"This aquatint, by Rudolf Tanner, shows Swiss gourmandizers in the famine of 1817 about to be led to hell." [From *Volcano Weather*; photo courtesy Kunsthaus, Zurich]

between excessive atmospheric turbidity and monsoon failure would not seem physically implausible.

The final three chapters deal rather cursorily with various explanations of the weather anomaly. Volcanoes can inject aerosols into the stratosphere, and the resultant turbidity can affect the surface radiation balance. The associated temperature change is different on land and sea surfaces and also depends on the latitude. It therefore affects the atmospheric circulation pattern. The authors could have given the general reader more insight into these physical relations without making the book much longer or more ponderous. I found it intriguing that the atmospheric turbidity theory of anomalous weather conditions was apparently first suggested by Benjamin Franklin almost exactly two centuries ago. Altogether, readers are likely to enjoy this book, particularly as a historical climate-impact study and as a delightful vignette of some aspects of New England life in the early 1800's.

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Coastal Dynamics

Circulation in the Coastal Ocean. G. T. CSANADY. Reidel, Boston, 1982 (distributor, Kluwer Boston, Hingham, Mass.). xii, 280 pp., illus. $52.50. Environmental Fluid Mechanics.

Blue-water physical oceanographers often refer disparagingly to continental-shelf seas as "the rim of the bath tub." The coastal ocean may indeed appear dirty, in more ways than one. There are practical problems involving fisheries, other resources, and pollution (requiring the physicist to collaborate with, or even serve, strange people like biologists or engineers), and the physics itself appears very messy, with forcing by wind, tide, surface heating or cooling, and freshwater input and with further complications introduced by irregularities of the coastline or sea floor. It is no wonder that physical oceanography departments at many major institutions have, until rather recently, placed greater emphasis on studies of the deep ocean.

However, as the dust jacket of this book states, "knowledge of coastal physics has developed explosively during the past two decades," and one welcomes a monograph by Csanady, who has himself generated quite a few of the explosions, providing in his papers a quantitative framework for many dynamical features of shallow seas.

The book is largely made up of mathematical solutions, and physical reasoning, associated with idealized models of circulation patterns with time scales greater than a few hours. Many of the results will seem strange at first to the newcomer. He or she will learn, for example, that the flow in the center of a long lake generally opposes the wind and that sea level at the coast is far more sensitive to winds parallel to the shore than to winds at right angles.

The professional will discern from a quick glance at the book that it is dominated by Csanady's own substantial contributions. The first half discusses transient currents, mainly as generated by an impulsively applied wind. The response of a homogeneous ocean is considered first, with the effects of stratification and topography being added later. Results, such as those mentioned above, and including some of the key effects for coastal upwelling regions, are derived and shown to account qualitatively for a variety of observations.

Bottom friction is added to the models in the second half of the book, in which low-frequency, quasi-steady circulation patterns are discussed. A variety of forcing functions are considered: onshore and offshore wind with different spatial patterns, a longshore pressure gradient (possibly imposed by the deep ocean), and horizontal density differences due, for example, to freshwater input at the coast. One particularly interesting consequence of forcing, by both longshore wind and a longshore pressure gradient, can be a convergence or divergence of cross-shelf bottom flow at a particular isobath. As reported by Csanady in his final chapter (and in his classic 1976 paper) this theory accounts for the observation that, in the mid-Atlantic Bight, bottom waters move slowly onshore in water less than 60 meters deep, offshore outside this isobath.

The final chapter contains other comparisons of low-frequency features of shelf circulation with theoretical models. Remarkable agreement is found, for example, between observed changes in sea level and simple models for the response to a spatially varying longshore wind. However, here, as in the earlier part of the book, the data on variable winds, currents, and sea level are largely presented as time series for "eyeball" comparison. Results of some statistical studies are mentioned, but no power spectra or cross spectra are shown. This is disappointing, given the extensive amount of time-series analysis that has been done, often showing clearly the transition from transient to quasi-steady response and telling one about the predictive value, as well as qualitative validity, of the theoretical models.

Some readers will also be disappointed by the neglect of numerical models. I largely agree with Csanady that "numerical models come into their own in synthesizing a variety of phenomena, *after* those phenomena have been identified and understood on the basis of simple analytical models," but this attitude tends to downplay the intuition-building role of numerical solutions for problems that are idealized but still analytically intractable.

More seriously, there is no mention, or inadequate treatment, of a number of major recent advances that one would expect to find in a book that aims "to summarize those aspects of coastal ocean dynamics relevant to 'circulation' or long-term motion." Most striking is the lack of any mention of the "H/U^3" criterion for the separation of regions that are well mixed by the tides from those that become stratified in summer. These regions occur quite widely in the world and do affect circulation, particularly at the fronts between mixed and stratified water. They are also of particular importance for a variety of biological processes. Fronts are discussed briefly in the book, but with excessive attention to models of frontal adjustment and insufficient consideration of the mean circulation, or cross-frontal transfers, associated with coastal-upwelling fronts or tidal-mixing fronts.

Csanady also omits any discussion of the mean flows that can be generated by the rectification, over topographic features, of oscillatory tidal currents. These flows may contribute significantly to large-scale current patterns (such as the gyre around Georges Bank) and, over small-scale topography, may be a dominant factor in lateral mixing.

Horizontal dispersion is largely neglected in the book (perhaps justifiably in view of the title). Csanady does discuss some mechanisms, but not convincingly or completely.

For the graduate engineer or meteorologist, at whom the new series Environmental Fluid Mechanics is partly aimed, this book is at once too limited in its perspective and, perhaps, rather too difficult in detail to be a good introduction. The specialist physical oceanographer will find the book to be a valuable summary of many of the key recent advances in dynamical coastal oceanography, particularly those advances associated with Csanady himself, and will be pleased to have it on his or her shelves. A teacher of a graduate course on the physical oceanography of the continental shelf will find much of the book to be very useful but will need to supplement it with a discussion of several other topics and approaches. In other words, this is a valuable book containing science of high quality, but its coverage is not as complete, or uniform, as the title or dust jacket suggest.

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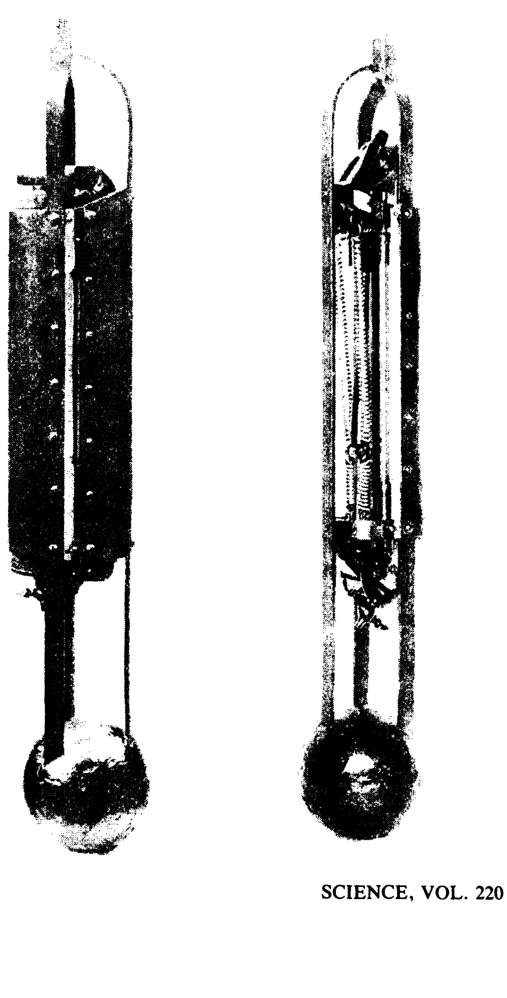
Tools of Oceanography

No Sea Too Deep. The History of Oceanographic Instruments. ANITA MCCONNELL. Hilger, Bristol, England, 1983 (U.S. distributor, Heyden, Philadelphia). xii, 162 pp., illus. $49.

The 1960's and 1970's were golden years in our exploration of the oceans, in which a new generation of instruments provided details of the structure and restless motions of the sea that were previously unsuspected. Remote sensing from satellites revealed patterns of eddies arising from convolutions in great current systems such as the Gulf Stream, and continuous echo-sounding of the ocean floor showed structures of rifts and fractures that led to a revolution in our view of global tectonics. This beautifully and extensively illustrated book reminds us of the newness of these techniques and how difficult it was, until quite recently, to take deep soundings of the ocean and to measure the temperature of the water below the top few hundred meters. "The greatest Victorian technology . . . , a telegraph system girdling the world," required trans-oceanic cables and closely spaced soundings with bottom samples along tracks fixed precisely by astronomical observations. The development of mechanical sounders was not at all a trivial task. They had to be lowered from a ship, often in rough seas, at the end of a line 5000 meters or more long and indicate precisely when (and where) they hit the bottom. Enormous pressures made temperature measurements unreliable.

McConnell's book is arranged more or less chronologically, beginning with the devices conceived by Robert Hooke and others in the 17th century and the early deep-sea thermometers and sounders of the 18th. The Arctic expeditions between 1773 and 1828 provided opportunities for oceanographic observations, since among the Arctic islands currents were taken as clues of the existence of the Northwest Passage. The development of more reliable thermometers con-



Martin Knudsen's high-speed bottle for taking water samples from a ship under way. In 1905, to increase the number of observations that could be made in a limited time, Fridtjof Nansen and V. W. Ekman designed an "automatic" insulated water bottle. "Nansen's experiences with this bottle were satisfactory, but [his ship's] winch could not take the quantity of line needed to stream the instrument at its maximum operating depth of 600 m. . . . Knudsen took the design further and in 1909 published details of [the bottle shown here]. With [his] ship travelling at 8 knots he was able to sound to the bottom, an average depth of 80 m, all the way [from Stavanger to Aberdeen] except in the deep trench adjacent to the Norwegian coast." [Reproduced in *No Sea Too Deep* from M. Knudsen, *Cons. Perm. Int. Expl. Mer. Publ. Circ. No. 50* (1909)]