



Garbis H. Keulegan

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1890–1989

By John F. Kennedy

Garbis H. Keulegan, physicist, hydraulic engineer, and specialist in theoretical and experimental fluid mechanics, died on July 28, 1989, at the age of ninety-nine years. In September of the preceding year he had retired after sixty-seven years of continuous employment with the federal government, first as a physicist with the National Bureau of Standards (from 1921 to 1962), and then as consultant and special assistant to the chief, Army Corps of Engineers' Waterways Experiment Station (WES) Hydraulic Laboratory (from 1962 to 1988). He served as a federal government employee longer, and to an older age, than any other person in the annals of federal service.

Keulegan was born on July 12, 1890, in Sebastia-Sivas in Turkish-occupied Armenia Minor, the first of six children born to his Armenian engineer father and his immigrant (daughter of an itinerant kiln designer and builder) German mother née Emma Marguerite Klein. Keulegan received his first degree, in engineering, from Anatolin College in Marsovan, Armenia Minor, in 1912. Later that year he came to the United States to continue his engineering education under a scholarship he had been awarded by Ohio State University, where he changed fields and received an A.B. in mathematics and physics in 1914 and an M.A. in physics in 1915. He then was employed by Westinghouse until he joined the army in 1918, where he served in France as a translator on the staff of General John J. Pershing until 1919.

His original plan to return to his native Armenia after the war and go into engineering practice in his father's business was ended by the 1915 Armenian massacre. Therefore, upon his discharge from the army he returned to Westinghouse where he remained until 1920, when he joined the staff of the Terrestrial Magnetism Department at Carnegie Institution.

Keulegan commenced his employment as a physicist with the National Bureau of Standards (NBS) in 1921. His early work there was concerned principally with solid mechanics, in particular hysteresis in structural members subjected to cyclic loading; development of various instruments and meters for use in aircraft; and, building on his M.S. thesis, temperature coefficients and elastic moduli of metals. Shortly after joining the NBS staff, he started work toward his doctorate in physics by taking night courses at Johns Hopkins University. In 1928 he received his Ph.D. after submitting a thesis entitled "On the Vibration of U Bars"; and in September of that year he married Nellie Virginia Moore.

In 1932 Keulegan was transferred to the then newly established NBS National Hydraulic Laboratory (NHL), which was envisioned to be "The Nation's Hydraulic Laboratory." It was there during the prewar years that he conducted his classic work on turbulent flow in open channels; roll-wave formation; water-wave theory; flow in curved pipes; and salinity intrusion.

From 1942 until 1946 Keulegan was seconded from NHL to the Army Corps of Engineers Beach Erosion Board (BEB), where he applied the extensive knowledge of waves, tides, and currents he had acquired at NHL to a variety of military problems. Particularly noteworthy at BEB was his work with the beach-intelligence group, whose mission was to provide the planners of military amphibious landings with information on beach slopes, sand characteristics, reef positions and sizes, tide and surf conditions, etc. This information was essential to the successful execution of amphibious-landing operations, and much of it had to be inferred from aerial photos and study of wave-diffraction patterns. The first study for an actual landing was of the North Africa coast for "Operation Torch." Subsequent studies were concerned with landing sites on Sicily and southern Italy,

and then the Pacific islands. Other BEB activities on which Keulegan worked during the war years included the beaching and retraction characteristics of landing craft; development of towed breakwaters; and feasibility of a mid-Atlantic floating landing field for aircraft refueling.

Following his return to NHL in 1946, Keulegan resumed his work on development of model laws for density currents, and theory of water waves and tides. His work on density currents was of great interest to the Corps of Engineers because of salt-water intrusion problems that were being encountered in large reservoirs and at the mouths of several large rivers, as well as at navigation locks between fresh-space and salt-water bodies. These problems were complicated by water waves, sand, and especially, tides. This work was to occupy much of his technical attention for the next sixteen years until he retired from NHL in 1962 and joined the staff of the Army Corps of Engineers' Waterways Experiment Station (WES).

Because of his age, special authorization had to be obtained to employ Keulegan at WES. These administrative hurdles finally were overcome, and in 1963 the Keulegan family moved to Vicksburg, Mississippi, where he was employed on a nominally half-time basis as a consultant and special assistant to the chief, WES Hydraulic Laboratory. There his work continued to be concerned principally with waves, tides, and density currents and salinity intrusion. During his first few years at WES, these interests were broadened to include flow through tidal inlets and resulted in his seminal work on this important problem. He was invaluable in designing strategies for, and guiding conduct of, particularly difficult model studies. He also worked closely with the WES group involved in the then rapidly growing field of numerical hydraulics, and he assisted them in developing the physical bases and mathematical strategies for their family of software. However, pencil and paper continued to be his principal tools. He never even adopted the electronic desktop calculators; instead, he utilized progressively longer slide rules as his eyesight became weaker. However, with the passage of time his workday became shorter, and eventually he spent just the mornings in his office. Three bouts of surgery, including cataract

removal in 1980 and its repair (following a fall outside his office at WES) in 1984, failed to stop his relentless research productivity. During the latter years of his career, his daily routine consisted of going to his office at 7:00 a.m. There he would work on the problems of interest to him, taking special delight in helping others find new ways to approach technical problems that were troubling them. At about 11:00 a.m. he would leave his office for lunch at home or a restaurant.

Among the most noteworthy of his numerous outstanding publications were his series of twelve progress reports on density-current model laws and related problems prepared at NBS under contract to WES between 1946 and 1960. The bibliography of his publications contains nearly one hundred entries, including Chapter 11, "Wave Motion," in Rouse's *Engineering Hydraulics*; Chapters 11, "The Mechanism of an Arrested Saline Wedge," and 17, "Model laws for Coastal and Estuarine Models," of Ippen's *Estuary and Coastline Hydrodynamics*; and the proceedings he edited (with NBS colleague K. H. Beij) of the 1951 *NBS Semicentennial Symposium on Gravity Waves*.

In the course of his long and very distinguished career, Keulegan was accorded a full complement of professional recognition. These included the Commerce Department's Gold Medal (1960), the National Medal of Science (1968), the Army Research and Development Award and honorary membership in the American Society of Civil Engineers (1969), U.S. Army's Meritorious Civilian Service Award (1973), the Commander's Service Award for Civilian Service and election to the National Academy of Engineering (1979), and selection for inclusion in the WES Gallery of Distinguished Civilian Employees (1986). He had numerous hobbies. He loved to read American history, especially that of the early West. He also liked western movies, particularly those starring Gene Autry or the Lone Ranger, and the family dinner hour was arranged so he could watch televised programs featuring these heroes. He was an avid gardener and prized his roses and tomatoes. His lifelong morning delight was to arise early (usually around 4:00 a.m.) and drink coffee and smoke cigarettes while "doing his thinking." Later, after the

birds arose, thinking was joined by watching them come to the bird houses and bird baths he built and tended.

In 1981 when asked to what he attributed his longevity and ability to work for so many years, Keulegan explained, "I never had big ideas. I did not want to be a section chief, I did not want to be rich—I'm just interested in my work. I love people; I love working in the hydraulics laboratory; I enjoy my work immensely—it helps keep me alert."

Keulegan had a professional career that spanned nearly eight decades. This is nearly double the time apportioned most professional people for their productive careers. He was a citizen of two countries. He was educated in science and engineering and did extensive research in both solid and fluid mechanics. He was a longtime employee of two agencies, NBS and WES. In short, he was granted the equivalent of roughly two lifetimes, and he used them, and enjoyed them, wonderfully well.