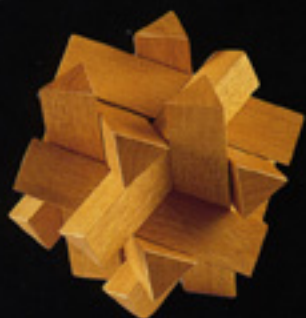


# PUZZLE

The Art of The

Astounding and Confounding

## Mechanical Puzzles



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# PUZZLE

Astounding and Confounding

## **Mechanical Puzzles**

Their History and Their Challenge

*by Jerry Slocum*

*Guest Curator*

Sam Loyd, the great American puzzle inventor of a century ago, once wrote: "I have always treated and considered puzzles from an educational standpoint. ...[They] sharpen the wits, clear fog and cobwebs from the brain, and school the mind to concentrate properly."

The most important aspect of Loyd's puzzle training, in my opinion, is the development of mental flexibility. If one approach to a puzzle fails, the solver needs to try a second, then a third, then a fourth, and so on, until the solution is found. This skill — the ability to look at a problem and attack it from many different angles — is honed by tackling mechanical puzzles, and is useful in almost every aspect of life, at both work and home.

Of course, puzzles are designed primarily for entertainment. That's why we do them. But it's nice to know that we're becoming smarter and better human beings in the process.

*Will Shortz*

*Crossword Editor, The New York Times*

**Katonah Museum of Art**

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# Mechanical Puzzles

## Their History and Their Challenge

by Jerry Slocum

### Introduction

**T**hroughout recorded history, mechanical puzzles have mystified, intrigued, educated, and entertained. They may be defined as hand-held objects that must be manipulated to achieve a specific goal. The goal may be to put the pieces together to form a specific pattern, as with *The Chinese Tangram*; take the object apart, as with a puzzle lock; or rearrange it, as with a *Rubik's Cube*. All mechanical puzzles pose deductive reasoning problems which frequently require unorthodox thinking. Solving a mechanical puzzle can indeed be astounding and confounding, but above all else, it is exhilarating.

**Art in Puzzles** Solving a puzzle can be a visual and tactile delight when the design and craftsmanship are superb. Elegant Chinese ivory puzzles were often exquisitely carved, displaying intricate scenes. The Chinese were so enthralled by the elegance of *The Tangram* that they even made them into ceramic and cloisonné bronze dishes (Figure 1). French color lithography provided elegant and imaginative boxes for hundreds of dexterity and wire puzzles (Figure 2). Modern polyhedral puzzles, designed by master puzzle designer Stewart Coffin, prove that wooden puzzles can also be objects of art (Figure 3).

Figure 1. Chinese Bronze Tangram, ca. 1840



Figure 2. French Dexterity Puzzle, ca. 1910

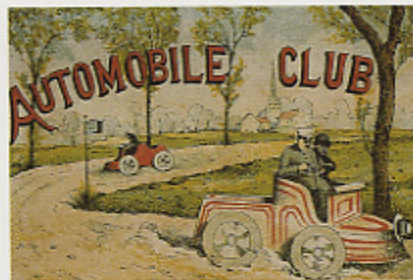


Figure 3. Stewart Coffin's Twelve-Point Puzzle, 1981



**Puzzles and Education** Puzzles are invented mainly to entertain, but they can also instruct. In the early twentieth century in Italy, Maria Montessori used puzzles in nursery schools to stress the importance of trial and error in learning. Chinese *tangrams* are used in countless elementary schools in the US, Europe, and Asia to teach geometry and many other subjects. A Los Angeles high school teacher finds that the best way to teach teenage criminals in jail is by using a variety of puzzles. At an advanced level, there may be no better way of teaching mathematical group theory than by the use of *Rubik's Cube*. Philosopher-logician Raymond Smullyan tells of a phone call from a friend whose son was enjoying one of Smullyan's puzzle books. "He loves your book," the friend said in a conspiratorial tone, "but when you speak to him, don't let him know he's doing math. He hates math!"



**Puzzles, Science, and Mathematics** It should not be surprising that many top mathematicians and scientists are fascinated by puzzles since math is solving abstract puzzles and science is solving the puzzles of nature. A Nobel Prize winning physicist, Richard Feynman, feels he owes his contributions to quantum mechanics to his lifelong passion for puzzle solving. Topology and graph theory had their origins in Leonhard Euler's eighteenth-century analysis of a popular puzzle about traversing the seven bridges of Königsberg, Germany, without going over the same bridge twice.

**Puzzles and Life** Puzzles can reflect what French historians have called the *mentality* of their times. For example, they may show patriotism (Figure 4) and historic events (Figure 5). Cultural and racial prejudice and family life are also often reflected in puzzles.

#### Mechanical Puzzle Classification

Even though mechanical puzzles have been around for centuries, they were first described at length by Professor Angelo Louis Hoffmann in his classic book,

*Puzzles Old and New*, published in London in 1893. He noted the difficulty of classifying puzzles and then described about 400 mechanical, mathematical, and word puzzles in detail, and provided the solutions. I have modified and expanded his approach to classifying puzzles, with the mechanical puzzles divided into categories based on what must be done to solve the puzzle and the form and material of the puzzle itself.

Figure 4. The Preparedness Puzzle, WWI

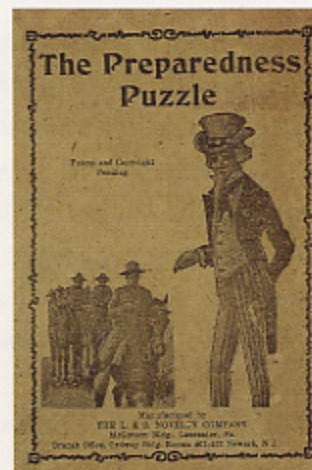


Figure 5. New York to Paris Aero Race, won by Lindy



1. *Put-Together Puzzles*: Putting the object together is the puzzle.
2. *Take-Apart Puzzles*: Opening or taking the object apart is the puzzle.
3. *Interlocking Puzzles*: Disassembly and assembly are required to solve the puzzle.
4. *Disentanglement Puzzles*: The puzzle is to disentangle and re-entangle parts of the puzzle.
5. *Sequential-Movement Puzzles*: The puzzle is to move parts of the object to a goal.
6. *Dexterity Puzzles*: Manual dexterity is required to solve the puzzle.
7. *Puzzle Vessels*: Drinking without spilling, or filling a vessel, is the puzzle.
8. *Vanish Puzzles*: The puzzle is to explain a vanished or changed image.
9. *Folding Puzzles*: The puzzle is to fold a paper, or a hinged object, to form a specified pattern.
10. *Impossible Puzzles*: The puzzle is to explain how an object was made or why it behaves in a seemingly impossible way.

#### Put-Together Puzzles

The oldest and largest class of mechanical puzzles consists of those puzzles that are solved by assembly or by fitting the pieces together. The most popular member of this class is the jigsaw puzzle. Dissected puzzles of a completely different type were popular much earlier in Greece, and they appeared in the mid-eighteenth century in Japan, and at the turn of the nineteenth century in China. The object of this type of puzzle is to put together a given set of geometric pieces to form a specified outline or figure. The earliest known example is the *The Loculus of Archimedes*, or *The Stomachion* (the problem that drives one mad!) (Figure 6). This puzzle, a fourteen-piece



Figure 6. The Elephant Solution to The Loculus of Archimedes



Figure 7. McLoughlin's Chinese Puzzle, 1875



dissection of a square, appeared in the third century BC and was reportedly played with and possibly invented by Archimedes. In the fourth century Magnus Ausonius wrote a poem about *The Stomachion* and in it he mentions that a thousand kind of things can be represented with the fourteen pieces, including a wild elephant, a flying duck, and a barking dog.

One of the most ingenious and imaginative dissection puzzles is *The Tangram*, formed by dissecting a square into seven pieces (Figure 7). *The Tangram* is singular in its ability to transform simple, geometric pieces into elegant, sophisticated, and sometimes paradoxical figures. It became popular in China about 1800 and by 1818 it was the first puzzle craze in Europe and America. It remains popular to this day and is widely regarded as the most elegant and beautiful of the dissection puzzles.

Other interesting dissection puzzles are obtained by cutting up crosses or letters. The most elegant is *The T Puzzle*, which is dissected into only four pieces (Figure 8). We all know that a "T" is formed by a horizontal and a vertical line; however to solve the puzzle, the key piece must be placed on a diagonal, making it very difficult.

Another class of puzzles in this section are magic figures, such as *The Magic Square* (Figure 9). Numbered blocks or marbles must be placed in an array so that the sum of numbers in each row, column, and diagonal is the same.

### Take-Apart Puzzles

Take-apart puzzles represent a broad range of objects and clever applications of principles of physics. They prevent you from opening them and finding their secret compartments. Some have been deliberately designed as puzzles and others have incidentally become puzzling to open, close, or use, due to functional improvements.

As early as the seventeenth century many trick locks were designed to improve the security of standard locks by making them more difficult to open. In the first half of the nineteenth century, high-security trick locks and a steel bar were added to safes to prevent thieves from using dynamite in the keyholes and blowing them open.

Figure 8. White Rose Tea Puzzle, 1903



Figure 9. Magic Square by Jacques, ca. 1950



These locks represented the highest level of the lockmakers' design and craftsmanship skills, and one of the most important uses of puzzles in the nineteenth century.

Trick matchboxes served two useful purposes: to prevent accidental fires in one's pocket caused by early unstable and unsafe matches and as entertainment to fool friends. The tricks employed did not always endear an owner to his or her friends. A popular trick



was to provide a knob that appeared to open the matchbox, but only pricked the finger of the unfortunate victim. (Figure 10). Other trick matchboxes, however, were very good puzzles. One that offered a free Johnnie Walker whiskey to any solver necessitated spinning the matchbox to open it.

The first puzzle knives appeared in the sixteenth century. The purpose of the puzzle feature was to prevent an individual's knife from being used against him. One of the tricks used on these early puzzle knives was to provide a secret latch that, when released, allowed the two sides of the handle to be counter-rotated, thereby revealing the blade and locking it open (Figure 11).

The Golden Age of secret opening puzzles was the period from 1870 to 1900. Famous stores such as Marshall Field in Chicago, Peck and Snyder of New York, and Hamleys of London sold a variety of very clever secret-opening puzzles. These were beautifully made of polished boxwood, ebony, brass, or nickel-plated steel. Professor Hoffmann's book, *Puzzles Old and New*, describes more than fifty secret-opening puzzles and there were probably at least twice as many available at that time. Some of these puzzles were used to carry matches, rings, and snuff, but the object of most was to amuse and bewilder. Often the puzzle was to remove an object such as a marble or ring from a barrel, a tower, or a cannon.

*The American Indian Puzzle Purse* (Figure 12) is from the Potawatomi tribe. The puzzle is to open it. In the 1890s it was used by the women of the tribe to hold and carry "dice" and money. They carried it by threading their belts through the strips of deerskin. The women would gamble with the dice while the men danced. The puzzle purse kept the winnings and the losings secret from the husbands. How do you open it? If you open the flaps,

Figure 10. "Touch-Me-Not" Trick Matchbox, ca. 1880



Figure 11. Russian Fish Trick Knife, 1992



Figure 12. Potawatomi Puzzle Bag and Dice, ca. 1880



both sides are sewed shut. The purse is opened by pulling the deerskin strips through the stitches, which are sewn between the strips. An identical purse is described in the book, *Recreations Mathematiques et Physiques*, written by Jacques Ozanam and published in 1723. Apparently the Indians learned the idea from the French.

Japanese puzzle boxes, which have been exported to the West since the last half of the nineteenth century, were generally more complex. Some require several sliding panels to be moved in a specific order before the "trick box" can be opened. During the last decade Japan has again become known for the originality and quality of its secret-opening puzzles. Dozens of extremely clever and beautiful secret-opening puzzles have been designed and made by Akio Kamei. Produced from the finest and rarest woods, the exquisite craftsmanship of these secret puzzles is matched only by the ingenuity of their design. Many use new principles of operation that offer stimulating take-apart challenges. Kamei, from Hakone, Japan, designs and makes some of the best secret-opening puzzles ever made. Two lumps of "sugar" must be put in *The Sweet Cup of Coffee* and stirred to release the locking pins and allow the secret compartment to be opened (Figure 13). The shape of the *The Egg* is the clue to finding its secret compartment (Figure 14). It is opened just the way an egg is opened.



## Interlocking Puzzles

Take them apart and then put them back together. This is the challenge of interlocking puzzles. They can be so ingeniously interlocked that their separation is quite difficult, but usually the greater challenge lies in reassembling them.

Little is known about the early history of these puzzles, but they were certainly being produced in both Asian and European countries by the eighteenth century. Recently, David Singmaster, a British historian of mathematical recreations, has found an example of a six-piece interlocking puzzle described in a 1733 Spanish book by Pablo Minguet E Irol.

The 1785 catalogue of Peter Fredrich Catel, a German toy manufacturer, included illustrations of two interlocking puzzles, the six-piece *Small Devil's Hoof* and the twenty-four-piece *Large Devil's Hoof*. Puzzles of this type used to be known as "Chinese" puzzles, and it is possible that they were invented by the Chinese, who used elaborate wooden joints in early earthquake-resistant wooden buildings held together without nails.

Edwin Wyatt's book, *Puzzles in Wood*, published in 1928, was devoted to interlocking puzzles. In the book Wyatt applied the term *burr* to the interlocking puzzles that resemble a seed burr. Now the name is commonly applied to almost all interlocking puzzles. The most common burr puzzle uses six pieces, although some have as few as three and others exceed one hundred.

During the nineteenth century, the six-piece burr evolved into solid, interlocking puzzles such as cubes, balls, and barrels (Figure 15). Initially, puzzles of this type were mainly produced in Germany, but by the late 1930's the market had largely been captured by Japanese manufacturers. The Japanese not only produced traditional burrs at much lower cost, but designed many new interlocking puzzles in the form of whimsical animals, vehicles, and weapons.

Stewart Coffin has created over a hundred new and complex burr puzzles based on polyhedral geometric forms (Figure 16). He selects the finest woods to show off the geometric features, cuts and glues, and then assembles the pieces with extreme precision, adding a perfect finish and making his beautiful puzzles unique works of art. Coffin, who lives near Boston, is the most outstanding designer and maker of interlocking puzzles the world has ever seen.

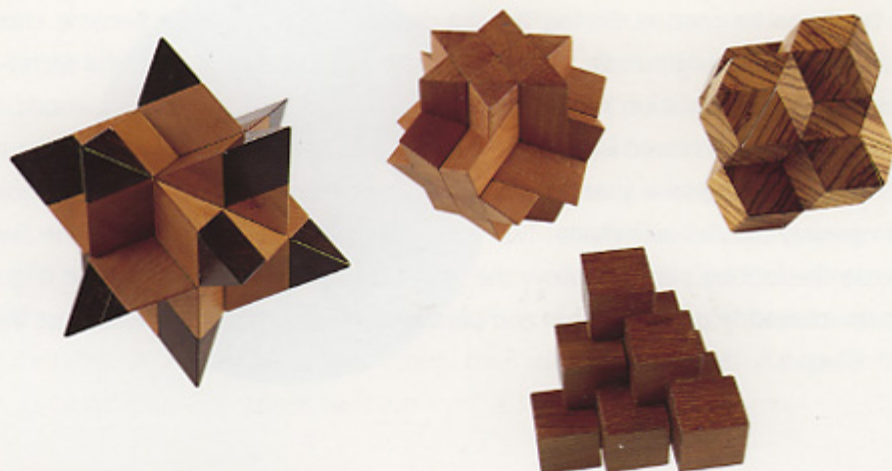
Keychain puzzles started in 1939 as a souvenir of the New York World's Fair. The theme of *The World of Tomorrow* had as its symbol a 700-foot high obelisk, the Tylon, and a 200-foot-ball-like structure called a



Figure 15. *Barrel*, 1890



Figure 16. Stewart Coffin's Polyhedral Puzzles





Perisphere. Irving Steinhardt patented a small plastic interlocking puzzle which represented the Perisphere with the Tylon sticking out of it. When the Tylon piece was replaced by a keychain, it became the first keychain puzzle. By the mid-1950s dozens of different keychain puzzles were on the market, and they are still being made in Europe.

### Disentanglement Puzzles

Disentanglement puzzles involve the problem of freeing and attaching a part of a puzzle, often a ring, loop of string, or handle. They are made of various materials such as cast iron, sheet metal, wire, or string.

One of the earliest of these puzzles found in America is a beautiful mother-of-pearl-and-string puzzle, known as *Solomon's Seal*. It was owned by John Hancock (1737-1793), American statesman and first signer of the Declaration of Independence. The lotus flowers carved into the mother of pearl indicate that the puzzle was made in China. The puzzle is to put the two "buttons" that are on separate loops of the string on the same side. It is a very difficult puzzle (Figure 17).

Figure 17. *Solomon's Seal*, 1804



Figure 18. *Chinese Rings*, 1840



Figure 19. *Horse Puzzle Hobble*, ca. 1880



In the year 1550, Geronimo Cardan described a wire-and-ring puzzle known as *Chinese Rings*, *Cardan's Rings*, and by various other titles (Figure 18). Although that makes it the earliest known disentanglement puzzle, other references have claimed that the puzzle was well known in China during the Sung Dynasty (AD 960-1280). There is a Chinese legend that it was invented in China in the second century by Hung Ming, a famous Chinese hero. In China the puzzle is viewed as a kind of wisdom game, useful in increasing one's intelligence.

Other wire puzzles have been popular for a long time. Examples have survived from the seventeenth century. The puzzle *Hobble* is a disentanglement puzzle with a very practical use (Figure 19). It was used by cowboys in the early settlement of the Western United States to tie the front feet of their horses together so they could graze at night, but not run away or be stolen by Indians.

### Sequential-Movement Puzzles

Sequential-movement puzzles involve moving parts of a puzzle to a given goal following the rules. They include a broad range of puzzle types from the relatively simple river-crossing puzzles described in the eighth century by the English scholar Alcuin to *Rubik's Cube* and its descendents.

The earliest sliding-block puzzle known is the *Puzzle of Fifteen*, which consisted of fifteen square blocks in a 4-by-4 square box. Early in 1880, *The Fifteen Sliding Block Puzzle* achieved "phenomenal popularity" in America and in Europe. By March 6, 1880, *The Daily Inter Ocean* stated, "it is well known to nearly everyone by this time." A diabolical version, called the *The 14-15 or Boss Puzzle* (Figure 20), had all the pieces in numerical order except the fourteen and fifteen pieces which were in the reverse order. The puzzle, to put all the pieces in their correct order, was impossible to solve! *The Fifteen and Boss Puzzles* became a craze in the United States and Europe. Although Sam Loyd, America's greatest puzzle inventor, claims that he invented *The Boss Puzzle* and offered a prize of \$1000 for the solution, no evidence to support his claim has been found.



Figure 20. Boss Puzzle, ca. 1880



Figure 21. Bűvös Köcka, 1979



Almost one hundred years later *Rubik's Cube* became a similar world-wide rage (Figure 21). The two puzzles are closely related. *The Fifteen Puzzle* is a two-dimensional puzzle with one empty space. *Rubik's Cube* is a more elegant and very difficult three-dimensional puzzle with no empty spaces. These two puzzles have been among the bestselling mechanical puzzles of all time. Over 100 million copies of *Rubik's Cube* were sold to make it the biggest puzzle craze, so far! And both puzzles were quickly followed by spin-offs that were stimulated by the success of the originals. New puzzles of both types still appear on the market.

### Dexterity Puzzles

Dexterity puzzles include throw-and-catch puzzles, mazes using balls, and rolling-ball puzzles. Surprisingly, logic is often the key to the solution. For example, there are ingenious puzzles that appear to require dexterity, but actually you must give them a spin — centrifugal force solves the puzzle.

Early throw-and-catch dexterity puzzles have been found in Alaska, pre-Columbian South America, Ancient Greece, Italy, China, and the Middle East. They often require skill related to survival and may have been used to teach eye- hand coordination and other hunting skills to children. In the pre-Columbian Americas, one of the most popular dexterity puzzles was *Pommawonga (Spear the Fish)* (Figure 22). American Indians had many versions of the toss-and-catch dexterity puzzle and Eskimos in Alaska made a skill puzzle called *Gazinta*, which consisted of a spike and washers.

A related toss-and-catch puzzle, *Cup and Ball*, became a rage in sixteenth-century France, even obsessing King Henry III (Figure 23). *The Flip Ball* played in ancient China is believed to be the forerunner of *The Cup and Ball*. However, other reports trace the puzzle back to ancient Greece and Italy.

Handmade wooden rolling-ball dexterity puzzles were made in England by 1840, but it wasn't until February 1889, when *Pigs in Clover* was first produced by Charles Crandall, that the public went wild over a rolling-ball puzzle (Figure 24). On 14 March 1889, the *New York Tribune* reported that when New York Senator

Figure 22. Pommawonga (Spear the Fish), ca. 1990



Figure 23. Cup and Ball, ca. 1850





Figure 24. *Pigs in Clover*, 1889



Figure 25. *La Potence du Pendu*  
(The Hang Him Puzzle), 1891-1903



Evarts brought the puzzle into the U.S. Senate chamber, it caused such a stir that a page was sent out to the nearest toy store to bring back more for the other senators. Even the new President, Benjamin Harrison, was depicted playing with *Pigs in Clover* while puzzling over his appointments in a political cartoon in the March 17, 1889, *New York World*. It asked, "Will Mr. Harrison be able to get all these hungry pigs in the official pen?" One factor in the puzzle's success was its low cost. It was made of wood and cardboard, with four clay marbles that were to be rolled into the pen in the center of the six-inch circular maze. It sold in the Montgomery Ward Catalogue of 1889 for ten cents. A patent was awarded to Crandall on September 10, 1889, but the puzzle was quickly and blatantly copied.

The first chapter of Professor Hoffmann's 1893 book, *Puzzles Old and New*, included twenty-five dexterity puzzles, almost all the rolling-ball type. An exception was the French *The Hang Him Puzzle* that uses blown air to hang a cork ball on a hook (Figure 25).

The firm of R. Journet and Company of London designed and produced well over one hundred different glass-top dexterity puzzles beginning in 1891 and continuing until the 1970s. During World War I dexterity puzzles made by Journet were sent to British prisoners of war in German POW camps. What the Germans didn't know was that Journet had hidden inside some of the puzzles a hacksaw blade, a compass, and a map to help the British prisoners escape and return to Allied-controlled territory.

### Puzzle Vessels

Puzzle Jugs and lidless wine containers (wine jugs and tea pots), two of many types of puzzle vessels, are the oldest surviving mechanical puzzles. The trick in drinking from puzzle jugs is not to spill the contents (Figure 26). These vessels have a lattice or series of holes around the upper portion of the sides of the jug and the liquid spills out if you try to drink in the conventional manner. The solution is to discover a hidden tube which is used like a straw to suck the liquid out. The remaining holes, including a traditional hidden hole on the underside of the handle, are covered by the fingers. A puzzle jug made in the South of France about 1400, and found in Exeter, England, is in the Exeter Museum. Similar jugs were made in England, the Netherlands, and Germany during the sixteenth, seventeenth, and eighteenth centuries.

Figure 26. *Drink If You Can* Puzzle Jug,  
late 19th century



Figure 27. *Chinese Justice Cup*, 1998





The Chinese cup and its base (Figure 27), are called by various names such as *Greedy Cup*, *Justice Cup* and *Tantalus Cup*. The cup can be used as a normal drinking cup, unless you are greedy and fill it completely full. Then all the contents automatically drain out of the bottom into the base, and the cup is empty.

### Vanish Puzzles

There are many geometric paradoxes which involve the dissection and rearrangement of parts of a figure. When the rearrangement is completed, a portion of the original figure has apparently vanished without a trace. When the pieces are further rearranged to their original form, the missing area or picture mysteriously appears again. The earliest known vanish puzzle was found by David Singmaster in a book by Sebastiano Serlio published in 1545.

In 1880 Wemple and Company of New York used a similar principle in *The Magic Egg Puzzle* (Figure 28). An illustration of a hen and nine eggs was cut into four pieces that can be rearranged to form six, seven, eight, ten, eleven, or twelve eggs.

Figure 28. *The Magic Egg Puzzle*, 1880



Figure 29. Sam Lloyd's *The Get Off the Earth Puzzle*, 1896



*The Get Off the Earth Puzzle* (Figure 29), first appeared in 1896 and was enormously popular. It consists of a brightly colored miniature Earth revolving on a central pin. Thirteen figures of Chinese men can be clearly seen. When the Earth is rotated a few degrees, one figure mysteriously vanishes, leaving only twelve Chinese men. The solution, although simple, is so well disguised that very few people can solve it. The explanation is that the thirteen men spiral across the circumference of the Earth, and when it is rotated, each of the twelve resulting men has grown slightly.

### Folding Puzzles

Folding puzzles have frequently been used for advertising and political purposes since late in the last century. During World War II several patriotic puzzles were published. One called *The Puzzle of the Five Pigs* showed drawings of four pigs. The fifth pig was to be found by folding. Solving the puzzle showed the fifth pig to be the face of Adolph Hitler (Figure 30).

### Impossible Puzzles

Nothing can capture the imagination more forcefully than an impossible puzzle. For some the question is: how was it made? For others: why does it behave in a seemingly impossible manner?

Perhaps the most popular of all impossible puzzles is *The Arrow through the Coke Bottle* (Figure 31). It is made with no glue from a single piece of wood and a single-piece glass bottle. Although Albert Hopkins explains how it is made in his 1897 book, *Magic*, few people know the solution and it is the only puzzle where the solution is a closely held secret.



Figure 30. Find a Fifth Pig, 1929



Figure 31. The Arrow Through the Coke Bottle, 1985

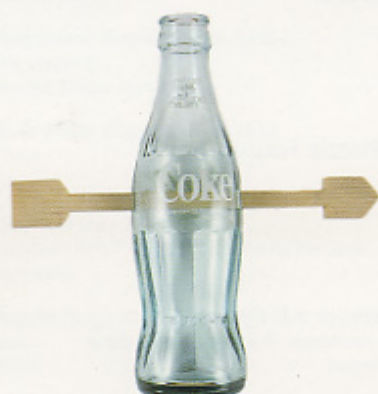


Figure 32. Turtle Celt, 1978



Physicists wrote about “impossible” tops over a century ago. One of these is called a *Celt* or *Rattleback*. A typical *Celt* spins normally in a clockwise rotation. When you try to spin it counterclockwise, after a few rotations it reverses its direction of spin. This appears to defy Sir Isaac Newton’s laws of physics. A new type of *Celt*, with turtles mounted on each end, has recently been invented by two Russian puzzle designers (Figure 32). The turtles are mounted on pins so you can turn each of them around 180 degrees on the *Celt*, pointing them in the opposite direction. The amazing *Celt* then spins normally in a counter-clockwise rotation. No matter which way you turn them, the turtles only want to go forward, and if you try to spin them backwards, they reverse the direction of spin of the *Celt*.

Putting objects in bottles is a very old form of impossible puzzles. The late Harry Eng, from La Mesa, California, was a master of impossible bottle puzzles.

## The Puzzle Exhibition

The mechanical puzzles in this exhibition have been selected to show how design and craftsmanship can enhance the experience of puzzle solving. To fully appreciate why a puzzle is puzzling, there is no substitute for trying to solve it yourself. Hands-on puzzles are an important feature of *The Art of the Puzzle*. Using your hands — and your mind — experience the challenge and reward of solving what may at first appear to be “impossible” puzzles.

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