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On Sphere-Making: How a 2000-Year-Old Computer is Changing Everything

By Ellie Baker
Edmond, Oklahoma

In 1901, a group of Greek divers discovered a shipwreck from the first century BC off the island of Antikythera. The shipwreck contained Greek treasures of incredible historical value: amphorae, bronze and marble statues, and ancient coins. It also contained an unrecognizable lump of heavily corroded metal that was nearly thrown overboard. Little did the divers know that it was this corroded lump that would change our perceptions of Ancient Greek civilization forever— and prompt modern-day technology in a new direction.

After being rescued from the sea, the seemingly insignificant lump sat in a storehouse for months until an unnamed museum worker, noticing detailed markings on the visible parts of the object, brought it to the attention of the museum director, Valerios Stais. “Stais had never seen anything like this,” says science journalist Jo Marchant. “It was ancient clockwork” (Marchant 38). Not just any clockwork: through microscopic and X-ray analysis, researchers have found that the device, known now as the Antikythera Mechanism, contained 69 gear wheels of varying sizes, some of the teeth as small as 1 mm across (Freeth). This is so immensely far beyond the previously-known technological ability of the

Ancient Greeks that even well-known researchers doubted the evidence of their eyes, and conspiracy theories began to spring up:

> There were some only too ready to believe that the complexity of the device and its mechanical sophistication put it so far beyond the scope of Hellenistic technology that it could only have been designed and created by alien astronauts ... I must confess that many times in the course of these investigations I have awakened in the night and wondered whether there was some way round the evidence of the texts, the epigraphy, the style of construction and the astronomical content, all of which point very firmly to the first century B.C. (de Solla Price, 12).

The burning questions in researchers' minds when the mechanism was discovered were the obvious: What was it, and what was it for?

The fragments of the Mechanism are covered in tiny markings and inscriptions in Ancient Greek that reveal it was used as an astronomical device. Researcher and naval officer Periklis Rediadis interpreted the Mechanism to be a simple astrolabe, a primitive device used to find one's way at sea by determining the positions of the stars. Classicist Albert Rehm, who had access to more fragments, identified it as something far more complex: a planetarium. The Mechanism's gears represented the cycles of the stars and planets; turning the gear for Mercury, for example, would turn the gears representing the other planets analogously to how the real planets would move. This intricacy was made possible by the exact gear ratios in the Mechanism and the precision sizing of the gear teeth. But was the Mechanism merely a classroom model, or did it serve a more practical purpose?

Research by physicist and scientific historian Derek de Sola Price reveals that the Mechanism was, in fact, an astronomical calendar. Rather than showing the positions of the heavenly bodies relative to each other in a planetarium display, it displayed "the current stage in their cycles of motion as a kind of time referent" (Jones 41): in other words, relative to a certain date in the past or future. The Mechanism was designed to take an input of a certain date through a crank and output the positions of the planets, allowing users to predict the exact dates – and even colors (Jones 155) – of astronomical events such as solar eclipses. This new interpretation led Price to identify the Mechanism as an example of an early analog computer.

One of the most important events in Ancient Greece was the Olympic Games, or rather the Olympiad, a four-year cycle of game events that fall on specific dates following the patterns of the planets. A study done by the Antikythera Mechanism Research Project states that an "upper subsidiary dial [of the Mechanism] is not a 76-year Callippic Dial as previously thought, but follows the four-year cycle of the Olympiad and its associated Panhellenic Games" (Freeth et al. 1). This suggests that the Mechanism was built not only as a general astronomical calendar, but to predict in advance the dates for societal and religious events dependent on astronomical cycles.

Historical evidence suggests that the Antikythera Mechanism was not the only one of its kind. In his book *De Natura Deorum*, "On the Nature of the Gods," the Roman orator Marcus Tullius Cicero mentions a "sphere, which was lately made by our friend Posidonius, the regular revolutions of which show the course of the Sun, Moon, and five wandering stars [the five classical planets]" (Cicero 76). Research suggests that Archimedes' lost work *On Sphere-Making* might have contained instructions on how to build similar mechanisms. The Antikythera Mechanism was very likely not a lone work of technology. There may have been dozens of similar devices, a network of advanced technology across the Hellenistic world.

The discovery of the Antikythera Mechanism has radically changed the academic community's perception of Ancient Greece. Previous knowledge of Hellenistic civilization has portrayed the Ancient Greeks as a society interested in knowledge for its own sake, but seldom putting it to practical use outside architecture and art. Several cautionary Greek myths involving technology, such as the story of Daedalus and Icarus, have even painted the Ancient Greeks as "tech-pessimists" (Pethokoukis). Nevertheless, the intricacy of the Mechanism is proof that Hellenistic technology was far more advanced than once believed, and shows that the Greeks did indeed put their advanced knowledge of the heavens to physical use, turning the modern world's conception of ancient Greek civilization on its head. But what does the Antikythera Mechanism mean for the future?

There are historically two main types of computers: digital and analog. Examples of digital computers are the vast majority of technology used today, from smartphones to laptops. Digital computers work by encoding data into binary, using strings of transistors in different states. An "on" transistor represents a 1, while an "off" is 0. Inside a digital computer, there is no "analog" for the number being stored: there is no physical "2"of something stored inside the computer. Instead, there are two transistors, one on and one off, *digitally* representing the number "2" in binary.

Analog computers, on the other hand, store information as an *analogy*. The Antikythera Mechanism, for example, stores information about the revolution of the planet Venus as an analogy in the gear representing Venus. For every movement of the planet in question, its corresponding gear moves a certain distance. Inside the Mechanism there is a physical analog of the number being stored, rather than a digital representation.

Although the Antikythera Mechanism is by far the oldest known example of an analog computer, there have been many throughout history. In the 1870's Lord Kelvin invented the first tide-predicting machine, which used gears and pulleys to analogize the factors contributing to the ocean's tide (Monahan). Another famous example is the Norden Bombsight, developed for the US Navy by Carl Norden in 1932. Although it "gave American forces bombing accuracy unmatched by any other nation at the time" ("Norden M-9 Bombsight"), the bombsight's intricate analog innards were too easily upset, leading to large miscalculations, and with the invention of solid-state transistors, more reliable and easily mass-produced digital computers quickly became the norm.

However, analog computing might be making a comeback. As the size of modern transistors approaches the limits of Moore's Law, analog computers are being revisited and recognized for their speed and energy efficiency. Smaller companies like Mythic are already on a mission to create analog chips for special uses, including artificial intelligence. Not only is analog faster and more efficient, making it the perfect engine for the neural networks of AI, but, as *Wired* journalist Charles Platt says, "Reality really is imprecise, no matter how much I would prefer otherwise, and when you want to model it with truly exquisite fidelity, digitizing it may not be the most sensible method.” In other words, even the imprecise aspects of analog may contribute to a more faithful imitation of reality.

Old does not mean outdated, and sometimes, to create the future, we have to go back to the past. The genius of these forgotten Greek engineers, and the design of the mysterious Mechanism they built, are still changing the world over two thousand years later.

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