



William H. Avery (1912–2004)

Bill Avery possessed the rare combination of the inquiring and critical mind of a scientist with the spirit of innovation and practical knowledge of an engineer. What made his talents especially effective was Bill's intense interest in solving major national and global problems. It was APL's good fortune that Bill chose to devote his most productive years in applying his intellect and energy to many of the Laboratory's most challenging endeavors.

Bill was born and grew up in Fort Collins, Colorado, when it was still a typical western frontier town. In an autobiography he was writing at the time of his death he tells of buying an old Ford and riding around Fort Collins at age 13. He breezed through school, receiving his B.S. in chemistry in 1933 from Pomona College and his A.M. and Ph.D. degrees in physical chemistry in 1935 and 1937, respectively, both from Harvard. There he worked with Dr. George Kistiakowski, who later became Science Advisor to President Eisenhower. While at Harvard he made many lifelong friends and met Helen Palmer, whom he married in 1938.

In 1939 Bill was invited by the head of Shell Oil's Research Laboratory in Houston, Texas, to join his team. Three years later, after the United States entered World War II, Bill was persuaded to apply his talents to the work of the National Defense Research Committee (NDRC), organized by Vannevar Bush to mobilize U.S. scientific and engineering efforts behind the war. He arrived in Washington in 1942, just as I also had volunteered to work for NDRC, and we both became assistants to Dr. R. E. Gibson, then Vice Chairman of Section H of the NDRC. Since early liquid fuel rockets were typically unreliable, inaccurate, and dangerous, Section H was charged with developing rockets using solid fuel propellants. It was thought that solid propellants could be developed to have more reliable performance and safer handling and storage.

Our first laboratory was at the Naval Powder Factory at Indian Head, Maryland, where we could test-fire rockets into the Potomac River. Usually they flew half way across the

river, but occasionally one would double back to the consternation of the people on shore. Bill's work at Indian Head was concerned with establishing the basics of how propellant composition and geometry affected rocket performance. If anyone could be called a rocket scientist in those days, it was Bill Avery.

After a year at Indian Head we secured a far superior site for the rocket laboratory in a valley near Cumberland, Maryland, that became known as the Allegany Ballistic Laboratory (ABL). One side of the valley was a sheer mountainside 600 feet high—an ideal target for rocket firings. Bill came to the new laboratory as director of propellant development. Solid rocket propellants are necessarily composed of an intimate mixture of a combustible fuel and an oxidizer, and had to possess the contradictory properties of burning rapidly when ignited while being stable and safe in normal handling and storage. There was substantially no prior knowledge of how the behavior of these mixed propellants varied as a function of composition and preparation. Bill applied his scientific skills to this challenge, converting previous cut-and-try efforts into quantitative experimentation by devising new instruments and analytical methods. Aside from the immediate products of these efforts, the work of Avery and his colleagues laid a scientific basis for solid rocket design principles that became vitally important for a generation of tactical and strategic weapons such as the Polaris and Minuteman Strategic Systems.

During the next two years we engaged in many exciting projects such as ground- and air-launched rockets, recoilless mortars, rocket-propelled mine-clearing devices, and numerous other rocket applications, some more hazardous to the users than to the enemy. And an occasional errant rocket would veer over its mountain target, but fortunately none were ever heard from again. Our main contribution, in which Bill played the leading part, was to establish the principles for making solid propellant rockets more predictable and reliable. In the war's final months, a prototype rocket, incorporating what we had learned, successfully demonstrated every important design principle employed for the next generation. The American Rocket Society would later recognize Bill's meritorious achievement in the field of solid propellant rocket propulsion by choosing him as the 1951 recipient of the C. N. Hickman Award.

At war's end, the NDRC was disestablished and ABL was turned over to the Navy. Dr. Gibson, several others, and I joined the Applied Physics Laboratory, which badly needed rocket expertise to launch the supersonic guided missiles they were developing for the defense of the Fleet. Bill joined us a year later after working at Arthur D. Little in Boston, finding that the environment of industrial research did not satisfy his desire for challenging problems and contributions to society and the nation.

When Avery joined APL, the Laboratory was engaged in developing a radically new propulsion system for its long-range anti-aircraft missile, Talos. This propulsion system, called the ramjet, has no turbine in front as used in turbojet engines but, when flying at supersonic speeds, uses the energy of the high-velocity airstream instead of a turbine to force the air into the combustion chamber. The ramjet system is much lighter and simpler than the turbojet; thus it was potentially far more suitable for propelling a high-speed missile. It does require acceleration to supersonic speeds before it produces a net thrust, and this was to be provided by a large solid rocket booster of the very type that Avery had been working on previously.

The development of the Talos ramjet was a truly pioneering effort, which many experts here and abroad originally deemed impractical. And indeed there were many fundamental multidisciplinary problems of aerodynamics, fuel injection and mixing, controlled combustion, and high-temperature materials to be solved. Bill Avery took over the direction of the ramjet program in 1950 and guided it to its successful development of the engine for the operational Talos missile. Talos was installed on cruisers and showed its prowess by bringing down two Vietnamese MIGs that threatened the U.S. Fleet in the Gulf of Tonkin.

The lessons learned in the successful development of the Talos ramjet laid the foundation for even greater advances in jet propulsion through the development of supersonic combustion and hypersonic flight (four or more times the speed of sound). Bill's APL team established a program that ranged from basic combustion research to the engineering of practical jet engines of increasing speed and capability. The effort brought international recognition to APL as the U.S. leader in the development of supersonic ramjets. Bill's leadership led to his being awarded the The Alfred C. Egerton Gold Medal of the Combustion Institute in 1972.

The development of ramjet propulsion systems required test facilities that could effectively simulate the interaction of a test missile with a supersonic airstream. After APL moved to its Howard County site, the original "Burner Lab" in Silver Spring was replaced, under Bill Avery's direction, by a fully automated facility for testing supersonic and hypersonic propulsion.

Bill's leadership responsibilities were expanded in 1961 to head the Aerodynamics Division, which encompassed APL's activities in missile aerodynamics and structures as well as propulsion. In this capacity he extended the Laboratory's contributions to nondefense activities, such as mass public transportation, and to new sources of energy. Motivated by the energy crisis of 1973, he used his rare combined talents as a scientist and engineer to invent an "accelerating walkway" as a key element of a rapid transportation system, or "people mover," for congested city centers. It was designed to enable a

system of cable cars to load and discharge passengers at a terminal without stopping, with the accelerating (and decelerating) walkway enabling passengers to effortlessly transition between walking and cable car speed. The accelerating walkway won the IR 100 Award as one of the top technical inventions of 1972.

In 1973 Bill Avery was appointed Assistant Director for Exploratory Development to apply his broad technical talents to all of APL's exploratory research and development efforts and to contribute his experience and wisdom to Laboratory affairs. As usual, Bill found time to make innovative technical contributions to challenging problems. The most important national problem at that time was the need to develop alternatives to fossil fuels to supply the rapidly growing energy needs of the nation and to reduce dependence on foreign fuel supplies. After much study of renewable energy sources, Bill selected an unusual system that had only recently been proven in concept but had thus far failed to demonstrate practicality and cost-effectiveness. The system, called Ocean Thermal Energy Conversion (OTEC), was intended to operate in tropical waters where the difference in temperature between the warm ocean surface and deep water could be used to produce energy by driving a heat engine. There were numerous problems, including design of the long cold-water intake pipe to withstand currents and ship motion, construction costs of a plant ship large enough to show a net effectiveness in energy production, biofouling of the cold-water pipes, and corrosion of the heat exchanger. Motivated to make a more personal contribution to this project, Bill stepped down from his Assistant Director position in 1986 and was appointed Director of Ocean Energy Programs.

Bill loved his work at APL, but finally decided to retire from his official duties in 1989. This occasion gave the Laboratory and the University the opportunity of naming an important research facility in his honor. The citation reads:

For over forty years, Dr. William H. Avery has served the Applied Physics Laboratory with great distinction. Dr. Avery is known for his pioneering work in combustion, solid rocket propellants, ramjet propulsion, design and testing of supersonic-combustion ramjets and hypersonic aircraft concepts. The Propulsion Research Laboratory (PRL) was established at APL under Dr. Avery's leadership in 1961. PRL was the first fully automated facility in the U.S. devoted to hypersonic propulsion. In recognition of Dr. Avery's

outstanding contributions in the field of propulsion technology, the Propulsion Research Laboratory will bear his name.

Characteristically, Bill's retirement did not mark the end of his technical career. In a small office in his beloved Propulsion Research Laboratory, Bill devoted his energies to writing a definitive treatise on OTEC. In this book, written in collaboration with Professor Chih Wu, he treated every theoretical, engineering, and economic aspect of OTEC, explaining in detail the advances made in the U.S. and foreign OTEC programs, with exhaustive calculations of construction and operating costs involved with its commercial application. The book makes a convincing case for OTEC as a major world energy source, competitive with fossil fuels and alternative sources. *Renewable Energy from the Ocean: A Guide to OTEC* was published by the Oxford Press in 1994.

Bill finally really retired in 1998, moving to Cape Cod where he and Helen had vacationed for many years in a cottage between two beautiful ponds that she had inherited. Even here Bill was busy writing a long chapter on OTEC for *The Encyclopedia of Physical Science and Technology*, published by Academic Press in 2002. He also maintained an active correspondence with his many friends and technical associates via the Internet.

Bill was as admirable for his personal qualities as for his technical brilliance. He was a talented artist and a devotee of the arts—painting, music, drama, and literature. He was also a connoisseur of mushrooms of all kinds. A devoted family man with two children, he and Helen were wonderful hosts, with succulent products of Helen's superb cooking and stimulating evenings of congenial conversation. An idealist, he displayed uncompromising honesty and integrity. He had the gift of friendship and humor and enjoyed a multitude of friends worldwide.

Bill leaves APL and the world a rich legacy of accomplishments, from his early innovations in propulsion to his unique scientific contributions described in his treatise on OTEC, an encyclopedia article, over 68 technical publications, and numerous presentations at scientific meetings. Even more important is the indelible impression that he left on his many friends and associates, and especially the magnificent example he set for dozens of young APL staff who were mentored by Bill and had the good fortune to be on his team.

Alexander Kossiakoff