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Graceful Moves, for a Boy Made of Metal

By HENRY FOUNTAIN

PHILADELPHIA — What makes an automaton tick?

For the one on display at the Franklin Institute here, the answer is: a couple of hefty spring motors. The automaton, a mechanized doll built more than two centuries ago by the Swiss watchmaker Henri Maillardet, uses the power from the wind-up motors, carried through linkages to its right arm, to write and draw.

A bilingual doll that can still write, draw and inspire after 200 years.

But it is what's between the motors and the arm that makes the two-foot-high Maillardet automaton seem like more than a machine. A stack of rotating brass cams precisely control the arm movements. As steel levers follow hills and valleys cut into the edges of the rotating disks, the arm moves smoothly along three axes — side to side, to and fro, up and down.

In essence, the disks are its read-only memory, giving the automaton a repertory of three poems — two in French and one in English — and four drawings, including one of a Chinese temple.

"It's amazing that it does it," said Charles F. Penniman, a retired museum employee who gently tends to the automaton. "But it's really amazing that it still does it after 200 years."

JESSICA KOURKOUNIS FOR THE NEW YORK TIMES

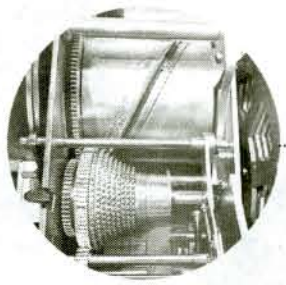
GIVING NEW LIFE Charles F. Penniman, a retired museum employee who tended to the automaton this month at the Franklin Institute in Philadelphia.

The Maillardet automaton hasn't always done it — in two centuries it has had about as many ups and downs as the undulations on the cams. It was exhibited across Europe for four or five decades, may have been brought to the United States by the 19th-century showman P. T. Barnum, and was damaged in a fire (perhaps at Barnum's museum in Philadelphia) before being donated by a local family to the Franklin Institute in 1928. Over the years it's been dressed as a boy (right) and a woman (wrong), and inspected, adjusted, modified and repaired, sometimes poorly.

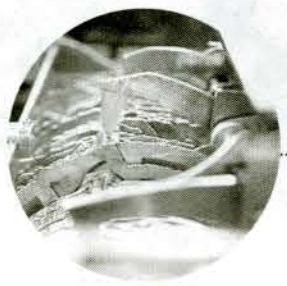
But these are heady times for the machine, and for others like it that were outgrowths of European watchmaking:

Mechanical Memory

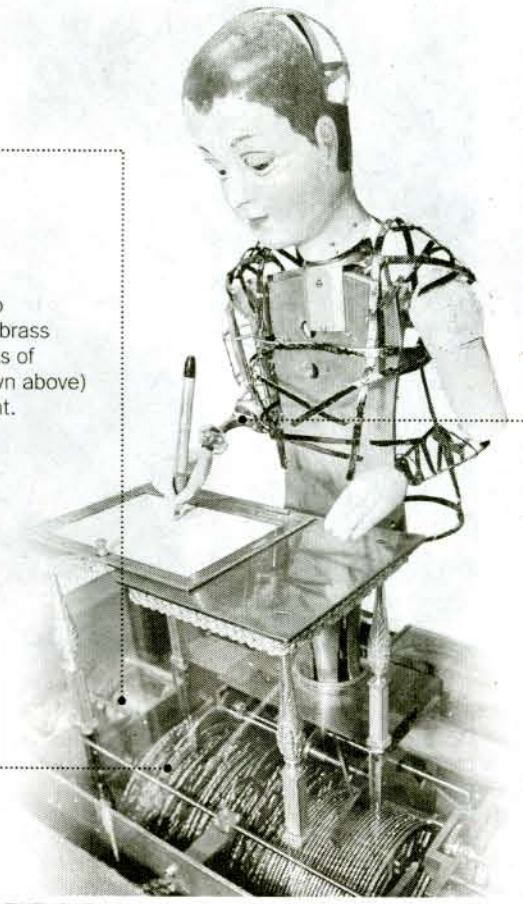
The Maillardet Automaton's motions are controlled by dozens of slowly rotating brass disks. These disks contain all the data necessary for its lifelike movement and drawings — in effect, they serve as a mechanical form of read-only memory.

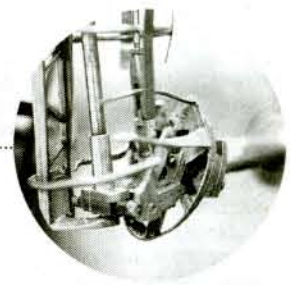


1. The writing hand is powered by two clockwork motors. One turns a set of brass disks — or cams — arranged in banks of three dedicated sets. The other (shown above) moves the cam assembly left and right.

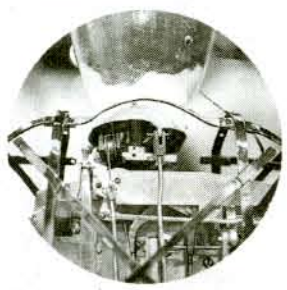


2. Each of the writing hand's 72 cams has a pattern cut into its edge corresponding to specific arm movements. As the cams rotate, metal styluses read the data.



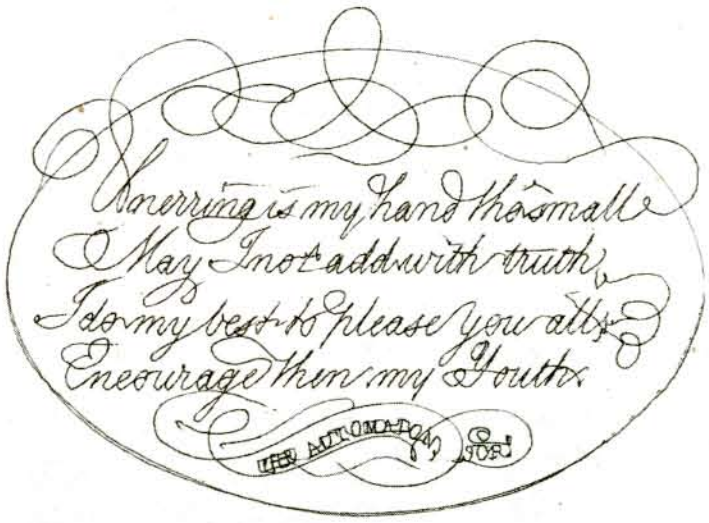


3. The styluses in turn drive a series of rods, providing motion. There is a separate stylus for each direction: forward and back, side to side and up and down.



4. The head, eyes and left arm are controlled by an integrated mechanism that takes its cues from a pair of cams. The cams are operated by the same rotational motor as the drawing cams.

Source: The Franklin Institute THE NEW YORK TIMES/PHOTOS BY FRANK O'CONNELL (MOTOR); DARRYL MORAN/FRANKLIN INSTITUTE (AUTOMATON); JESSICA KOURKOUNIS FOR THE NEW YORK TIMES



THE FRANKLIN INSTITUTE

PORTFOLIO A poem in English, and a drawing produced by an automaton at the Franklin Institute in Philadelphia.

An automaton plays a crucial supporting role in the current Martin Scorsese film, "Hugo," and in the 2007 illustrated novel the film was based on, "The Invention of Hugo Cabret," by Brian Selznick.

Mr. Selznick was inspired, in large part, by the machine at the Franklin Institute. While working on the book he learned that Georges Méliès, the early French filmmaker who is central to the story, had a collection of automatons that was eventually thrown out. Mr. Selznick knew little about the machines. An Internet search turned up references to the Franklin Institute's automaton.

"When I called, that's when I was informed it had broken many years earlier," he said in an interview. "And that it was in the basement and out of view."

When Mr. Selznick visited, the Maillardet automaton's head was off, and it could not actually write or draw. But Mr. Penniman was able to wind it up and show him how things moved, and how all the gears and cams worked. "It feels like Charles has this very personal friendship with the automaton," Mr. Selznick said.

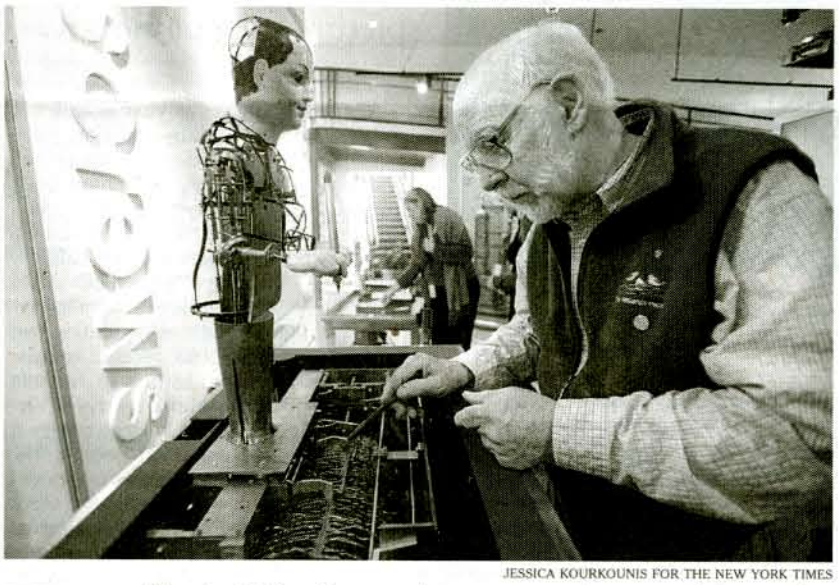
> Once wound up and turned on, a doll can produce a drawing or poem in three minutes.

Mr. Selznick was also instrumental in getting the machine repaired, by Andrew Baron, a designer of pop-up books and restorer of vintage mechanisms in Santa Fe, N.M.

Mr. Baron came to the museum for several weeks in 2007 and set to work, with the aid of photographs Mr. Penniman had taken. "On one photo, Charlie had written, 'Possible shoulder impingement,'" he recalled. "I operated it for the first time and it jammed up — and it was the shoulder."

He took apart some elements of the mechanism, had a crucial replacement part produced by the museum's machinist, and oiled and adjusted the rest. The automaton, which sits, unclothed, in a glass display case as part of the museum's permanent "Amazing Machine" exhibition, is now in working order, although it is demonstrated only rarely.

When it is operated, Mr. Penniman and museum staff treat it with kid gloves, using a block of aluminum to delicately set the hand and its pen (the original writing instrument is unknown; it was lost long ago) in the proper position over a small piece of paper. Once wound up and turned on, the machine whirs into action, producing a drawing or poem in about three minutes. Each requires multiple cams, and trouble can arise when the machine has to move the whole stack, by only an eighth of an inch, to shift cams. If all goes exceedingly well, it will automatically begin another drawing or poem shortly after finishing the first.



JESSICA KOURKOUNIS FOR THE NEW YORK TIMES

RESTORATION Charles F. Penniman took apart some elements of the mechanism, had a replacement part produced, and oiled and adjusted the rest.

Automatons of this type were exhibited by makers of fine watches as advertising and public relations tools to build exposure to their wares, said Jeremie Ryder, conservator of the Murtogh D. Guinness Collection of automatons and mechanical musical instruments at the Morris Museum in Morristown, N.J. Early-19th-century audiences would have been astonished by the lifelike movements.

No one knows exactly how they were made — trade secrets were common at the time — but the precision of the work is remarkable. "The pieces that date from that period were the pinnacle of complexity," Mr. Ryder said. "There was an extreme amount of hand labor that went into them."

"It's hard to get a very lifelike, fluid motion of a simple arm movement or hand movement without becoming jerky," he added. "Here they were doing it just brilliantly."

Mr. Penniman said he first understood how extraordinary the machine was when he studied the movements encoded by the cams. "I said, 'Oh, I did geometry — x, y and z axis,'" he recalled. But then he realized that it was not so simple: If Maillardet wanted the automaton to draw a straight diagonal line, for instance, he had to encode the cams to move the arm back while it was moving side to side — otherwise it would draw an arc.

"How do you think that through?" Mr. Penniman said. "Yes, you're a clockmaker, and yes, you've had that experience. But this is a lot more complicated."

Even more remarkable for Mr. Baron, the restorer in New Mexico, were the movements of the head and eyes, which are controlled by a couple of simpler cams.

"Maillardet could have had the head in a fixed position, the eyes in a fixed position," he said. Instead, when the automaton stops writing briefly as the cam stack shifts, the head comes up and the eyes turn up and gaze out for a few seconds, and then lower as the hand begins moving again.

"In this moment, he appears to his audience as if he's thinking about what is going to do next," Mr. Baron went on. "It's performance art."

Maillardet "created an illusion of life," he said. "That, to me, is the real magic."