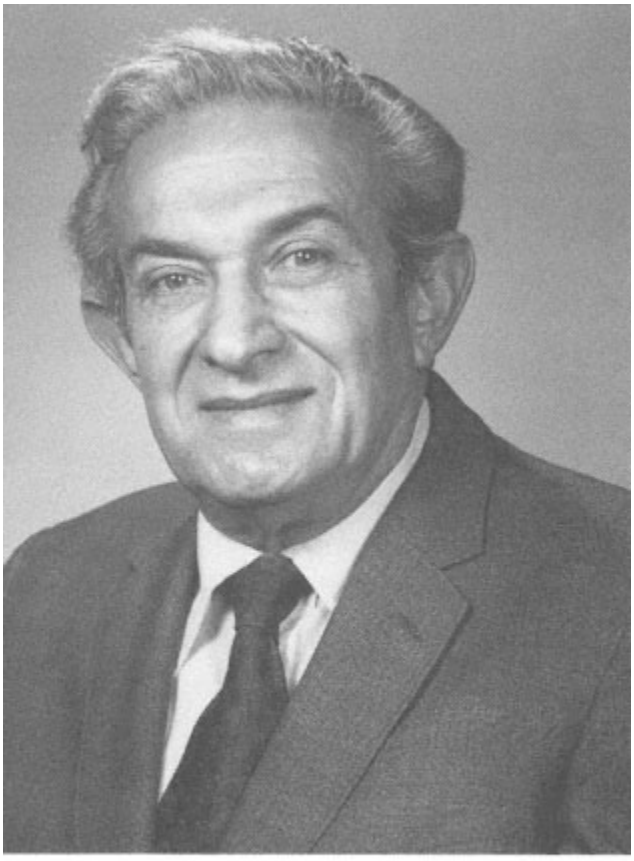

Philip S. Klebanoff

1918-1992

Written By G. E. Mattingly And L. P. Purtell

Submitted By The Nae Home Secretary

PHILIP S. KLEBANOFF, a prominent researcher in turbulence, died on May 2, 1992, at the age of seventy-three.

Phil was born July 21, 1918, in New York City. He graduated from Brooklyn College, where he studied physics, then joined the National Bureau of Standards in Washington, D.C., in 1942. His early years there were spent participating in the development of rapidly advancing experimental techniques in aerodynamics under the direction and leadership of Galen B. Schubauer. He also pursued advanced studies at George Washington University from 1942 to 1945.

His early projects were pursued in a time of great ferment in experimental turbulence research. In particular, the hot-wire anemometer had been established as a powerful instrument and Phil and his colleagues took full advantage of it to study both transitional and fully turbulent flows. One of the most frequently referenced works in this field is Phil's extensive study of turbulence characteristics in the boundary layer, published as a National Advisory Committee for Aeronautics technical note in 1954. His turbulent boundary layer data are still used to establish validity of current experiments and full numerical simulations in the boundary layer.

Building on his training with Schubauer on the problem of boundary-layer transition from laminar to turbulent flows, Phil later studied the development of waves in the laminar region, far

beyond the linear range explored previously. Using the vibrating ribbon technique, he established experimentally the complicated three-dimensional nature of boundary-layer instability. The resulting 1962 publication in the *Journal of Fluid Mechanics* ranks as a stellar classic in the field of boundary-layer transition, and the three-dimensional waves discovered by him are now commonly referred to as Klebanoff modes.

During the early 1960s, Phil began what was to be a long and fruitful collaboration with Francois Frankiel, a theoretician who cofounded the American Physical Society (APS) Division of Fluid Dynamics, and later became editor of the journal *Physics of Fluids.* Together they explored the fundamental statistical description of turbulence, particularly the smaller scales at high Reynolds number. They were among the first to make extensive use of the new power of digitized experimental data, employing it to examine the nature of the probability distribution of small scale turbulence.

In 1979 Phil was invited to visit Hokkaido University, Sapporo, Japan, to lecture, to write a summary paper on transition and turbulence, and thus to receive an earned doctorate in engineering. Phil was honored by election to the National Academy of Engineering and by fellowship in the American Physical Society, the American Institute of Aeronautics and Astronautics, and the Washington Academy of Sciences.

Throughout his career, Phil received numerous awards for his contributions to the study of turbulence. Among these were the Naval Ordnance Development Award received in 1945. In 1968 he received the National Bureau of Standards Certificate of Commendation and in 1975 the Department of Commerce Gold Medal for "his outstanding contributions to the field of fluid mechanics . . . opening up new fields of research in aerospace sciences, air pollution, meteorology, and rocket propulsion ... and leading to important applications in coastal and ocean engineering, oil spill travel, submarine waves, liquid and gases in pipes, high speed atmospheric re-entry, nuclear power, and energy conversion." In 1981 he received the APS Prize in Fluid Dynamics "for his careful experimental studies of the turbulent boundary layer, his fundamental contributions to the

understanding of transition to turbulence in boundary layers, and his leadership in the study of turbulence."

There were no aspects of turbulence that were not of interest to Phil. In collaboration with his colleagues at the National Bureau of Standards, he contributed to studies of boundary-layer separation and the influence of roughness on transition, and with his younger colleagues, magnetohydrodynamics, low Reynolds number effects, and anemometry instrumentation. His last paper, an extensive examination of the development and evolution of boundary-layer turbulence induced by a roughness element, was published in the *Journal of Fluid Mechanics* just before his death. This paper, like its predecessors, exemplifies the care, thoroughness, and integrity Phil always practiced and also inspired in those who worked with him. He will be missed.