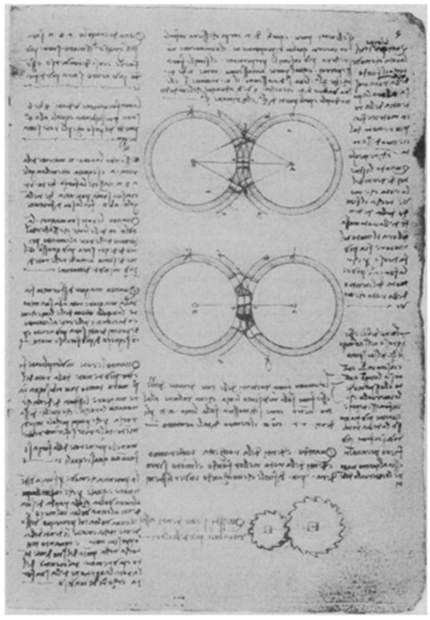
LEONARDO'S 'UNFINISHED SYMPHONY'



Newly published da Vinci manuscripts reveal broad musings and solid technology

by John H. Douglas

In conjunction with the publication of the Madrid Codices, *14 of the original manuscript pages are being displayed in the National Museum of History and Technology of the Smithsonian Institution in Washington until January. The exhibit includes working models of machines produced from Leonardo's drawings by* IBM.

Leonardo da Vinci remains one of the most enigmatic figures of history: "The more you know about him," writes Kenneth Clark, "the more mysterious he becomes." Now we know about 20 percent more; some 700 pages of notes and drawings, long considered lost, were rediscovered in Madrid's Spanish National Library in 1965 and have just been published in facsimile and English translation. The so-called *Madrid Codices* span the most productive period of Leonardo's life, 1491 to 1505, when the artist was about 40 years old. The publisher, McGraw-Hill, has simultaneously issued an interpretive volume of lively scholarship, *The Unknown Leonardo* (see listing in SN: 9/7/74, p. 146), which places the new discoveries into a historical perspective for the average reader.

As an artist, Leonardo stands tall in an age of giants: He painted the "Mona Lisa" about the same time Raphael was becoming established in Florence and four years before Michelangelo began to paint the Sistine Chapel. But he is remembered most for the versatility of his genius, his uncanny ability to produce great art while plumbing the secrets of human anatomy or designing machines whose usefulness would not be appreciated for centuries. Here the mystery deepens.

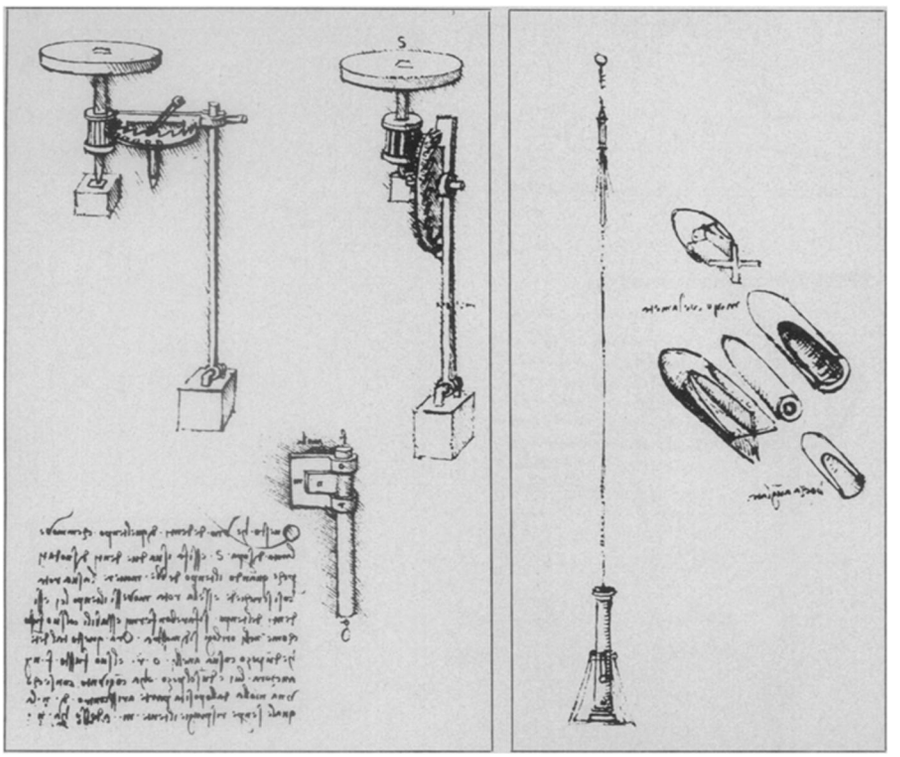
Leonardo's birth coincided with the development of the printing press and publication of the Gutenberg Bible. He left a larger written record than any artist who ever lived, discussing everything from the theory of painting to practical labor-saving devices for laborers—yet none of his works were published until a century and a half after his death.

As a scientist, he produced anatomical drawings and analyses unequaled until well into the 17th century. He said a cannonball would follow a parabolic trajectory—a discovery usually credited to Galileo in the next century. He intuitively understood, illustrated and described qualitatively what would eventually become the central theorem of hydrodynamics, announced by Daniel Bernoulli some 200 years later. Yet his ideas had almost no impact on the development of scientific thought, and the Encyclopedia Britannica dismisses his scientific researches as a "backwater in the history of science."

The *Madrid Codices* offer new insight into the magnitude of his work and contribute to a better understanding of how achievements that appear so startling to us could have been so long ignored.

The new manuscripts can be divided into three distinct parts. *Codex I* represents Leonardo's first draft of a proposed treatise on the science of mechanics, a kind of technical handbook, the most voluminous of his surviving notebooks. Usually the invention of the worm-gear is credited to an 18th-century English clockmaker, Henry Hindley, but a diagram in the recently uncovered manuscripts shows unambiguously that Leonardo thought of it first. Similarly, in the 20th century, when the Sperry Gyroscope Company needed a very-low-friction bearing for airplane instruments, their engineers came up with a design in which the conical end of a rotating shaft rests on a ring of ball bearings. After seeing pictures from *Codex I*, former Sperry President Preston Basset wrote a friend exclaiming that the modern gyro "is a dead-ringer of Da Vinci's sketch!" Indeed, so complete was Leonardo's mastery of mechanical devices that when French scholars at the École Polytechnique made what they thought was the first systematic list of machine elements, all but three of the twenty-two had already been drawn and explained nearly four centuries earlier in *Codex I*, and only one—the rivet—was not discussed anywhere by Leonardo. Of special historical importance is the discovery that Leonardo used pendulums as oscillators and mentions their use in clockwork. Galileo is usually credited with this discovery—after watching a chandelier swing during a church service.

Codex II is divided into two parts. The bulk of the volume represents the largest and richest sample of Leonardo's personal notebooks, filled with the sketches, thoughts and observations that flowed daily from his prodigiously

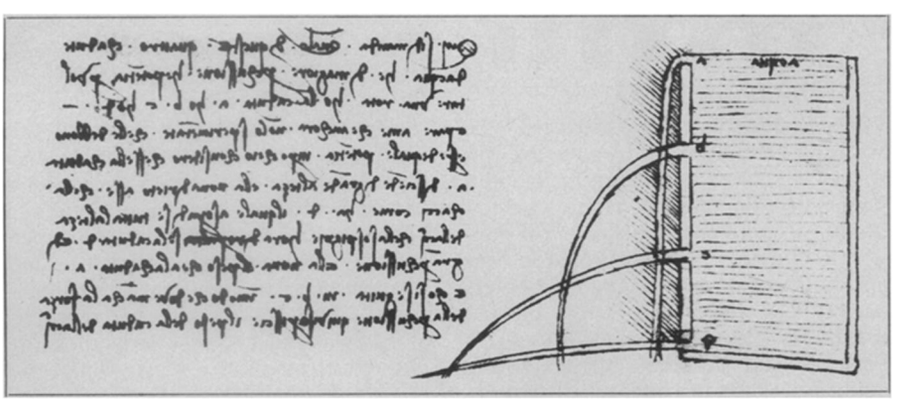


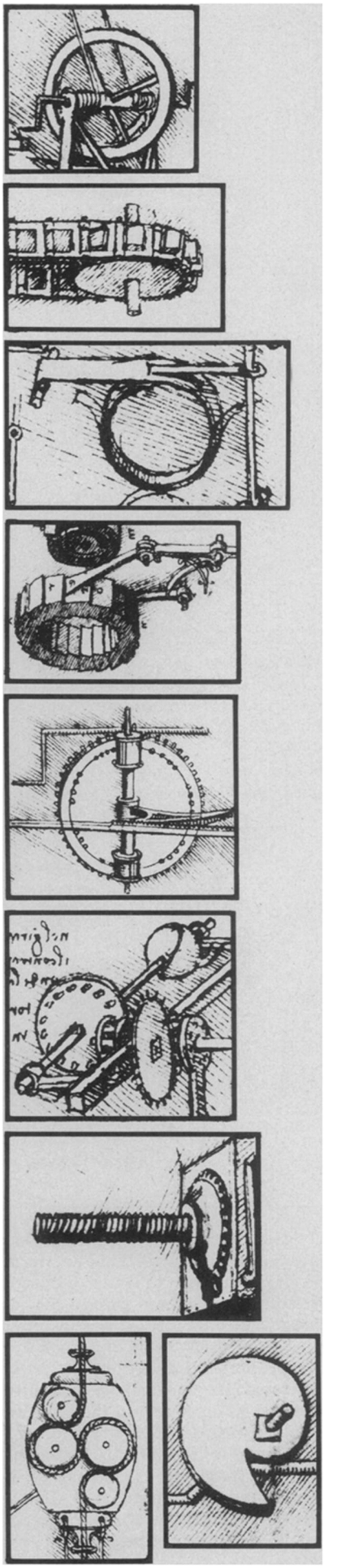
Leonardo designed pendulum regulated devices (left) long before Galileo and proposed a two-stage rocket and streamlined projectiles, including fins.

curious mind. He was always asking questions and answering them with detailed diagrams and explanations: How do waves move? He watched them and drew pictures of how they reflected, propagated and interfered. His accompanying description correctly stated the laws of their motion in qualitative terms —169 years before Christian Huygens formally enunciated them. Is perpetual motion possible? No, he concluded, and constructed a "mental discourse" of diagrams to prove it. How do birds fly? His sketches form a sequence of stop-action pictures from which he draws conclusions about wing configuration and body shape. How can musical instruments be better made to fit the hand? He dissected dead men's arms to see how the fingers moved, then designed keyboards for wind instruments to conform (the present flute keyboard was not developed until 350 years later).

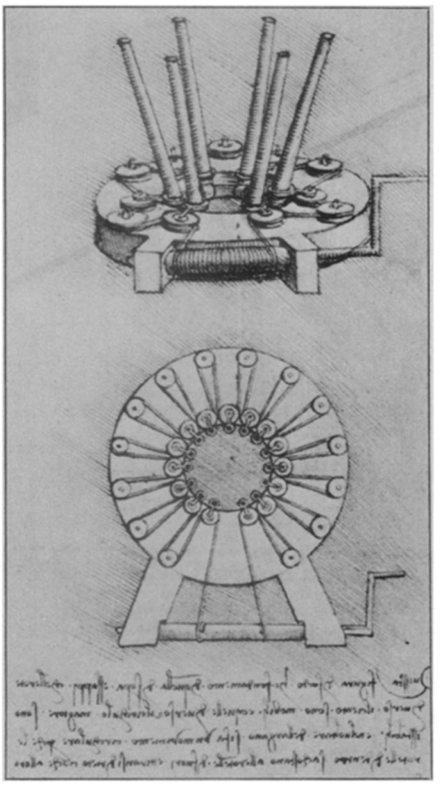
At the end of *Codex II* is a short section on Leonardo's plans to make a huge statue of Duke Francesco Sforza on his horse. In order to cast the 24-foot-high bronze statue, Leonardo had to invent an entirely new method of casting. The project would have been the largest of its kind—before or since —but suddenly war threatened; bronze was needed to make cannons, and Leonardo's clay model became a target for archery practice. His new casting method was first successfully used 200 years later to make a statue of France's "Sun King," Louis XIV.

Leonardo tried to use art as a language to express science and philosophy. Painting, he wrote, is "a most

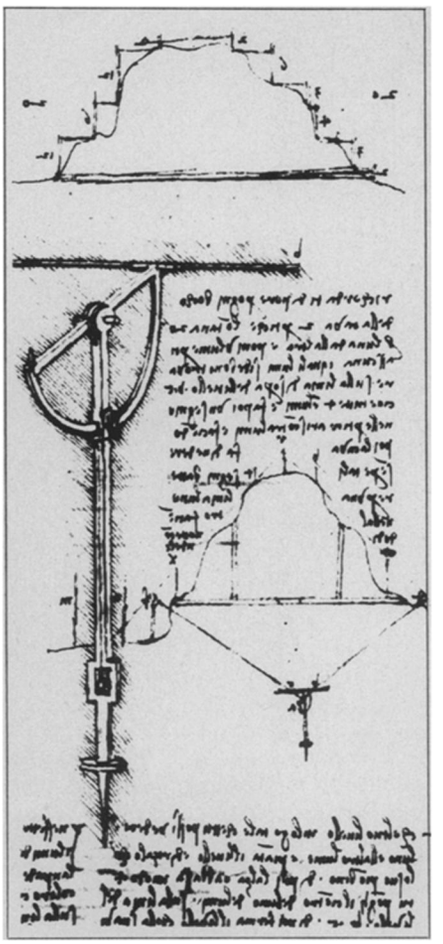




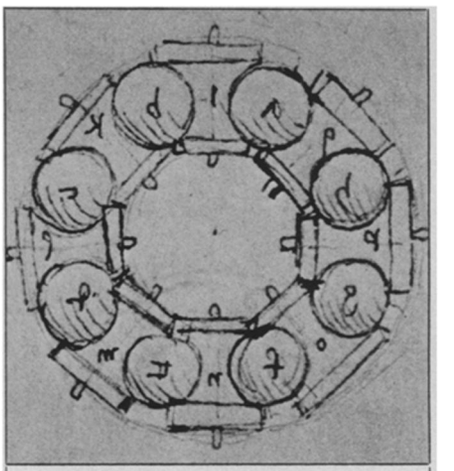
(Above) Leonardo's demonstration of fundamental hydrodynamics principle. (Right) Elements of machines from Madrid Codex I: (from top) flywheel, chain drive, brake, rachet, disengaging gear, pins and shafts, screw, belt-drive, cam. This list preceded a similar classification by French engineers by 300 years.

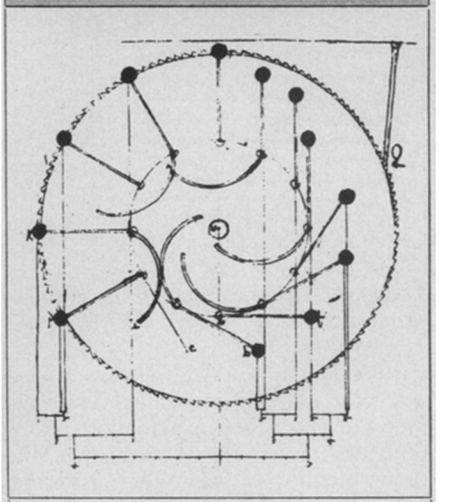


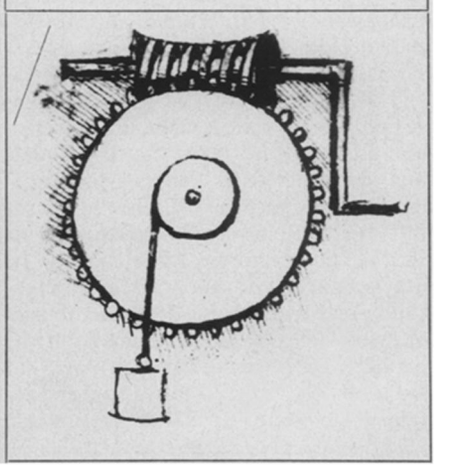
(Above) One of several labor-saving devices Leonardo designed—a textile machine. (Below) Leonardo's sketch of a new bronze casting method later used (right) in France. Lines indicate tubes to carry molten metal into mold, in which the horse is cast upside-down.



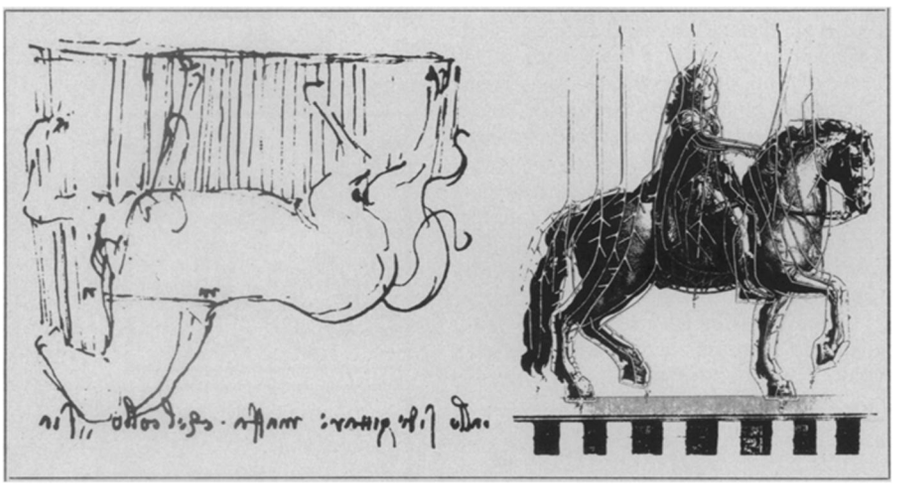
Design of tunnel through a mountain.







(Top to bottom) ball-bearing ring, disproof of perpetual motion, screw-gear.



subtle science which by philosophical reasoning examines all kinds of forms. . . . (It) is the true daughter of nature." Certainly no one ever carried the idea further, but ultimately it was his downfall. The illegitimate son of a small-town notary, apprenticed early into what was considered the low-calling of artistry, Leonardo never mastered the other two languages that, through the medium of print, were to revolutionize thought—Latin and mathematics. Though he discovered intuitively so much of what we now call science, including the experimental method of research ("Test it first and state the rule afterward," he wrote), Leonardo could not use his special language as effectively to influence scientific thought as his contemporary Copernicus could use the language of mathematics. Leonardo was also a humanist who sketched laborers in the field while other artists painted mainly nobles and saints. But his sketches and peculiar mirror writing could not shake the intellectual foundations of Europe as did the Latin essays of Erasmus and Thomas More, or the reformist tracts of Calvin and Luther —all his contemporaries.

Leonardo seemed well aware of this irony and feigned no modesty in condemning those who would ignore him: "Since I am not a man of letters, I know that certain presumptuous persons will feel justified in censuring me, alleging that I am ignorant of writing—fools!" The *Madrid Codices* reveal in stark detail what a legacy was thus lost, and other manuscripts may still come to light, further illuminating Leonardo's singular vision. Together they form what Vincian scholar Ludwig H. Heydenreich calls Leonardo's great "unfinished symphony." □