

Tides, moonlight, machines, and D-Day

Bruce Parker's article in the September 2011 issue of *PHYSICS TODAY* (page 35) presented a clear and thorough account of the important role of tide predictions for the Normandy invasion on 6 June 1944. The exceptionally rapid rise of the water level that morning meant that the engineers had only a short time to blow up beach obstacles while they were exposed just after low water. We can verify Parker's statement that the water-level rise was "at least a meter per hour—perhaps even faster due to shallow-water effects."

Our calculation of the tide curve for the Normandy coast near Omaha Beach includes shallow-water constituents and gives a rate of rise of 1.5 meters per hour while the demolition teams were struggling to blow up the beach obstacles; the rate of rise exceeded 1.9 meters per hour shortly thereafter.¹

Perhaps less clear is Parker's comment about the time of moonrise. Parker states that the paratroopers needed to see their drop zones during the preceding night and therefore "there had to be a late-rising Moon."

According to our astronomical calculations for Omaha Beach (49°22' N, 0°52' W), the Moon had risen about 1.5 hours before sunset on the preceding day (5 June). It then arced across the sky during the night of 5–6 June and reached its highest point for that night just as the airborne assault began, about five hours after moonrise.¹ We calculate that moonrise on 5 June occurred at 18:33 Greenwich Mean Time (GMT), that sunset at 20:04 GMT marked the beginning of civil twilight, and that the period of brightest moonlight fell near 23:22 GMT. Our calculations agree well with the approximate times determined by reading down the left edge of the official 1944 tidal and illumination dia-

gram reproduced as Parker's figure 4.

General Dwight Eisenhower later explained that the Allied forces "wanted a moon for our airborne assaults,"² and Winston Churchill agreed that "moonlight . . . would help . . . our airborne troops."³ Brigadier General James Gavin of the 82nd Airborne gives an eyewitness account. As his C-47 military transport aircraft approached a drop zone west of Sainte-Mère-Église, Gavin could clearly see that "the roads and the small clusters of houses in the Normandy villages stood out sharply in the moonlight."⁴

References

1. D. W. Olson, R. L. Doescher, *Sky Telesc.* **87**(6), 84 (1994).
2. D. D. Eisenhower, *Crusade in Europe*, Doubleday, Garden City, NY (1948), p. 239.
3. W. S. Churchill, *Closing the Ring*, Houghton Mifflin, Boston (1951), p. 591.
4. J. M. Gavin, *Airborne Warfare*, Infantry Journal Press, Washington, DC (1947), p. 57.

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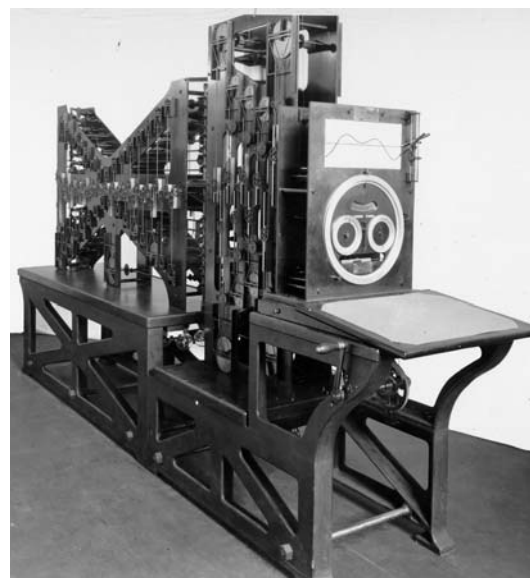
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■ **I'll bite. What did happen** to those beautiful brass tide-predicting computers Bruce Parker mentions? Presumably they didn't get bombed, and certainly they are no longer needed. Were they sold for scrap, placed on display, or retired to the back attics of their institutes?

Damned good article. Thanks!

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■ **Parker replies:** The two American machines are in the Washington, DC, area. The Harris machine (see photograph), used to make the tide predictions for the North African and Pacific campaigns, is on the National Oceanic and Atmospheric Administration's campus in Silver Spring, Maryland. That machine is still operational, at least in that the pulleys and gears move; for an accurate tide prediction it would probably need recalibration. The Ferrel tide-predicting machine is in the Smithsonian's National Museum of American History in downtown DC.



The Harris tide-predicting machine, constructed around 1910 and retired from service in 1965. (Courtesy of the National Oceanic and Atmospheric Administration.)

The two British machines used by Arthur Thomas Doodson at the Liverpool Tidal Institute are in the Merseyside Maritime Museum in Liverpool.

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Correcting the Coriolis correlation

From the letter by Christopher Graney (*PHYSICS TODAY*, August 2011, page 8) I learned that 16th-century Italian scientists Giovanni Riccioli and Francesco Grimaldi were apparently aware of the Coriolis effect nearly two centuries before Gaspard-Gustave Coriolis. However, the description of the effect and the diagram reproduced from their book are only half correct.

For an object moving horizontally with a given speed, conservation of angular momentum, seen from a rotating planet, results in the same amount of deflection regardless of the object's direction. Contrary to the assertion by Riccioli and Grimaldi, a cannonball fired eastward in the Northern Hemi-

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sphere will be deflected to the right—southward—by the same distance as its cousin fired northward is deflected eastward. (In the Southern Hemisphere, both will be deflected to the left.) Therefore, it would have been impossible for Riccioli and Grimaldi to determine whether Earth rotates by comparing the deflection of cannonballs fired in different directions.

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■ **The first two letters** in the August 2011 issue of PHYSICS TODAY (page 8), on Georges Lemaître's Hubble relationship and on the Coriolis effect, have more in common than being printed on the same page. Two scientists highlighted in the letters were Catholic priests. Lemaître was a Belgian priest and Giovanni Riccioli an Italian Jesuit.

The science described in the letters—the expansion and fate of the universe and Earth's motion—bears on matters important in the history of science and religion, so it seems worthwhile to point out the other vocation of the two men.

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Einstein, too, miscredited Hubble's "discovery"

The letter by Michael Way and Harry Nussbaumer (PHYSICS TODAY, August 2011, page 8) refers to Edwin Hubble's "discovery" of the expansion of the universe as one of the "falsehoods still being promoted today" by "prominent people writing in the popular press." I note that the same story was also promoted early on by Albert Einstein. I found the following in his *Relativity: The Special and the General Theory* (Random House, 1961), which I had just finished rereading when my issue of PHYSICS TODAY arrived. In appendix 4, apparently written sometime before June 1952, Einstein writes about the impact to his general theory of the discovery of the nonstatic nature of the universe. After a discussion about Alexander Friedmann but no mention of Georges Lemaître, Einstein says,

A few years later Hubble showed, by a special investigation of the extra-galactic nebulae ("milky

ways"), that the spectral lines emitted showed a red shift which increased regularly with the distance of the nebulae. This can be interpreted in regard to our present knowledge only in the sense of Doppler's principle, as an expansive motion of the system of stars in the large—as required, according to Friedman, by the field equations of gravitation. Hubble's discovery can, therefore, be considered to some extent as a confirmation of the theory.

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A resource for laboratory safety

Two letters regarding laboratory safety, especially in academic environments, have caught my eye (PHYSICS TODAY, August 2011, page 9; October 2011, page 11). When I was a postdoctoral researcher, I learned a great deal about safety and safety management in a laboratory environment at the Princeton Plasma Physics Laboratory. I find myself introducing ideas about safety management and referring to PPPL's safety manual frequently in my current university environment. The manual, online at http://www.pppl.gov/eshis/ESHD_MANUAL/sm.html, is a wonderful resource for those concerned about laboratory safety.

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Czech sculptor deserves credit

How about giving us the name of the contemporary sculptor who created the work on the cover of the September issue of PHYSICS TODAY? You credit the photographer; that is a good first step. Now go the rest of the way and honor the fine arts along with the sciences.

Mary Dryburgh

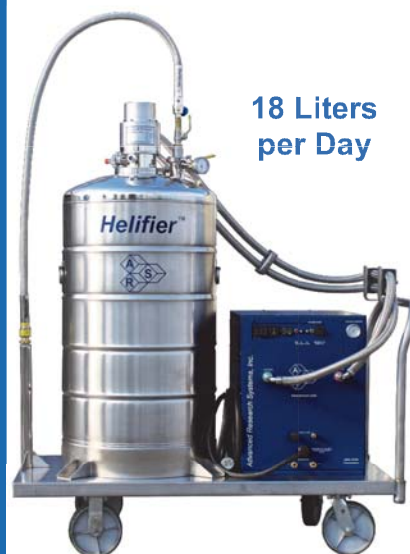
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[Editor's note: The statue of Tycho Brahe and Johannes Kepler, completed in 1983, is the work of Czech sculptor Josef Vajce. We thank Mary Dryburgh for her inquiry.] ■

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