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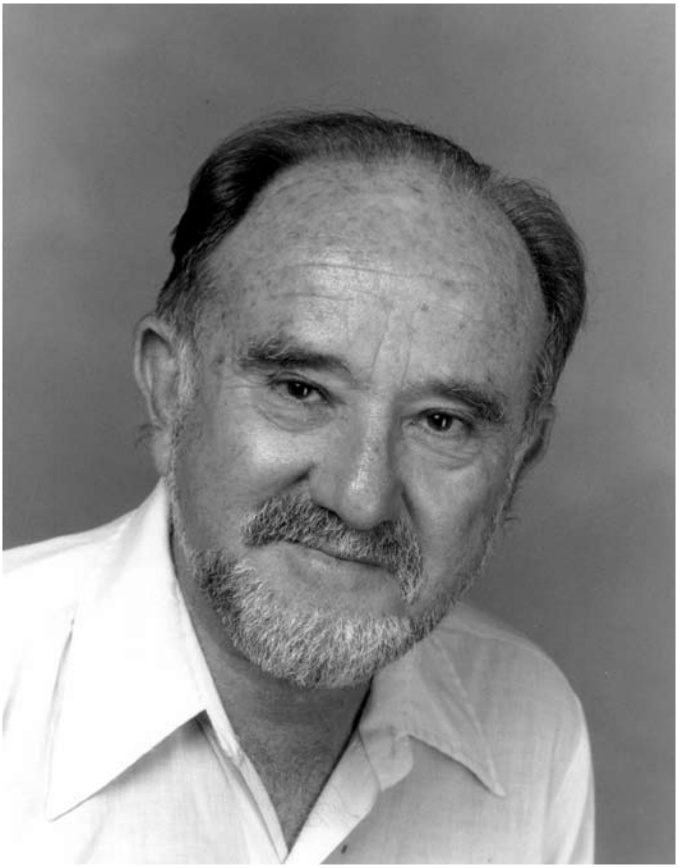
MELVIN E. STERN
1929–2010

A Biographical Memoir by
JOSEPH PEDLOSKY



Melvin E Stern

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January 22, 1929–February 2, 2010

BY JOSEPH PEDLOSKY

MELVIN STERN WAS ONE OF THE FOUNDING FATHERS of the discipline of geophysical fluid dynamics, the application of fluid mechanics to the understanding of phenomena in both the atmosphere and the ocean. His work, largely theoretical and highly original, was characterized by deep physical insights as well as the construction of innovative and illuminating mathematical models. His work gives evidence of a deep, insistent concentration on the physical essence of the behavior of fluids in widely varying geophysical circumstances.

Melvin was born in Manhattan on January 22, 1929, just before the onset of the Great Depression to middle-class parents, Solomon and Fritzi (née Kupferberg) Stern. Melvin was named after the very popular New York Giants baseball player of the time Mel ("Master Melvin") Ott. The family—parents plus Melvin and his two sisters—experienced the economic travails common to many American families of the time. His father, once an advertising executive, became the owner of a small clothing store he ran with the help of Melvin's mother. The family moved to the Bronx and then Queens, living in Jewish working-class neighborhoods, where Melvin grew up, the apple of his father's eye, and attended public schools. His father was very influential in his upbringing; a favorite family story describes his father showing Melvin a photo of a car and asking Melvin what it was. His reply was, "A car." "No," his father remarked, "it is a picture of a car." One can imagine that lesson resonating in Melvin's mind all his life as he frequently struggled to find just the right and accurate articulation of a concept.

His early aptitude for mathematics was noted by a grammar school teacher, and Melvin was encouraged to apply to Stuyvesant High School, famous for its strong academic programs, for which an entrance exam was required. He was successful in obtaining admission, the first of his many academic successes. He was apparently simply entranced by the mathematics he was exposed to at Stuyvesant and completely absorbed by problems in mathematics. Economic need, however, also required that Melvin work after school, often as a delivery boy for a kosher butcher, at other times for a printer.

After Stuyvesant, since money was very tight in the Stern family, Melvin enrolled at Cooper Union, a tuition-free school. He selected electrical engineering as his major, largely under the influence of his very pragmatic mother, and he later deeply regretted not having majored in physics. Again, economic necessity required Melvin to work his first two years in college and he was unhappy at the time taken away from his studies. His tendency to deep, scholarly concentration, evident to his colleagues in later years, was already well developed.

After receiving his undergraduate degree in 1950, Melvin enrolled at the Illinois Institute of Technology and received an M.S. degree in physics in 1951. While there Melvin made the acquaintance of both Willem and Joanne Malkus, who were both teaching at the institute; this was undoubtedly a significant factor in his decision to direct his scientific ambitions to meteorology and later to oceanography. After the institute, Melvin took a position as research assistant in physics at Woods Hole Oceanographic Institution, where the Malkuses had joined the staff. Some of his first published papers involved work he did jointly with Joanne on the flow over a heated island.

In 1951 the military draft was looming, so Melvin joined the U.S. Air Force the following year and, possibly as a result of efforts at Woods Hole, was allowed to serve his tour of duty at the Air Force's Cambridge Research Center. While in the Air Force with the rank of lieutenant, he pursued his Ph.D. degree in meteorology at MIT under the supervision of Professor Morton Wurtele with a thesis entitled "The Modification of Fluid Flow by External Heating and Cooling." Melvin received his doctoral degree in 1956. It was during that period that he made the acquaintance of colleagues at MIT and Woods Hole who were to remain essential stimulants to his research career. The biweekly geophysical fluid dynamics seminar involving Woods Hole, MIT, and then Harvard had started and led to many car trips from Cambridge to Woods Hole. An exceedingly brilliant group of scientists, including Jule Charney, Norman Phillips, Louis Howard, and Melvin, regularly shared the ride and scientific conversation. There must have been occasions when the conversation in the car was far more interesting than the seminar they were traveling to hear.

Melvin fulfilled his Air Force obligation and returned to Woods Hole in 1957 as a physicist; he remained there until taking up a position as professor at the University of Rhode Island in 1964. His transfer to Rhode Island occurred during "the Great Migration," when many, if not all, of his colleagues were obliged to leave Woods Hole after an unsuccessful attempt to persuade the trustees to remove Paul Fye, the Woods Hole director at the time—the so-called "Palace Revolt."

He stayed at Rhode Island as one of the few theoreticians until 1984, when he joined the faculty of Florida State University. He remained at Florida State—where he enjoyed a larger set of theory-minded colleagues than he had at Rhode Island—until his death. An escape from winter also figured into the decision to leave Rhode Island, especially so for Melvin's wife. During his time in Cambridge, Melvin met his future wife, Astrid Bastadjian, an Armenian Christian who grew up in Palestine in the Armenian quarter of Jerusalem during the British Mandate. After a time in England, Astrid came to the United States, settled in Cambridge, where she worked as an administrative assistant at Harvard. She met Melvin at the Foreign Student Union at MIT while he was deeply engrossed in a chess game. Immediately attracted, she introduced herself and that was the beginning of their courtship. Melvin and Astrid were married on December 11, 1955, a marriage that their children characterized as loving and fulfilling for both. Melvin and Astrid had three children, Phillip, Amanda, and Darienne.

Although Melvin was always deeply absorbed with his research work, he had other serious interests outside science. In addition to being a skillful chess player, and surprisingly to those of us who knew him mainly from his academic side, he was an avid skier, a serious cello player, and an enthusiast of the opera. In fact, a broken ankle and Astrid's willingness to carry his cello for him formed an integral part of their early courtship. His children recall him, at home, talking to them at length about salt fingers (see below).

In many ways a solitary, independent thinker, Melvin was noted for being a prodigious walker and colleagues in Woods Hole, where he often summered after moving to Rhode Island and Florida State, would come across him deep in thought, a pipe clasped firmly in his jaw, strolling along the Cape Cod seaside. He did enjoy the company of his colleagues and students, who remember him on the whole as a kind and generous mentor with an "almost superhuman ability to focus," blocking out all distractions. He could be frank with students, sometimes brutally so, if he felt truth required that frankness but it must not have been easy for him. He had an impish and very individual sense of humor that would often express itself with an avuncular guffaw at some manifestation of the human comedy. He took no one, including himself, too seriously.

Melvin died on February 2, 2010, of kidney failure, having suffered from kidney disease and diabetes for a number of years. He was working and collaborating with younger colleagues until the very end.

Melvin's work and his pioneering contributions can be arranged into the following main thematic threads; although such a description is neither complete nor free of overlap, it makes a discussion of his prolific scientific output at least manageable.

DOUBLE DIFFUSION

While Melvin was still in Cambridge engaged in his doctoral studies, Henry Stommel, on the staff at Woods Hole, and Arnold Aarons, a frequent visitor there, stumbled onto a nonintuitive, improbable but engaging oceanic phenomenon that they considered a "curiosity." They imagined a long pipe extending to great depths in the ocean in those regions where the surface water is warm and salty and the deep water is cold and fresher. They reasoned that the deep water, once perturbed upward, would exchange its heat with its surroundings through the tube's wall but, of course, maintain its salt, which could not pass through the wall. After adjusting to the temperature of its surroundings, the water, fresher than the surroundings, would be lighter since it contained less salt and would continue to rise. They envisioned the water spouting out of the top of the tube as a perpetual salt-driven fountain; after doing a laboratory experiment with Duncan Blanchard that confirmed the prediction, the duo published a short, two-page note entitled "An Oceanographic Curiosity: The Perpetual Salt Fountain" (Stommel et al., 1956). However, as Arnold Aarons later noted (Aarons, 1981), they did not realize the deeper significance of the idea and considered it, as they mentioned in their paper, a "curiosity" of very limited utility.

Quite independently (Aarons, 1981) Melvin considered the oceanographically relevant problem of the stability to small perturbations of a region of warm, salty water lying over a layer of cold, fresher water. Melvin approached the problem as a hydrodynamical stability problem and showed quite clearly (1960) that the basic state with warm, salty water over colder, fresher water would be unstable to small perturbations even if the density of the original arrangement decreased upward (i.e., even with lighter fluid lying over heavier fluid). Thus, even this gravitationally "stable" arrangement would begin to convect as long as the coefficient of diffusivity of heat, κ_T, is much greater than the diffusivity of salt, κ_S, in the fluid as it is for sea water where the salinity diffusion is 100 times smaller than the heat diffusion coefficient. The pipe argument still holds for each fluid parcel but now it is the relative inefficiency of the salt diffusion with respect to thermal conduction that plays the role of the impenetrable pipe wall holding the salt anomaly fixed in the fluid while the temperature equilibrates to its surroundings. He went on to show that linear theory would predict, for strongly unstable salt gradients, that the most unstable wave would have the form of very narrow fingers, subsequently called "salt fingers." Melvin's concise but complete analysis opened up a completely new area of buoyancy-driven convection. The instability of the otherwise stable arrangement is due only to the strong difference in the diffusion coefficients of the two components contributing to the density and became known as “double diffusion.” Over the course of years since that original contribution many workers have added to or elaborated on the original analysis. The phenomenon has been directly observed in the ocean (Williams, 1974) and is generally considered an important vertical mixing process (i.e., anything but a mere curiosity; see, for example, Schmitt et al., 2005).

Melvin was clearly entranced by the physics of double diffusion and returned to the subject from time to time for the remainder of his life, publishing at least 20 papers on double diffusion and its ramifications. The subject has expanded explosively with many other applications since Melvin’s original paper; Google Scholar now lists over 176,000 articles just for salt fingers.

It’s fair to say that Melvin’s work not only opened a new field of research but also clearly established him immediately as a powerful and original thinker in the developing field of geophysical fluid dynamics. I remember quite clearly how enthusiastic Melvin was about the phenomenon of salt fingers in 1960 and how eager he was to share his insights into this new physical fluid mechanism.

MODONS

In the period between 1971 and 1976 a large-scale field experiment to study the dynamics of eddies found in the midocean (i.e., removed from major boundary currents like the Gulf Stream) occupied the efforts and imaginations of many oceanographers, observationalists, and theoreticians alike. The experiment had been stimulated by the unexpected discovery of deep eddying currents by John Swallow and James Crease in the R/V *Aries* expedition of 1959 (Crease, 1962). The most surprising thing about the discovery of the oceanic eddy field was that it was so surprising to oceanographers. The eddies were obviously the oceanographic counterparts to the spontaneously developing eddy field in the atmosphere associated with weather events, the so-called "synoptic scale disturbances," and on that basis ought to have been anticipated even before being observed. The realization that the ocean was also churning with such a population of eddying vortices was a shock to the oceanographic community's picture of the large-scale ocean circulation as a steady, fixed pattern flowing with only minor fluctuations. The response of that oceanographic community was intense and energetic and many theoreticians turned their attention to the nature of the oceanographic field of eddies. It is therefore not surprising to find that Melvin had also given serious thought to the possibility of long-lived eddy structures that might exist in the ocean.

In his characteristically profound approach to the general problem (1975) Melvin pointed out that while a symmetric vortex on a *flat* Earth could be a steady equilibrium solution, an eddy with the same monopole structure would self-destruct on a spherical Earth (or on the beta-plane, in the meteorological and oceanographic dynamical equivalent to the spherical geometry) by radiating energy away as Rossby waves. So, he first proved that such equilibrium solutions would have to have at least a dipolar structure (or a higher multipolar form) so that the integral of the stream function over the area of the eddy would vanish. He later showed in a paper written with colleagues (1983) that this condition was equivalent to the necessary absence of mean angular momentum in the eddy.

Further, Melvin found an explicit solution, indeed, a family of stationary, permanent eddy dipoles on the beta plane. Melvin called his solution a "modon," a witty reference clearly to the ongoing MODE[3] experiment and also to the hope that the structure formed a fundamental building block for the oceanic eddy field in analogy with fundamental particles in atomic physics. It was characteristic of Melvin's approach that he was interested in the eddy structure he found not only as an example of an ocean eddy but also as a possible fundamental building block for the total eddy field.

In its gravest modal form, the first member of the family of solutions consists of a cyclonic (counterclockwise) eddy north of an oppositely rotating anticyclone, the pair contained within a circular domain. Such structures are not new in fluid mechanics. The Hill vortex (Hill, 1894) is a three-dimensional structure of the same type. The novel features of Stern's solution are that (1) it is held stationary: the mutual eastward advection tendency of the two vortices is exactly countered by the westward propagation tendency of the beta effect and (2) the modon does not radiate energy as Rossby waves and hence conserves its energy.

In retrospect, the modon itself is the result in Melvin's study that has been found to be of greatest interest. The structure has been suggested as a model for many applications in both meteorology and oceanography. It has been put forward as a candidate for the atmospheric phenomenon of "blocking," a persistent stationary disturbance to the atmospheric westerly flow in midlatitudes; see Flierl (1987) for a more complete discussion and list of references to further work and to McWilliams et al. (1981) for a discussion of the robustness of the modon. However, it is clear from Melvin's original paper that his interest in the problem extended more deeply into the question of the existence of this special solution. He formulated the problem as a variational problem searching for the solution satisfying the governing adiabatic equations that contained the minimum mean enstrophy (square vorticity) for flow contained in a given radius and was able to show that all solutions in the family had the same total enstrophy for a given total radius. This search for a deeper context for a particular calculation is a constant feature of Melvin's theoretical work.

STABILITY THEORY

One of Melvin's long-term interests was in the general problem of hydrodynamic instability and its application to the theory of the spontaneous generation of fluctuations in both the atmosphere and the oceans. In a manner completely characteristic of his desire for both generality and originality he made several substantial and fundamental contributions to the theory. Perhaps the most noted of his contributions is the theorem (1962) he proved with Jule Charney, his colleague at MIT, on a necessary condition for the instability of a baroclinic shear flow (i.e., a flow whose eastward velocity varied with height that required the presence of lateral density variations). The resulting condition, now known as the Charney-Stern theorem, showed that in the case where the lower boundary, the ground, was a surface of constant temperature, the instability of an atmospheric zonal jet required the gradient on isentropic surfaces of the potential vorticity to change sign somewhere in the meridional cross-section of the current for instability to be possible. Its application to oceanic currents is also immediate with minor alterations. The theorem is the central concept in understanding the incessant variability of weather in the atmosphere and eddying and the meandering of currents in the ocean.

The Charney-Stern theorem was presaged in an earlier work by Melvin on the instability of what he called "thermoclinic jets" (1962). This was a model of a single layer of moving ocean water over a very deep layer of inert fluid and perhaps the simplest representation of the oceanic thermocline. Analogous models of shear instability were well known in fluid mechanics. Lin (1955) had recently published a significant monograph collecting important known results on the instability of nonrotating shear flows. The model Melvin investigated was an extension of the classical shear flow problem to include both the effects of Earth's rotation and the density stratification of the ocean. The latter effect was included by considering the ocean as a system of two layers with only the upper layer active; the lower layer was so deep that its inertia rendered its velocity negligible. In current terminology the model would be called a one-and-a-half-layer model. One of Melvin's first results was to show that although the model contained substantial potential energy manifested in the slope of the density interface between the two layers, the growth of any perturbation in the system had to be due to the release of kinetic energy of the current by the lateral eddy transfer of momentum. The result was considered surprising at the time given the large store of available potential energy in the sloping interface but the inertness of the lower layer precluded energy transfers related to the potential energy even though the interface itself was in motion. In the modern formulation of quasi-geostrophic theory the result might be considered obvious but at the time of Melvin's work it was, characteristically, surprising and a reflection of deep thought about the nature of the dynamics. The presence of the moving interface was important since it could actually stabilize a unidirectional jetlike flow; Melvin's theorem, demonstrating a necessary condition for instability, allowed him to find a criterion on the depth of the moving layer below which the flow would be stabilized by the deformable interface. Calling on the analogues of the classical results contained in the Lin monograph, Melvin was also able to demonstrate the instability of a class of flows, and not simply to find the necessary condition for instability.

Perhaps more significantly, his theorem for the first time introduced the potential vorticity and its gradient as the key factors in determining the propensity, or not, for instability. For the single-moving-layer model the potential vorticity is the total vorticity divided by the thickness of the moving layer.

Of great interest for this note is the acknowledgement section in this paper of Melvin's where he credits Jule Charney for the suggestion that the earlier work summarized in Lin's monograph could be directly applied to produce the central theorem of Melvin's paper. This of course is exactly what Charney and Stern did in their classic 1962 paper in which they developed the basic theorem for the instability of zonal (east-west) flows in the atmosphere and ocean. The paper was in itself a recapitulation of a larger body of work, starting with a more systematic derivation of the quasi-geostrophic potential vorticity equation than had previously been published. Using that approximation and the restriction that the bounding surfaces be isentropic, the theorem follows almost immediately, demonstrating the necessity for the vanishing of the potential vorticity gradient somewhere within the flow for instability to be possible. For reasons not entirely clear, the slight extension of the theorem to the case of nonisentropic bounding surfaces was not explicitly made although the form of the theorem is altered in only a relatively minor way. The earlier work of Eady (1949) and Charney (1947) is quoted to acknowledge the ability of nonisotropic boundaries to destabilize flows that possess potential vorticity gradients of a single sign in the interior.

The Charney-Stern paper refers back to Melvin's thermoclinic instability paper as perhaps the simplest example of the role of the potential vorticity gradient in determining the stability properties of a meteorologically or oceanographically pertinent flow. The theorem itself was applied to a discussion of the instability of the Polar Night Jet Stream in Earth's stratosphere.

This collaboration between these two pioneers in the development of geophysical fluid dynamics led to many subsequent extensions, elaborations, and applications of the theorem, and it is perhaps one of the most important contributions in Melvin's career; in its power and elegance it is a reflection of his never-ceasing effort to understand the dynamics of the ocean and atmosphere in its essentials.

Melvin wrote a fair number of papers on problems of shear flow instability in addition to the Charney-Stern paper; perhaps one of the most original of them all is his work on the instability of the Ekman layer. There are two modes of instability. One is a classical shear flow instability in the inviscid limit that is related to the inflection points in the Ekman layer velocity profile. The second mode, which such an analysis misses, and indeed the growth rate vanishes for vanishing viscosity, was suggested by Melvin on the basis of a really very complex calculation (1960) involving an interaction between the shear and the Coriolis force. A concise description can be found in Greenspan (1968) and it must be said that Melvin must have known exactly where he was going because the calculations presented in the paper are so dense that it is nearly impossible for the reader to follow. Nevertheless, he emerged from the thicket of the equations with the result that could be, and was, confirmed experimentally.

ROTATING HYDRAULICS

One of the principal problems in oceanography is the formation of deep water in polar regions and its spreading through the world oceans. The transit from the polar regions to more temperate latitudes often requires the water to pass over narrow, relatively shallow sills, especially in the North

Atlantic. That process of overflow leads naturally to the discussion of the hydraulics of such flows and the presence, or not, of a critical condition at a sill or contraction where the flow speed might match the free wave speed by which the flow responds to perturbations. If the flow is critical, such a state allows for a prediction of the total mass flux in terms of easily measured parameters of the flow (e.g., the thickness of the fluid at the sill). It is not surprising then that the problem was the focus of much oceanographic investigation.

The oceanographic version of hydraulic flow is rendered especially difficult by the presence of rotation and the complexity of the geometry of the sill passageways. Several early attempts at the problem relied on strong simplifications. One of the most influential was the paper by Whitehead et al. (1974) in which the potential vorticity of the flow was taken to be uniform. Of particular interest was the condition for criticality of the flow since the velocity of the fluid is not uniform in the cross-stream direction so a simple equality between flow speed and wave speed at a point would be an unlikely criterion. In a short and very elegant paper that was a comment on the Whitehead et al. paper Melvin found an integral condition as a requirement for criticality and his result was of a generality that far exceeded the conditions of the relatively simple models that had been worked out previously. It was also valid for flows with nonuniform potential vorticity. He used a technique that would be later formalized in a beautiful way by Gill (1976), and once again we have an example where Melvin has anticipated this further development following his own line of thought at once original and deep and, it must be added, not entirely easy for others to follow. The integral result that was found, showing that somewhere in the flow the speed must match the long gravity wave speed, was later redone in a more direct way (Pratt and

Whitehead, 2008), using the formalism presented by Gill, but Melvin's work preceded that; if it is difficult to follow Melvin's thought process, it is something that often is the hallmark of pioneering work.

COASTAL CURRENTS

In the period of the 1980s Melvin discovered the power of contour dynamics, which he apparently independently reinvented for himself as a method of dealing with the evolution of currents, their instabilities, and the tendency of generated filaments to entrain or detrain fluid from the current. Although the method is limited to flows with simple potential vorticity distributions, Melvin employed the method to study a large number of phenomena, such as the dynamics of density currents along a coast (1982), the separation of coastal currents (1990), the pinch-off of eddies from simple models of the Gulf Stream (1986), and for some fundamental ideas about bursts in turbulent flows. The work is of very high quality but it must be said that it did not have the impact of some of the earlier work. What was especially notable about it from the viewpoint of Melvin's relation to his science was that many of the papers involved the use of laboratory experiments, usually with the collaboration of J. A. Whitehead and sometimes others, to either confirm the predictions of Melvin's theoretical calculations or to suggest new phenomena to be studied. Melvin himself was not a particularly adept experimentalist but he was an active and enthusiastic participant and this writer, whose office was next to Whitehead's laboratory, can testify to the frequent exclamations of pleasure, dismay, delight, and excitement from all participants. Melvin was clearly having a wonderful time and his joy was infectious and memorable.

His theoretical work was not limited to the subjects mentioned above although they constitute the bulk of his *oeuvre*. He did equally innovative work with his theory of the "moving flame experiment" conceived with the circulation of Venus in mind. Again, a perplexing physical phenomenon, the putting into mean motion a fluid solely by moving a heating element around the periphery of the otherwise unforced fluid, anticipated later work on wave-mean flow interactions. He also contributed to the theory of turbulence, the dynamics of fronts, and the nature of the wave field in the equatorial zone. His fluid dynamical interests were broad and deep and he seemed to have a special talent for finding the unusual pathway into new problem areas.

TEACHING AND MENTORING

Melvin's first seven years after his Ph.D. were spent at the Woods Hole Oceanographic Institution. At that time the institution did not have a degree-granting education program and Melvin's interactions with students was limited to advising students on their research activities during the summer geophysical fluid dynamics program that was started in 1959. No official records were kept, so it is not possible to easily determine how many students Melvin advised then and in later years when he participated in the program after his move to the University of Rhode Island. The number, conservatively speaking, must be measured in the dozens. I remember Melvin as my mentor during two summers, 1960 and 1962; he was an inspiring and encouraging adviser. He was adept at imagining himself as a fluid parcel and although his work was often expressed with complex mathematics his goal was always to penetrate to the very center of the physics involved in whatever phenomenon was under discussion. Kind and generous, he seemed to instinctively understand the emotional uncertainties of younger associates.

After his move to Rhode Island, Melvin became involved in more formal teaching, both in the classroom and as a Ph.D. adviser. It appeared that the need to give regular formal lectures in the classroom also brought about a greater clarity and economy in his seminars and scientific discussions although he is also remembered fondly for long, ruminating questions whose length sometimes obscured their original purpose.

One colleague remembers Melvin's early classroom style. During the first class of the semester he simply assigned the students the first chapter of his own book (1975), a rather personal view of ocean physics, for the second class. At the second class he asked students if there were any questions. He took the resulting silence to mean everything had been understood and just assigned the next chapter for the third class. Whether the semester proceeded that way to the end is not told.

Melvin had eight Ph.D. students, equally divided between Rhode Island and Florida State, and they are listed below. His students remember him as a demanding teacher but one with a "soft inner core" of kindness and fairness. Often his students became close colleagues and collaborators after obtaining their degrees with Melvin. Indeed, one of them, Timour Radko, was working closely with Melvin right up to the time of Melvin's death. He was remembered for his ability to live with his science in a different and exciting private world to which the student was invited to enter. His commitment to scholarship seemed to form him as a person immune to the unavoidable, small unpleasantness of reviewers and critics and equally immune to the transient pride of honors[2] and not because he was detached. Melvin had a deep emotional connection with his work but he accepted success and disappointment with mature understanding. He was a wise and sage creator in his chosen field of study and his students and colleagues were better scientists and people because of him.

MELVIN STERN'S STUDENTS

At the University of Rhode Island:
J. Demenekow, N. Paldor, C. Shen, and S. Ramp.

At Florida State University:
Q. Du, J. Bidlot, T. Radko, and J. Simeonov.

The author has benefited greatly from the assistance of the following: William Dewar, Louis Howard, Willem Malkus, Nathan Paldor, Larry Pratt, Timour Radko, Thomas Rossby, Ray Schmitt, Amanda Stern, Phillip Stern, Tony Sturges, George Veronis, and Mark Wimbush. All errors of fact and interpretation are, of course, mine alone.

NOTES

1. Although, as usual, Melvin was generous in acknowledging others—in this case Stommel—for their contributions to his thinking about the problem.
2. Melvin was elected to membership in the National Academy of Sciences in 1998 and was the first recipient of the Henry Stommel award of the American Meteorological Society.
3. MODE was the acronym: Mid Ocean Dynamcis Experiment.

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