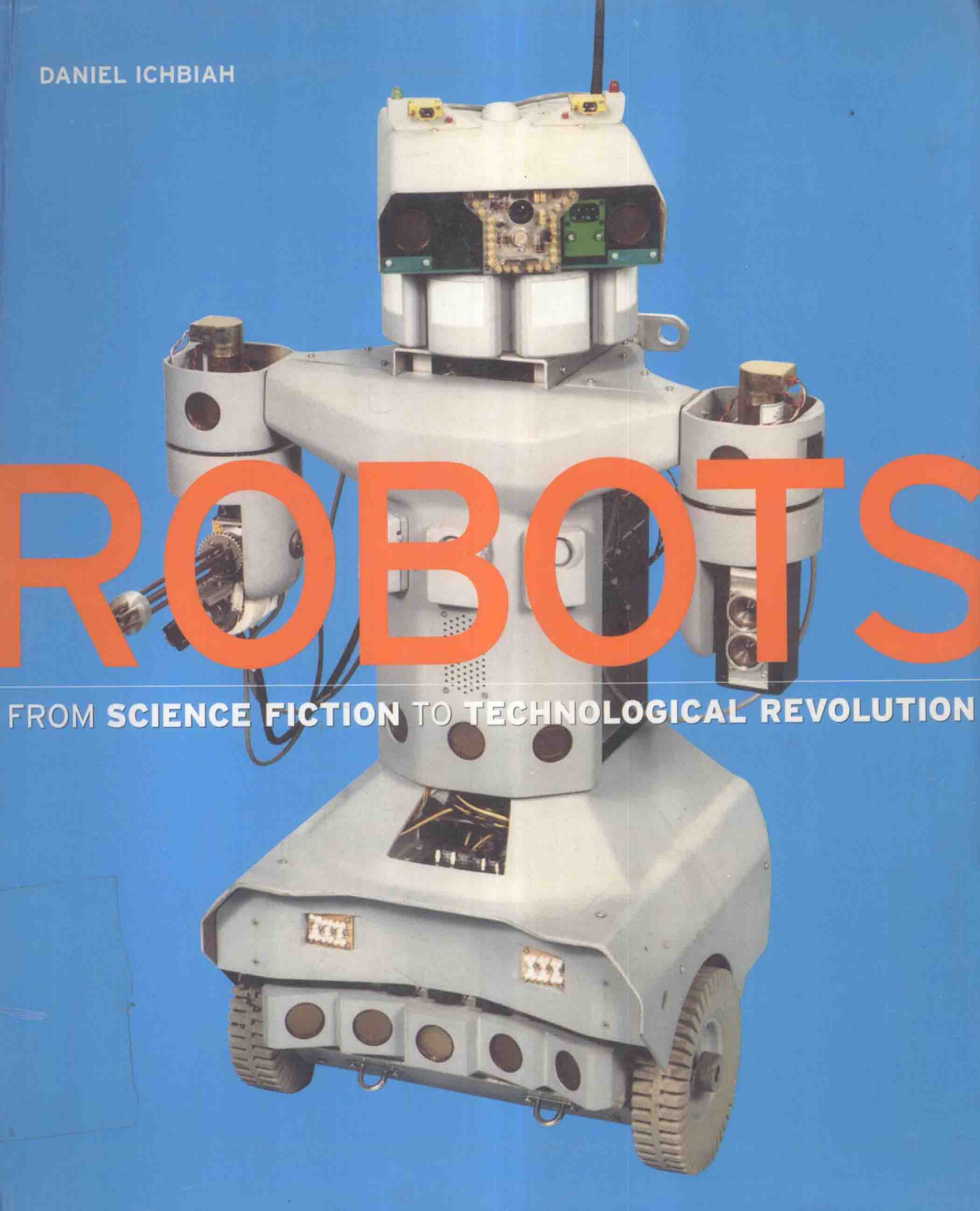
DANIEL ICHBIAH



ROBOTS

FROM **SCIENCE FICTION** TO **TECHNOLOGICAL REVOLUTION**

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From Science Fiction to Technological Revolution

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Translated from the French by Ken Kincaid

Harry N. Abrams, Inc., Publishers

Front cover: Autonomous security robot prototype Robart. Courtesy of Spawar. *Back cover:* (left and center) Robot toys. Collection of Jean-Pierre Hartmann. Photograph by Christophe Recoura. Courtesy of FYP Éditions. (Right) Sony's android, Qrio. © Courtesy of Sony

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Foreword

by Will Wright,
creator of the video games
Sims and *Sim City*

One of the deepest and most abiding interests of my adult life is robotics. I have been building various robot-related things since I was a teenager. So I feel honored to be given the opportunity to write the foreword to this book dedicated to robots.

I think that what really attracts me to robotics is the desire to more fully understand what it means to be human. Robotics and artificial intelligence are, fundamentally, attempts to model various aspects of ourselves. Until you have tried to build a functioning model of a human hand, it is impossible to appreciate fully what a marvelous mechanism it actually is!

A few years ago, in parallel with my video game programming activities, I started a small group of robotics enthusiasts. We would build interesting robots and take them into the street to see how average people would respond to them. One of the things that we are investigating is what happens when the lay person has an unexpected encounter with machine intelligence. It is a very enriching line of inquiry, because it enables me to explore what the social design of the intelligent machine might be. What's more, it raises primary problems that are not even considered in research laboratories. I want to see what happens when robotic devices are forced out of the laboratory into the world. What real problems do they actually encounter? Should they act like appliances? Or a pet? Or a person? There are a number of interesting robotics programs at universities around the world, yet the problem is that most of the prototypes they develop stay in their laboratories.

Over time, our definition of robots has constantly changed, and continues to constantly change. Intelligence was a clear-cut, well-understood concept until we started building thinking machines. Even when the

movie *2001, a Space Odyssey* came out in 1968, people walked out of the theater commenting, "I can't believe HAL could beat that guy at chess." The assumption was that chess required a high degree of intelligence and that the natural conversation that HAL engaged in was relatively easy. We have since found that the reverse is true. Our concept of what intelligence is has been altered by this realization.

As we solve problems and robotic machines enter our lives in relatively transparent ways, we will cease to think of them as robots. It is merely a question of time. They will submerge into our environment and gradually become invisible to us. Today, I do not talk about my car's "robot codriver," but about its navigation system. It does not occur to me that it is a robot.

The primary challenge facing robotics today is that of situational awareness. We can build very capable hardware that can perform useful tasks under human control. But the hard part in automating that control is giving computers the same level of awareness that the human has. Similarly, we can attach decent cameras to a robot and send the signal into a computer. But the ability to convert the pixel data into an accurate 3D world model seems to involve substantial real-world knowledge. We need to give our robots the ability to build better models of the real world.

Ironically, though, as we build robots that are, in some sense, models of ourselves, we begin to glimpse that one of the fundamental skills that we must learn to give them is the ability to build models of their own.

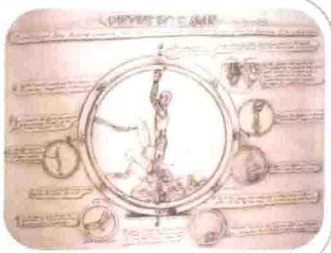
THE HISTORY OF ROBOTS

What exactly is a 21st century robot? It is a very powerful computer with equally powerful software housed in a mobile body and able to act rationally on its perception of the world around it.

Interestingly, the popular imagination naturally pictures robots in human likeness. Whether tall or tiny, they are necessarily androids. It is as if they embodied humankind's tireless search to create and control a double of its own making.

Man's quest to replicate living beings goes back thousands of years, constantly incorporating developments in technology, from hydraulic engineering and clockwork to electronics. To arrive at the thinking android of the 21st century, the robot has evolved through many a stage.

Chico MacMurtrie's kinetic Fetus to Man *sculpture and public clock is made up of a life-sized metal clock-jack. The human figure, or jack, are the hands of the clock, acting out a different stage in the cycle of life every hour. From a fetus in the womb at 6 o'clock, it slowly straightens up until it stands erect at 12. It then turns around to show a careworn face, and gradually bends under the weight of the years, before finally crumpling at 6 o'clock.* Fetus to Man *was installed on the facade of the Concorde building in the city of Lille in Northern France on December 6, 2003. It was commissioned to commemorate the city's stint as European Capital of Culture in 2004.*



Where do robots come from?

1- *Ctesibius's water clock. Ctesibius was a gifted, ingenious Greek engineer who lived in the 3rd century BC. He repurposed the* aulos, *a traditional double-reed woodwind instrument that was widespread at the time, making it into a clock driven by water.*

2- *Jacques de Vaucanson was born in the city of Grenoble, France, on February 24, 1709. He built uncannily lifelike automata, two of which,* The Duck *and* The Flute Player, *made him famous.*

3- *Born in 1721, the Swiss watchmaker Pierre Jacquet-Droz built mind-boggling automata. Three are celebrated to this day:* The Writer, The Musician, *and* The Draughtsman.

4- *Jean-Eugène Robert, known as Robert Houdin, was born in the central French town of Blois in 1805. He created dolls and automata such as* the Writer-Draughtsman.

5- *Czech writer Karel Capek was born in 1890. It was he who coined the word "robot," which first appeared in his most famous book,* RUR, *published in 1921.*

Ctesibius, Vaucanson and Walter are among those ingenious engineers who, over the ages, strove to create predictable, harmonious motion in objects of their own making. Fired by their fascination with machines that appeared to move of their own accord and so looked as if they were alive, they gave them human and animal form, repertoires of gesture and set sequences of motion. For thousands of years automata relied on springs, cogs and other mechanisms, exuding a grace that even today we still admire. Then information technology entered the picture in the shape of the revolutionary microchip, which could store huge quantities of data and sequences of movement. Robots had arrived, and so sophisticated have some become that they themselves can now seek solutions to problems.

Key stages in the history of robots are:

■ **The moving masks and statues of the Ancient World.** They performed "fake miracles" designed to put fear of the gods into the faithful.

■ **Timekeeping.** From the earliest water clocks and clockwork motive power of automata to the complex inner workings of computers and androids, high-precision timekeeping has been essential to robots at every stage in their history.

■ **The automaton.** The term is derived from the Greek, *automatos*, meaning "that which moves by itself." Early automata were mechanically actuated embodiments of man's infatuation with machines that resembled living beings and could accomplish one or more tasks. Unlike its successor, the robot, the automaton performed specific, predetermined tasks and was unable to respond to external stimuli.

■ **Informatics.** Informatics is the science of automated information management. It originated with Jacquard's weaving looms and gathered growing momentum with the emergence of electronics, the invention of the transistor and the development of computers.

■ **Artificial Intelligence.** The branch of computer science that seeks to reproduce the pattern of human thought processes—analysis of a situation giving rise to decision, then to action.

■ **First-generation robots.** Highly minimalist in design, they perform specific tasks like paint-spraying or welding in an assembly plant. Although they are electronically operated, they are similar to early automata in that they are intended to perform a single task and are devoid of all ability to perceive.

■ **Second-generation robots.** They are equipped with sensors that enable them to examine their surroundings through sight or touch. They then take appropriate action.

■ **Third-generation robots.** Robots of the third generation are the culmination of thousands of years of research. Their artificial intelligence enables them to reason and act with no outside help.

Those, briefly, are the main chapters in the life story of the robot. As to the meaning of that life, etymology provides a clue. When Czech writer Karel Capek first forged the term in 1921, he knew just what he meant. He coined it from the Czech word for work, *rabota*, to mean "servant, enslaved worker." The artificial being's fate was sealed. Indeed, what else is the robot, but man's auxiliary, the embodiment of his dream of developing a race of glad and willing slaves, happy to slog away at menial chores or soar into the skies on reconnaissance missions to space as part of man's unquenchable thirst to explore the unknown?

6- *William Grey Walter was a pioneer in the field of cybernetics. Born in the USA in 1910, he was educated and worked in the UK. It was there that his research into artificial intelligence led him to create two three-wheeled, turtlelike machines with plastic shells that were powered by telephone batteries. He endowed them with two "neurons," electric circuits that amplified and transmitted signals from sensors to two motors. The turtles were drawn to light, which they detected through dedicated sensors. However, if the light was too bright they would turn away.*

Masks and statues

The origins of masks and statues that move can be traced to ancient Egyptian times. An ibis-headed mask in the likeness of the god Thot, and one of the hawk-headed Horus both seemed to be endowed with lifelike motion. Their chief characteristic is that the automated mechanisms embedded within them were used by the priest caste to exert power over both the people and the pharaohs. The miracles that priests worked to awe their contemporaries were in reality the result of their skill in operating hidden mechanisms. Temple doors opened and the statue of the god Amon lifted its arm not because the oracle spoke, but—more likely—because the flames from the holy fire caused air to expand, so compressing water and causing it run, which, in turn, set a system of ropes and pulleys in motion. A similar explanation could well be behind the milk that seeped so mysteriously from the many-breasted goddess Artemis.

The first automata that were presented as such are thought to go back to around 380 BC. A friend of the great Greek philosopher Plato, Archtyas of Tarentum, is alleged to have made a wooden pigeon. According to some accounts, it flew in loops—a motion probably caused by jets of compressed air.

In 1781 the French abbot Mical made two talking heads, which were able to produce portentous utterances like "The king brings peace to Europe".

Clocks

Let us now turn our backs on seldom accredited phenomena that were either the product of trickery or the stuff of legend and turn to questions that exercised the minds of scientists of old. A fascination that exerted its hold as early as Antiquity was the regular flow of time.

From the constantly beating heart to the cycle of the four seasons that rolled on according to the position of the sun, the workings of the universe seemed to obey a rhythm. An early timepiece that emerged in response to the need to measure the passage of time at night and during the day was the clepsydra. It relied on the flow of water to keep time in an approximate manner.

Records take us back to 246 BC in our search for the first great time-keeping inventor—a certain Ctesibius, who lived in the city of Alexandria. He succeeded in creating a clock so accurate that a revolution of its dial took exactly one solar year. At last a perfect match had been achieved between a man-made timepiece and a phenomenon from the natural, physical world. But the genius of Ctesibius was not to stop there.

He followed up the water clock with a hydraulic music-making machine, an early forerunner of the street organ. The strange apparatus was operated by water running through a system of pumps, counterweights, valves and pistons that were connected to a dozen wind instruments, known as *aulos*. Hence the name given to the organ—*hydraulis*. Its renown spread swiftly to surrounding lands. During a stay in Asia Minor in 78 BC the great Roman orator and philosopher Cicero waxed ecstatic about the sounds the *hydraulis* produced, likening them to "a sweet delicacy". In Rome it became the in thing to show off at fashionable parties. On the other side of the world, in China, the same desire to bring objects to life had emerged.

Between 140 and 87 BC Emperor Woo converted a palace into an opera house complete with stage machinery actuated by acrobats, jugglers and tightrope-walkers to bring movement to a strange bestiary of animals from the natural and imagined worlds.

In the 14th century the carillon, or chime-clock, heralded the beginnings of mechanical music. It cleared the way for blade-operated musical movement, from singing birds to musical boxes. In 1865, one Charles Reuge settled in the village of Sainte-Croix, Switzerland, where he began to make musical pocket watches. In 1953 the Reuge company resumed the production of multi-melody musical movement.

© Reuge 1865 – Lépine Pocket Watch.
Left: Musical pocket watch with automaton-driven scene, The Fountain.
Above: The same model featuring an erotic scene on the back of the watch.

From Oriental automata to European clock-jacks

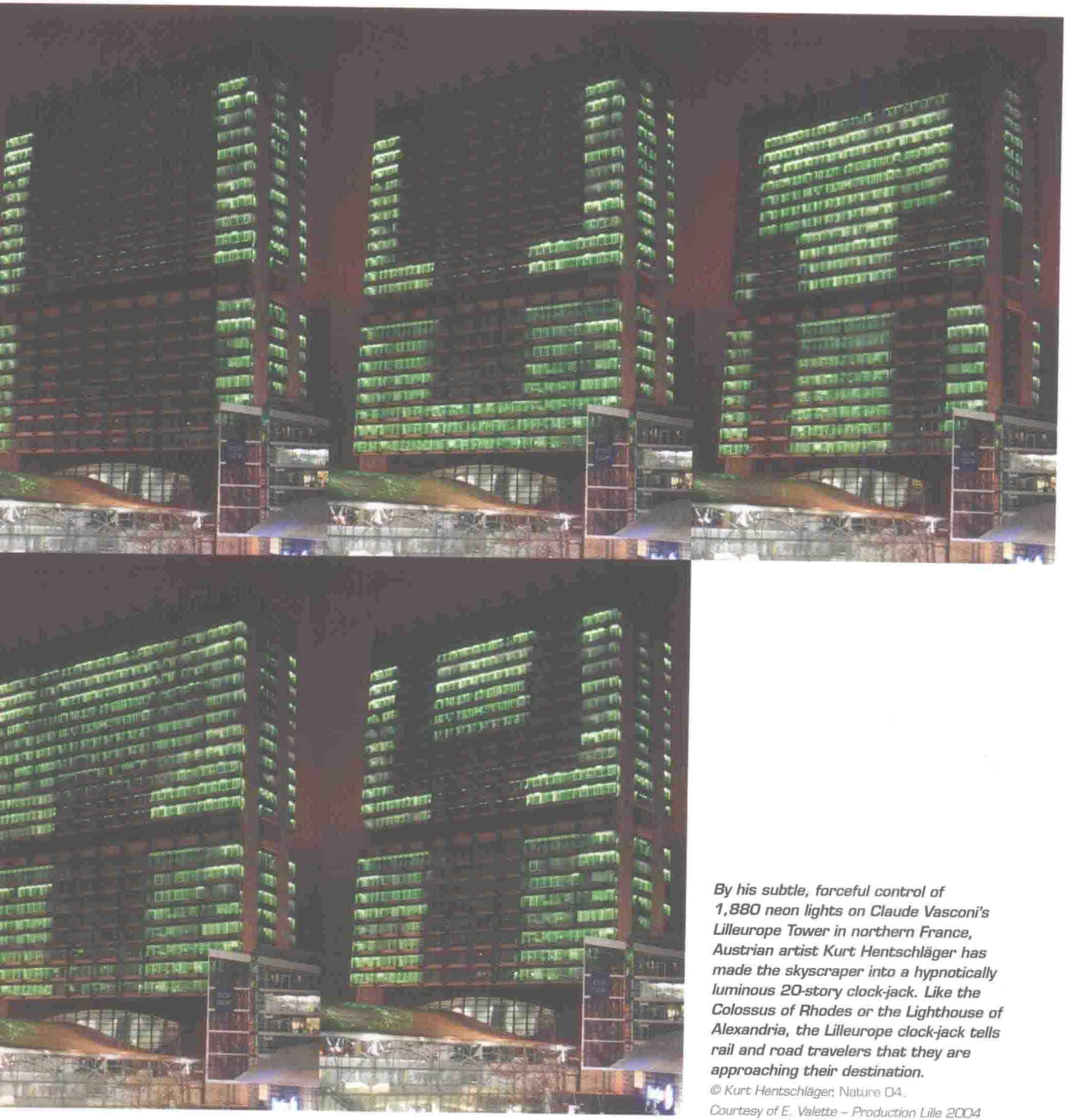
In the first century of our era a Greek mathematician and engineer, Hero of Alexandria, wrote a treatise on automata in which he demystified ancient miracles by explaining that mastery of hydraulics and physics had made them possible. Most important, however, Hero spelled out the fundamentals of automatic movement, i.e., the elasticity of steam and its capacity to drive movement when heat and pressure are applied.

Arab engineers were the first to put the teachings of Hero (and Philo of Byzantium) into practice on a large scale. In 809 the Sultan Harun Al-Rasheed sent a mechanical automaton to Emperor Charlemagne as a gift. Then in the course of their eight expeditions to the East between 1096 and 1291, the European Crusaders discovered for themselves the astounding refinement of the waterclocks crafted by Al-Jazari for Harun Al-Rasheed. There were birds that opened their beaks to drop marbles on cymbals, trumpet-playing musicians, and doors that opened to reveal human figures.

To secure the constant flow of water needed to animate the automata, Al-Jazari had developed a quite ingenious system, based on the discoveries of Archimedes. His largest clock was 3.3 meters high (11 feet) and 1.35 wide (4 feet 6 inches). Whether or not he was the inspiration for the clockmakers of France when the Crusaders returned home, the late Middle Ages saw a proliferation of spires and steeples topped with clock-jacks. These were human figures made from lead or cast iron, which struck bells to mark the time of day. Their chimes would echo across cities as people went about their lives and business.

The oldest such automated clock was made in 1351 in Orvieto, Italy, while some steeples, like that of Cluny Abbey in France, were stages for the enactment of entire clockwork scenes. An angel hailed the Virgin Mary and a dove symbolizing the Holy Ghost swooped down, while God the Father blessed his creation. Such feats of precision engineering were partly intended to awe the church-going faithful who, totally ignorant of clockwork mechanics, were dumbfounded.

Clock-jacks, Strasbourg Cathedral, France.



By his subtle, forceful control of 1,880 neon lights on Claude Vasconi's Lilleurope Tower in northern France, Austrian artist Kurt Hentschläger has made the skyscraper into a hypnotically luminous 20-story clock-jack. Like the Colossus of Rhodes or the Lighthouse of Alexandria, the Lilleurope clock-jack tells rail and road travelers that they are approaching their destination.

Toward the golden age of the automaton

By the time of the Renaissance automata had become commonplace toys and attractions in the homes of the well-to-do. A great many of them were hydraulically operated. The gallery of Hesdin Castle in the northern French region of Picardy, where the local gentry liked to sojourn, was home to stick-wielding automata that would give guests a drubbing and-or blow white powder into their faces. All to great amusement. Around 1500 Louis XII had a mechanical lion built. The creature could walk, stop and designate the royal coat-of-arms when the king ordered it to do so. It was a fair reflection of the inventive genius of French craftsmen of the time.

Nowhere, however, did automata enjoy such pride of place as at the royal residence at the château of Saint-Germain-en-Laye, to the west of Paris. The grounds held grottoes that were packed with hydraulic machinery, which the great Florentine engineer Thomas Francini designed and made for the sole entertainment of the upper classes. In 1598 René Descartes described the automata in his book, *Treatise on Man*: "Those who enter certain of the fountains' grottoes themselves cause, and without so realizing, the very movements that take place before them, for they may enter only by treading on certain tiles, which are so arranged as to make the bathing Diana, should they approach her, hide among the reeds; should they then proceed further in her pursuit, they will cause Neptune to come forth and to brandish his trident; should they seek to take another path, they will cause a sea monster to sally forth and to vomit water in their faces, or such similar things according to the whim of the engineer who made them."

Other descriptions mention a sea where fish frolic. A clap of thunder suddenly turns into stormy waves and the scene then changes to reveal the dauphin (the king's son) descending from on high in a chariot.

It was the 18th century that was to assert itself as the golden age of the automaton. One of the greatest inventors of things mechanical was King Louis XV's protégé, Jacques de Vaucanson (1709–1792). It was said that Vaucanson had a dream—to build an artificial man. He had, however, to content himself with making a mechanical duck, which