in these models, rather than leaving to future archeologists the task of digging out from the rubbles and heaps of the past signs of these inventions. And so, in that sense, they are a monument to an age and a free lesson to our own.

So salutations and respects to these Johann Sebastian Bachs in wood and metal, untiring improvers of the human condition, concretizers of ideas, and to Peter Cooper, Mechanic of New York, man of progress, their worthy companion, greatest among their leaders, whose 200th birthday we hereby celebrate.





Patent model for a kiln for baking bricks, patent number and date unknown.
The dome of this kiln hardly approaches the soaring profile of Brunelleschi's S. Maria del Fiore— its Romanesque form was conceived for function.
The model maker has lovingly depicted every detail of its masonry.
Cliff Petersen Collection
Photography, Joanne Savio.

At left is a photograph of a similar building in use.
Courtesy Hagley Museum and Library.

ON MODELS AND MODELING

Jean Le Mée, Albert Nerken School of Engineering
The Cooper Union

The requirement of having a model of the invention filed together with the drawings and description of that invention was peculiar to the American patent system.

There may be some commonsense reasons why it was so. For one, if you are designing a machine or any mechanical contraption and have trouble calculating what the forces, sizes, or materials ought to be for a given purpose, the only thing to do is to "try," by building your proposed structure on a small scale first—it's cheaper and safer—and then scale up step by step if it proves successful. That, essentially, is the essence of modeling. Now, there is no doubt that the determination of the forces at play, the stress and strain in the machines the patent models represented, were well beyond the capacities of even the better-trained engineers of the time. This was, in fact, the period when the sciences of strength of materials, of elasticity and of thermodynamics, which form the basis of such calculations, were being established, when the very concepts of stress and strain were being worked out. The only way to figure out what to do was, therefore, to build a model.

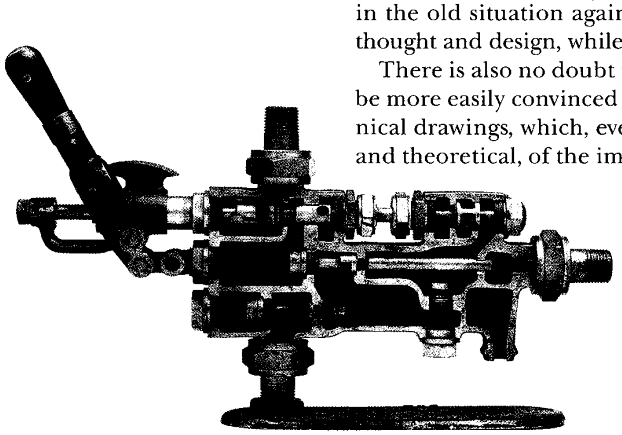
Another reason for the model requirement is that relatively few of the inventors probably knew much about technical drawing and reading drawings. Though drawings have been made from time immemorial, (c.f. Altamira and Lascaux), it was only around 1800 that Gaspard Monge invented descriptive geometry and laid the foundations of modern technical drawing. There is no doubt that the inventors and tinkerers, "practical men" and "men of progress," most of them untutored or self-taught in the arts and sciences, felt more comfortable with working models than with abstract representations and descriptions of their devices. It was assuredly easier for them to communicate directly with the model maker, if they used the services of one, than through graphical means with a distant patent examiner.

The use of models in technical design has a long history. There is some evidence that the ancients built models of their proposed constructions. Medieval master masons and engineers certainly did, as can be seen from account rolls in some cathedrals.[1] Judging from the costs mentioned in these accounts, the models must have been large and elaborate. The tombstone of Hugues Libergier (d. 1263) in Rheims Cathedral, the architect of the now defunct church of St. Nicaise, represents him holding in his left hand his measuring rod and in his right hand a model of his church. Vasari tells us in his life of Brunelleschi that in 1417 "the wardens of works of Santa Maria del Fiore in company with the consuls of the Wood Guild called a congress of local architects and engineers to discuss how to raise the cupola... Following this, models were designed and executed."[2]

We are furthermore informed by Prager and Scaglia that Brunelleschi "worked extensively by means of models and full-scale constructions and not in general by writing or drawings."[3] Interestingly, these authors remarked that Brunelleschi "had pupils and admirers who witnessed his performance. Some of them, in turn, left a secondary record of his teachings... for example, the engines in Taccola's treatises... [which] reappear in many textbooks and treatises of the late Quattrocento."

Judging from the notebooks of Villard de Honnecourt (ca, 1250) and Leonardo da Vinci (c. 1500) this practice of working from models and using drawings for the record, must have been common practice and must have extended to the nineteenth-century world of our inventors. It is only with the rise of the engineering schools and the teaching of descriptive geometry since the end of the nineteenth-century, that the practice reversed itself: drawings being used for thinking and design and the model, if used at all, for the purpose of record or public presentation. Interestingly enough, with recent development in Computer Aided Drafting and Design (CADD), we find ourselves in the old situation again, where "physical" modeling takes precedence in helping thought and design, while drawing finds itself relegated to record and documentation.

There is also no doubt that in case of litigation, judges, attorneys, and juries would be more easily convinced by "working models" they could see and touch than by technical drawings, which, even in their patent versions, retained an aura of the abstract and theoretical, of the impractical.



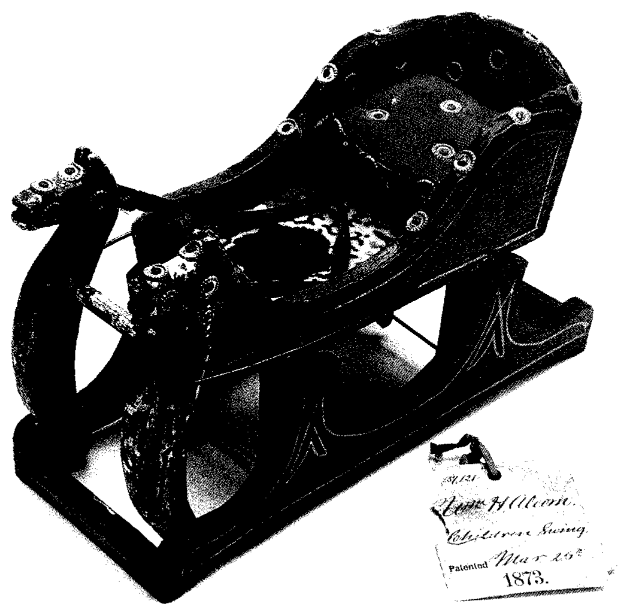
PATENT No. 537,279
T. M. Eynon and J. W. Gamble, Inventors 1895
In this model of an injector, the skin has been cut away to to reveal its internal anatomy. An injector acts as a pump to introduce water into a boiler under pressure. It has no moving parts, and is thus robust and free of trouble. Using steam from the boiler as a propellant, it also acts as a water heater.
Cliff Petersen Collection
Photography, Joanne Savio.

The model requirement, therefore, must have been perceived as a vindication of the common man, of the mechanic, in line with the Constitution, which confers upon Congress the power of "securing to inventors the exclusive *right* to their discoveries," as against the claims of the school-trained gentlemen, men of paper and of drawing, and against the English law whereby the Crown *may grant* or confer upon the inventor the royal privilege of a patent, subject to conditions and limitations from the same Crown.

Modeling, however, is a difficult art and a subtle science—more difficult and more subtle than was realized at the time. It is ironical that the patent model requirement was being phased out as the science of modeling was being established. Characteristically, it also occurred during the same period that electrical engineering, aeronautical/naval engineering, and chemical engineering came into their own.

Electrical phenomena are not as readily apprehended by the senses as movements of levers and connecting rods, but on the other hand, they lend themselves more readily to mathematization, and the inventions they brought forth could be more easily evaluated on paper than on three-dimensional physical models. As for aeronautical/naval and chemical engineering, which deal with complex phenomena that defy any simple mathematization and modeling, these required a whole new approach to the modeling art based on sound scientific principles. Everything, therefore, in the development of technology and engineering conspired to bring to an end the glorious and naive faith in patent models. It is among the ironies of history that one of the founders of dimensional analysis, the basis of modeling theory, which was to play a central role in the development of aeronautics, was William Thomson, First Baron Kelvin, who ponderously announced that "Heavier-than-air flying machines are impossible."

PATENT NO. 184,919
J. M. Simpson, Inventor 1876
The typical steam engine, like the modern internal combustion engine, with its system of cranks and connecting rods, are kinematically complex and dynamically abhorrent. The soul of the true engineer yearns for the pure, even rotation. Before the invention of the steam turbine and the gas turbine, numerous inventors proposed "rotary engines." This is a is particularly elegant one. The rotating cylinder acts as its own sliding valve to distribute steam on the two sides of the piston. Moving parts are reduced to a minimum. When it turns, it purrs.
Cliff Petersen Collection
Photography, Joanne Savio



PATENT NO. 137,121
W. H. Alcorn, Inventor 1873
Here is a stately thing, an oscillating carriage to teach a child self-reliance: "My invention... shall be constructed that a child sitting upon its seat and pulling upon a lever can give the seat an oscillating movement." The child-activated swing with a set of levers and connecting rods is a popular theme in the nineteenth century. Dozens and dozens of swings were patented.

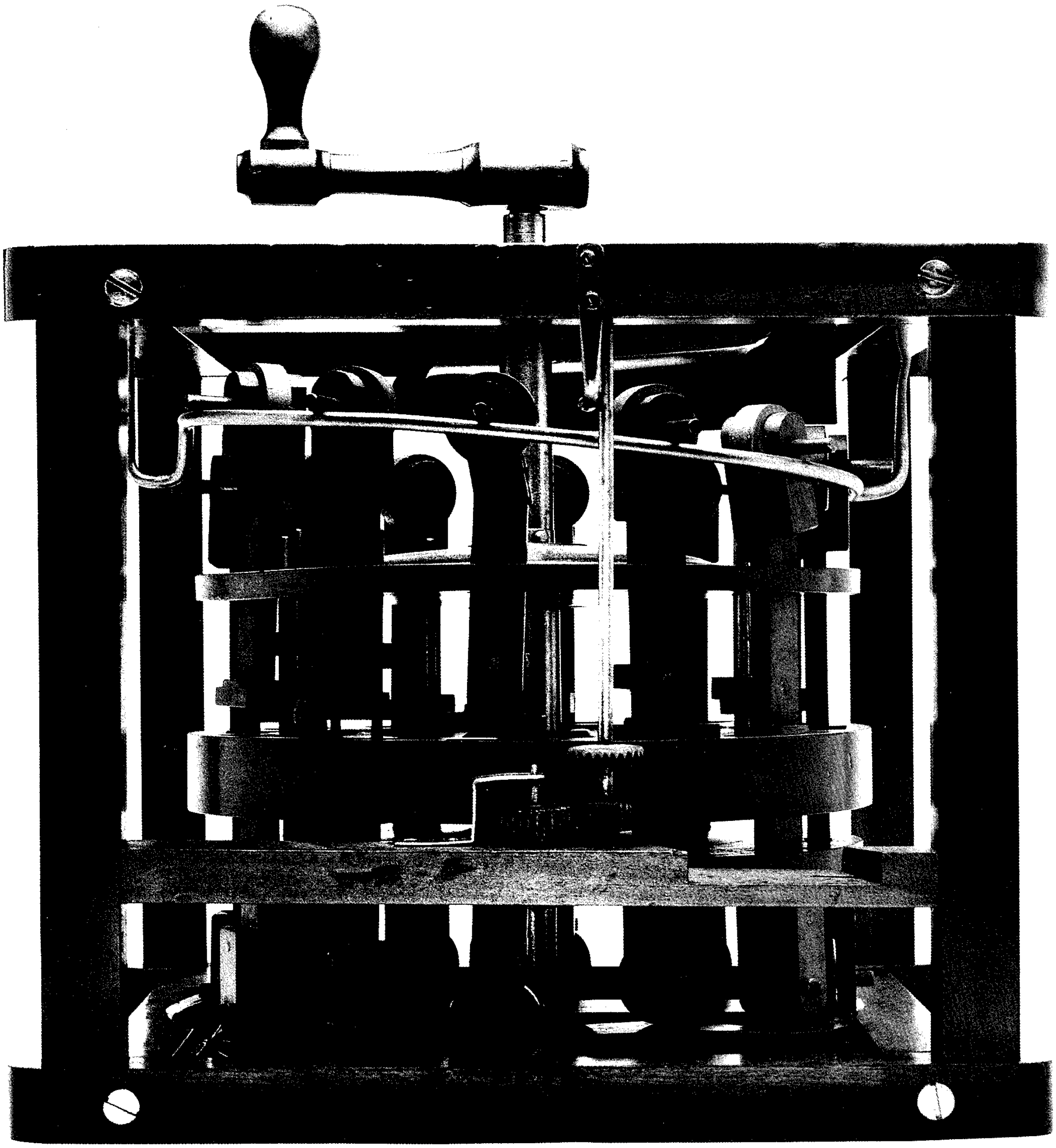
Be that as it may, it is of interest to note that, for the most part, patent models could not have been more than of qualitative value in judging the performance of the proposed inventions. As Galileo pointed out with his "square-cube" law, scaling up has its problems. Suppose, for instance, you are designing a steam engine. For a given pressure, the power is proportional to the piston area and to the stoke, and, therefore, to the cylinder volume. If you double the linear size of your machine, the volume goes up by a factor of $2^3 = 8$, while the surface will go up by a factor of $2^2 = 4$. The power yield is, therefore 8 times greater, and so would be the weights and forces involved in the moving parts, while the stresses and temperatures which result from the ratios of forces to surface and power to surface, respectively, would, therefore increase as the lengths. So double the size, double the stress, double the temperature, double your trouble!

Of course, if stress is no problem and temperature is not involved, as in masonry buildings, where only static stability is of concern, then scaling up will work well. That explains Brunelleschi's success with his models, as well as that of innumerable others. It may also explain some of the disastrous boiler explosions and industrial catastrophes that monotonously punctuate the nineteenth century. Patent models were adequate to give an idea of how "the thing" would look, what its kinematics would be (i.e., how it would move, whether this part would clear this one and by how much in slow motion), but not what its dynamics would be (i.e., the forces, the stresses, and strain that would develop under full scale working conditions). One need only look at the double-pendulum type swings proposed by some of our inventors to realize that either they knew not what they were doing or they were animated by a rare degree of gleeful insanity.

NOTES
1. John James, *Chartres, The Masons Who Built a Legend* (Boston: Routledge and Kegan Paul, 1982) 71.
2. Georgio, Vasari, *Lives of the Artists*, Vol. I (Baltimore: Penguin Books) 141.
3. Frank D. Prager and Gustine Scaglia, "Brunelleschi as Structural Engineer," in *Modern Perspectives of Brunelleschi* (Cambridge, 1970).

Patent No. 135,738
E. A. Tuttle, Inventor 1873
Ah! What fun it must have been to play on one of these. Imagine the dear cherub swinging chaotically on this double-pendulum swing when his shoe-laces get caught in the springs. It is good to know that the intentions of the inventor, at least, were honorable:
"My invention... shall be constructed that the seat of the swing, throughout the whole extent of its vibration, may be close to the ground, thus obviating the danger of injury from an accidental fall from the swing."
In slow, coordinated motion, of course! The double-pendulum structure of this swing set makes it a chaotic system.

In the young nation construction was a booming business.
Particularly in cities, brick was a choice building material, since it is strong, easy to manipulate, and, above all, fire resistant.
Courtesy Hagley Museum and Library.

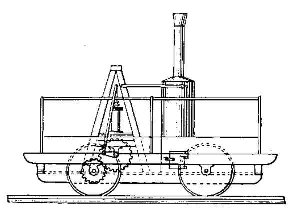


PATENT 6,933 *John T. Brown and Moses Fuller, Inventors* 1849
The demand for bricks stimulated the design of brick-making machines throughout the nineteenth century. This machine includes a mechanical discharging device to replace manual handling.

PETER COOPER, REPUBLICAN INVENTOR

Peter G. Buckley
The Cooper Union Faculty of Humanities and Social Sciences

Peter Cooper loved his inventions. In his unpublished *Reminiscences* he devoted many pages to detailing their conception and operation, and like an indulgent father he had particular regard for those that had gone astray. He considered his torpedo ship, for instance, to be one of the most important works of his life. Designed in 1824 to support the Greek independence movement against British oppression, the small steam-powered ship was supposed to carry a bomb to its naval target while being directed from the shore by wires that could stretch up to ten miles! It could, moreover, return intact: "When the explosion should take place, it would bend the iron holding the torpedo, and this would reverse that action of the steam engine, and cause it to go right back to the place from which it started."



Peter Cooper's Tom Thumb was the first practical steam locomotive built on the American continent. Successful inventions like these play a minor role in Cooper's *Reminiscences* compared to such fanciful devices as the torpedo ship.

Filled with enthusiasm, Peter took the boat down to the New York Narrows, only to find that "a sail vessel crossed our track and broke our wire, and I could not find how far we might have gone on successfully." The supply ship sailed for Greece in the next week, without taking Cooper's torpedo; nevertheless he "had the satisfaction of believing that I had something to do in bringing that unfortunate threat of hostilities on the part of England to a peaceful termination."

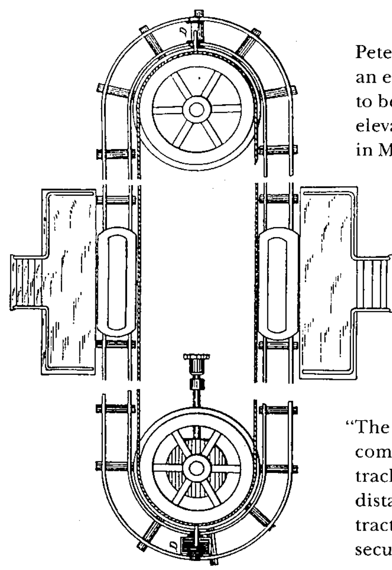
Though a failure, this torpedo experiment sheds some light on the process of invention, both in Cooper's own life and for the period. First, it illustrates that much invention in the early nineteenth century involved the simple adaptation of existing technologies. Cooper's boat was to be powered by a "rotary" steam engine which he had built two years earlier, and the design for which was to be used again to such dramatic effect in his Tom Thumb railroad engine of 1830. That engine indeed worked, but only just. Cooper referred lovingly to it as his "Teapot," jobbed together from musket barrels, a boiler, wheels, lumber and some found objects of hardware. Like his torpedo boat, one suspects that it was supposed primarily to serve as a demonstration rather than operate as a enduring machine.

De Tocqueville noted during his American travels that, in contrast to France, "scarcely anyone [devoted] himself to the essentially theoretical and abstract portion of human knowledge."

Second, one is struck by the way that Cooper almost glories in the small details of his devices, delighting in a curious blend of common sense and fertile imagination. Inventors of his generation certainly valued the "practical' over the "scientific." Never receiving any formal education in science, Cooper believed, like his hero Ben Franklin, in simply "learning-by-doing"—in his own words "always fussing and contriving" in the hope that something useful and profitable might turn up. The range of his invention is truly remarkable: from rocking baby cradles and hub-mortising machines to cable-cars and rocket propulsion. Indeed, the more tangential the effort to his work in glue and iron manufacture, the more he trumpeted his inventive genius; he did not include in his *Reminiscences* any mention of the two patents that truly brought him wealth—a design for a high-pressure steam boiler and a method for improving "the art of making Glue," signed by President Jackson in 1830.

Americans saw this practical, almost Rube Goldberg, approach as uniquely democratic, open and available to all regardless of academic accomplishment. Priority was given to physical rather than mathematical modelling. Even in the specialized fields of ship and bridge-building, it was more common to take measurements from scale models of proven designs than to develop new forms based on geometry and material science.

Celebrating the range of his application certainly was not supposed to end in mere self-praise. Cooper thought that ingenuity was not the property of particular individuals; rather it belonged to the artisan and mechanical classes from which he had come. In this he was correct. In a time before large corporations and research universities, almost all technological improvement came from the shop floor or the farm house. This did not, however, immediately confer social status upon the artisan—quite the reverse. Many educated merchants, lawyers, and doctors in New York still viewed the tradesmen with suspicion and distaste. Not only did laborers get their hands dirty but their wills, since they were constantly engaged in making a living, were not free to rise above their own self-interest to see the true nature of political virtue. Cooper's celebration of the practical and useful was part of his life-long battle with what he termed "polite" society. His social and political education, through the years of Thomas Jefferson to Andrew Jackson, made him part of the generation that raised the status of the artisan.



Peter Cooper's design for an endless cable and track to be used on New York's elevated railways, patented in May, 1879.

"The arrangement and combination of the endless track, the stations equally distant apart, the endless traction rope, and the cars secured thereto at distances corresponding to the distances of the stations, in the manner herein shown and described, so that all the cars on the circuit will simultaneously stop and start from all the stations on the circuit."

For Cooper, then, mechanical invention was not inimical to political virtue but rather essential to it. Invention fleshed out the spirit of the American Revolution. Now freed from despotic authority, the young country was required to develop its own natural resources in land and people; indeed, it was forced to do so since Britain, though the loser in military terms, still looked upon its old colonies as an enormous market upon which to dump its goods.

Ironically, one important result of raising the social status of mechanical pursuit was that the business of invention became highly personalized. Specific machines such as McCormick's reaper or Colt's revolver came to represent a whole field of technological improvement even though many other new machines, social practices, and market demands had come together to promote such change. Behind the machine lay a unique individual. Inexpensive pocket biographies paraded inventors before their readers not only as skilled geniuses but also as heroes of the republic and men of virtue. "If we have no Alexander, or Caesar or Bonaparte or Wellington, to shine on the stormy pages of our history," stated one observer in 1866, "we have such names as Franklin, Whitney, Morse and a host of others, to shed a more beneficent lustre on the story of our rise."

"If we have no Alexander, or Caesar or Bonaparte or Wellington, to shine on the stormy pages of our history, we have such names as Franklin, Whitney, Morse and a host of others, to shed a more beneficent lustre on the story of our rise."

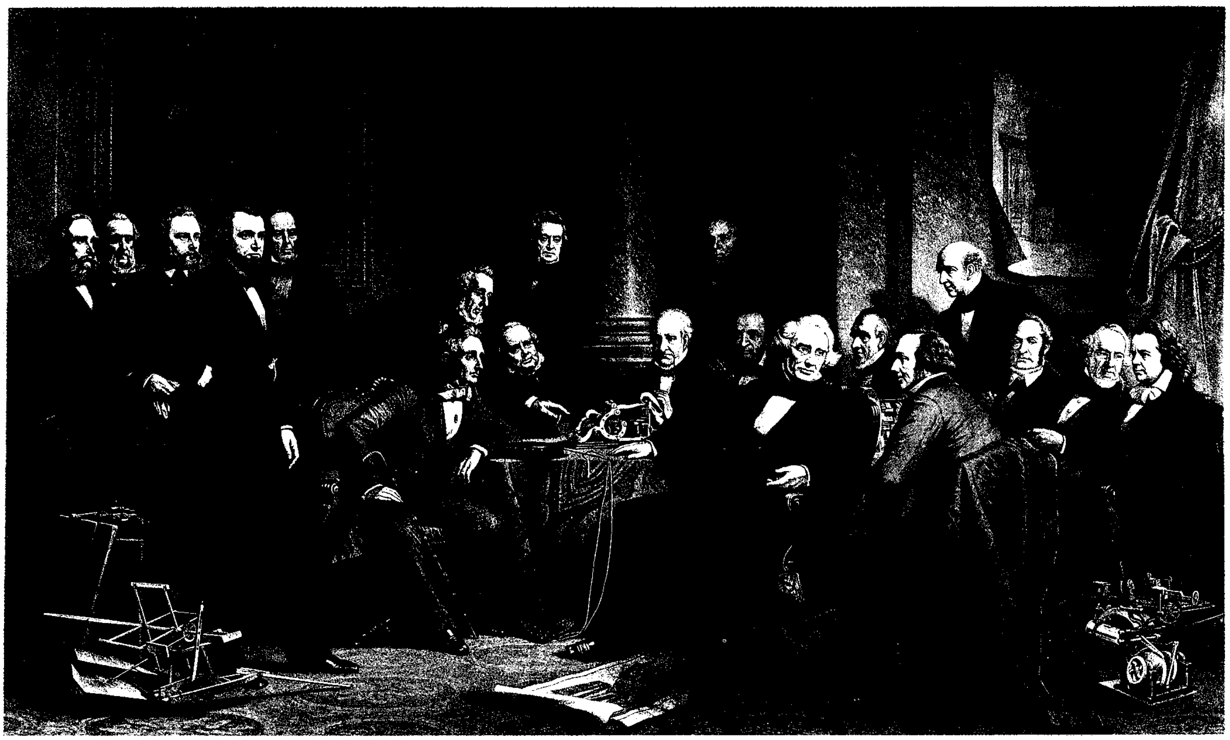
In Christian Schussele's "Men of Progress," painted in 1861, Peter Cooper at last found himself in such company, presided over by the ever-watchful image of Ben Franklin on the wall. Even before the picture was composed, one might note, Cooper had directed that a portrait of Franklin be hung in The Great Hall, along with Lafayette and Washington, to serve as a constant moral and political example to the public and especially to the youthful students.

Cooper certainly hoped that the education offered by his "Union" would be cast within this democratic and very practical mold. The public would show up for lectures and demonstrations and take in new information through direct sense impressions, rather than developing systematic knowledge on which they could be examined. On the third floor a museum, including dioramas and models, would show how mechanical objects and natural creation actually worked. Space would also be set aside for various craft and trade associations so that new processes and techniques might be more widely distributed. And, most importantly, the Free Reading Room would contain all of the trade and scientific journals as well as copies of patent drawings. Cooper Union was indeed a large and imposing structure for its time, for it was required to house almost every form of popular knowledge and educational scheme in existence.

The opening of Cooper Union in 1859, according to Peter's original plan, may be seen, then, as the culmination of a first phase in America's industrial and technological revolution. Democratic and practical, the "internal improvement" of the country was supposed to flow from the republican political conditions that would liberate the common man's inventiveness. Cooper Union was to be an engine of material progress and an agency of civic virtue; in Cooper's mind these objectives were linked inseparably.

Yet Peter, having completed his mission with the founding of his Union, lived on. His life, one might say, slipped over into the period in which the whole business of "invention" was progressively drawn into the orbit of science. This change was quickly registered in the history of Cooper Union itself. Soon crammed with students admitted with little selection and who were never examined on what they learnt, the trustees, under Hewitt's direction, formalized admission requirements and set about developing a thorough-going technical education. As the Annual Report stated in 1868, the original ideas were indeed "practical, but of practically no effect on the class for which they were intended."

In the highly organized and industrialized nation that emerged from the Civil War, systematic knowledge would prove a broader avenue to success than "learning by doing." And the students, though appreciative of The Peter Cooper Medal, awarded after five years of night instruction, petitioned the Trustees in 1881 to award a regular baccalaureate degree instead. Fusing invention ever more firmly to science has led to tremendous improvements in material comfort and health—a process of which Peter Cooper would have approved. Yet what we have lost is Cooper's sense that technology also deserves to be framed by social need and political virtue.



Men of Progress
1862
Christian Shussele
(1824-1879)
Oil on canvas

In 1856 Jordan Lawrence Mott, the New York ironware manufacturer, commissioned Christian Shussele to do a painting portraying selected *Men of Progress*, which was to include Mott himself and eighteen of his contemporaries. The men were never actually assembled as they are shown; as was customary for such large group portraits, each sat separately for the painting, which took six years to complete.

The *Men of Progress*, though all worthies, are a peculiar convocation mainly representing the fancies of Mott, who positioned himself between Peter Cooper and Joseph Henry in the imaginary scene. Joseph Henry, inventor of the first electric motor, held no patents—he regarded them as antithetical to a spirit of free inquiry, as a corrupting form of self-indulgence to which no "true man of science" would resort.

Yet Henry is shown in apparent fellowship with Samuel Morse, who had patented and commericialized devices conceived by Henry, and whom Henry detested. Other men in the portrait were more significant as entrepreneurs than inventors, including Mott himself, a major manufacturer of anthracite stoves.

PATENTS AND MEDICINE

Stanley B. Burns, M.D.

During the nineteenth century medicine came out of its dark age. Today, it is hard for us to imagine medical practice that could not correctly diagnose most diseases and whose main therapeutic devices were bleeding and induced vomiting, diarrhea, and skin blisters, used to treat nearly all illnesses. The most common medicines were arsenic, strychnine, mercury, and opium compounds. Surgery was in an even worse state; when it was attempted at all, it was a heroic event resulting in excruciating pain, and if the operation was survived, death often occurred from post-operative infection. Surgery was performed as a last desperate resort, and as a necessity in trauma cases. Speed and strength of character were the surgeon's main attributes—a leg could be amputated in a couple minutes.

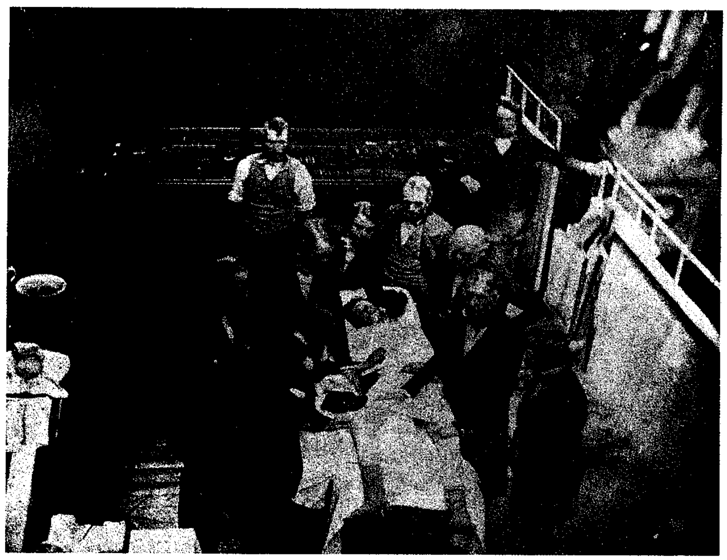
Dr. Crawford Long about to amputate a leg, 1858. Dr. Long was the first to use ether for surgery in 1842. Here we seem him operating in the style of the times—concerns for sterility were not in vogue until the 1880s. A good surgeon could amputate a leg in a couple minutes. Courtesy Stanley B. Burns, M.D., and The Burns Archive.

By the end of the century, accurate diagnosis and specific therapeutics became hallmarks of modern medicine. The discovery of anaesthesia (1846), antiseptic and asepsis technique (1867), bacteriology and the germ theory of disease (1882), and the X-ray (1895) propelled medicine into the twentieth century. Surgery became the symbol of medical achievement, as internal cavities (head, chest, abdomen) were invaded miraculously by skillful knives. The abdomen became the playground of the surgeon, and millions of lives were saved from diseases and tumors that were once thought impossible to treat. In 1894 the world saw its first specific therapeutic agent—diptheria antitoxin. Soon scores more joined the list.

In the tradition of European physicians, applying for patents for medical inventions was frowned upon; it was expected that knowledge about life and its preservation would be freely shared. The entrepreneurial spirit of the industrial revolution soon permeated medical practice, however, and physicians and others with good ideas obtained patents for products for the emerging field of scientifically based medicine.

The discovery of general anaesthesia was America's greatest gift to medicine and perhaps one of the greatest discoveries of all time. It freed man from his fear of pain, and, with its concept of a peaceful sleep, helped change his view of death. It allowed surgery to advance, although post-operative infection still killed many patients. Anaesthesia was not patented. Dentist William Morton, who successfully demonstrated its potential at Massachusetts General Hospital on October 16, 1846, tried to secure a patent, but his attempt met with failure because others involved in the discovery raised a great furor. In the long fight for recognition for the discovery of anaesthesia, three of the claimants ultimately went insane. The now acknowledged discoverer, dentist Horace Wells, committed suicide in jail. Morton died at 49 in Central Park, and Charles Jackson died in McLean Asylum, Summerville, New Jersey. Wells, however, did not plan to patent his discovery. Dr Crawford Long of Georgia is now recognized as the first to have used anaesthesia—as early as 1842. The village physician, however, did not report its use until well after Morton's demonstration.

Medical men where generalists throughout most of the nineteenth century. Many helped advance other fields: dentist Alexander S. Wolcott received on May 8, 1840 the first U.S. patent for photography, for his development of a camera that takes a picture with a concave mirror instead of a lens. This patent model is still on display at the Smithsonian Institution. The New York physician John W. Draper teamed with telegraph inventor Samuel Morse to take some of the United States' first daguerreotypes and to develop the daguerreian photograph as a scientific tool.

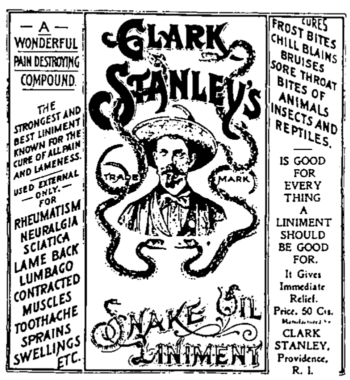


Operation under ether, Massachusetts General Hospital, 1846. Josaiah Hawes, photographer. Harvard's chief surgeon, John Collins Warren, is about to operate. Courtesy Stanley B. Burns, M.D., and The Burns Archive.

One of the biggest stimuli for invention always has been war. The Civil War, America's bloodiest conflict with 625,000 dead and almost 200,000 amputees, stimulated the field of prosthesis development and other medical patented achievements. The magnitude of the problem is indicated by the fact that almost half of the state budget of Mississippi in 1866 went to pay for prosthesis.

After the war the rise of scientific, laboratory based diagnostic and treatment centers encouraged the outpouring of thousands of medical inventions and patents. The emergence of sub-specialties, such as opthamology, otolaryngology, and urology, required new tools to peer inside the body and to treat specific diagnostic entities.

Because of the very real fear of death with surgical intervention of any sort in pre-antiseptic days, a host of devices was invented and patented to alleviate pain and suffering, and, most importantly, to avoid surgery. Trusses for hernias, pessaries for uterine prolapse, devices for fistulas, and numerous other contraptions were marketed. Today, hernia repair is one of the most commonly performed operations, with few complications. Throughout most of the nineteenth century, however, hernia repair in males usually resulted in castration, as the hernia sac often contained the testes.



The most familiar of all medical associations with the word "patent" is "patent medicine." This is a misnomer, for while the words sound impressive, the medicines were not only not patented, but they were the exact opposite of patents: they were secret remedies. A patent spells out for all concerned the exact details of the device or substance patented, and explains that it is new and useful. The term "patent medicine" originated in England. For centuries the king granted "patents of royal favor" to various trade peoples, who supplied the king's products. Amongst them was the medicine maker. Thus to have a "patent medicine" meant a medicine fit for a king's use. Our early English colonists esteemed the medicines which bore the token of royal favor, and used the term "patent medicine" for the various remedies they made.

Patent medicines were made-up concoctions—usually alcohol or opium with any number of strange, exotic, or even plain ingredients. Some were just folk or Indian remedies, but most were purposely prepared addictive elixirs. Until the end of the nineteenth century, they were better in many cases than physicians' nostrums. The sad story of patent medicine is that because of the lack of any government regulation as to the claims to a drug's effectiveness or its contents, thousands of people took patent medication instead of seeking adequate medical care, until their disease states were well advanced. Addiction to these medications became a national scandal; in fact, the number one opium addict at the end of the nineteenth century was the middle class woman "who had her daily tonic." The second largest class of addicts were the Civil War wounded and diseased veterans. The enactment of the Pure Food and Drug Act of 1906 ultimately put an end to the dangerous nostrums.

Today, medical patents continue to advance the healing art, as the modern emphasis on genetics allows the patenting of new and developed protein and life forms for the healing of man. It is now acknowledged that Man's ultimate conquest of disease will come only through genetic engineering.

PATENT NO. 37,282
T. F. Engelbrecht, R. Boeklin, and W. Staehlen, Inventors 1863
"This invention consists in certain provisions for the adjustment of the parts of an artificial limb in such a manner as may be desirable to adapt it to the length of the natural limb and conformation of the foot of the intended wearer, by which means the necessity of making a limb to suit each particular case is to a great extent obviated, and in consequence the cost of manufacture is considerably reduced."
Cliff Petersen Collection
Photography, Joanne Savio

The Civil War
was America's bloodiest conflict,
with 625,000 *dead*
and almost 200,000 *amputees.*
Nearly half the state budget
of Mississippi in 1866
went to pay for prosthesis.
A good surgeon
could amputate a leg
in a couple of minutes.

Above left and far left, patent models for artificial limbs, identification unknown. Cliff Petersen Collection Photography, Joanne Savio

Above right, *A Morning's Work* (1865), by Dr. R. B. Bontecou, Surgeon in Charge, U.S. Army General Hospital, Washington DC. Amputation during the Civil War was usually indicated because the slow, heavy bullets of the period mangled the extremities, resulting in deadly infections. Courtesy Dr. Stanley B. Burns and The Burns Archive.

A BRIEF HISTORY OF THE WASHING MACHINE

Or, DON'T AIR YOUR DIRTY LAUNDRY *in* PUBLIC

Ellen Lupton, The Cooper Union School of Art and Faculty of Humanities and Social Sciences

By 1873, *around* 2,000 *U.S. patents had been filed which dealt with the mechanization of laundry.*

Over the last two hundred years, the American home has offered the inventor's imagination a fertile terrain of unsolved problems and a lucrative market to the clever entrepreneur who might solve them. Of the domestic chores traditionally assigned to American wives, laundry was one of the most arduous. Unmechanized clothes washing involved filling tubs of water at a well and hauling them to the kitchen or backyard where they could be heated on a stove, and then soaking, pounding, rinsing, wringing, hanging, and ironing the articles by hand. The entire process demanded at least a day and half of physically exhausting and intellectually unrewarding labor. The procedure was taxing in temperate months and close to impossible in the dead of winter. The numerous domestic washing machines patented and manufactured during the nineteenth century lightened the task only minimally: these manually driven devices required constant attention and had to be filled and emptied by hand.

With the rise of industrialization beginning in the early nineteenth century, the space of the home was increasingly marked as the special sphere of women's labor; men went to work for wages in the marketplace, and women remained at home as managers of bodily health and comfort. Whereas poor women became a major part of the industrial work force, the primary activity of middle-class wives was housework. (The social category "middle class" was rapidly expanding, and one condition for membership became the non-participation of wives in wage labor.) Because housework lacks the *monetary* value explicitly attached to men's work, numerous nineteenth-century domestic guides infused household duties with *moral* and *social* value, helping make the role of women more palatable. Catharine Beecher, for example, compared housework to such exalted disciplines as science, business, and the religious ministry; her 1869 book *American Woman's Home* helped establish the servantless, single-family dwelling as the ideal architecture of middle-class America.

Yet even while Beecher treated cooking, shopping, and child-care as morally elevated tasks that should be personally administered by the housewife, she hoped for the rise of community laundry services, that would remove washing from the private home: "whoever sets neighborhood laundries on foot will do much to solve the American housekeeper's hardest problem" (334). Middle-class and working-class women were quick to delegate laundry to hired helpers—even in the early decades of the twentieth century, when domestic servants were becoming less common. Laundry, devoid of the creative potential of cooking and child care, did not occupy a cherished place in women's lives.

The woman in this 1869 ad for a washing machine looks decidedly disenchanted with her task, despite her advanced equipment.

Many domestic activities did indeed exit the household during the course of industrialization. Textile manufacture was mechanized early in the nineteenth century, and clothing production began leaving the home with the ascendence of the commercial sewing machine after 1850. The 1880s saw the rise of commericial bakeries, modern food processing factories, and nationally branded packaged goods. These developments moved procedures out of the home and placed them under the control of private businesses: the focus of domestic labor shifted from *production* to *consumption*.

The nineteenth century also witnessed the rise of a commercial laundry industry, whose business steadily grew between the 1840s and the Depression, regained strength briefly after WWII, and then plummeted—perhaps for good—in the 1950s. The early commercial laundry industry focused on the care of men's garments. Around 1830 detachable cuffs and collars were invented, which could be washed independently of the rest of the shirt—standards of hygiene did not yet suggest that the entire article should be cleaned just because its collar had gotten gray. Collar manufacturers soon provided laundry services to their customers. Commercial laundries also met the demands of various bachelor communities, such as New York merchant seaman in the 1830s and California goldminers in the 1850s. The *family* laundry market emerged after 1890, its services ranging from "wet wash," which delivered damp laundry to be dried and ironed at home, to mechanically ironed "flatwork," to "fully-finished" garments.

The annual volume of the commercial laundry industry rose from $104,000,00 *in* 1909 *to* $541,000,00 *in* 1929.

By 1949 *around* 61 *percent of the nation's* 24,500,000 *non-rural households possessed washing machines.*

The commercial laundry business proved its popularity in the U.S. in the 1920s, a period which saw the dramatic expansion of the consumer economy and the accelerating impact of technology on the domestic environment. In a time when women were learning the patterns of consumerism—such as purchasing canned soup and ready-made clothing—the idea of sending out laundry to a commercial establishment was hardly alien, and seemed, in fact, to be part of technological progress.

Yet a battle was being fought between the commercial laundry business and washing machine manufacturers, who identified the home as a lucrative mass market. Rather than sell a few large machines to central establishments, manufacturers sought to sell many smaller units to individual households. Advertising and door-to-door salesmanship tried to persuade households to invest in washing machines. Migrations to the suburbs also encouraged washing machine purchase, by increasing dependence on the automobile (another private domestic appliance) and discouring centralization.

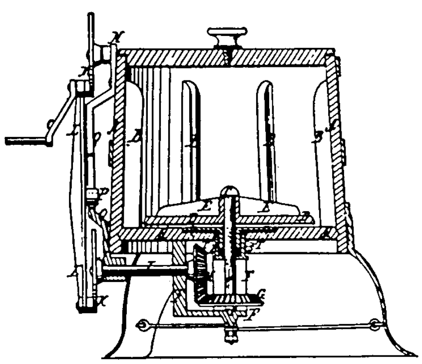
"The advent of individually-owned electric washing machines... has slowed up the trend of laundry work—following baking, canning, sewing and other items of household activity—out of the home to large-scale commercial agencies... the installation of costly electrical machine units used only one day a week in hundreds of Middletown homes, represents not 'progress' but a back-eddy in home-making technique."
HELEN AND ROBERT LYND, *Middletown*, 1925

Looking back at history, one is tempted to view contemporary products and customs as the happy ending, the necessary resolution, of the narrative "story" of "progress." If one glances backward at American laundry, howeveer, in relation to other regions of the industrialized home, one sees not a uniform march towards the customs of the present day but a wandering path whose destination was, for a time, uncertain.

By 1929 *there were fifteen patents for powered machines fitted with a rotary agitator.* 76 *percent of the washing machines listed in the* 1930 *Electrical Merchandising Index employ the agitation principle.*

Nineteenth-century domestic washing machines can be grouped into two basic classes: those which imitate the principal of the traditional wash board by rubbing the soiled garments against an abrasive surface, and those which circulate hot, sudsy water *through* the fabric. Designs of both type existed side by side until the early twentieth century, when circulation-based machines became the standard.

In 1859-60 Hamilton E. Smith of Pittsburgh patented a commercial washing machine consisting of a perforated inner cylinder suspended inside a water-tight outer cylinder, both constructed from wood. When the inner cylinder is rotated, soapy water circulates through the clothing. In 1863 Smith improved his invention with a pulley device which automatically reverses the direction of the cylinder, and thus prevents the articles from clinging to the sides of the tub, keeping them in constant agitation. Most commercial washers in use after the Civil War were indebted to Smith's device. Smith patented another washing machine in 1869 (see PATENT NO. 88,816 on the following page), which also reverses the motion of the tub, but in a more dramatic fashion.



According to Siegfried Giedion, a domestic washing machine was patented in 1869 (PATENT NO. 94,005) that functions just like a modern home washing machine, although the design went more or less unnoticed at the time. It consists of a cylindrical tub with a four-blade agitator driven by a shaft passing through the bottom of the tub, turned by a hand crank. The motion of the gyrator circulates soapy water through the garments. Motorized washing machines based on this principle became the norm in the twentieth century. More common nineteenth-century designs beat the fabric with a "dasher," "dolly," or "beetle," while others tumble the garments in water or use pressure to squeeze water in and out of the fabric.

Most nineteenth-century washing machine designs pay little attention to visual appearance; many resemble ordinary wash tubs with mechanical appendages, while others are rectangular troughs which look more at home in the barnyard than the household. In the 1920s and 30s manufacturers hired professional designers to improve the marketing appeal of home washing machines; one successful design strategy was to conceal the mechanical elements inside a smooth shell, making the machine more at home in the modern kitchen. In the 40s and 50s, the dominant form became a cylindrical tub enclosed inside a legless rectangular box, visually related to the modern stove and refrigerator. This style remains the norm today.

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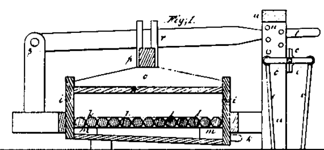
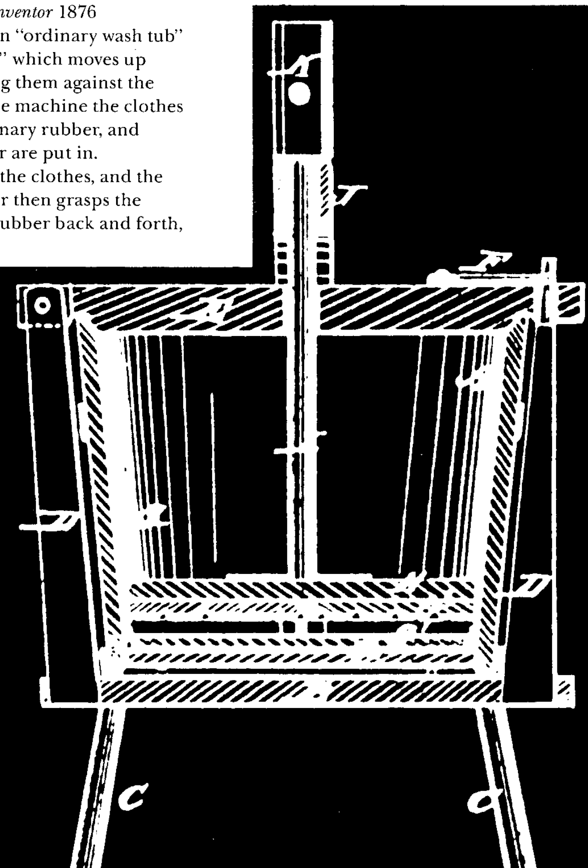
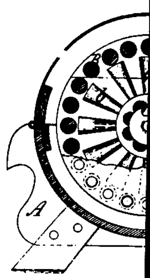


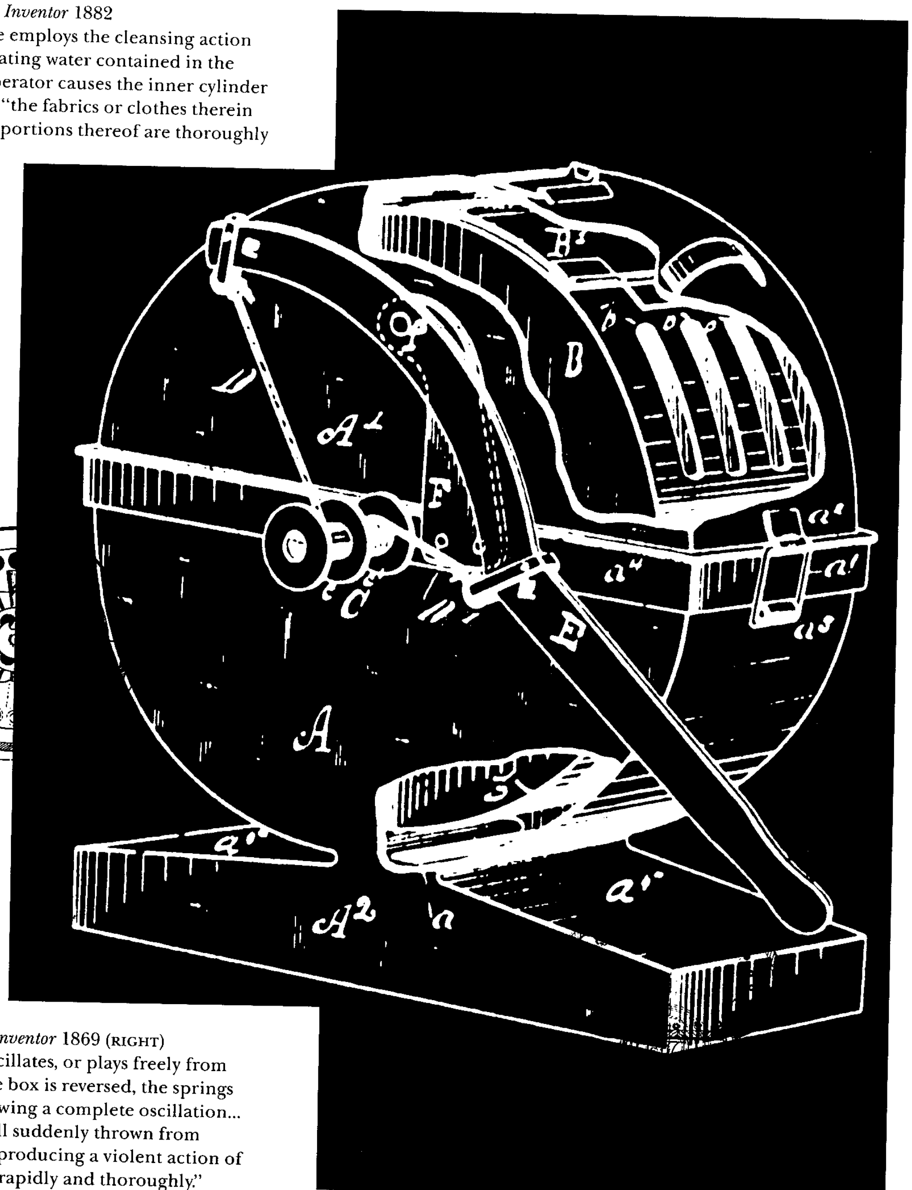
PATENT NO. 177,687 *William Bymaster, Inventor* 1876
This washing machine type involves an "ordinary wash tub" to which has been attached a "rubber," which moves up and down against the clothes, grinding them against the ridged bottom of the tub. "In using the machine the clothes to be washed are placed upon a stationary rubber, and a sufficient quantity of soap and water are put in. The movable rubber is lowered upon the clothes, and the cover is secured in place. The operator then grasps the cross-bar in his hands, and turns the rubber back and forth, which washes the clothes very quickly and thoroughly." This design uses a principal similar to the "clothes pounder," a commonly available object consisting of a sometimes elaborately modelled surface with a long handle, which could be used with any wash tub. Here, the pounder is a broadened disc which has been integrated into the structure of the tub, passing through its cover.



PATENT NO. 15,711 *John B. Kinney, Inventor* 1856
This type of washing machine forces the clothing back and forth along slats on the bottom of the tub. The uniqueness of this particular design is to attach a traditional washboard to the lever which pushes around the clothes, allowing the operator to clean selected items by hand: "By my machine the clothes are beaten moderately to remove the dirt, and then the beater is drawn back... The operator then, by hand, washes out the dirtiest parts... [saving] the clothes from much useless rubbing." The design testifies to the hardship inflicted on fabric by friction machines.

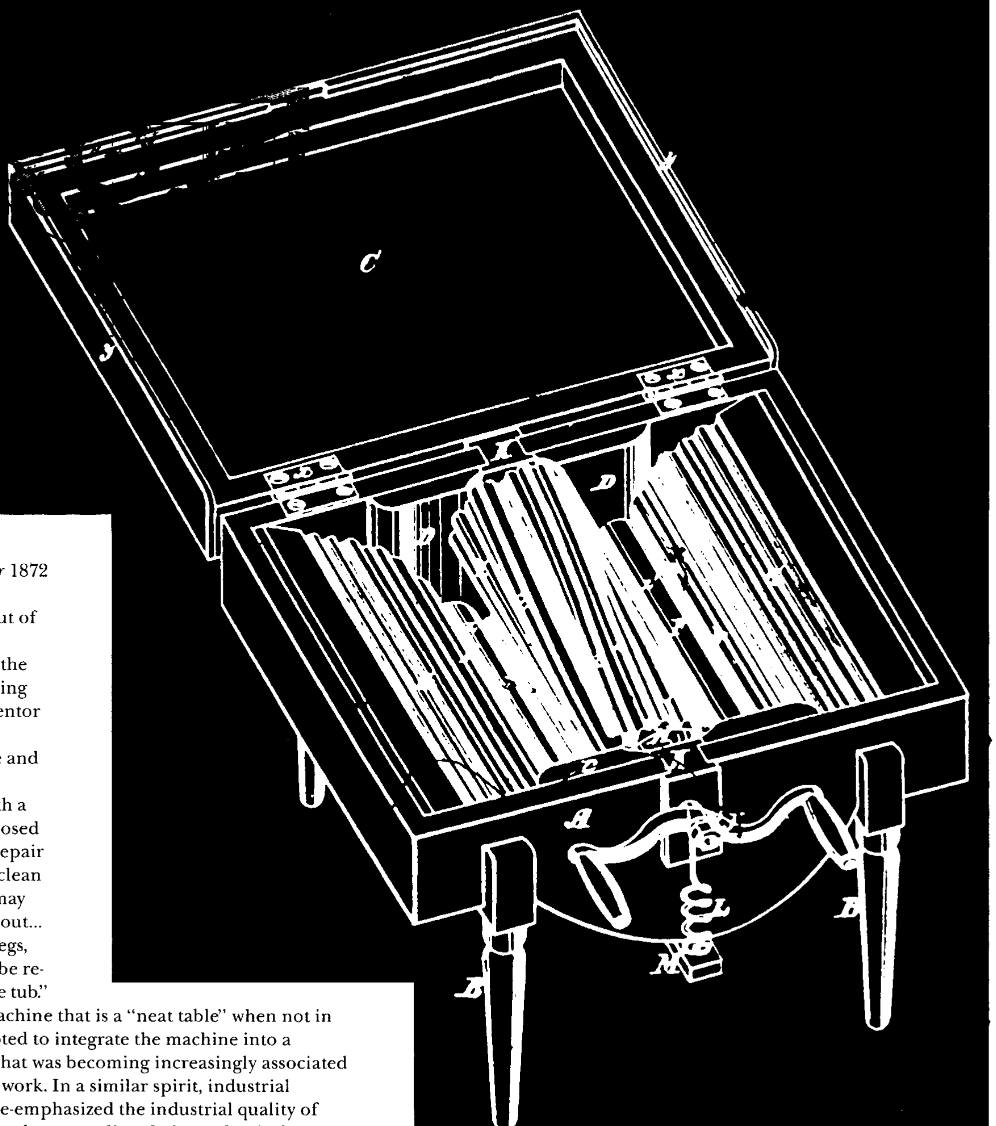
Patent No. 258,409 *George W. Glick, Inventor* 1882
This commercial washing machine employs the cleansing action of steam, which is generated by heating water contained in the base. By moving the lever E, the operator causes the inner cylinder to rotate in alternating directions: "the fabrics or clothes therein are rolled and tumbled, so that all portions thereof are thoroughly subjected to the action of the steam." The ability to reverse the direction of agitation is central to modern washing machines—without this feature, the clothing would wind around the central agitator or cling to the sides of the tub.





Patent No. 117,353
Decatur West, Inventor 1871
In this domestic machine, the turning central axle forces the clothes against a set of rollers, whose downward motion keeps the fabric from winding around the axle.

Patent No. 88,816 *Hamilton E. Smith, Inventor* 1869 (right)
The tub of this industrial washer "oscillates, or plays freely from side to side... When the motion of the box is reversed, the springs contract and expand alternately, allowing a complete oscillation... causing the water and clothes to be all suddenly thrown from one end to the other of the box, and producing a violent action of the water, which cleanses the clothes rapidly and thoroughly."



Patent No. 130,202
Thomas W. Edgar, Inventor 1872
This washing machine squeezes water in and out of the fabric by passing it through a set of rollers; the same rollers also can wring the clothes dry. The inventor has paid remarkable attention to appearance and ease of maintenance:
"The tub is furnished with a hinged top, and when closed forms a neat table... To repair a part or to thoroughly clean the whole the cylinder may be released... and taken out... For transportation the legs, crank, and springs may be removed and packed in the tub."
By making a washing machine that is a "neat table" when not in use, the inventor attempted to integrate the machine into a domestic environment that was becoming increasingly associated with leisure rather than work. In a similar spirit, industrial designers in the 1930s de-emphasized the industrial quality of electric washing machines by concealing their mechanical elements inside a smooth shell.

DON'T SLEEP ON YOUR RIGHTS

EGBERT *vs.* LIPPMAN, A CASE STUDY *in* PATENT LAW

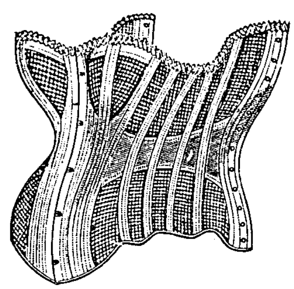
Tori Egherman, The Cooper Union School of Art

Like Mr. Moliere in *Candide*, who spoke prose without knowing, many make innovations without knowing. Just as innovations continue unceasingly, so continues the entanglement of the Patent System. Independent inventors have often found the system discouraging, and of those who have entered its maze, many have given up years of their lives and much of their savings to the Courts. Lee de Forrest, the inventor of the vacuum tube, often found himself near bankruptcy while defending his patents. Edwin H. Armstrong, the inventor of FM, discouraged after five years of litigation in an infringement case against RCA, committed suicide in 1954.

Bringing with them old notebooks, letters, drawings and witnesses, many inventors have found themselves before the Courts seeking to prove that they were the first to make a discovery. The irony of the patent system is that instead of "promoting Science and the Useful Arts," it so often inhibits them. The law insists that if application for a patent is not made immediately after an invention is formalized, then there is an intention to conceal rather than to reveal information. This often punishes not only the public, who might benefit from the invention, but the independent inventor as well.

In the 1881 Supreme Court case *Egbert v. Lippman*, the Court was confronted with the issue of private versus public use. Mr. Justice Woods, writing for the Court, explained,

One well-defined case of public use is enough to annul a patent.



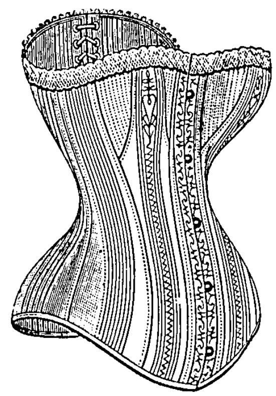
"We observe... that to constitute the public use of a patent it is not necessary that more than one of the patented articles should be publicly used. The use of a great number may tend to strengthen the proof of public use, but one well-defined case of public use is just as effectual to annul the patent as many."

In an earlier case, *Elizabeth v. Pavement Company*, the Court ruled that although Mr. Nicholson had tested his new pavement in public, the pavement was never meant to become public domain. Its public use was deemed necessary as an experiment, and thus the patent was approved. Mr. Justice Woods wrote,

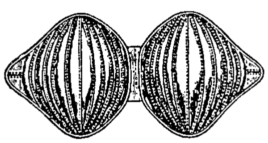
"...a use necessarily open to public view, if made in good faith solely to test the qualities of the invention, and for the purpose of experiment, is not a public use within the meaning of the law."

When the patent for the Barnes corset steels came up for renewal in 1881, many corset manufacturers testified that even before Barnes' original patent application in 1866, a similar principle was already in use. The Court stated:

"It is fair to presume that having learned from this general use that there was some value in his invention, Barnes attempted to resume, by an application for a patent, what by his acts he had clearly dedicated to the public."



Barnes' wife related the following story to the Court: *While visiting a woman friend, Mr. Barnes overheard her discussing the problem of weak corset steels with another woman. Sure that he could make steels that would be more durable, he promised to bring new ones. At their next meeting, he presented the young woman with a new set of steels. When those wore out three years later, Mr. Barnes presented his friend with a new set. Eventually he married the beneficiary of his invention and kept her in corset steels for the next eleven years before applying for a patent.*



Exploring the notion of public and private use, the Court noted that Barnes never explicitly had asked his wife to conceal the corset steels:

"She might have exhibited them to any person she pleased, or might have made other steels of the same kind, and used or sold them without any violation of any condition or restriction imposed on her by the inventor."

Mrs. Barnes could have walked down public streets exposing her corset steels to any stranger! and Mr. Barnes, by his lack of admonition, tacitly supported this. The Court denied the renewal, stating: *"According to the testimony of the complainant, the invention was completed and put in use in 1855. The inventor slept on his rights for eleven years. The patent was not applied for till March 1866."*

In his dissent, Mr. Justice Miller wrote:

"The opinion argues that the use was public because with the consent of the inventor to its use, no limitation was imposed in regard to its use in public. It may be well imagined that a prohibition to the party so permitted against exposing her use of the steel spring to public observation, would have been supposed to be a piece of irony. An objection quite the opposite of this... is, that the invention was incapable of public use..."

Mr. Justice Miller has a good point. The Court, it seems, got carried away by the irresistibility of insisting that Mr. Barnes had *"slept on his rights"*—the legal term for relinqishing one's rights by waiting too long to apply for a patent—and neglected more substantial issues. Because the Court determined that Barnes had never tried to conceal his invention—although, as Justice Miller points out, the very nature of the invention implies concealment—the inventor forfeited his rights to the ownership of the patent. The decision, though humorous, raises a question about the patent system: Does it always promote the spread of invention? Or, does it prohibit others from benefitting from invention?

THE FUTURE OF SUPERCONDUCTIVITY

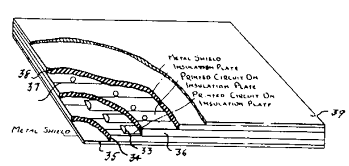
Michael Ebert
Albert Nerken School of Engineering, The Cooper Union

An idea ceases to be a secret when it is patented and thus goes public. The literal meaning of the word "patent" is "open letter," but putting the public on notice of an idea by no means signifies that its time has come.

The discovery of so-called "high-temperature" superconductors is regarded by many as the greatest technological advance since the transistor. The public has been bombarded with futuristic projections on superconductivity, whose launching pad is the 1986 Nobel Prize-winning discovery by Bednorz and Muller, two Swiss scientists working in Zurich for IBM. They found that the phenomenon of *zero electrical resistance* is attainable in certain exotic ceramics when cooled to about 40 degrees Kelvin above absolute zero. Not long after, Chu and Wu, researchers at the University of Houston, made a ceramic superconductor that works at 95 degrees Kelvin. This dramatic step forward ignited the scientific community, for now liquid nitrogen could serve as the cryogenic agent. Since liquid nitrogen is no more expensive than milk (at New York City prices), Chu and Wu's discovery appeared to open the door to practical applications that were unfeasible with the more intensely cold and costly liquid helium.

Whether substances ever will be found which superconduct at close to *room temperature* appears to lie in the lap of the Gods, yet the real payoff in superconductivity may have to await this breakthrough. The fact that the Japanese Patent Office is flooded with thousands of applications relating to superconductivity, and the U.S. Commissioner of Patents has set up a special superconductivity section, is no assurance that any one of those seeking patent protection has come up with a room-temperature superconductor. The much touted rivalry between Japanese and U.S. industrial giants to gain dominance over this promising new field does not mean that either side will prevail, for at the present state of the art, commercial applications are not earthshaking.

In 1962 I obtained, on behalf of IBM, a patent (No. 3,043,512) on a superconductive computer conceived by two young Duke University physics professors. The brain of this computer is composed of microscopic superconductive memory cells packed on a common substrate (if a computer can't remember, it can't think). The inventors and I then thought their scheme would revolutionize computer technology, but we failed to consider the inconveniences imposed by needing to maintain the computer's logic at the temperature of liquid helium.



Patent No. 3,043,512
M. J. Buckingham et. al., inventors 1962
Superconductive persistatrons and computer systems formed thereby

Now, more than a quarter-century later, after IBM had apparently abandoned ship on superconductivity, I find that two of its researchers in Zurich were working in this field, but under wraps and without official authorization. Their discovery overcame a barrier that for generations appeared unsurmountable.

A fair number of significant inventions were conceived ahead of their time. The familiar maxim "Nothing is so powerful as an idea whose time has come" offers scant comfort to the idea's creator, who may not be around when its time has come. For every inventor who lives to enjoy a handsome royalty under a patent, there are many others less fortunate. Some gifted inventors never reap a just reward for their contributions, for by the time the market recognizes the merit of the invention, their patent has already run out.

In the late 50s I patented for the Bulova Watch Company the very first electronic watch—the Accutron. In this extraordinary watch, a single transistor (then recently invented) controls the magnetically-induced vibrations of a tiny tuning fork. Impulses taken from the tuning fork drive gear works turning the watch hands. The Accutron created a sensation, for it was far more precise than the very finest spring-powered watch. However, the accuracy of an Accutron depends on a miniature battery whose voltage must remain constant for at least a year while its energy is being continuously drained—a most difficult requirement. No such power cell existed when Max Hetzel of Switzerland conceived the Accutron, but luckily for Hetzel, such a battery was later invented (not at Bulova), and the Accutron became a commercial reality.

The history of invention is a chronicle of surprises, and some pioneering discoveries remain just that, without any follow-through innovations to render them commercially viable. The feasibility of a pioneering invention may depend on a follow-through innovation not yet in place, and there is no guarantee that it will ever surface.

While I knew at the time that it was within the realm of technical possibility to create an even *more* precise timepiece by using a quartz crystal as the time base, the electronic circuits that had to be linked to this highly stable oscillator entailed dozens of transistors. There was no way to crowd these transistors into a watch case. What I could not then anticipate was the much later follow-through invention of the integrated circuit, which incorporates a multitude of transistors into a tiny chip. The integrated circuit rendered the Accutron obsolete and laid the foundation for the quartz watch, that now dominates the market and has shifted the centers of watch-making from Switzerland and the U.S. to Japan and Hong Kong.

It was the integrated circuit, not the original transistor, that ushered in an industrial revolution predicated on microcomputers—hand-held and desk top calculators, the word processor, and an endless series of computer-controlled systems and mechanisms. But at the time the transistor was invented, who could have predicted the invention of the integrated circuit? When I was embroiled on behalf of N. V. Philips, the Dutch-based electronics giant, on an interference in the U.S. Patent Office with Bell Laboratories to determine who was entitled to a U.S. patent on the first transistor, none of us appreciated the future value of this solid state device.

A climate conducive to pioneering in technology generally pervades a free enterprise system, but it is not usually found within highly structured government or corporate research facilities. These do not tolerate defiance of authority, disrespect for conventional wisdom, and free-wheeling behavior—the playful and at times chaotic spirit the real innovator. Thus while tightly organized R & D labs often yield refinements and important incremental advances, and thereby justify the heavy cost of running them, many if not most of the significant inventions of the last fifty years have originated with independent inventor-entrepreneurs.

The question before us, now that it has been proven possible to operate a superconductor at the temperature of liquid nitrogen, is whether we have reached an impassable dead end. By way of example, let's consider the impact of Thomas Alva Edison's contribution to the electric light bulb, and the problem he faced in conceiving his invention. When a voltage from a power station is supplied to a transmission line leading to a light bulb, say, a mile away from the station, the voltage may never get there because of the resistance of the line and the resultant voltage drop.

Thomas Edison, strictly speaking, did not invent the light bulb. His patent on a practical incandescent bulb is based on a seemingly trivial change in the filament: all he did was reduce its diameter.

Let us now turn the clock back to Edison in 1878, when he was only thirty-one. Twenty years before, Joseph Swan in England had devised an incandescent bulb with a carbon filament. But Swan's lamp, which operated on a low voltage and drew a high current, could not be powered over a long transmission line. By changing the filament, Edison created a high-voltage, low-current bulb: power could be conveyed to this bulb over a transmission line with only a small voltage loss—as long as the line was not too long. Edison's first Pearl Street Station in lower Manhattan signalled in 1882 the start of the electric utility industry. The station generated 100 volts direct-current, which it supplied to roughly 200 customers, all located within a mile from the station. Because of voltage losses on the line, he could not service customers beyond this range.

Yet Edison's basic invention inspired a major breakthrough by his young assistant, the brilliant and neurotic Nicola Tesla, who began his inventing career in Hungary. Edison taught Tesla the advantages to be gained by operating at high voltage. Tesla, however, recognized that with DC, the voltage level was limited to what the operator could produce, whereas if one generated 100 volts alternating current (AC) at the power station, it was then feasible by means of a Tesla-invented transformer to step up this voltage and transmit it over a line and thereby sharply reduce the voltage drop. At the customer's site, the line voltage would be stepped down by another transformer to a level appropriate to light bulbs. This made it possible to supply power over much longer distances.

What, you may now ask, has the Edison-Tesla saga got to do with superconductivity? The answer is simple: these great inventors struggled to minimize voltage losses in conductors, while the superconductor promises zero resistance. In the age of superconductivity, it will be no longer necessary to manipulate voltages as Edison and Tesla did to minimize voltage losses, or to worry about the hazards of high voltages. However, this new dawn of superconductivity is not quite on the horizon, for zero-resistance superconductive wires operating at ambient temperature and capable of replacing conventional lossy transmission lines have yet to be consummated. They do not and may never exist.

"Whenever a fellow gets bad lost, the way home is just the way he didn't think it is." Davy Crockett

Thus we have reached a familiar impasse, for though we now know of certain materials that superconduct at cold temperatures well above that of liquid helium—and this discovery may enable levitating trains and other important practical applications—something vital is still missing: the follow-through advance like Tesla's giant step forward beyond Edison. Can we expect the follow-through advance of an ambient temperature superconductor inevitably to appear just because thousands of engineers and scientists are deeply engrossed in this problem and are spurred on by the promise of fabulous rewards? Or does the history of invention tell sus that this discovery awaits the second coming of an inventive genius, and, like Godot, he may never show up?

FROM BETTER MOUSE TRAPS TO BETTER MICE

Jean Le Mée, Albert Nerken School of Engineering
The Cooper Union

How much has the patent system really contributed to the "progress of science and of the useful arts?" Science seems to have done fine without it. Scientific discoveries as such are not patentable in the first place. Through a system of grants and prizes from private and governmental foundations, science has done rather splendidly. As for the useful arts, from the engineering of mousetraps to the engineering of mice, the record would appear rather mixed. There have been vociferous arguments for and against the patent system. In the end, it has been generally accepted "since nothing else seemed to be found to replace it," as one governmental commission put it. Meanwhile, it has spread virtually all over the world.

The intent of patents is to benefit society while encouraging and protecting the inventor. But if one could total up the benefits received by society that it would not have received otherwise and the profits and encouragements received by inventors, and if one could compare them to the losses incurred by various negative practices, together with the despair to which many an inventor has been driven through ruinous law suits, the patent system might appear as an enormous and unwieldy machine whose ultimate beneficiaries are neither science, the useful arts, the inventors, nor society, but patent agents, attorneys, and functionaries, who eventually collect their fees or paychecks.

Since the 1982 reorganization of the Federal Court System that deals with patents, the attitude of the courts has swung from considering patents as "marginally enforceable claims" to "immensely valuable assets," while the notion of "intellectual property" has been expanded to "include life forms, mathematical formulations, and even financial tactics" (E. L. Andrews, *New York Times*, May 13, 1990). The "proprietary community"—i.e., patent experts and companies heavily involved in research—is very much in favor of the shift, but some worry that "society is not well served when protection becomes ubiquitous and pervasive" (U.S. Rep. Kastenmeir). No doubt, in time, this attitude will change, as it always has in the past, with the rhythm of the economy.

Meanwhile, damaging precedents may be set. The matter of intellectual property rights is reckoned to become a major and volatile issue of international trade during the 1990's. Research firms in industrialized nations are anxious to obtain returns on their investments, while developing countries fear to be kept out of profitable ventures and to be recolonized by technobusinesses.

In the scramble to stake out claim upon claim on more and more areas of the "intellectual commons," few are willing to pause and ask fundamental questions. A chilling thought occurs. Around 1760, at the onset of the first Industrial Revolution, after the British Parliament passed the Enclosure Acts, enclosing the commons for the benefits of local squires, masses of vagabonds suddenly appeared on the roads as if by magic. When the frontier closed in the American West, with the land all staked out by land and railroad companies, a whole new proletariat appeared at the gates of the new factories. When the "commons of knowledge" is staked out as soon as it emerges, who will be the new vagabonds of the mind? Where will they dwell and how will they live? The fundamental question is, therefore: "How do we optimize creativity in a global information commons without covering it with a net of intellectual barbed wire?"

"Knowledge is becoming what physical labor, land, minerals, and energy used to be: the primary source of power for each person, each organization, each society... information cannot be 'owned' (only its assembly and delivery service can). Knowledge isn't exchanged in a market but shared in a kind of commons... the mark of a commons is that it cannot be readily divided or appropriated and that it requires an unusual degree of cooperation to be explored or used at all."
HARLAND CLEVELAND
Change (May/June 1989)

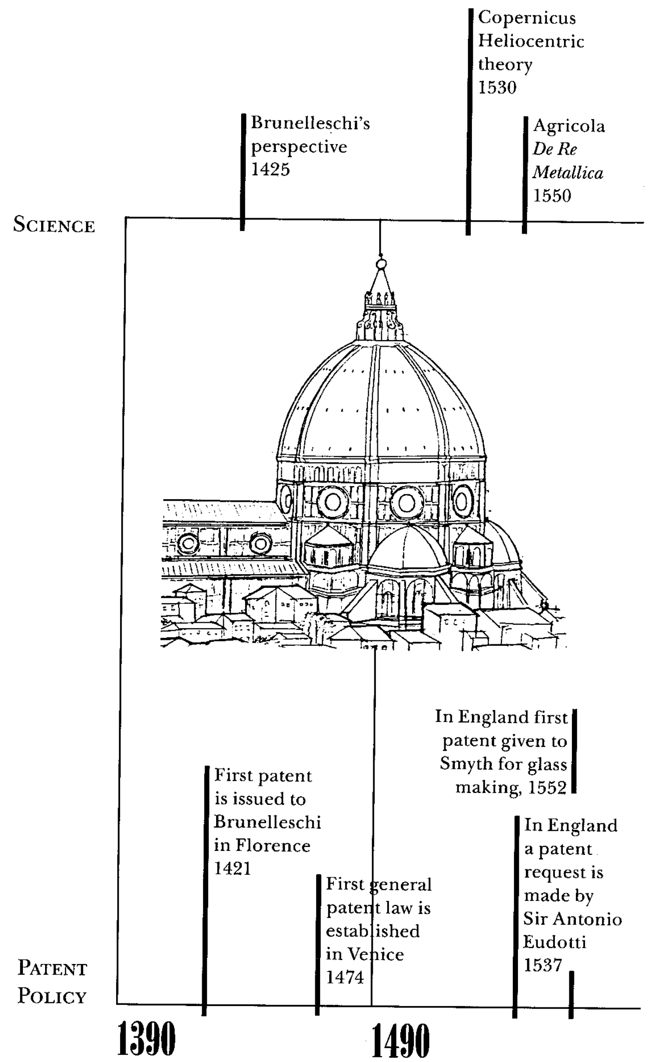
"You could arrive at the point where every idea, every concept, every minor device is somebody's property. The transaction costs of conducting business and even of just living life would be prohibitive."
ROBERT P. MERGES
Professor of Patent Law
Boston University

EARLY PATENT POLICY, 1390-1790

What is a patent? Essentially, it is a legal device to spoil someone else's pleasure! It gives its owner the right, for a period of time, to block others from developing or commercially exploiting what the owner claims (s)he can do.

Filippo Brunelleschi obtained a patent from the Florence City Council in 1421 for a hoist mounted on a barge to lift large marble slabs. With his patent he was granted, for three years, permission to fine his imitators 100 ducats and burn their imitations. How is that for spoiling their fun?

Similar monopolies were granted to guilds, craftsmen, and merchants by princes and principalities throughout the Middle Ages, but it is with Brunelleschi that the system takes on its modern guise. Soon after, in 1474, the Senate of the "Serenissima" Republic of Venice issued a statute whose spirit still informs modern patent statutes. France, England, and the U.S. each contributed to the development of patent policy at the beginning of the Industrial Revolution.



Newton's
Mechanics
1687

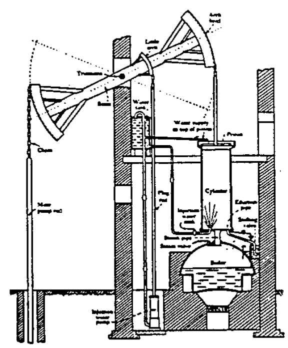
Galileo's
telescope
1610

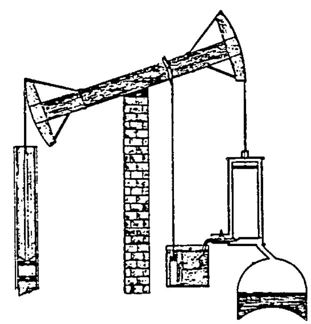
Descartes
Analytic
geometry
1640

Newton's
Optics
1704

Bernouilli's
Hydrodynamics
1738

Lavoisier and Priestly
found modern chemistry
1772





In England
Statute of Monopolies
is put in place,
the Magna Carta of
inventors' rights, 1623

First American patent is
granted to Samuel Wilson
by General Court of
Massachusetts for salt
manufacture, 1623

Newcomen
engine
1712

Beginning of intense
Enclosure Acts in
England.
Beginning of Industrial
Revolution.
1760

James
Watts's
engine
1775

U.S.
Constitution
Article 1,
Section 8:
To promote
the progress
of science
and
useful arts
1787

1590 **1690** **1790**

To reward inventors
"by privelege leading to monopoly
positions cannot be regarded
as beneficial to the welfare
of the country."
JOHANN HEINRICH VON JUSTI
Germany 1758

"The temporary monopoly
granted to the inventor of a
new machine could be justified
as a means of rewarding
risk and expense."
ADAM SMITH
Scotland 1776

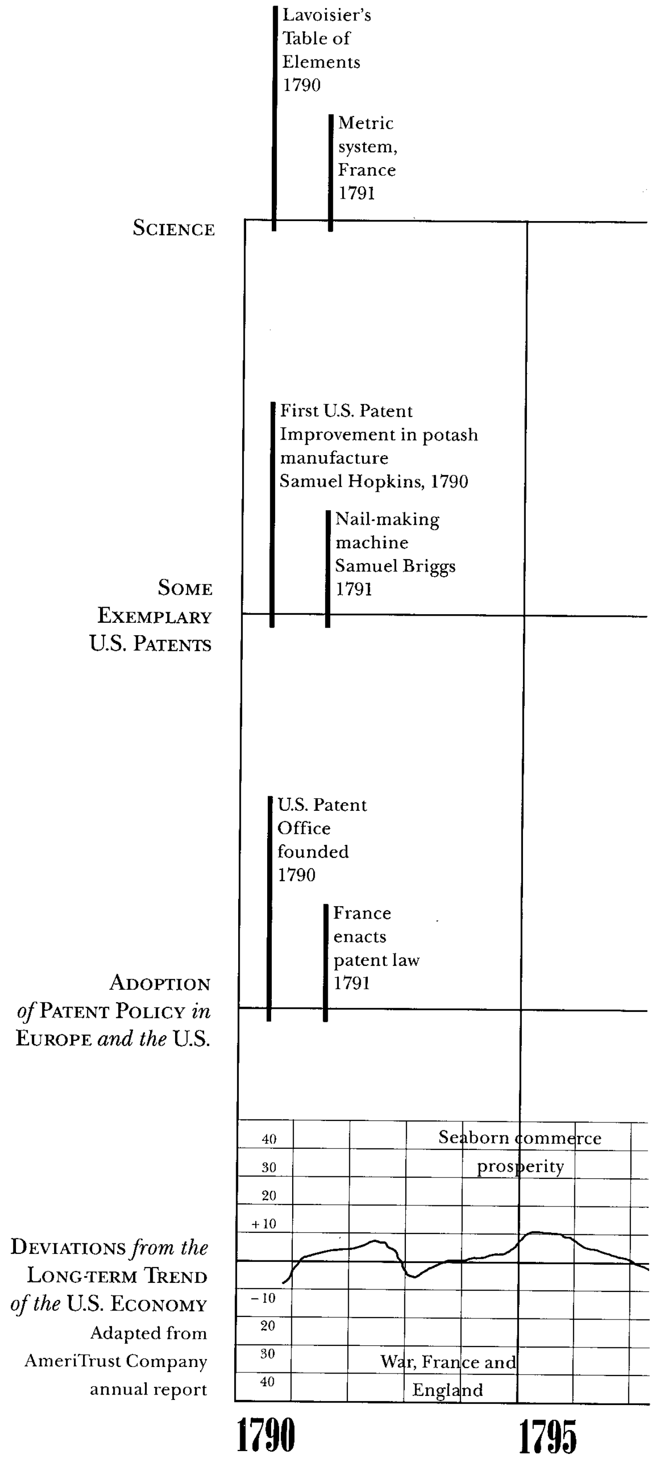
U.S. PATENTS IN CONTEXT, 1790-1990

It has often been said that necessity is the mother of invention; some have turned the phrase around and called *invention* the mother of *necessity*. Perhaps it is more appropriate to say that science and the economy are the parents of invention, and that invention, in turn, primes the economy and stimulates science. As we move toward the contemporary period, invention becomes more scientific and science more inventive, while both become big businesses with tremendous effects not only on the economies of nations, but, consequently, on their policies, politics, and ideologies. The patent system is bound, contained, and informed by the dual track of the economy and scientific ideas.

As a legal system designed to "protect" the incubation and commercial exploitation of inventions for limited periods, the patent system has had detractors as well as supporters. Being monopolistic and protectionist in nature, the patent system has given rise to abuses when left unchecked. During the first hundred years, periods of economic expansion saw a general tendency—reflected in the number of articles, pamphlets, and speeches—to want to diminish the power of the patent system or to do away with it altogether, while periods of economic contraction saw a desire to strengthen it.

Frequency of arguments IN FAVOR OF PATENTS *is represented by a bar extending* ABOVE *the line.*

Frequency of arguments OPPOSED TO PATENTS *is represented by a bar extending* BELOW *the line.*



Volta's
batteries
1800

Dalton's
atomic
theory
1803

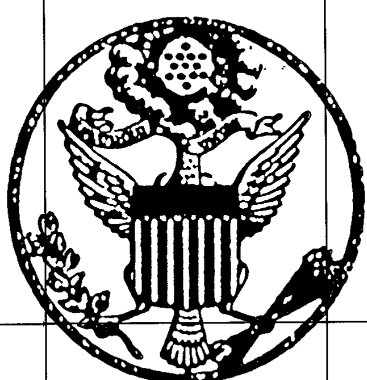
La Place's
celestial
mechanics
1808-23

Laennec's
stethoscope
1816

Cast iron
plow, Charles
Newbold
1797

High-pressure
steam engine
Oliver Evan
1804

Steam boat
Robert Fulton
1811

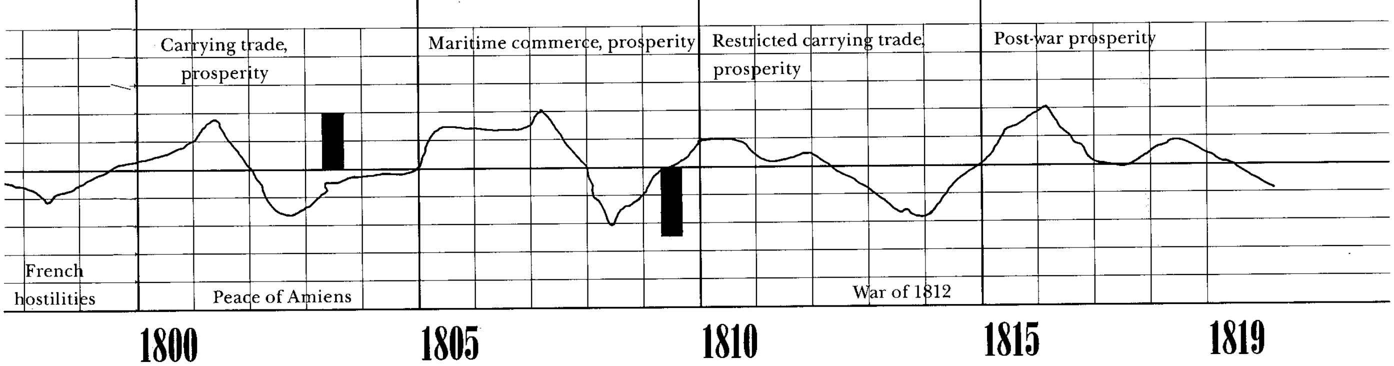


Austria
1810

Russia
1812

Prussia
1815

Belgium
and Holland
1817



Ampere's electro-magnetic theory 1820

Fourier series; photoelasticity 1822

Carnot's principle 1824

Ohm's Law 1827

Thorium and silicon Berzelius 1828

Faraday's Law of Electrolysis
Lenz's Law of Induction
Babbage's analytical engine
1834

"To impugn the principle of patents...
would make the men of brains
still more than at present
the needy retainers and dependents
of the men of money bags."
JOHN STUART MILL 1848

Telegraph
S. B. Morse
No. 1,647, 1840

Collapsible
tube, J. Rand
No. 2,252, 1841

Washing machine Chester Stone 1827

Steam boiler Peter Cooper 1831

"An exclusive privelege
is of all rewards
the best proportioned,
the most natural,
and the least burdensome."
JEREMY BENTHAN 1822

Bavaria enacts patent policy 1825

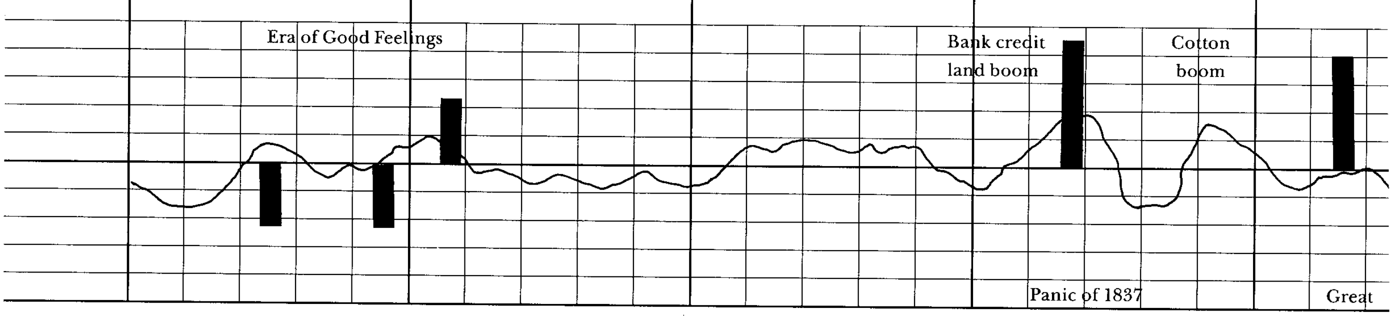
Sardinia 1826

Vatican State 1832

Sweden 1833

10,000 patents filed in U.S., 1836

Portugal 1837



1820 **1825** **1830** **1835** **1840**

Doppler effect 1842

Joule's equivalence heat work 1847

Absolute zero temperature (-273 °C), Kelvin 1848

Bacteriology Pasteur 1856

Darwin's *Origin of Species* 1859

"The patent system added the fuel of interest to the fire of genius."
ABRAHAM LINCOLN 1859

Sewing machine E. Howe No. 4,750 1846

Steam engine Corliss No. 6,162

Safety pin W. Hunt No. 6,281 1849

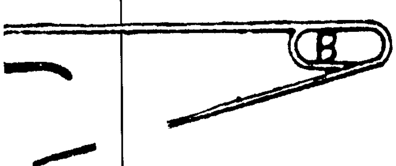
Ice machine J. Gorrie No. 8,080

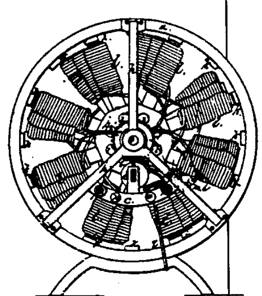
Electromagnetic engine, J. Neff No. 7,889 1851

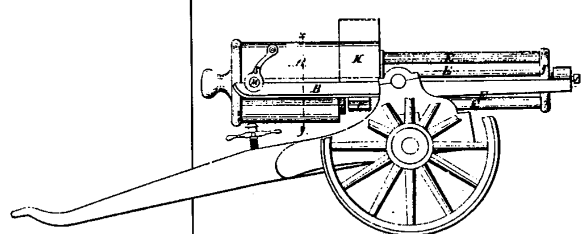
Sewing machine J. Singer No. 13,661 1855

Steel process Bessemer No. 16,082 1856

Machine gun R. J. Gattling No. 36,836 1862



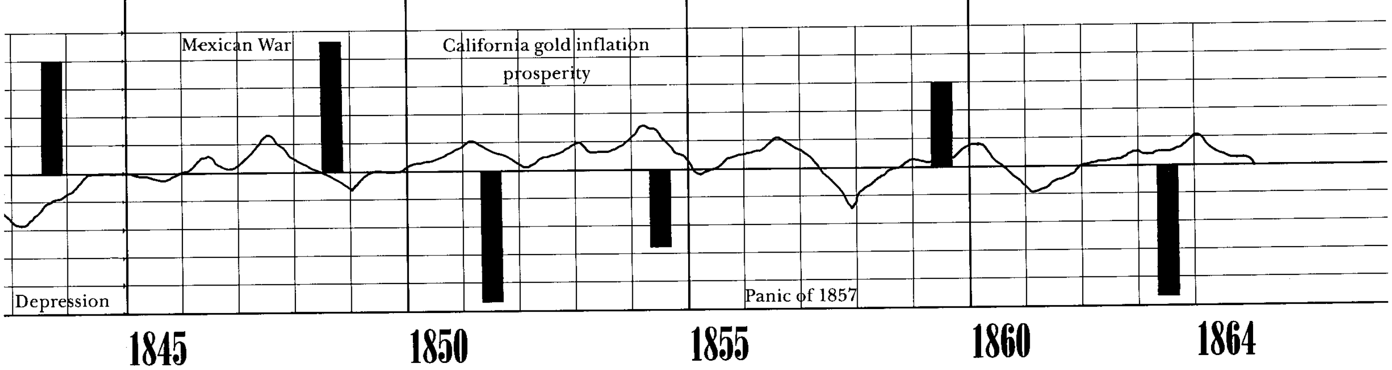




Saxonia 1843

20,000 patents filed in the U.S., 1856

German economists condemn patents, 1863



Mendel's
Law of
Heredity
1865

J. C. Maxwell's
Treatise on Electricity
1873

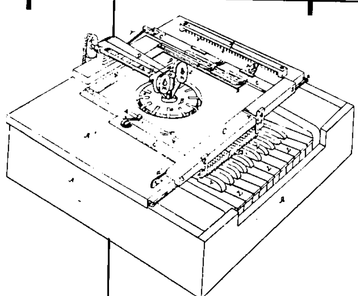
Pasteurization
L. Pasteur
No. 79,265
1873

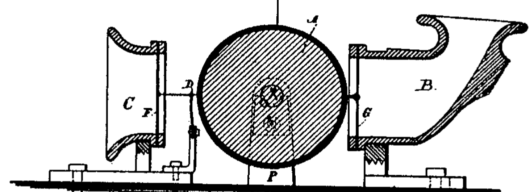
Internal combustion
engine, N. Otto
No. 194,047
1877

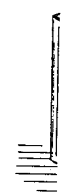
Typewriter
Sholes, Glidden and Soule
No. 79,265
1868

J. F. Glidden
Barbed wire
No. 157,124
1874

Phonograph
T. Edison
No. 200,251
1878

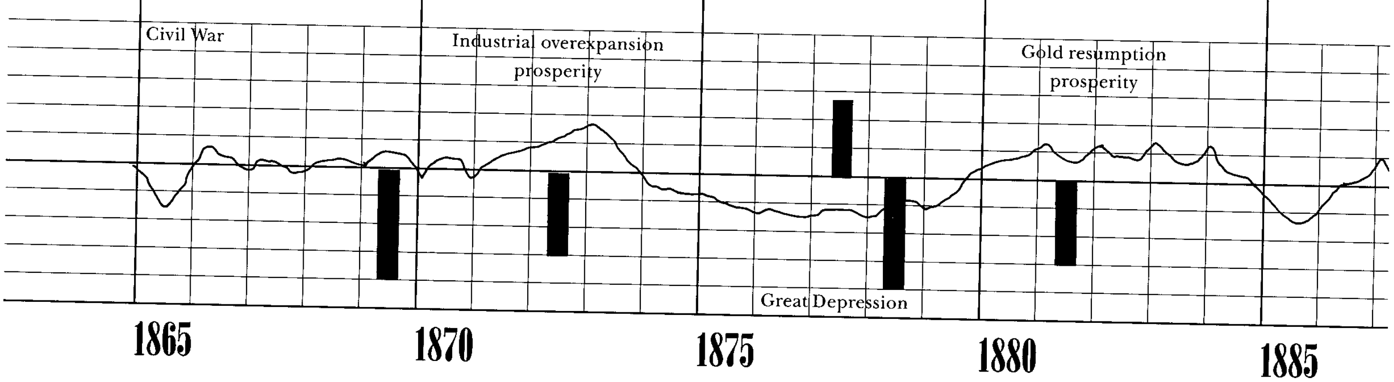






Patent system repealed
in Holland, 1869

200,000 patents filed
in the U.S., 1874



X-rays
Rontagens, 1895

Radioactivity
Becquerel
1896

Radium
Curies
1898

Quantum
Theory
Planck
1900

Relativity
Theory
Einstein
1905

"What is it that makes the U.S. such a great nation?
We have investigated and found it was patents.
And now we will have patents."
JAPANESE OFFICIAL IN THE UNITED STATES 1900

Record disk
E. Berliner
No. 372,786
1887

Roll film camera
G. Eastman
No. 388,850
1888

Zipper
W. Judson
No. 505,038
1893

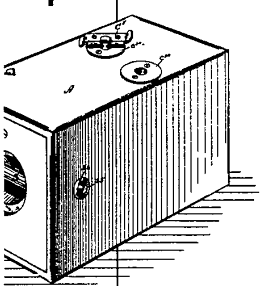
R. Diesel's
engine
No. 608,845
1898

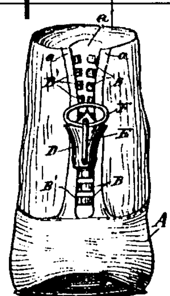
Aspirin
F. Hoffmann
No. 644,077
1900

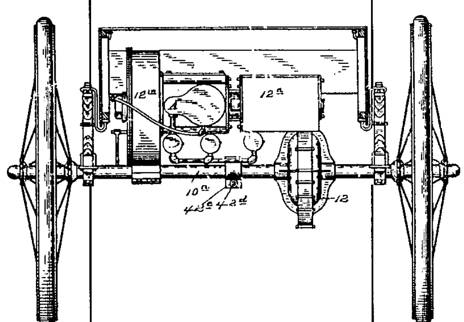
Motor
carriage
H. Ford
No. 686,046
1901

Air conditioner
W. H. Carrier
No. 808,897
1906

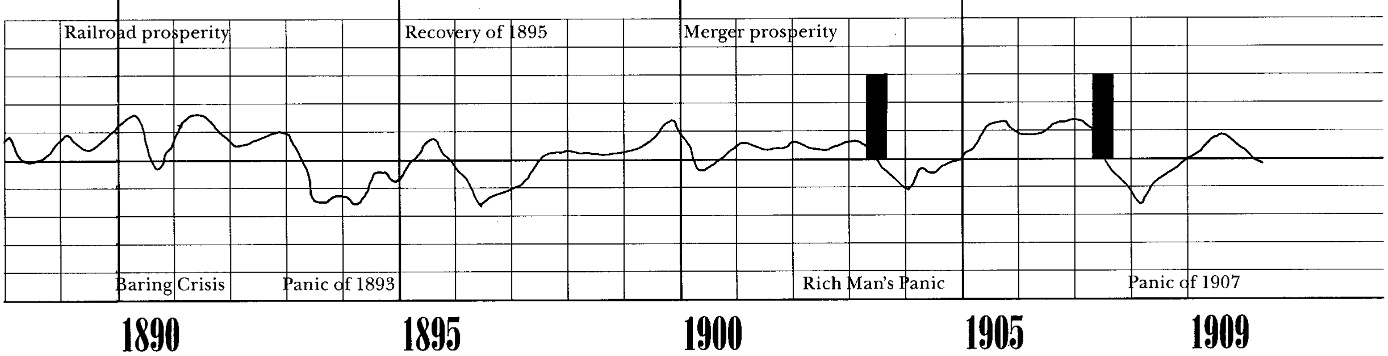
Triode
L. DeForest
No. 879,532
1908







Switzerland
enacts patent policy
1891



Theory of Atomic Structure
Rutherford
1911

General Theory of Relativity
Einstein
1915

Chromosome theory of heredity
T. H. Morgan, 1921
Disintegration of elements
Rutherford and Chadwick, 1921

Penicillin
Fleming
1928

Unified Field Theory
1929

"The object claimed and owned by the patentee is merely the expected behavior of other people to be obtained through expected restraint of competition and control of supply."
J. R. COMMONS 1924

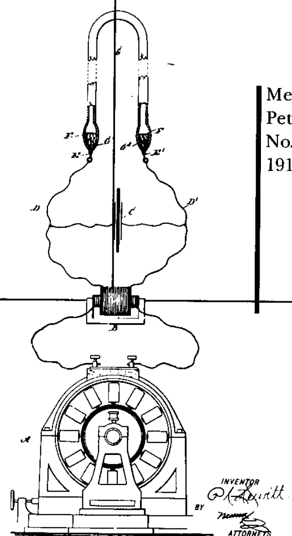
Mercury vapor lamp
Peter Cooper Hewitt
No. 1,030,178
1912

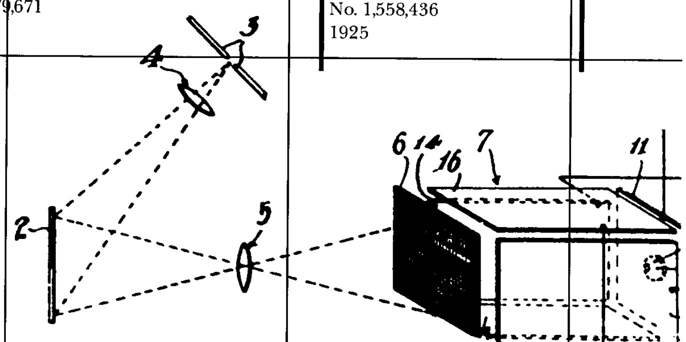
R. H. Goddard
Fire bomb
No. 1,103,503
1914

Gyrocompass
E. A. Sperry
No. 1,279,671
1918

High-vacuum radio tube
I. Langmuir
No. 1,558,436
1925

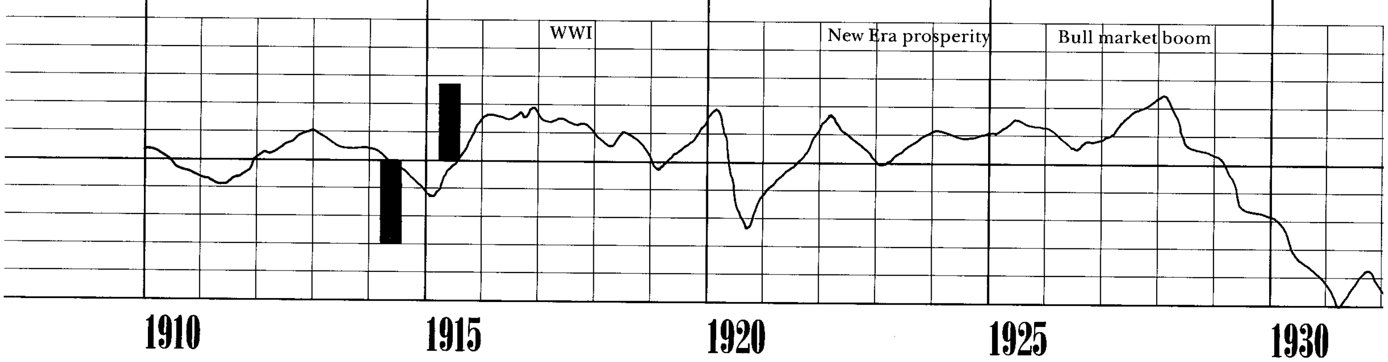
Television system
Farnsworth
No. 1,773,980
1930





1,000,000
U.S. patents filed, 1911

Holland enacts patent policy
1914



Programming theory
Manhattan Project
Electronic digital computer
(ENIAC), 1941

Information
theory
Shannon
1949

Hydrogen
bomb
1952

On Computable Numbers
A. Turing
1937

Controlled
nuclear
reaction
1942

Nuclear
bomb
1945

General
field theory
Einstein
1950

DNA double
helix
Watson, Crick,
Wilkins, 1953

"I believe that patent law is essentially deficient
because it aims at a purpose which cannot be rationally achieved.
It tries to parcel up a stream of creative thought into a series of distinct claims,
each of which is to constitute the basis of a separately owned monopoly."

M. POLANYI 1942

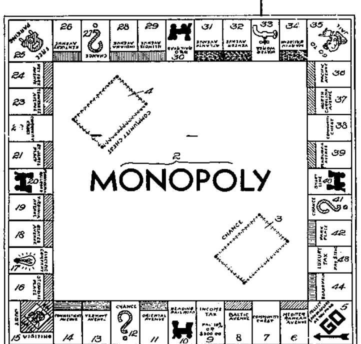
Monopoly game
C. B. Darrow
No. 2,026,082
1935

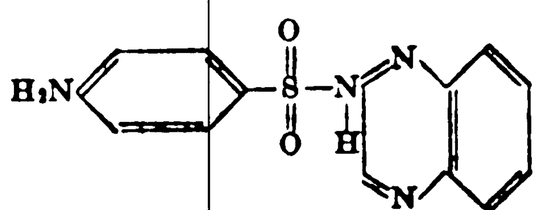
Cyclotron
E. O. Lawrence
No. 1,948,384
1934

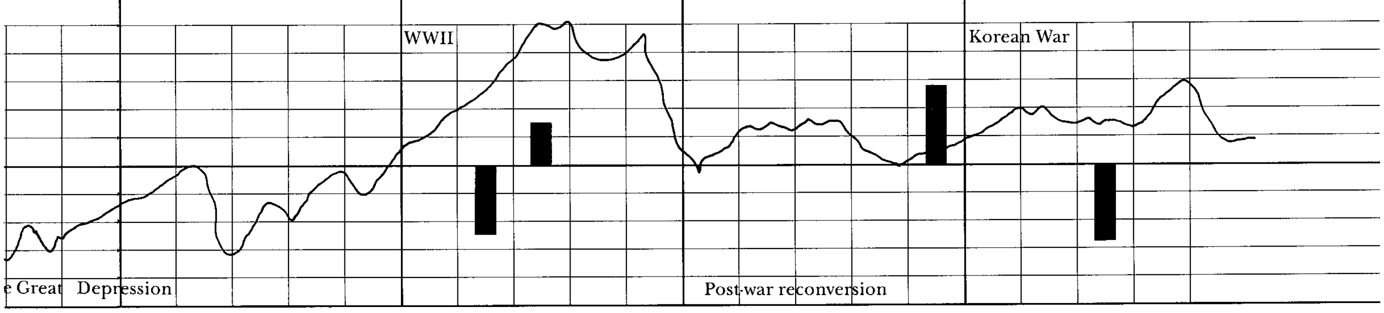
Nylon
W. Carother
No. 2,071,251
1937

Electron photography
C. F. Carlson
No. 2,221,776
1940

Sulfa quinoxaline
Max Tishler
No. 2,404,199
1946







1935 1940 1945 1950 1954

Salk, new anti-polio vaccine 1955

Sputnik I 1957

Van Allen Belt 1958

Friendship 7 John Glenn in orbit 1962

Rachel Carson *The Silent Spring* 1963

Apollo 8 To the moon and back 1968

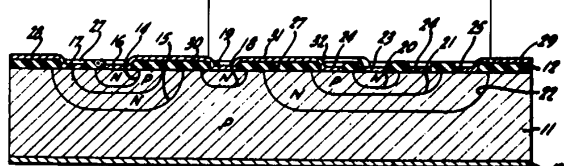
Unified field theory, Glasmow & Georgi, 1973

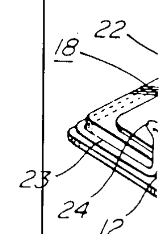
U.S. Mariner Pictures of Venus & Mercury, 1974

"The patent system is wasteful.
It is almost impossible to conceive of
any existing social institution so faulty in so many ways.
It survives only because there seems to be nothing better."
J. Jewkes 1968

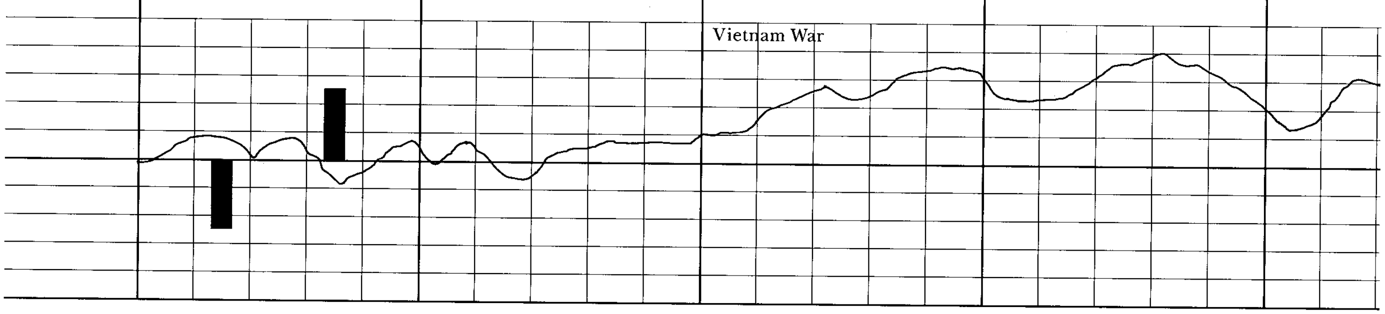
Video taper recorder C. Ginsburg No. 2,956,116 1960

Integrated circuit, R. Noyce No. 2,981,877 1961





3,000,000 U.S. patents filed, 1962



1955 1960 1965 1970 1975

First
test-tube
baby
1978

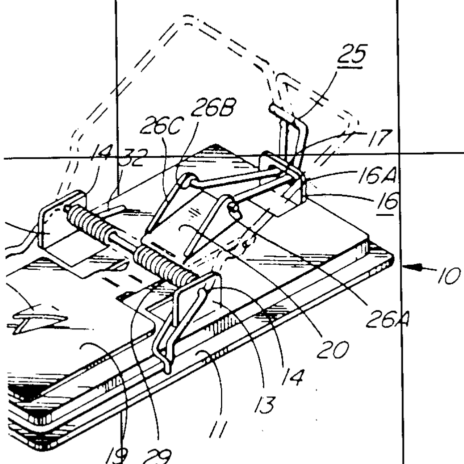
The Mandelbrot
Set, fractals and
chaos theory
1980

Top Quark
discovered
in Switzerland
1984

Scientists claim
Greenhouse effect has
come to pass
1988

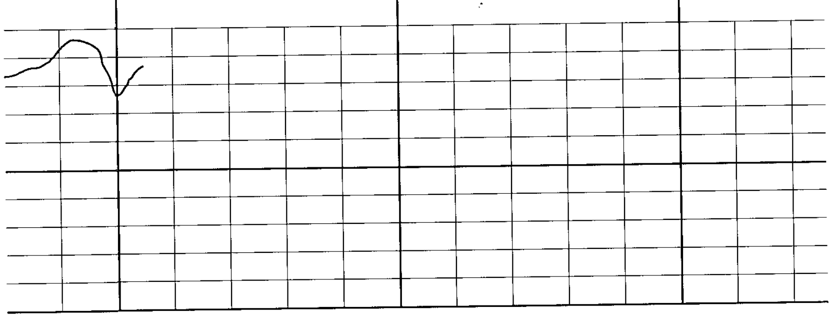
"What builds a great company or a great nation
is not the protection of what it used to do well,
but the development of products and processes
that have never before been seen on the face of the earth."

H. CLEVELAND 1989



Mousetrap
Variation on the
classic "clap trap"
No. 4,574,519
1986

5,000,000
U.S. patents
filed, 1990



1980 **1985** **1990**

LENDERS TO THE EXHIBITION

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The Anacostia Museum
AT&T
Army Medical Historical Society
Burndy Library
Stanley B. Burns and The Burns Archive
Denver Public Library
Hagley Museum and Library
Chuck Hoberman
Invent America Foundation
The Robert Kwalwasser Collection
Ed Lam
Library of Congress
Maytag Corporation
National Archives
National Museum of Health and Medicine
Joseph Newman
The New Orleans Historical Society
State Historical Society of Wisconsin
Xerox Corporation

THANKS TO

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Edip Agi
Edmund Andrews
Kamran Ashtary
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Arora Diamond
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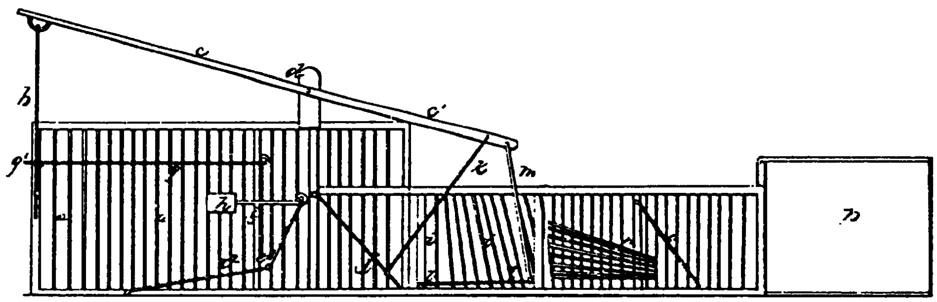
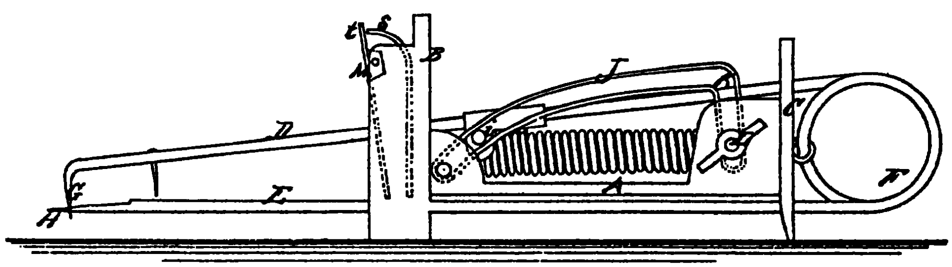
The Cooper Union
for the Advancement
of Science and Art
7 East 7th Street
New York, NY 10003



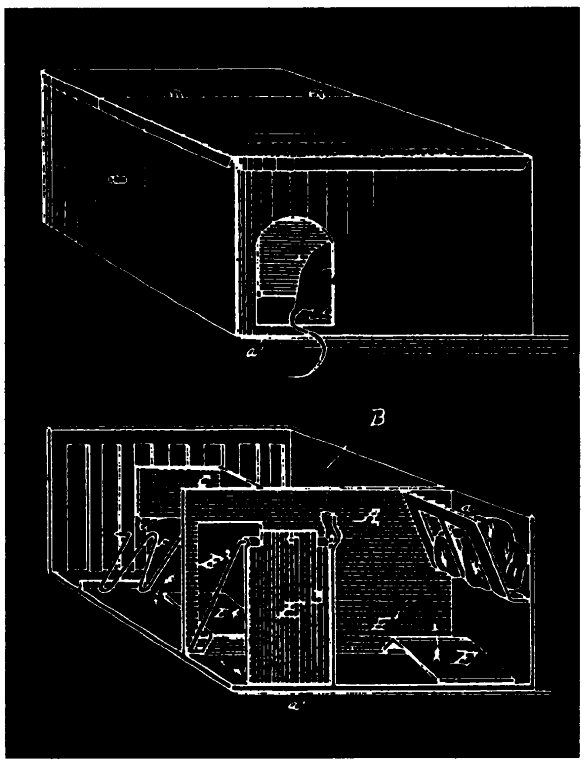
Patent No. 621 *T. Kell, Inventor* 1838
Trap for Catching Rats and Other Animals
"when a rat enters and presses the platform *c*" or takes hold of the bait...
this will retract the bolt and the door will fall, confining the rat...
The retreat of the animal is cut off by the falling of the door *b*,
but the same action opens a way to a second compartment *i, i*...
The rat then advances upon the draw bridge or platform *b, b*,
his weight upon which will suffice to draw down the end... of the lever *c*,
through the medium of the connecting rod *m*,
which will also close the trap door *j* and reset the trap."



Patent No. 119,237 *John H. Mooney and George A. Lloyd, Inventors* 1871
Improvement in Animal Traps
"Our invention consists of two rods moving nearly parallel
through a suitable supporting frame.
These rods are connected together at their rear ends,
and their front ends are armed with sharp points.
A spring is so arranged as to throw the rods forward
if the holding-catch is disturbed after being set,
and by a peculiar arrangement of mechanism,
the upper one of the rods is made to describe an arc
with its forward end as it shoots out,
thus reaching over and grasping the animal
which has approached the trap."

PATENT NO. 216,430 W. *McArthur, Inventor* 1879

"The interior is divided into two compartments: the bait chamber A and the prison B, connected by a subchamber or hall C. At one end of the bait chamber is a bait holder or rack; at the other end is the entrance, which remains open when the trap is set. Into this open doorway the mouse, enticed by the smell of the bait, enters, seeing before him what appears to be a blank wall. Guided by the scent, he turns right and reaches the end of the chamber containing the bait rack. As he attempts to reach the bait, he encounters the platform E, pressing it enough to make it fall. This platform is attached to a rock shaft, which carries at the other end an arm, to which the door is swung in such a manner that its own weight will close it when thrown past the center in either direction. When this door is swung outward, it closes the front door of the structure, and when swung inward it closes the opening from the bait chamber into the passage way. The mouse, when he touches the platform E, in order to reach the bait, throws said platform down, and causes the door to swing back and close the entrance opening. The mouse thereupon, naturally disturbed by the noise, turns to escape by the way he came, but discovers the door closed, and seeing the opening into the hall way C, enters there. No sooner has he borne his weight upon the tilting platform which forms the floor of this chamber than the platform sinks beneath him, causing the outer doorway to open and the inner doorway to shut, and thus resetting the trap. The mouse, not being able to return, goes forward, lifting the inclined gate F, which falls behind him, and enters the prison chamber, from whence there is no escape. One side of the prison is made of open work, in order to admit light into the prison-chamber and induce the mouse to seek his escape at the side farthest from the true opening of the trap."



American inventors, known world over for their legendary "Yankee ingenuity," often directed their energies toward the taming of nature and its forces, and more than once found themselves challenged by one of man's greatest foes: the mouse.

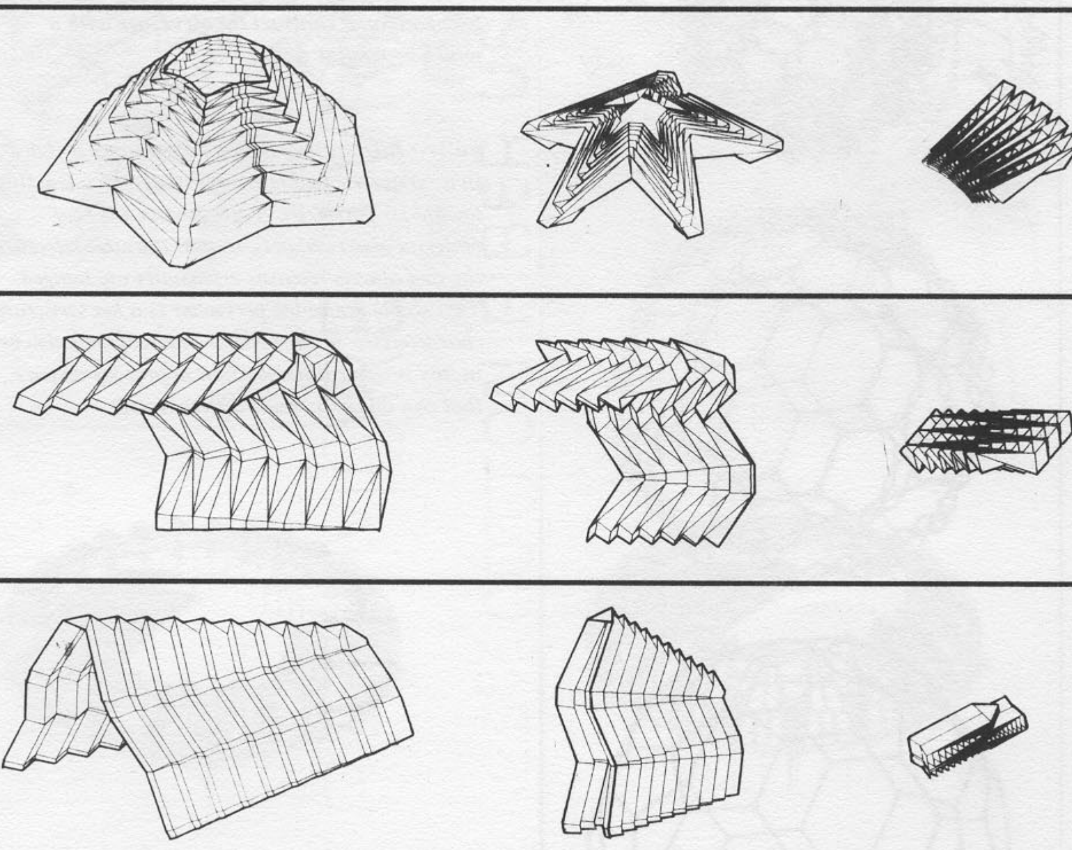
The mousetrap is the model of the inventive spirit writ small. Solutions to the problem of controlling mice range from chemical warfare to the simple clap trap (still available at any five and dime) and more elaborate devices which drown the mouse, flip it from springs, or delude it with subtle illusions. Nineteenth-century mousetrap designs range from physically cruel contraptions resembling medieval instruments of torture to architectural enclosures whose violence is more psychological than bodily. The designer of the mousetrap depicted here has tried to imagine the emotional response of the mouse as he wanders through the booby-trapped structure of this miniature prison—and has perhaps underestimated the rodent's own capacity for "Yankee ingenuity." (Mice are notorius for finding ways to take the cheese without really getting caught. And an especially resourceful mouse might turn this trap into a comfortably furnished apartment.) Developing the better mousetrap has been a quandry since the beginning of history, yet it seems that humans have had more success developing a better ***mouse*** than a better ***trap***.

We have trained mice, experimented with mice, bred mice, trained mice with mazes, kept mice as pets, marketed cartoon celebrity mice—we have even patented mice. Yet despite our famous ingenuity and our opposable thumbs, we still have not found a cheap, safe, efficient, consistent, and humane way to control the common household mouse. [The text at left was adapted from the original patent, "Improvement in Animal-Traps," No. 216,430, W. McArthur, 1879.]

FOLDING STRUCTURES

Chuck Hoberman, Hoberman Associates
B.F.A. Sculpture, The Cooper Union
M.S. Mechanical Engineering, Columbia University
Faculty Adjunct, School of Architecture, Columbia

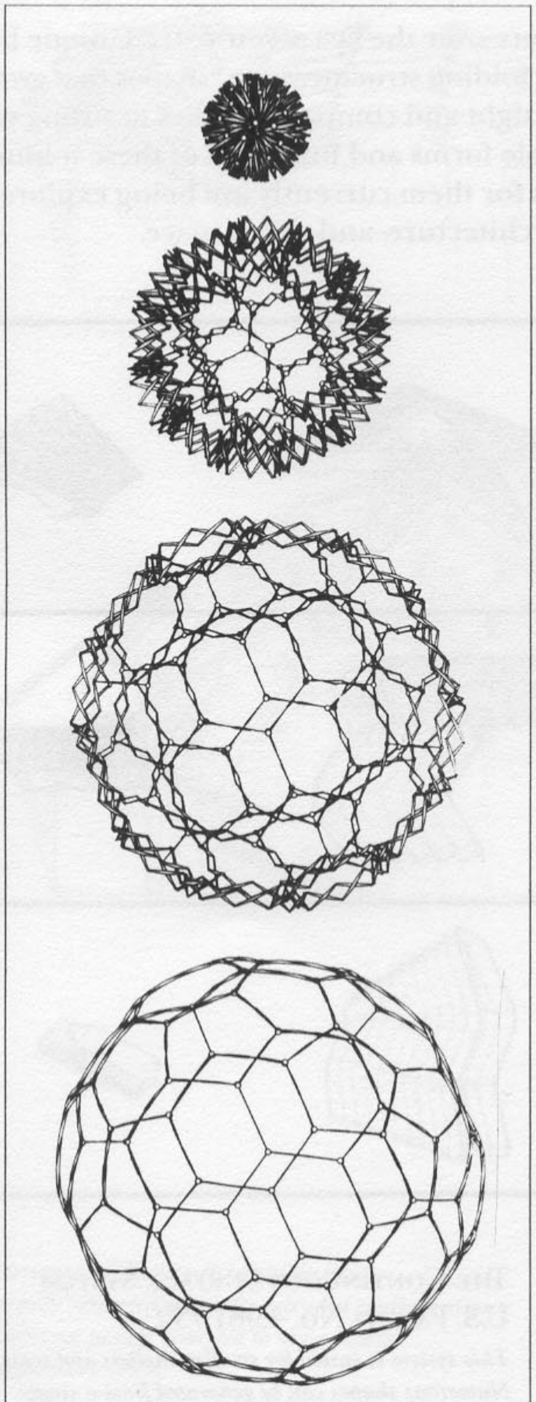
I have developed the work presented here over the last seven years. Unique hybrids of both structure and mechanism, folding structures are "shapes that grow themselves"—fluidly transforming from tight and compact bundles to strong yet graceful structural elements. The possible forms and functions of these folding structures are virtually unlimited. Uses for them currently are being explored in the areas of toys, tents, packaging, architecture, and outer space.



THE CONTINUOUS SURFACE SYSTEM
U.S. PATENT NO. 4,981,732

This system is suited for smaller shelters and tents. Numerous shapes can be generated from a single sheet of material. Manufacture is inexpensive, and structure may be made waterproof. Allowance is made for the finite thickness of the sheet.

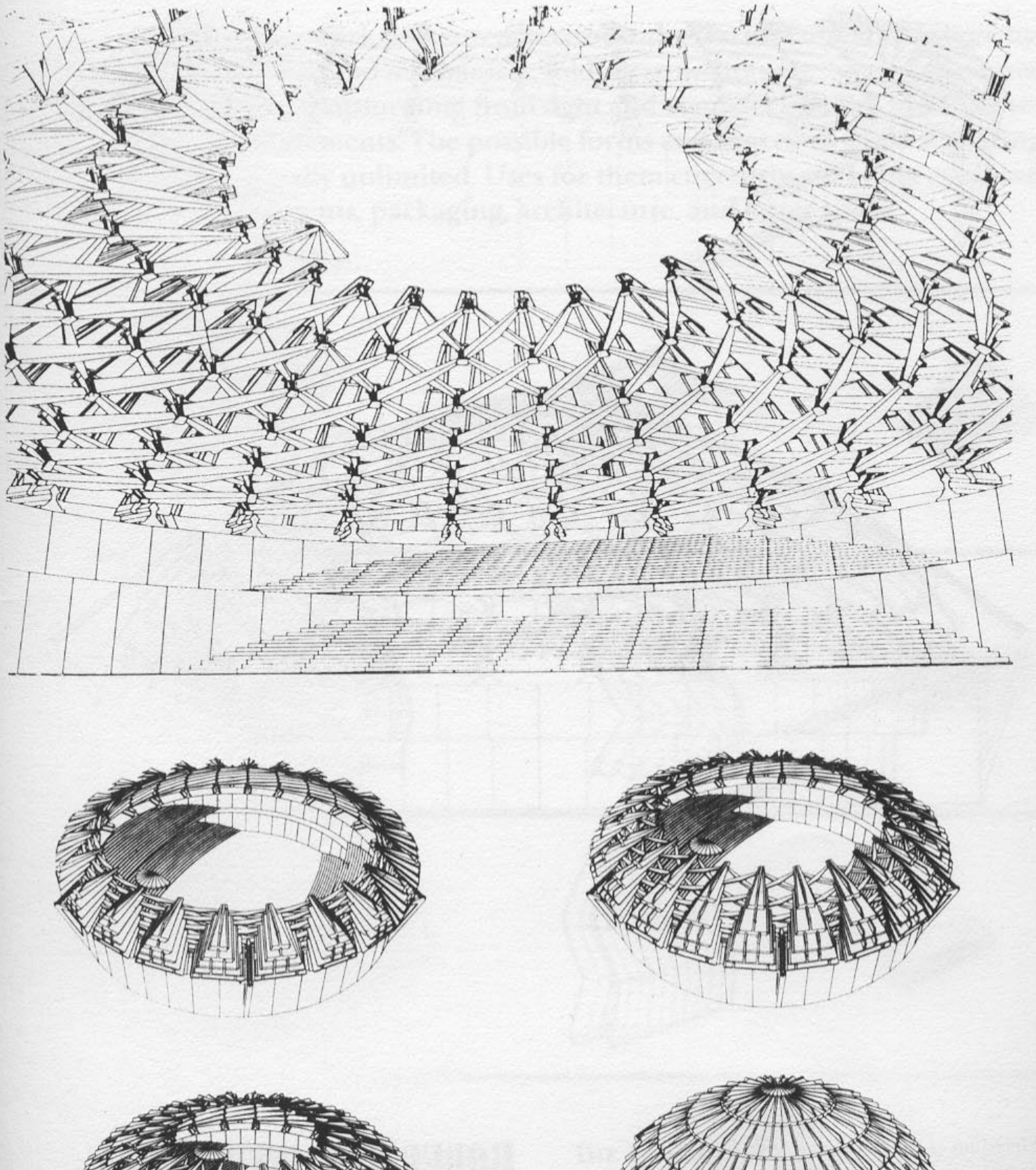
TYPE: RADIAL EXPANSION TRUSS
U.S. PATENT NO. 4,942,700
International Patents Pending

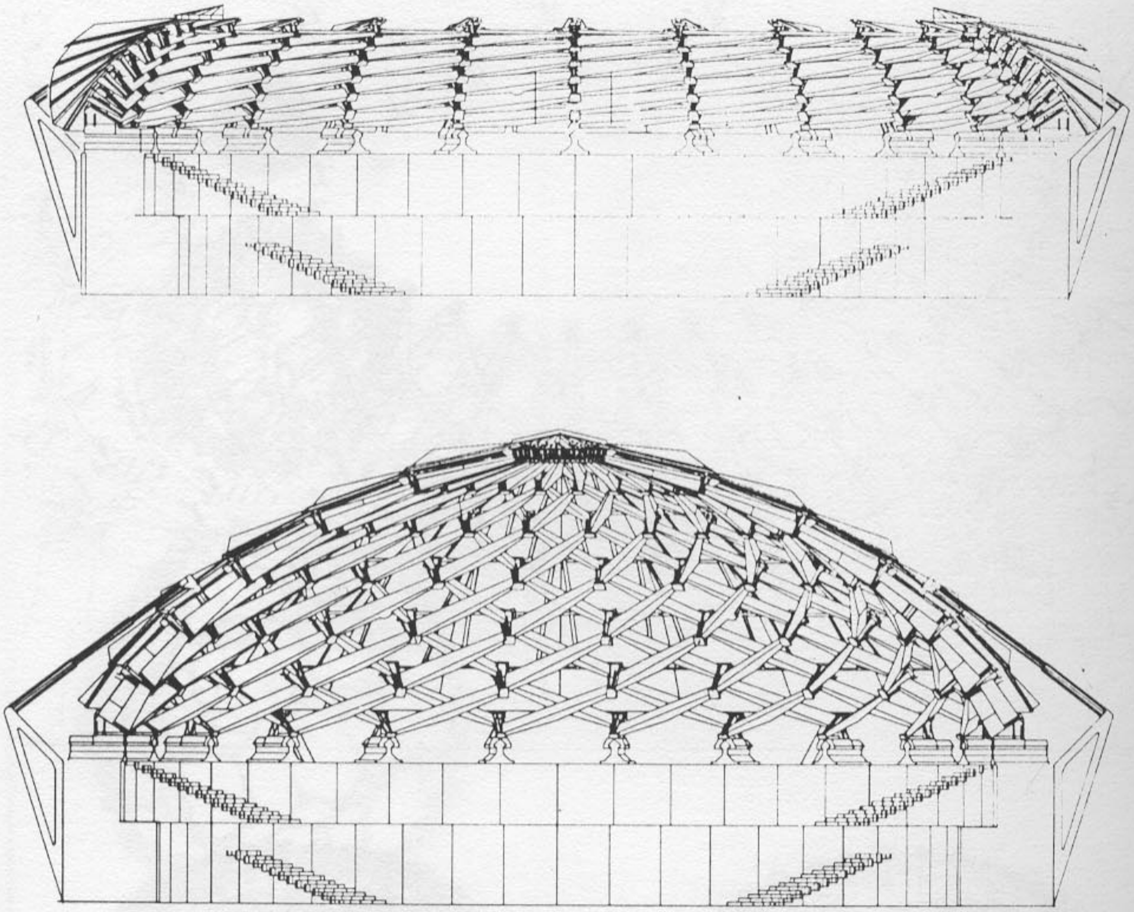


LEFT: *This is a highly flexible system, whose structures exhibit smooth, stable expansion and contraction. One can design a collapsible truss of virtually any shape. Whatever the specified shape, it does not change as the truss is expanded and contracted. For example, a hemispherical dome will remain self-supporting at all times during deployment. As the structure expands, each point on its surface radiates out from the center. These straight-line trajectories easily may be used to expand and contract the structure with a winch or similar device.*

RIGHT: *Like an iris, the roof opens over a space in a symmetric fashion, with its center retracting toward its perimeter. As it retracts, the roof material also compacts, so that the circumference of the roof always remains essentially unchanged. This stable grounded perimeter is a key structural characteristic of the system. The roof may also be set in any intermediate position to provide a space that can adapt to many different uses.*

Iris-type Retractable Roof
(Radial Expansion Truss with Covering)





Elevation of the Iris Retractable Roof,
in fully retracted and fully extended configurations.
Covering panels removed to show Radial
Expansion Truss.

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