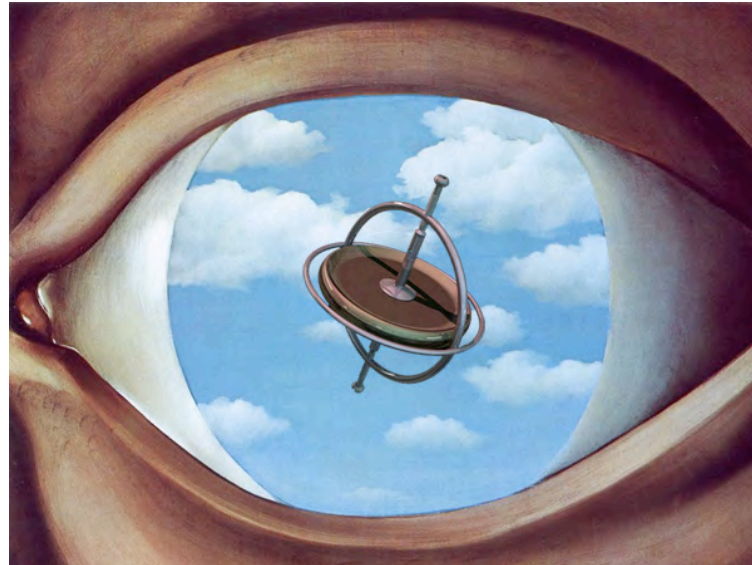


On the Late Invention of the Gyroscope



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Why an APS Talk on Gyroscopes?

Gravity Probe B: most expensive spinning top

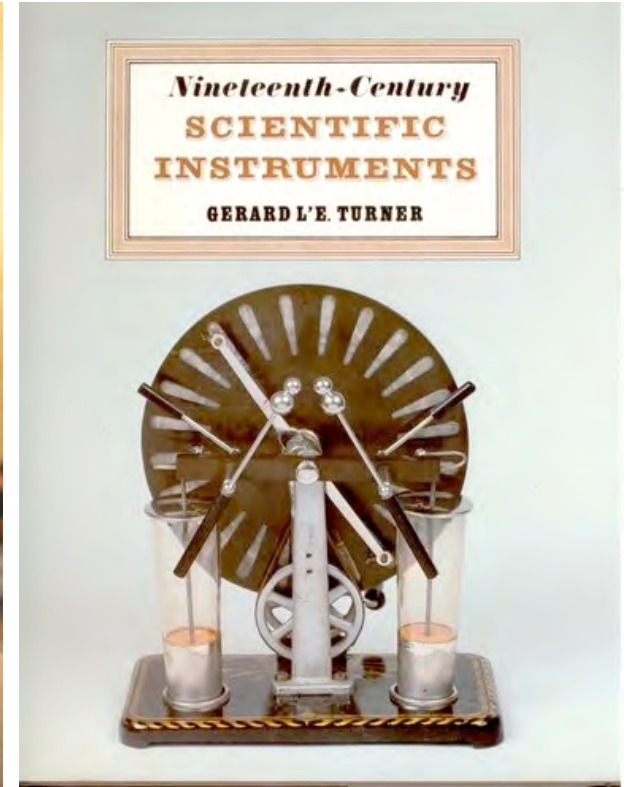
Cell phone gyroscopes: their new ubiquity

Physical gyroscopes in education (and in play)

2012 (+/-): Bicentennial of its actual invention

KB visit to Paris Musée des Arts et Métiers

Standard History of the Gyroscope



Gyroscope at the Musée des Arts et Métiers in Paris (c.) where it says “invented by J. B. L. Foucault (l.) in 1852”. Textbooks & books on early scientific instruments - e.g., by Gerard L’E. Turner (r.) - usually state this as a fact.

Actual Invention of the Gyroscope



The gyroscope (which he called “the machine”) was invented by German physicist (l.) J. G. F. Bohnenberger (University of Tubingen) ca. 1812 (first paper 1817). The example in the center is ca. 1813 (found in the Tubingen Kepler Gymnasium in 2004). The one on the right is ca. 1850. It was well known in France & Germany by 1852.

Early 19th Century Gyroscopes

Basic Components:

Freely rotating central mass (sphere or disk)

Gimbal rings (one, two or three)

Support structure

When did individual components first appear?

Brief History of Spinning Tops

Rotating masses in the form of tops, yo-yos and other toys go back to antiquity. Plato (ca. 400 BC) wrote about them, as did Virgil (ca. 50 BC). (Note also: spindles & millstones.)



Spinning top from the tomb of Tutankhamun ca. 1300 BC (l.); image of a yo-yo on a Greek bowl ca. 500 - 450 BC (c.); child playing with a top in a Breughel painting ca. 1560 (r.).

Brief History of “Cardan” Gimbal

Gimbals were discussed by Greek inventor Philo of Byzantium (280 – 220 BC). In Han Dynasty China, a gimbal incense burner was invented by Ding Huan around 180 AD.

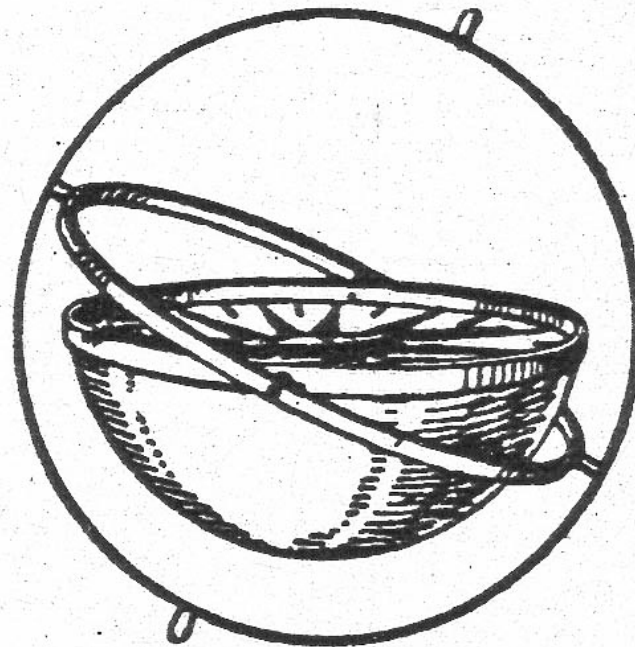


Illustration from 1280 AD of the Cardan gimbal (l.) – named for Gerolamo Cardano (1501 - 1576) who was the first to write extensively about it. Suspended compass from 1570 (c.). 21st century gimbal application (r.).

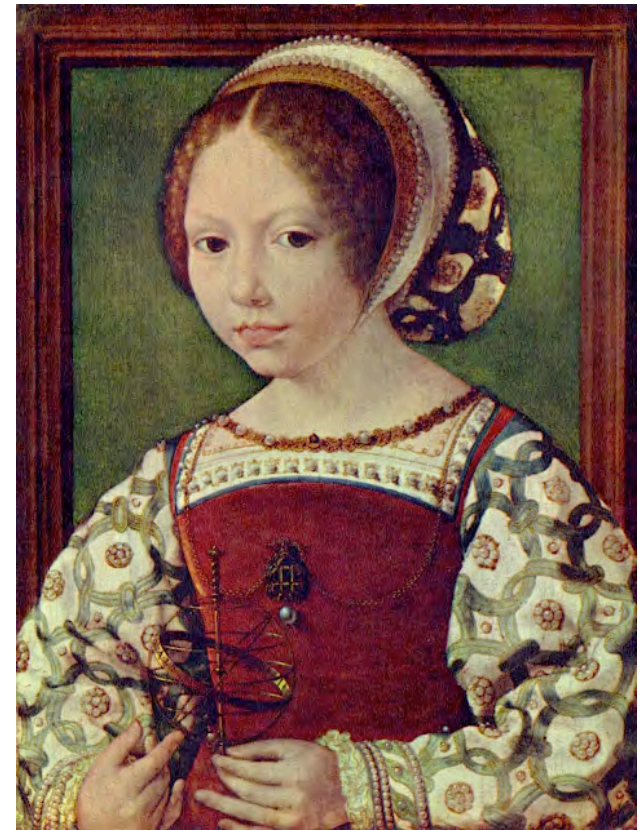
Brief History of Armillary Spheres

Though they are discussed as early as the 2nd century BC, no examples survive from earlier than about 1500 AD.



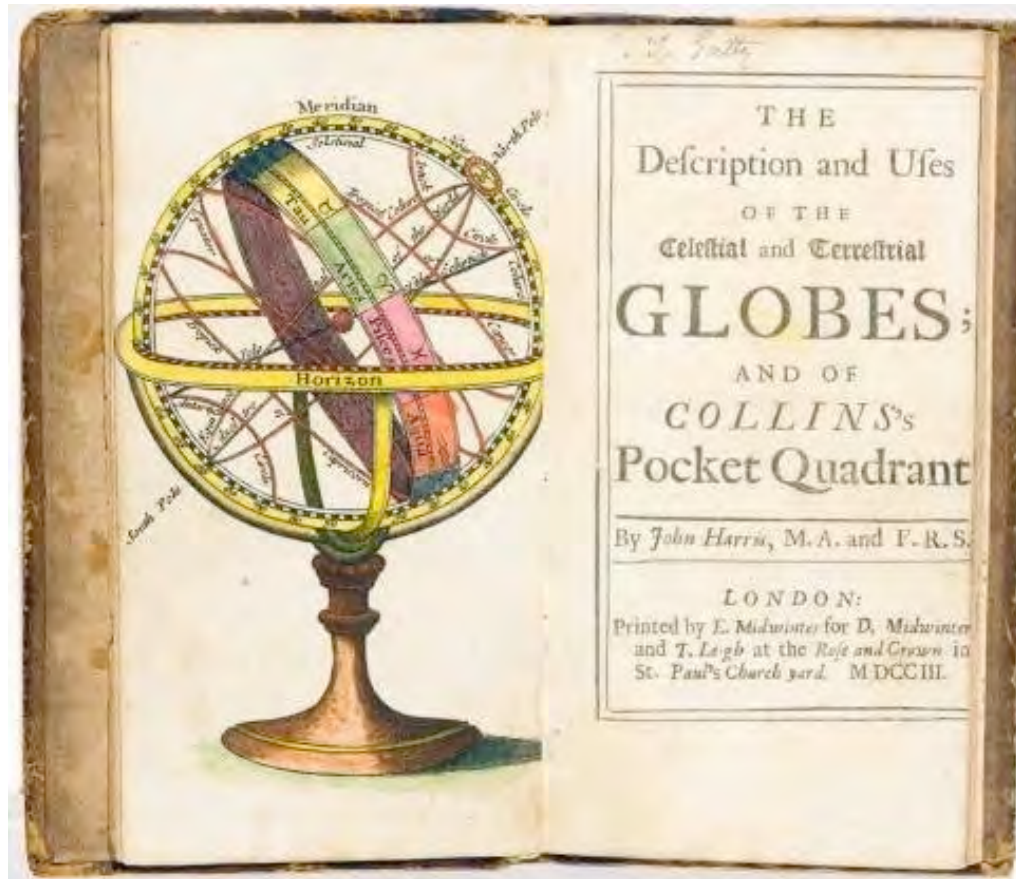
Armillary sphere (l.) ca. 1450, based on Ptolemaic solar system model. Armillary sphere (c.) 1543. Modern reproduction of 16th century armillary sphere (r.)

Armillary Spheres in Early Art



Fresco entitled “Saint Augustine in His Study” by Sandro Botticelli (1480) (l.) Ptolemy and Armillary Sphere in the Urbino Gubio (1476) (c.). “Portrait of a Young Girl” by Jan Gossaert ca. 1520 (r.). There are many other examples in paintings beginning in the 15th century and in illustrated manuscripts much earlier.

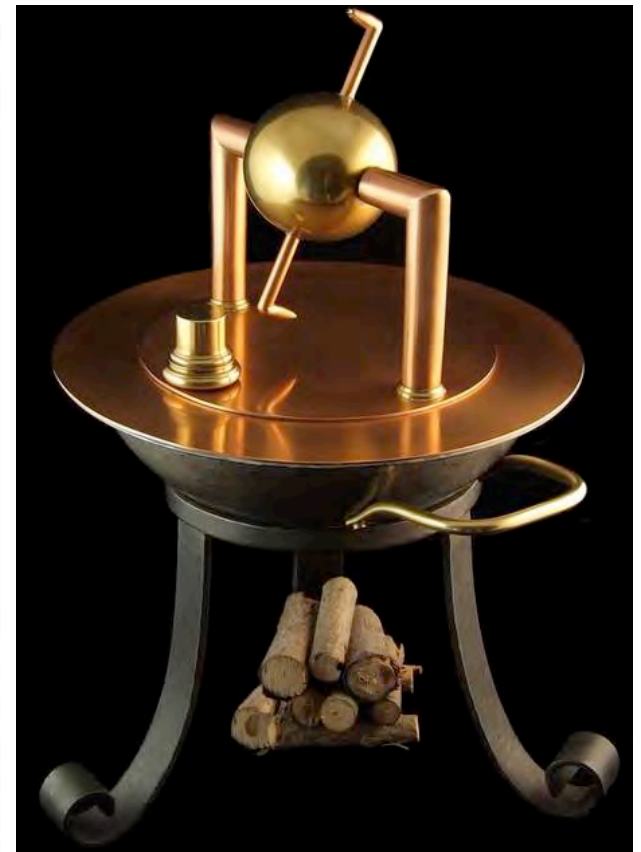
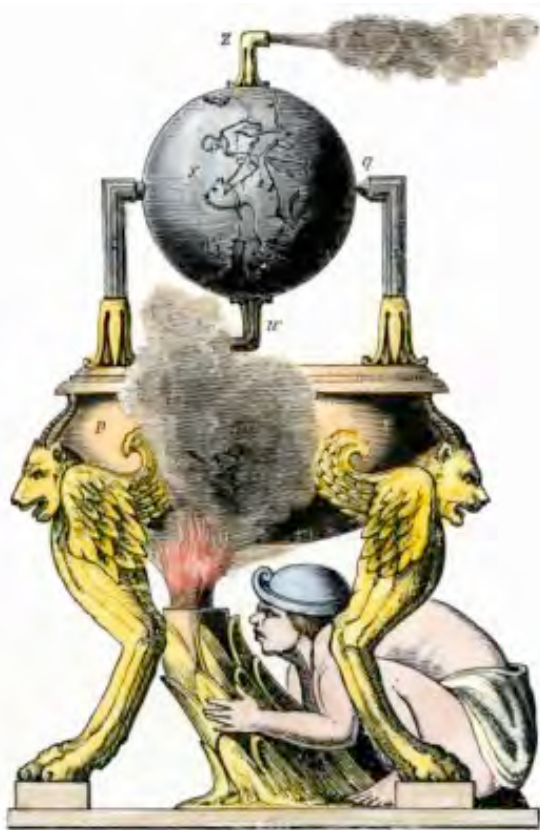
Armillary Sphere Images in Books



This is a lecture demonstration book from 1703 with a frontispiece illustration of an armillary sphere. Armillary spheres continued to be made and used for teaching through the 18th century.

Early Complex Rotating Machines

There are several examples of ancient rotating machines about as complex as the gyroscope. A good example is the steam engine devised by Hero of Alexandria around 50 AD.



Modern reproductions and a sketch of Hero's aeolipile (steam engine).

Armillary Spheres and Gyroscopes

Early gyroscope, globe and armillary sphere:



Bohnenberger style gyroscope (l.) ca. 1850; Vermeer painting “The Astronomer” (c.) 1668; French armillary sphere (r.) ca. 1770.

Question: Didn't anyone ever spin the central ball in an armillary sphere or globe and notice and think about its inertial properties?

What is the Point of Gyroscopes?

Scientific measurements and demonstrations:

Test the properties of inertial space (GP-B)

Demonstrate the rotation of the Earth

Practical (engineering) applications:

Find the horizon in cloud-covered conditions

Inertial guidance (gyrocompass) – satellites, ships, airplanes

Stabilization of ships

So Why Was It Invented So Late?

Some Possible Reasons:

To show inertial properties of space - demonstrations and science museums only developed in 18th & 19th centuries.

Earth's rotation: without electric motors, gyroscopes spin for < 10 minutes, not long enough for a good demonstration.

Theoretical concepts like angular momentum (and its conservation) only developed in the 19th century.

Applications of gyroscopes require electric motors and low friction bearings - not available until the early 20th century.

Hindsight is 20/20. Why was the bicycle invented so late? (It was invented in Germany ca. 1817 and France ca. 1818.)

A New Bohnenberger Machine



Randy Rhine (with KB) 2012

Acknowledgments

Many thanks to the artist/craftsman Randy Rhine for fabricating the 21st century version of the Bohnenberger gyroscope that is shown in the talk.

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