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Aimed at providing up-to-date information on gear drive design and application, this installment takes a look back in time... with some surprising revelations.

The June 2005 column covered standards development and highlighted ANSI/AGMA 6123-BXX "Design Manual for Enclosed Epicyclic Gear Drives." Because of the use of epicyclic arrangements in diverse applications including automatic transmissions, mill drives, and high-power wind turbines, the continual development and refinement of this standard is still occurring in one of the most active AGMA application committees.

Reported History of Epicyclic Drives

In discussing the new work on the epicyclic drive standard for the transmission of power, the gear arrangement was attributed to a 1781 patent by James Watt "for certain new methods of producing a continued rotative motion around an axis or centre, and thereby to give motion to the wheels of mills or other machines." It seems that now, after more research, I was a little off on early epicyclic gear use.

In 1901 the remains of a gear mechanism were found near the Greek isle of Antikythera in an old shipwreck. This artifact, now called the "Antikythera mechanism," is among the treasures of the Greek National Archaeological Museum in Athens. It was reported in the June 1959 *Scientific American* from the work by Derek J. de Solla Price—a British physicist and historian—under the title "An Ancient Greek Computer." A number of years passed before Price arranged for gamma-radiographs and, later, x-radiographs of the mechanism, in the 1970s. In "Gears Form the Greeks: The Antikythera Mechanism—A Calendar Computer from ca. 80BC" (1974) Price describes the mechanism being

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constructed as two separate gear trains connected via axles squared at the ends and held in place with wedges, one attached to a front dial and the other attached to rear dials. The mechanism was housed in a wooden box that was covered with inscriptions. It was comprised of 38 gears, ranging from 15 teeth to approximately 255 teeth, that appear to have been cut by hand from a single sheet of bronze 2.0-2.3 mm thick. The mechanism also appears to have been a device for calculating the relative motions of the sun, the moon, and maybe even the stars and planets.

Analogue Computer

The Antikythera mechanism has a complexity in advance of what we expect to see in an ancient device. Its uses of an epicyclic differential gear to adjust the motion of the sun and moon to produce the month and cycle phases of the moon represent the first

The Antikythera mechanism

known example of such gearing. A 1996 paper written by Rupert Russell states that "The full functions of the mechanism may never be known, but it appears certain that it displayed the position of the sun in the zodiac throughout the year as well as the phases of the moon. It was the requirement of displaying the phases of the moon based on the synodic month of about 29 ½ that necessitates a complex gear train to subtract the revolutions of the sun from those of the moon to produce the cycles of the synodic months." It was this requirement, along with the inscriptions and the dial settings, that led to an archaeological analysis that placed the Antikythera mechanism's construction in Rhodes between 87 and 82 B.C., and the shipwreck in about 80 B.C.

The AGMA Epicyclic Committee met recently to finalize the latest edition of the new standard. There is always new gear knowledge to obtain, or rediscover. Anyone interested in standards development projects is encouraged to participate in the appropriate committees. Detailed information is provided on the AGMA Web site [www.agma.org].

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