become obvious when larger boards are considered.

To be really useful, the computer should be capable of generating the ministick artwork itself, since this is the most time-consuming part of the ministick layout procedure. With a program to generate a suitable output tape from the results of this layout program, an automated drafting table could be used to generate the artwork directly, provided the accuracy were high enough not to prohibit the photo-reduction of the artwork to actual size. Automatic tables such as this are made by the California Computer Products Company and the Gerber Scientific Instrument Company.

In the future, when part or all of the logic design itself can be automated, it is not inconceivable that the computer will be able to design a circuit from preliminary specifications, referring to a library of available (and acceptable) integrated circuits, generate the interconnection pattern and wiring list, partition and position the flat packs, and generate the ministick artwork, all with a minimum of human intervention.

Excerpts from the REPORT of the DIRECTOR *of the Applied Physics Laboratory*

JULY 1, 1965—JUNE 30, 1966

TO THE PRESIDENT OF THE UNIVERSITY:

Technical Activities

The technical operations of the Laboratory have generally continued in the pattern of the past two years. The effort is concentrated in four principal areas: (1) Navy Surface Anti-Air Missile Systems, (2) Fleet Ballistic Missile Systems, (3) Space Development Program, and (4) Supporting Research and Exploratory Development.

Recently an analysis was made of the distribution of effort in the Laboratory among different types of technical activity. The results were quite revealing of the diverse nature of the Laboratory's operations. The types of activity, percent of each, and examples of the work involved are given below:

1. Research 13%

This includes basic independent scientific research carried on largely by the APL Research Center and applied research, such as the investigation of clear air turbulence for the Air Force.

2. Exploratory and Advanced Development 17%

This includes most of the work of the Aeronautics Division in the area of jet propulsion and such developments as the gravity-gradient satellite stabilization system.

3. Engineering 29%

The bulk of the in-house engineering done by the Laboratory is the design and fabrication of satellites. This category also includes technical direction and technical support of engineering performed by contractors in guided missiles and radar.

4. System Engineering and Integration 19%

The major portion of this work is done in the surface missile program. It includes formulation of system requirements, system analysis and simulation, and evaluation of prototype subsystems in a system environment.

5. Technical Evaluation of Operational Systems 22%

This category relates to analysis and test of operational systems to determine their performance, reliability, readiness, or other operational capability. The Laboratory's effort in the Polaris program falls into this category, as well as certain recent simulation work in connection with tactical air operations.

SURFACE ANTI-AIR MISSILE SYSTEMS—The Navy's commissioned guided-missile fleet of 12 cruisers, 26 frigates, 23 destroyers, and 3 carriers is armed with Talos, Terrier, and Tartar missiles, which were conceived by the Laboratory and developed in cooperation with its associated contractors. In 1962 the Laboratory was asked by the Navy to take technical responsibility for the shipboard fire-control systems which were initially developed for

the Bureau of Naval Weapons by industry. Since that time a great effort has been concentrated on the solution of engineering problems encountered in the operational evaluation of weapon systems on existing ships and in the integration of weapon systems for new and modernized ships.

The leading role which the Laboratory plays in the development of Navy anti-air systems was recognized by its designation as Chairman of a Naval Laboratory Committee on Fleet Defense. This is one of a family of continuing committees set up by the newly appointed Director of Naval Laboratories to strengthen the participation of Naval laboratories in operational planning and to lay a prime foundation for the Navy's exploratory development programs. APL was the only non-government laboratory designated as Chairman of a continuing committee.

A substantial portion of the development and engineering efforts has been devoted to improving the operation of the weapon systems in hostile operational environments. A broadly based program of procedural and equipment improvements is being carried out. Since the proficiency of operating personnel is a critical factor in these environments, special support, including the production of motion pictures, has been provided the training programs. Special operating procedures have been developed, proven aboard ship, and translated into training documents. Equipment modifications to enhance weapon system performance have been developed, tested, and engineered in conjunction with the system equipment contractors.

The availability of digital computers aboard the newer Fleet ships has been exploited for automated maintenance testing. Special computer programs have been developed at the Laboratory to provide for a comprehensive and highly automated Daily Systems Operability Test for the weapon systems. These programs and the special ancillary equipment have been developed, tested, and recently introduced into the newest Fleet ship.

Concurrent with the engineering program for the Standard Missile, the necessary adaptations of the shipboard systems have been developed. A concentrated effort has been devoted to the analysis of interfaces and to the engineering design of changes to assure compatibility of the new missile with the older shipboard systems. At-sea test programs have been conducted with prototypes of the modifications.

R. E. Gibson, Director

The scope of the Laboratory's program for the Navy surface missile systems has been expanded to include work on search radars sponsored by the Bureau of Ships. These efforts have addressed the elimination of excessive data errors and the improvement of signal processing, especially under foul weather conditions. A typical search radar has been installed in the System Evaluation Laboratory and utilized to support this work.

The Navy programs for new ship construction and major modernization have been supported by the preparation of specific Performance and Compatibility Requirements documents for each ship class. These define the critical system functional characteristics and specify the performance requirements in each of the many operating modes of the weapon system. Two ship classes have been completed for approval and used by the Navy and additional ship classes will be documented as the programs develop.

The test and evaluation activities have been continued with ten significant at-sea test programs conducted. The Laboratory's efforts have involved test planning, on-board technical coordination, analysis reporting, and interpretation of results. Special instrumentation for these tests has been designed, fabricated, and installed aboard ship. Several unique instrumentation techniques are under development to support the evaluation of shipboard system performance. The availability of commercial video tape recorders is being exploited in the adaptation of such equipments for recording and realistic playback of radar signals.

In the area of missile engineering, test, and evaluation, tests in the Guidance Systems Evaluation Laboratory have led to the discovery of hitherto unsuspected effects of target echo fluctuations which explain flight anomalies observed in a number of target intercepts. The more realistic target model developed in these investigations will in turn make possible the introduction of modifications into the guidance systems to render them more effective.

FLEET BALLISTIC MISSILE SYSTEMS—The second major area of Laboratory support of the Navy's mission is the evaluation and improvement of the Fleet Ballistic Missile (FBM) Weapon Systems.

The Polaris Division has continued its analysis of the System Demonstration and Shakedown Operation (DASO) testing of the FBM Weapon System at Cape Kennedy, Florida. Testing of the SSBN-640 Class—the newest and final class—as well as testing of the newly overhauled SSBN-598 Class ships is in progress.

Analysis of Operational Testing of deployed SSBN-616 and SSBN-627 Class ships has continued during the year. In addition to the regular analysis, special studies of re-entry body accuracy have been made.

At the recommendation of the Joint Chiefs of Staff, the Department of Defense has requested that APL apply its Polaris analysis techniques to the Army's Pershing program. At the present time, APL has participated in two DASO tests and has started a program to evaluate the operational readiness and performance of the batteries deployed in Germany.

Polaris Division support of the United Kingdom FBM Weapon System has increased with several correlation meetings to consult with the British on various aspects of their program.

Our efforts in the area of submarine control—both hovering control and improved compensation systems—have progressed significantly; many submarines are now equipped with the control system developed by the Laboratory.

Evaluation work on the Defensive Weapon System has increased during the year with particular emphasis on improvement of sonar performance. The 50-foot motorsailer, which has been donated to the Laboratory for two years by Mr. George L. Todd, is an invaluable aid to sonar and Defensive Weapon System analysis.

SPACE DEVELOPMENT PROGRAM—The Space Development Program now includes support of the Navy Navigation Satellite System, a number of projects for NASA, and a new project DODGE, primarily for the Department of Defense.

As of June 30, 1966, 29 satellites, developed and made at APL, have been placed in orbit. Satellite 1961 omicron 1 celebrated the fifth anniversary of its launching on June 29. It is still functioning properly.

Navigation Satellites. — During the year the Navy asked the Laboratory to re-enter the field of operational navigation satellites, referred to as OSCARs, by inspecting, modifying, and giving final tests to OSCARs 4, 6, 8, and 9, components of which were supplied by another facility. These satellites were tested and launched by the Laboratory and OSCARs 6, 8, and 9 constituted the operational configuration of satellites during most of this period. As a further step to increased reliability, a new satellite memory has been designed utilizing integrated circuit chips and a new packaging technique developed by the Laboratory known as Ministick. This approach has greatly reduced the size of the memory and is expected to result in a substantial improvement in reliability. It will be used for the first time in OSCAR 10 which will be launched shortly.

Geodesy and Navigation Accuracy.—A greatly improved model of the Earth's gravitational field developed in our satellite geodesy studies was introduced into the operational navigation program in January 1966 and has resulted in navigation accuracies substantially better than a tenth of a mile. Meanwhile the geodetic program has continued and a new determination is expected to result in further substantial increase in accuracies available operationally in 1967.

Motorsailer used by APL in Polaris operations off Cape Kennedy.

New Applications.—A technique known as translocation has been developed. It is based on the use of simultaneous position determination at two separated points using the same satellite pass. The relative position accuracy that results is of survey quality. Man-transportable equipment, known as "backpack," to exploit this capability for various military purposes, is under development both for the Marines and the Army. The surveying capabilities of the system are being exploited by the development of small, highly portable equipment known as Geoceiver. Finally, the feasibility of using the system from aircraft was demonstrated and development of aircraft equipment is beginning.

NASA Satellites.—The Direct Measurement Explorer (DME-A) satellite and the GEOS-A satellite were launched and are operating successfully. The GEOS-A satellite, intended for exploration of a number of types of geodetic work, is gravity-gradient stabilized and required a very interesting inversion maneuver after launch. The initial stabilization was accomplished with the satellite upside down. This had been allowed for and a technique for turning the satellite over in space by retracting and subsequently re-extending the stabilization boom was successfully carried out to provide right side up stabilization. The early Beacon Explorer satellites continue to operate and, in fact, all satellites built for NASA are still functioning and meeting program objectives.

The DODGE Satellite. — The DODGE Program (Department of Defense Gravity Experiment) is intended to explore quantitatively three-axis gravity-gradient stabilization in orbits that are nearly synchronous (upwards of 18,000 miles altitude). The satellite is nearing completion and is scheduled for launch in early 1967.

SUPPORTING RESEARCH AND EXPLORATORY DEVELOPMENT PROGRAMS

Aeronautics Division. — The work of the Aeronautics Division has

continued to concentrate on the development of advanced airbreathing systems. Three projects are receiving active support. The first involves study of the potential benefits in substitution of a small ramjet for the solid propellant rockets in future missiles. Experiments have demonstrated the feasibility of the proposed design. The second program is a continuation of investigations of ramjets employing supersonic combustion—so-called Scramjets—which would operate at speeds from 5,000 to 7,000 mph (Mach 7 to 10). Performance data on inlet and combustor configurations are being obtained. The third program involves evaluation of the potential gains in conventional rocket performance through air injection and afterburning of the rocket exhaust. This is now in the stage where preliminary engineering studies are underway.

In addition to these propulsion programs the Aeronautics Division is conducting analytical and experimental studies to determine the feasibility of warheads in which a major part of the energy of the explosive is concentrated in a predetermined direction. The work also includes studies of damage phenomena and intercept kinematics. Significant effort is also applied to: Studies of re-entry phenomena, based on the unique simulation capabilities of the arc heater; investigation of aero-thermal-elastic behavior of structures such as radomes and airfoils; analysis of the aerodynamic behavior of Polaris re-entry bodies in operational tests; and evaluation of proposed engineering improvements to current Naval surface-to-air missiles.

Research Center.—The application of electron spin resonance techniques to the study of elementary chemical reactions involving free radicals has continued, and the rate constants for the reaction of oxygen atoms with hydrogen molecules and methane molecules have been determined over a wide temperature range.

A number of small, highly unstable free radicals containing fluorine have been prepared in inert gas matrices at 4°K and electron spin resonance has been used in favorable cases to identify the radicals (e.g. FCO) and to give information on their molecular structure.

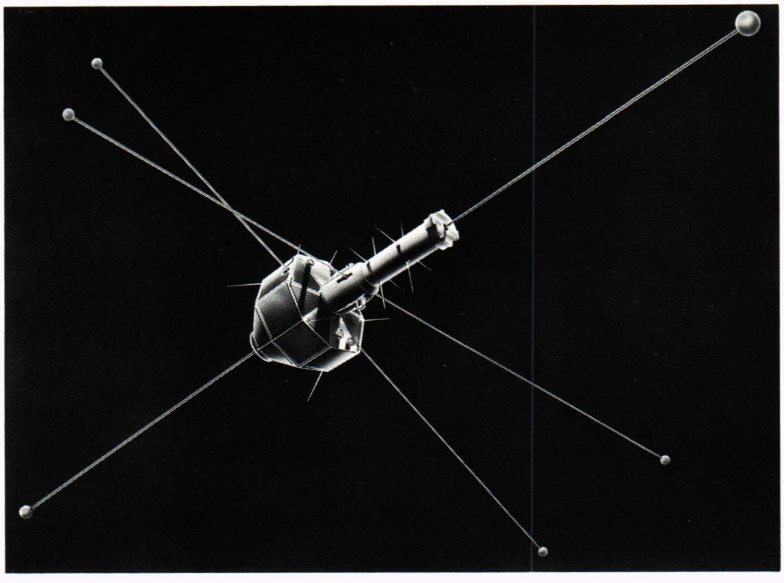
A short duration pulsed electrical discharge system for production of free radicals and metastable molecules has been coupled to the collision free beam sampling mass spectrometer. Using this equipment, the imine (NH) free radical was directly observed mass spectrometrically for the first time and detected in both the normal and electronically excited states. In addition, nitrogen molecules were observed with excitation energies up to about 9 electron volts and a definitive determination of the ionization energy of the methylene (CH_2) free radical was made, with the result that the long-standing discrepancy with the spectroscopic value was removed.

In a study of the properties of gas lasers, a Michelson interferometer was used to measure the effect of an optical cavity on the shape of an emission line when the medium exhibits a net gain and yet is below the lasing threshold.

In the theoretical studies of acoustic instability of rockets, a new model of propellant burning was examined in which the controlling mechanism was assumed to be a reaction between a gas phase component and the propellant surface. The model leads to a frequency dependence of the acoustic response in better agreement with experimental measurements on double-based powders than that given by previous models.

In work on the theory of stellar evolution, calculations have been made on the evolution of a rotating protostar. Some protostars are found to approach starhood ultimately via expansion rather than contraction as generally assumed.

Cooperation with The Johns Hopkins Medical Institutions.—For some time the Laboratory and the Medical Divisions have been exploring areas of mutual interest with a view to active collaboration in the interdisciplinary areas bordered by modern physical sciences and technology on the one hand and problems of medical science and practice on the other. Many joint seminars and conferences have been held. Concrete results have emerged during the past year and the possibilities of setting up joint programs have been explored with the National Institutes of Health (N.I.H.). A program for the development of new radioisotope scanning systems has been proposed and accepted and is in progress. Another larger project for developing and producing short-lived radioisotopes and radiopharmaceuticals has been drawn up and submitted to N.I.H. An important element in this project is the application of a 60-inch cyclotron which



Artist's conception of Department of Defense Gravity Experiment satellite.

has been offered by the Carnegie Institution of Washington. A third program in ophthalmological research and instrumentation is in a formative stage.

Radar Studies of Clear Air Turbulence.—Using the Wallops Island multi-frequency radar system, APL personnel have successfully tracked single insects released from a small aircraft. Moths, dragonflies, and bees were used in this experiment. From the results signatures have been obtained of the insects in terms of radar cross sections and spectra of the received radar signals. The experiments have direct bearing on the "dot angel" problem. Similar experiments were performed using various species of birds. Although birds have been tracked before, to our knowledge these were the first tests in which individual known birds were released and tracked by radar. At present attempts are being made to relate the spectral characteristics with the wing-beat rate of the individual birds.

A clear air region of the atmosphere between 30,000 and 50,000 feet above the surface was found to be a radar reflecting zone on eight occasions on five different days during February and March of this year. This region was identified from radiosonde measurements as the tropopause. This constituted an encouraging set of detections since, on theoretical grounds, there is reason to believe these regions are turbulent.

The Wallops Island radars operated by the Laboratory have also yielded an astonishing series of observations in the clear air in the lower 20,000 feet of the atmosphere. During the course of any day, especially in the warmer months of the year, the extremely sensitive radars are used to photograph many layers and convective cells in the air not optically visible. These layers and cells were shown by direct measuring probes to be regions of air in which there is a large variance in the refractive index of the air. As a result of these findings a system has been developed which can explore the motions of the clear atmosphere in a manner not heretofore possible. It is now feasible, as examples, to obtain a three-dimensional picture of the wind, to study the intricate structure of a sea-breeze circulation, and to study physical processes involved in the interaction between the sea and the air above it.

Satellite Exploration in Astrophysics and Geophysics.—The data from the ultraviolet radiation photometer on the APL satellite 5E-5 (1964 83C) have been used to calculate the ultraviolet color indices, the associated interstellar absorption, and the effective temperatures as a function of stellar type for 143 stars. Also, the ultraviolet albedo of the moon at 1376 Å has been measured at least twice.

The APL satellite 5E-1 (1963 38C) carried a number of particle detectors and a set of vector magnetometers. The satellite continues to operate after three years and a number of studies have been carried out using data from this satellite. Outer radiation zone measurements at high latitudes have revealed: (1) a definite correlation between electron intensity and magnetic activity; (2) a diurnal variation which can be explained in terms of the natural motions of trapped particles in a magnetosphere distorted by the solar wind; (3) a 27-day variation related to the rotating structure of the interplanetary magnetic field; and (4) correlation between the nightside trapping boundary and the magnitude of the magnetic field in the tail of the magnetosphere. At lower latitudes a longitudinal variation in electron intensity indicates that electrons are continually precipitated into the atmosphere in the region of the South Atlantic magnetic anomaly.

The artificial radiation belt produced by the Starfish high-altitude nuclear detonation has been monitored for 27 months and particle lifetime measurements show that loss mechanisms which preferentially remove high-energy electrons must be dominant over much of the region. Atmospheric losses are important only at low altitudes.

An interesting area of research was opened up by the discovery of transverse magnetic disturbances with periods of 1 to 10 seconds and amplitudes to 500γ ($1\gamma = 10^{-5}$ gauss) in the auroral zone at 1100 km altitude. The disturbances are confined to a narrow latitude region near the edge of the trapping region and the disturbance region is found to vary with local time and magnetic activity. The "waves" are present in over 90% of the observations.

Comparing the time history of the February 5, 1965, solar proton event as observed by 1963 38C in the polar regions with that seen by the Mariner IV spacecraft 3000 earth radii from earth in the anti-solar direction, has shown significant differences. These can be interpreted several ways and one approach yields an estimate of 0.3 astronomical unit for the length of the earth's magnetic tail.

Injun III data from September 1963 have been used to study the effects of a large magnetic disturbance on inner zone protons. The disturbance resulted in the depletion of 1 to 2 Mev protons by as much as a factor of ten near the outer edge of the inner zone. The narrow energy interval and spatial region affected suggests a resonance phenomenon and power spectral analysis of the magnetic field variations lends some support to this view.

The work described here was supported jointly by the Navy and the National Aeronautics and Space Administration.

Research Projects for ARPA.—The permanent relationship with the Advanced Research Projects Agency (ARPA), established during the previous year, has continued with advantageous consequences for both APL and ARPA. The Advanced ALBIS study of defense against sea-launched missiles was the principal activity during the year. This was successfully concluded and the results presented at numerous meetings, including Subgroup F of the Tripartite Committee (U.S., Canada, U.K.) in London. In certain areas of nuclear vulnerability, the Laboratory has achieved leadership and chairs the pertinent national committee. Another related and significant activity was the experimental participation by the Laboratory in the current underground tests of nuclear effects which are supported by ARPA and the Defense Atomic Support Agency (DASA). During the year several studies pertaining to current operational problems were

undertaken. The effort on over-the-horizon radar has expanded and the Laboratory is in the process of developing (with the Mitre Corporation) the specifications for an experimental facility.

BOARD OF VISITORS—A Board of Visitors for the Applied Physics Laboratory was established this spring. The seven members, appointed jointly by the Secretary of the Navy and the President of the University, are:

- Admiral John H. Sides, USN (Ret.), Lockheed Aircraft Corporation, Chairman
- Dr. Paul M. Fye, Director, Woods Hole Oceanographic Institution
- Mr. E. H. Bedell, Bell Telephone Laboratories
- Dr. J. E. Henderson, Director, Applied Physics Laboratory/ University of Washington
- Dr. R. L. Sproull, Vice-President for Academic Affairs, Cornell University
- Dr. E. A. Walker, President Pennsylvania State University, President National Academy of Engineering
- Hon. Herbert York, University of California, formerly Director of Defense Research and Engineering

The Board met on May 18 and 19 and on July 15, 16, and 17, and will hold meetings again each year. The annual report of the Board will be submitted formally to the Secretary of the Navy with copies made available to the Laboratory. The purpose of the Board is to conduct a periodic review of the activities and performance of the Laboratory and of the use made of it by the Navy.

INFORMATION ACTIVITIES

Reports, Papers, and Patents.—Technical reports, papers presented before scientific societies, papers published in the scientific literature, and patent disclosures are extremely important products of the Laboratory's efforts. During the current year there was considerable activity in these areas.

Approximately 200 unclassified and 125 classified formal technical reports were issued by the Technical Reports Group; 92 papers were published in the open literature; and more than 200 formal Polaris reports were issued by the Polaris Division. In addition, well over 3,000 informal documents on a wide variety of topics were issued by the individual Groups.

During the year 95 inventions were disclosed to the Department of the Navy, 18 patent applications were filed, and 34 patents were granted.

The APL TECHNICAL DIGEST continued into its fifth year of publication. The May-June 1966 issue (Vol. V, No. 5) was dedicated to P. Stewart Macaulay who retired June 30 as Executive Vice-President of the University. In recognition of Mr. Macaulay's interest and activities in the entire University, papers were contributed by authors in other divisions.

Ninety-six staff members presented 107 papers before scientific engineering, and lay societies. Of these, 21 were presented abroad.

The APL Colloquia continued to be well received. Twenty-six meetings were held, with all of the speakers except two being from outside the Laboratory.

Library. — The APL Library service is furnished by a Reference Library and a Document Library; both are making extensive use of an IBM 7094 computer.

In addition to the usual library activities, the APL Library is presently engaged in several projects that merit special mention. These are: (1) compilation of the *List of Scientific-Technical Journal Titles and Holdings in the Washington-Baltimore Area,* which now contains more than 2000 journal titles from 17 different libraries; (2) the development of a visual aid card catalog and associated computer index system; (3) the development of automatic purging criteria for ridding active magnetic tape files of obsolete data; and (4) the preparation of computerized bibliographies featuring automatic indexing techniques.

Chemical Propulsion Information Agency.—In its regular, complete information program as a DOD-sponsored Information Analysis Center, CPIA produced 55 publications covering all aspects of chemical propulsion during the year. CPIA also assisted its sponsoring organization, the Interagency Chemical Rocket Propulsion Group (ICRPG), in conducting 14 technical meetings of specialists concerned with various areas of chemical propulsion.

A "chemical typewriter" has been received from the Army and CPIA is now preparing an index of the unique chemical compounds in its files for the Army's Chemical Information and Data System (CIDS). This includes the numerous compounds synthesized under the Advanced Research Projects Agency's Project Principia (1959–1965).

Handbook of Supersonic Aerodynamics.—The *Handbook of Supersonic Aerodynamics* (published as NAVWEPS 1488 by the Government Printing Office) was initiated at APL in 1948 as a compilation of basic information for use by designers of supersonic vehicles. For the past six years Mrs. I. D. V. Faro has edited the *Handbook* and now brings the project to a conclusion with the publication of the final section on "Viscosity and Heat Transfer Effects."

Staff Activities

EVENING COLLEGE PROGRAM AT APL—The University Evening Center at the Laboratory has continued to expand. Six courses were taught in the 1964-65 academic year, 11 in 1965-66, and 16 are scheduled for 1966-67. Enrollment totalled 241 in the 1965-66 academic year with approximately 60% of the students being Laboratory staff members.

Two Master's degree curricula are now offered at the Laboratory—M. S. in Engineering (with a major in Electrical Engineering) and M. S. (with a major in Numerical Science). The latter is a new degree program which requires the completion of five graduate courses: three in mathematics, one in computer science, and one in the probability and statistics area.

One of the new courses to be taught next year is "The Elements of Space Technology." This course will include both theory and design of spacecraft and the application of space technology to communication, navigation, meteorological, and research satellites. An actual operation with an orbiting satellite will be ar-

ranged for the students, who will then analyze the results from telemetry records.

FELLOWSHIP PROGRAMS—Dr. C. K. Jen, Vice-Chairman of the APL Research Center, was invited to be the first recipient of the William S. Parsons Visiting Professorship at the University and Dr. W. G. Spohn was awarded the William S. Parsons Fellowship. Both appointments are for the 1966-67 academic year.

Three graduate students in the Department of Electrical Engineering of the University are working toward the Ph. D. degree on APL Fellowships. Two additional graduate students have been awarded Fellowships to start in September.

Administrative Operations

ORGANIZATIONAL CHANGES — A number of changes in the administrative organization of the Laboratory were made following the untimely death of Mr. J. A. Slingluff, Administrative Manager of the Laboratory since 1950 and a valued member of the staff since 1947. The Purchasing Group was incorporated into a new Procurement Branch which now includes both the Contracts and Purchasing Groups under the supervision of Mr. C. J. Smith. Functions of a personnel nature formerly performed by the Administrative Manager were transferred to Dr. H. C. Anderson, Supervisor of the Personnel and Education Group, and Dr. Anderson was designated Director of Personnel and Education for the Laboratory. An Administrative Services Division was established under Mr. D. R. Marzetta who was appointed Manager of the Division. This Division includes the Plant Engineering, Office Services, and Security Groups and the Laboratory's Safety, Fire, Medical, and Civil Defense programs as well as a number of other service functions.

BUILDING PROGRAM—As a result of an increasingly critical need for additional laboratory and office space, the University Trustees have authorized the Laboratory to construct an additional building at the Howard County location of some 100,000 gross square feet and generally similar in design to the major laboratory and office building completed in 1963. This building will permit the Laboratory to give up rented space in Silver Spring, remove people from marginal space now being utilized at Howard County, and relieve current overcrowding in a number of areas.

R. E. GIBSON
Director

ADDRESSES

The listing below comprises the principal recent addresses made by APL staff members to groups and organizations outside the Laboratory.

F. F. Hiltz, "An Analog Device for the Detection of Intracellular Neuronal Events," *20th Annual Conference on Engineering in Medicine and Biology*, San Francisco, Calif., Nov. 13–16, 1966.

F. F. Hiltz (APL) and R. E. Burke (NIH), "Statistical Properties of Miniature Synoptic Potentials During Muscle Stretch," *20th Annual Conference on Engineering in Medicine and Biology*, San Francisco, Calif., Nov. 13–16, 1966.

R. A. Dickmann, "A 1966 Survey of Test Use in Computer Personnel Selection and Its Implications," *Diebold Research Program—Europe*, Amsterdam, Netherlands, Nov. 22–24, 1966.

I. Katz, "Probing the Clear Atmosphere with Radar," *Electrical Engineering Department Seminar, The Johns Hopkins University*, Baltimore, Md., Jan. 10, 1967.

T. G. Konrad, "Probing the Clear Atmosphere with Radar," *Electrical Engineering Department Seminars, University of Colorado*, Boulder, Colo., Jan. 12, 1967, and *University of Wyoming*, Laramie, Wyo., Jan. 13, 1967.

R. C. Orth and J. A. Funk, "An Experimental and Comparative Study of Jet Penetration in Supersonic Flow," *AIAA Fifth Aerospace Sciences Meeting*, New York, N.Y., Jan. 23–25, 1967.

R. M. Fristrom, "Molecular Beams —A Tool for Chemical Studies," *Aerospace Corporation Seminar*, El Segundo, Calif., Jan. 26, 1967.

L. E. Bowen, "Satellite Geodesy," *Ancient Order of Hibernians, Emerald Isle Division*, Washington, D.C., Jan. 27, 1967.

R. M. Fristrom, "The Structure and Chemistry of Flames," *Department of Mechanics Seminar, University of California*, Berkeley, Calif., Jan. 31, 1967.

C. F. Noyes, "Packaging the Navy's Navigational Satellite Memory," *National Electronic Packaging and Production Conference*, Long Beach, Calif., Jan. 31–Feb. 2, 1967.

D. W. Fox, "Error Bounds for Approximations to Expectation Values of Unbounded Operators," *Mathematics Colloquium, Georgetown University*, Washington, D.C., Feb. 3, 1967.

A. I. Mahan, "A Macroscopic Approach to Stimulated Emission," *Engineering Department, Catholic University*, Washington, D.C., Feb. 7, 1967.

C. K. Jen, L. C. Aamodt, and A. H. Piksis, "Changes Induced in the Phosphorescent Radiation of Aromatic Molecules by Paramagnetic Resonance in their Metastable Triplet States," *International Symposium on the Triplet State*, Beirut, Lebanon, Feb. 15, 1967.

J. J. Hicks, "Clear Air Turbulence," *Department of Space Science and Applied Physics, Catholic University*, Washington, D.C., Feb. 16, 1967.

H. D. Black, "The Attitude of a Satellite," *Heat Transfer Division Meeting, ASME*, Washington, D.C., Feb. 23, 1967.