

Presentations to the Trustees' Committee on APL on the Occasion of the Research Center Dedication Ceremony

RESEARCH CENTER HISTORY

Richard B. Kershner

Since its beginning during World War II, the Applied Physics Laboratory has been devoted to the practical application of the principles of physics to the solution of problems posed by the requirements of society. However, from the earliest times, even before the end of World War II, a small fraction of the Laboratory's efforts has been devoted to pure research in the physical sciences with no practical application in immediate view. In fact the Research Center, where this work is centered, is second in age only to the Director's Office as an enduring organizational entity.

The first opportunity for significant physical research was quite accidental. When the German troops retreated after the successful invasion of France by the British and Americans, they left behind, among the other booty of war, a number of V-2 long-range liquid fueled rockets. Some of the rockets were sent to the United States. It was clear to the American military forces that these devices represented a major advance in the military arts with which they must become familiar. Accordingly, they planned a series of experimental firings from a range established at White Sands, New Mexico. A small group of physicists at APL headed by James A. Van Allen persuaded the Navy that it would be a shame not to take advantage of that opportunity to make basic physical measurements at hitherto unreachable altitudes. Specifically, measurements were of interest that cannot be made on the earth's surface because of the grossly modifying effect of the atmosphere. Cosmic rays and their atmospheric by-products, such as electrons and ions, were of special interest.

The results of these early V-2 firings were exciting enough for the Navy to support the Laboratory in the development of a high altitude rocket known as Aerobee to continue the rocket tests and physical measurements. The work culminated a few years later, after Van Allen had moved to the University of Iowa, in his epochal discovery of a layer of electrically charged particles that are trapped in the earth's magnetic field, a layer now known as the Van Allen belt.

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Shortly after the end of the war, George Gamow was a consultant and frequent visitor to the Research Center. There, he and Ralph A. Alpher, a graduate student, with Robert C. Herman, a young staff member, wrote papers that for the first time outlined the "big bang" concept of the origin of the universe. They suggested that all the elements "froze out" as a result of cooling during the first few seconds, after a primordial explosion at very high temperatures and pressures made possible nuclear reactions that produced all existing elements from a dense neutron soup. Although this concept, like much of Gamow's work, did not hold up in detail, recent work has restored considerable belief in some of the concept and the big bang theory is currently popular again (although not for producing the heavy elements).

After this, the Research Center was organized in accordance with principles established by Ralph E. Gibson, Alexander Kossiakoff, and Frank T. McClure in a way that made it essentially an integral part of APL. It worked on basic problems, but problems that were associated in some way with the mission of the Laboratory.

For example, we were developing a ramjet engine. There were countless unknowns in the combustion mechanisms that influence the chemical dynamics. A serious attack on combustion, flame propagation, and other problems was mounted successfully. Short-lived molecules that had been postulated as possible intermediates in the combustion reaction (such as HO₂) were clearly identified for the first time.

In the field of solid rockets, a long-standing problem had been the occasional abnormal behavior known as unstable or resonant burning. This usually resulted in the unexpected destruction of the rocket. With brilliant intuition, McClure, then Chairman of the Research Center, postulated that this behavior in solid rockets resulted from the establishment of acoustic vibration modes in the rocket-motor gases during burning which, because of the increase in burning rate caused by the velocity of the gases across the unburned powder, could produce resonance effects that greatly increased the rocket pressure. A marvelous series of controlled experiments and calculations by McClure and Robert W. Hart established the validity of this hypothesis.

Up to that point, most of the research accomplished within the Research Center had a reasonably direct and obvious tie to answering problems of concern in our efforts to develop missiles and rockets. Even the cosmic ray experiments were largely motivated by the desire to acquire knowledge of the behavior of high performance liquid fuel rockets; the high-altitude physics measurements more or less went along for the ride. However, there was no rule requiring that research undertaken within the Research Center have any visible relevance to Laboratory development tasks.

The wisdom of this policy was amply illustrated by the results of a small research program undertaken in late 1957 after the Russians launched Sputnik, the first artificial satellite, into orbit about the earth. Two physicists, William H. Guier and George C. Weiffenbach, used Laboratory equipment to monitor the transmissions from the satellite. They made the remarkable discovery that it was possible to determine a quite accurate orbit for Sputnik simply by analyzing the Doppler shift, the frequency change imposed on the received signal by the relative motion of the satellite and the ground observing point. This fact was by no means obvious and it is true only because of the severe constraints imposed on the geometric path of an object that is orbiting the earth. McClure realized that the inverse problem—of determining an unknown location on earth by monitoring the signal for a satellite in a previously established orbit—would be even easier and would provide the means for at-sea navigation of unprecedented accuracy. This led to the Laboratory proposing the development of the Transit navigation satellite. The concept was enthusiastically supported by the Polaris project of the Navy as a potential solution for one of their most difficult problems, which was how to maintain a precise knowledge of the position of a submarine at sea after weeks on station. Support was quickly provided and the APL Space Department was established under Kershner to carry out the development. Thus a major Laboratory program, which for many years accounted for approximately one third of the Laboratory's efforts, was a direct outgrowth of a modest research program undertaken in the Research Center without initial expectation that it might have direct developmental significance.

It is interesting that the symbiotic relationship between pure research and a development program can operate in either direction. Not only did the Transit program grow out of pure research, but it also led directly to additional pure research by the Laboratory in several new areas. For instance, it turned out that to determine Transit satellite orbits with sufficient precision required much more detailed knowledge of the gravity field of the earth than was available from previous geodetic research. Fortunately, the geodetic measurements made by the Transit satellite proved to be the most useful

ones made to date. We were able to produce a fine geodetic model as early as 1964. Less obvious is the fact that the Transit program caused us to resume the high altitude physics measurements that had been started under Van Allen at the end of the War. This happened because the design of a satellite that could survive in the high altitude environment required a detailed knowledge of that environment.

There are now five Transit satellites in operation, three of which have been working continuously for more than twelve years and show no sign of failing. There is also widespread Navy use of Transit on surface ships as well as on submarines and a very substantial commercial sale of Transit equipment for ships as small as fishing boats, for ocean drilling rigs, and for research platforms. Currently, the number of commercial users doubles annually. As for Navy use, perhaps I can do no better than quote from a letter written by Chief of Naval Operations to Chief of Naval Material on June 26, 1979 stating (in part) that "It has been determined that Omega receivers are not required on those surface ships which have had a Transit navigation system installed. This is due to the low accuracy of Omega as compared to that provided by Transit. Furthermore...the use of an electronic backup for a system with the proven reliability of Transit cannot be justified."

GENESIS OF THE COLLABORATIVE BIOMEDICAL PROGRAM

Joe T. Massey

Several of the Laboratory's civil programs, among them the collaborative biomedical program, had their origins within the Research Center. The biomedical program was initiated formally in the mid-1960's, by Frank T. McClure, Robert W. Hart, Alvin G. Schulz, and myself, who were then members of the Research Center, and by Richard J. Johns, Chairman of the Biomedical Engineering Department of The Johns Hopkins University School of Medicine. I shall briefly describe the program's genesis, summarize the first 10 years of its life, and discuss its relationship with the Research Center and with the Laboratory as a whole.

Following a 1965 decision to explore formally the application of the physical sciences and technology to the solution of medical and biological problems, a series of seminars was held at the Laboratory with Dr. A. E. Maumenee and the faculty of the School of Medicine's Department of Ophthalmology to seek out problems, propose solutions, and learn each other's specialized vocabulary. A comprehensive program resulted in which Research Center scientists and their counterparts in the Department of Ophthalmology identified projects

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