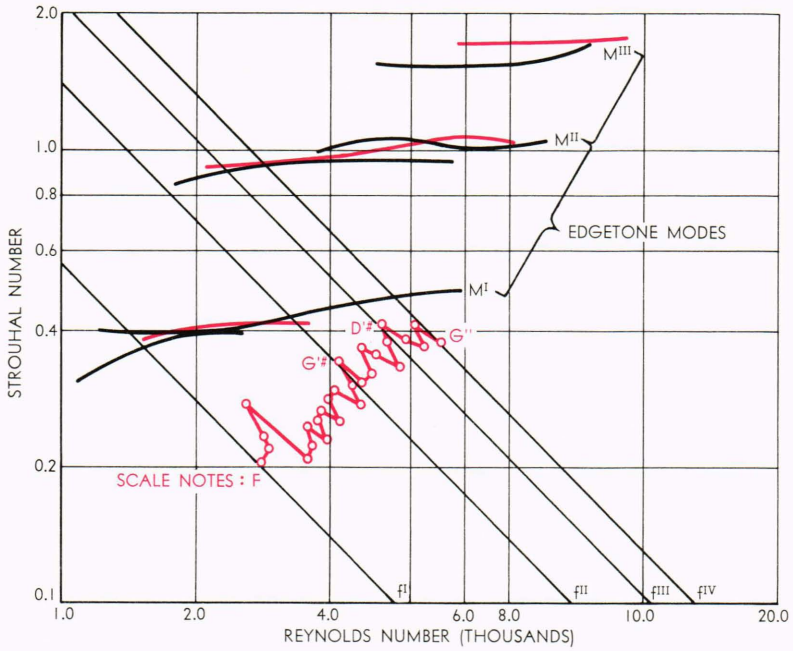


**Fig. 7—A universal mode diagram plot of the entire two-octave scale of an alto recorder reveals that the first edgetone mode is the only one used as a driver. Note that four pipe harmonics are required to cover the scale range.**

distribution along the recorder bore and have also furnished a clue to the puzzling problem of jet-edge asymmetry.

In Fig. 5, which shows a cross-section of the mouth region of a recorder, the edge is seen placed below the center of the jet as it comes out of the orifice. For some scale notes sound is radiated entirely from the mouth of the recorder, and these notes seem to require an asymmetrical jet. Other notes, for which there is sound radiated from the foot and open finger holes, seem to demand symmetry. The actual position of the edge is evidently a matter of compromise.

Mr. von Huene still hasn't finished his Great Bass in F. On the basis of the dimensions he showed me last summer, I predicted that it should require about 210 cc/sec to strike the lowest scale note and that the sound power should be comparable to his size-smaller C-bass. Some time next year I should have the answer.

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*Excerpts from the*

# REPORT of the DIRECTOR

## *of the Applied Physics Laboratory*

July 1, 1962—June 30, 1963

To the President of the University:

This year has seen the addition of 80 acres of land and three major buildings to the property associated with the Laboratory in Howard County. The decision of a neighboring farmer to dispose of a parcel of his property enabled us to acquire a strategically situated strip of land which not only protects our outlying operations, such as the Propulsion Research Laboratory and the Radar Building, from potential interference with housing developments, but also provides the possibility of an alternate outlet to Route 29.

In the early summer of 1962, it became apparent that the work of the Laboratory on problems arising in missile systems deployed on surface ships would gain considerable significance if certain key elements of the tactical equipment, such as search and track radars and computers and display equipment, could be operated and studied in-house. A building provided with a strong roof for mounting radars, and commanding a range for calibration, together with laboratories and shops, was designed. Building started in the late fall and one radar was operating before the end of June.

The laboratory and office building (Building 4) and the library mentioned in my last report were completed and occupied. The library deserves more than a passing word in that its formal opening on June 7 was a milestone in the academic growth of the Laboratory. The upper floor of this building comprises the library proper which is large enough to accommodate five times as many volumes as we now have (40,000 volumes) and still provide ample space for study or browsing, as well as offices for the library staff and translators. On the lower floor are four classrooms, each capable of accommodating 40-45 persons. The

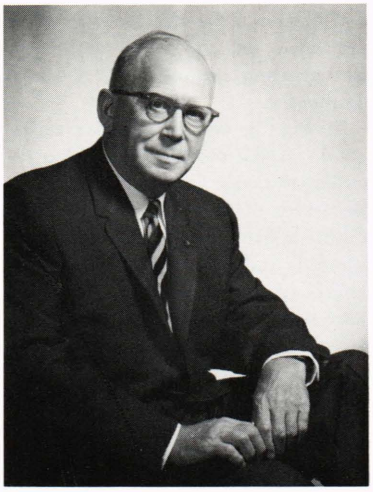


Photo by Udel Bros.

**R. E. Gibson, Director**

whole building is outside the security perimeter of the Laboratory, having an entrance of its own through which we hope many from other branches of the University and from scientific institutions in Howard and Montgomery counties will come to avail themselves of its facilities. The speeches at the dedication by Dr. Frederick Seitz, President of the National Academy of Sciences, and Mr. Albert Hutzler of the Board of Trustees highlighted the significance of the library as a link between the Laboratory and the world of science on the one hand and with the University and the local science community on the other.

A new landmark has made its appearance on the Laboratory grounds, namely a large parabolic antenna, sixty feet in diameter, mounted on a tower and provided with an "x-y" mount for tracking satellites and communicating with them. The figure of this parabola is accurate to a few hundredths of an inch so that it can be used in the microwave regions as well as in the 100-megacycle region of the spectra for which it is primarily intended.

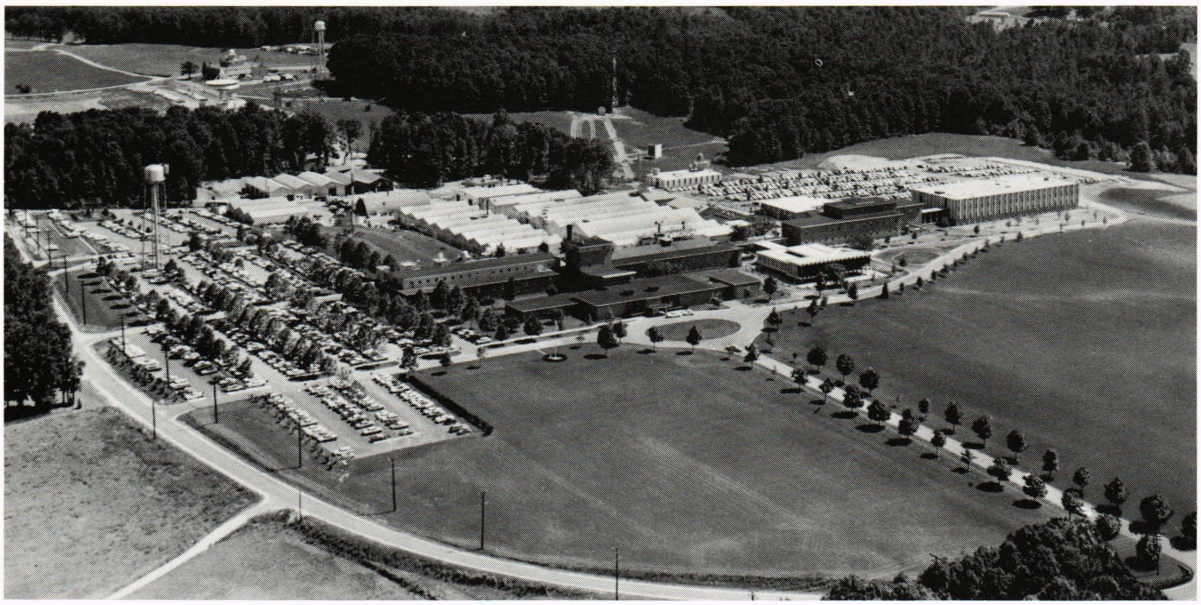
It is with a feeling of some regret that I report the complete evacuation and demolition of the Forest Grove Station. Although the activities at this Station have diminished rapidly during the past five years, it was for ten years the scene of much of our most productive practical work. The name Forest Grove will recall to many the building of the Mark 61 Gunfire Control System, the development of telemetry systems which have found application far beyond the Bumblebee missiles, the early development of ramjet engines and the ground test of the Cobra vehicle for testing these engines in flight, intensive studies of ignition and combustion under supersonic as well as subsonic flow conditions, the birth of missile systems tests with the early design test equipment now in service use, our first excursions into the design of homing systems, and the development of radomes for use in all-weather supersonic flight. Here, Terrier and Talos missiles were readied for test flights. For ten years the Laboratory's central shops were located at Forest Grove, and here we acquired our first experience in missile systems engineering when the modular design concept developed at the Laboratory was reduced to flight hardware in the Terrier 1B program.

### Organization and Activities

During the past year, there have been few changes in the programs of research development undertaken by the Laboratory or in the organization set up to carry them out. Such changes as have occurred are noted below.

The *Fleet Systems Division,* organized last year to devise methods of improving the effectiveness of Terrier, Tartar, and Talos systems installed on warships, has grown in size and in the intensity of its efforts. There are now some 24 ships equipped with Terrier, 18 with Tartar, 3 with Talos, 1 with Terrier and Tartar, and 2 with Talos and Tartar ( a total of 48 ) deployed in the Fleet. . . . In cooperation with the Assessment Division, The Fleet Systems Division has devised mathematical models in which the various factors influencing the availability and effectiveness of the systems may be studied and the gains to be expected from different lines of improvement assessed. This is proving to be a powerful tool. Nearly two years ago the Laboratory was instrumental in organizing technical teams headed by Naval officers who joined newly commissioned missile ships in order to assist the crews in learning to operate and maintain these systems. These Ships Qualifications Assistance Teams, as attested by reports from ship commanders, have been so effective that they are now being taken over by the Navy on a permanent basis. A major program effort has been concentrated on the identification and correction of shipboard equipment deficiencies. A substantial subcontract program with equipment contractors has been essential to achieve the needed quick response. Several ships have been temporarily withdrawn from operations and assigned to support the Laboratory and its contractors for Development Assist Tests where problems can be solved and the efficacy of engineering solutions tested before commitment to large-scale modification programs is made. It is impossible even to touch on all the activities this division has initiated but I may mention two more, the establishment of a program of improved maintenance procedures and the experimental study of fire-control systems at the Laboratory. The first seeks to formulate systematic methods for isolating failures in deployed equipment and correcting them expeditiously. This is proceeding with the cooperation of contractors making the various items of equipment and has already led to a significant reduction in the time required for some repairs. In the second activity an SPG-55B radar has been installed in the Systems Evaluation Building at Howard County and a program of testing is underway.

The *Typhon Program* is one in which the Laboratory has responsibility for systems integration of the complete weapons system, as well as technical direction of the development of the missile and of the fire-control system. The systems integragration work and the development and design of the missiles are handled by the Typhon Program Office and associated Groups. The development of the SPG-59 radar and associated fire-control equipment is the responsibility of the Typhon Division, and the prototype fire-control system is being built by Westinghouse.



**Aerial view of the main complex of buildings at the Howard County site of the Applied Physics Laboratory. In the upper left is the 60-foot parabolic antenna, the Radar Building behind it, and the Propulsion Research Laboratory behind the adjacent water tower.**

During the past year, a number of important phases in the development of the Typhon guidance system have been completed and the results checked in flight. The year imposed severe demands on the systems integration work but the results have amply justified the concept that it is easier to plan and execute an integrated program than to attempt to solve the interface problems in a system which has not been integrated from the start. A noteworthy achievement this year was the design and complete testing of a new control system for the missile by the Laboratory Control Group.

The *Typhon Weapon Control Division* has made some noteworthy contributions to the performance of the radar and to the extension of its applicability to ships of different sizes. However, they are now devoting more and more effort to directing the work of Westinghouse in the final stages of the fabrication of the prototype radar SPG-59 and its installation on the USS *Norton Sound,* which began on March 10 when the antenna tower was lifted into position on the ship.

The *Space Development Division* has devoted the major portion of its effort this year to: (1) The final design, fabrication, and testing of operational navigational satellites, including the preparation of a set of firm specifications governing the manufacture of these satellites by the Naval Avionics Facility, Indianapolis. (2) Assisting the Navy in instrumenting the launching stations for these satellites at Point Arguello, California, and the installation of equipment and the training of crews of the Operational Tracking Stations. (3) The launching and control of satellite ANNA 1B. (4) The fabrication of satellite S-66a spacecraft for NASA to permit world-wide studies of the ionosphere. (5) The final design and fabrication of the SRN-9, a simplified set of navigational equipment, including receivers and computers, for use on surface ships; these components are now being tested aboard ship. . . . (6) Continued study and refinement of the computations on data received from ANNA 1B and other satellites carrying stable oscillators from which doppler shift observations can be made to determine quantitatively the shape of the earth's gravitational field. (7) Refinement of time standards for use in satellite systems. (8) Study of methods for protecting satellite equipment from extraordinary radiation damage and prolonging their lives in the normal radiation environment. (9) Operation of a development doppler tracking network TRANET—and the refinement of equipment therefor. (10) Study of high-energy particles and other aspects of the physics of the outer atmosphere of the earth.

After two years in orbit, navigational satellite 4A (1961 Omicron 1), launched on June 29, 1961, still transmits excellent signals and has responded to more than 500 commands from the Laboratory injection station. It has been a wonderful source of information about the figure of the earth and its gravitational field. Continuous data taken over such a long time has established the fact that orbits may be predicted many months ahead with gratifying accuracy.

Toward the end of the year, the method developed at the Laboratory for "gravitational stabilization" of a satellite was confirmed experimentally. In this method, a boom some 100 feet long and carrying a weight at the far end is deployed from the satellite when it settles down in orbit and its initial spin is removed. This combination causes the entire unit to become aligned in such a way that

one face is continually looking toward the earth. Oscillations of the configurations are damped out by a lossy spring-and-weight combination deployed from the end of the boom remote from the satellite.

On October 31, 1962, satellite ANNA 1B, designed and built at APL, was successfully launched into orbit from Cape Canaveral. This satellite, jointly sponsored by Army, Navy, Air Force, and NASA, carried three methods for determining its orbit with high precision. Of these, two have worked well. The radio-frequency doppler tracking has yielded good data in copious amounts through the TRANET network of tracking stations. Lights mounted on the satellite and capable of giving a sequence of five flashes, each of 8 million candlepower for one millisecond, are controlled by a memory system on board. A program giving the exact time of each series of flashes is provided by the Air Force in accordance with the needs of observers equipped with cameras to photograph the flashes against the star background. This program is transmitted to the satellite from the Howard County injection station and the memory is charged with exact instructions as to when the lights are to be flashed during the next twenty-four hours. This part of the system has worked well with some interruptions. Many photographs have been taken. Reduction of these data to determine satellite positions is long and tedious—the results come much more slowly than those from the doppler tracking systems but, where comparisons are possible, good agreement has been demonstrated. ANNA provides a link between the classical optical observation of heavenly bodies and the modern observations utilizing other regions of the electromagnetic spectrum. . . .

The *Polaris Division* serves the Navy's Polaris Program by devising methods, mathematical models, and procedures for assessing the availability, reliability, and accuracy of the FBM Weapons system. It is concerned with pre-deployment tests of all new Polaris submarines, establishing procedures for the final indoctrination of the crews in the use of the system, and assessing their effectiveness. Rapid methods of data analysis have been developed so that within twelve hours the results of a complete test are available for evaluation; 1566 individual data functions were recorded for each submarine tested. Each test involves about 4 miles of magnetic tape. The Division is also responsible for the analysis of data obtained by submarines when on operating patrols. The work of this Division is increasing, mostly due to the increasing tempo of the Navy's program but also due to the adoption of Polaris by the British government. Administrative problems connected with this program are essentially those arising from the necessity of the Laboratory maintaining a sizeable technical operation at a remote station, namely Cape Canaveral. . . .

A reorganization involving the *Research Center* and the *Aeronautics Division* took place on May 1, 1963. Two new Groups were established in the Research Center, the Chemistry Research Group and the Chemical Physics Research Group. Previously, the people involved in these groups had been part of the Propulsion Group in the Aeronautics Division. At the same time the Fluid Mechanics Group was transferred from the Research Center to the Aeronautics Division, and a new Group, the Hypersonic Propulsion Group, was established in this Division. . . . This reorganization consolidates into the Aeronautics Division the Groups concerned with propulsion, supersonic and hypersonic aerodynamics, arc tunnels and gun tunnels, aerodynamic design, and structural engineering. It also brings together in the Research Center basic research in chemistry and chemical physics with similar work in electron physics, microwave spectroscopy, and conduction of electricity through gases, including laser research. More than 90 of the 600 or more reports published by the Laboratory during the year indicate progress that has been made in the basic and supporting research areas.

Among the more interesting unpublished results is a series of experiments designed by Dr. S. N. Foner to investigate the burning of solid rocket propellants under controlled conditions of acoustic resonance. The experiments, designed to test and extend the theory of McClure, Hart, Bird, and Cantrell, employ an ingenious combination of artificially induced acoustic resonance, frequency control, and electronic measurement to estimate the departure of certain propellants from conditions of stability in a given rocket chamber. The results promise practical applications as well as a test of the theories.

A noteworthy exploratory development in the field of masers was reported by G. E. Friedman and A. W. Nagy who demonstrated the operation of a sapphire maser containing trivalent iron in the complete absence of an external magnetic field. This observation led to the substitution of powdered iron-doped sapphire for single crystals, and here again good maser operation was observed. . . .

During the past year, members of the Laboratory staff met with members of the staff of the Carnegie Institution of Washington in a seminar organized by Drs. Roberts and McClure and devoted to a study of various aspects of the functioning of the human brain in the light of modern molecular biology, information theory, automatic computation, adaptive mechanisms, and learning processes. As a medium for stimulating cross fertilization of ideas between biologists on the one hand and physicists and systems engineers on the other, the seminar was definitely successful and we look forward to its continuation in the future.

The Laboratory also participated in an interdisciplinary seminar on "Systems" inspired by the Dean of Engineering Science. This seminar met seven times during the winter and spring. . . . Meetings were held alternately at Homewood and at the Laboratory. . . .

The Friday afternoon Scientific Colloquia continued to attract large audiences, including many from the Washington-Baltimore scientific community. . . .

R. E. Gibson
*Director*