the institute The IEEE news source

https://spectrum.ieee.org/history-lesson-the-magnetic-compass

A History of the Magnetic Compass

This navigational instrument led to advances in trade, military might, and science

By JOHN VARDALAS 8 November 2013

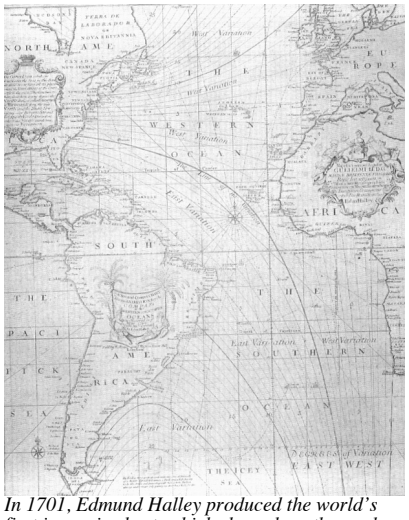
Inhospitable as it can be, the sea has played an essential role in human history, and so did that indispensible navigation tool, the magnetic compass. The sea provided the cheapest way to move goods over great distances, generating wealth through trade. Navigating the oceans successfully also played a pivotal role for many countries in gaining political and military power. Along the way, the compass contributed to innovations in physics and electrical engineering.

Far from the sight of land, the sea is a seemingly endless, undifferentiated expanse. For most of history, getting lost at sea was a very real danger, often with disastrous consequences. Even when close to land, seafarers can become disoriented in bad weather. For ancient Greek and Roman sailors, weather conditions even limited visibility enough to shorten the sailing season in the Mediterranean Sea. The Roman military writer Publius Flavius Vegetius wrote in the fourth century that travel from June to mid-September was safe, but that sailing any other time was risky. He called the period between mid-November and mid-March *mare clausum*, or the time when "the seas are closed."

Seafarers adhered to these guidelines until the early 14th century, when the magnetic compass made its first appearance in the Mediterranean. No longer completely dependent on landmarks, the mariner could now find his position relative to Earth's magnetic field. With the Mediterranean now "open" for most of the year, trade increased substantially, which contributed to the rise of the Italian city-states.

FIRST APPEARANCES

Though the behavior of lodestone, a naturally magnetized piece of the mineral magnetite, was observed by the ancient Greek philosophers Thales of Miletus and Socrates, the evidence is clear that the idea for using it in a compass first appeared in China. There are allusions in the manuscript *Wu Ching Tsung Yao*, written in 1040, to "an iron fish" suspended in water that pointed to the south. And the earliest reference to a magnetic direction-finding device for land navigation is recorded in a Song Dynasty book dated to 1040-44.



In 1701, Edmund Halley produced the world's first isogonic chart, which shows how the angle between magnetic north and true north varies at different points in the Atlantic Ocean.

Photo: IEEE

In 1088, Song Dynasty scholar Shen Kuo wrote that when "magicians rub the point of a needle with lodestone, then it is able to point to the south...It may be made to float on the surface of water, but it is then rather unsteady...It is best to suspend it by a single cocoon fiber of new silk attached to the center of the needle by a piece of wax. Then, hanging in a windless place, it will always point to the south."

In Europe, the magnetic compass first appeared in Amalfi, Italy, around the turn of the 14th century. But it is not known if the magnetic compass was also invented in the West or if it migrated to Europe along trade routes from China. However, it is clear that because sea trade and military advantage were of far more strategic importance to Western nations, they pushed the technology of the magnetic compass far more intensely than did the Chinese. With the successive rise of the Portuguese, Spanish, Dutch, and English empires, development of the compass shifted to the European nations facing the Atlantic Ocean.

The biggest challenge raised by the compass was what we now call magnetic variation: the angular difference between geographic or "true" north and the magnetic north, or the direction in which a magnetized needle points. Under clear skies, one could find the geographic north-south axis for comparison with where the compass pointed by either referring to the polestar or looking at the sun at noon.

Across the Mediterranean, the difference between geographic north and magnetic north was relatively small. However, in the Atlantic, particularly in the northern latitudes, the difference was considerable. If this difference had been constant, there would be no problem, but it varied greatly as one traveled east to west. During his first voyage to North America from Spain in 1492, Christopher Columbus observed this mysterious behavior, but he kept it from his crew, fearing it would spook them.

FURTHER DISCOVERIES

Beginning in 1698, with the support of England's Royal Society and the Admiralty, Edmund Halley, who would later be named the country's Astronomer Royal, set out on several long expeditions to measure Earth's magnetic variations across the northern and southern regions of the Atlantic Ocean. This data offered great advantage to the English Navy. In 1701, Halley produced the world's first isogonic chart, which shows how the angle between magnetic north and true north varies at different points in the Atlantic Ocean [see photo].

The study of magnetism set the stage for work in electrostatics. And the compass also served as a scientific instrument. With it, Danish physicist Hans Christian Ørsted observed in 1820 that an electric current from a battery flowing through a wire produced a magnetic field. This important discovery in electromagnetism paved the way for telegraphy.

In 1831, English scientist Michael Faraday showed that moving a conductor in a magnetic field produced an electric current, leading to advances in electric power generation. **James Maxwell (http://theinstitute.ieee.org/technology-focus/technology-history/did-you-know-someone-else-wrote-maxwells-equations)** combined the electric and magnetic phenomena in a set of elegant field equations. Heinrich Hertz's discovery of radio waves, a type of electromagnetic radiation, set the stage for wireless telecommunications. This great chain of discoveries and inventions was set in motion by the seafarer's compass, the tool that made it possible to voyage across Earth's inhospitable seas.

*The **IEEE History Center (http://www.ieee.org/about/history_center/index.html)**, which contributed this article, is funded by donations to the **IEEE Foundation (https://www.ieee.org/organizations/foundation/)***