

the satellite clock against the standard station, and compute the error in the station clock epoch relative to the standard station. Measuring error is limited by the signal to noise ratio associated with the received timing signals and is presently about 30  $\mu$ sec RMS for the data received on a single pass.

Frequency errors which are constant throughout a satellite pass produce no errors in the computed position of the station or satellite. Oscillator drift during a pass, however, may produce a small error in the minimum range, similar to that which would be produced by an along track velocity error. Frequency standards currently in use typically have drift rates of a few parts in  $10^{11}$  per day, corresponding to negligible position errors due to this effect.<sup>6</sup>

<sup>6</sup>R. R. Newton, "The Navy Navigation Satellite System," *Proc. COSPAR 7th International Space Science Symposium*, May 1966.

## Summary

The TRANET system is capable of providing high-density, high-accuracy doppler data for a large number of satellites in a form ready for immediate computer processing.

The TRANET system is capable of measuring the doppler frequency received from a satellite with an accuracy of 1 part in  $10^{10}$  and the satellite position with a precision of 10 meters. Accuracy of orbit determination is limited to about 50 meters by incomplete knowledge of the earth's gravity field.

It is estimated that the TRANET system could reliably handle as many as ten near-earth satellites in full time operation with maximum accuracy. With lessened accuracy requirements the number of satellites which the system could be called on to track would be greatly increased.

## ADDRESSES

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

- A. A. Westenberg, "Application of ESR Spectroscopy to Gas Phase Chemical Kinetics," *5th Aerospace Sciences Meeting of the AIAA*, New York, N.Y., Jan. 23, 1967.
- R. A. Farrell, "The Lattice Gas—Phase Transitions," *Physics Department Seminar, Catholic University*, Washington, D.C., Mar. 3, 1967.
- A. A. Westenberg and R. M. Fristrom, "Structure and Chemistry of Flames," *751st Meeting, Chemical Society of Washington*, Arlington, Va., Mar. 9, 1967.
- P. M. Bainum, "Design of Satellite Attitude Control Systems by Lyapunov Techniques," *Department of Engineering Control Systems Seminar, The Johns Hopkins University*, Baltimore, Md., Mar. 16, 1967.
- F. F. Hiltz, "Neuron Simulation and Data Processing," *Training Symposium on Mathematical Modeling and Analysis of Biological Systems*, Kensington, Md., Mar. 17, 1967.
- K. S. Bonwit (APL) and R. E. Rasche (Sperry Gyroscope Company), "CESSAM: Conversion Equipment System, Surface-to-Air Missile," *IEEE International Convention*, New York, N.Y., Mar. 20–23, 1967.
- M. L. Moon, "Surface Missile Systems," *U.S. Naval Reserve Research Company 5–11*, Annapolis, Md., Mar. 21, 1967.
- I. Katz, J. J. Hicks, and T. G. Konrad, "Radar Experiments with Chaff for Measuring Atmospheric Properties," *Conference on Physical Processes in the Lower Atmosphere, University of Michigan*, Ann Arbor, Mich., Mar. 20, 1967.
- I. Katz, "Probing the Clear Atmosphere with Radar," *Joint Session of IEEE Antennas and Propagation and Geoscience Electronics Groups*, Washington, D.C., Mar. 21, 1967.
- M. T. Miyasaki, "Using Hot Wire Anemometers for Airborne Meteorological Measurements," *International Symposium on Hot Wire Anemometry, University of Maryland*, College Park, Md., Mar. 21–22, 1967.
- R. A. Makofski, R. W. Henderson, and F. F. Mark, "A High-Pressure Hypersonic Gun Tunnel," *Fifth Hypervelocity Techniques Symposium*, Denver, Colo., Mar. 16–17, 1967.
- J. C. Murphy and J. Bohandy, "Growth of PbS Crystals in Silica Gel" and "ESR of  $Mn^{2+}$  and V in Strontium Tartrate," *March Meeting of the American Physical Society*, Chicago, Ill., Mar. 28, 1967.
- J. H. Martin (APL), R. L. Statler (NASA), and E. L. Ralph (Heliotek Corporation), "Radiation Damage to Thin Silicon Solar Cells," *Photovoltaic Specialists Conference*, Cocoa Beach, Fla., Mar. 28–31, 1967.
- Jane Olmer, "APL Information Processing System," *National Federation of Science Abstracting and Indexing Services Annual Meeting*, Philadelphia, Pa., Mar. 29–30, 1967.
- D. K. Anand and J. M. Whisnant, "Stability and Dynamic Response of Thermally Bent Booms Subjected to Varying Radiation Pressure," *Structural Dynamics Conference*, Palm Springs, Calif., March. 29–31, 1967.
- M. L. Hill, "Materials for Small Radius Leading Edges for Hypersonic Vehicles," *AIAA Structures*

## ADDRESSES (continued)

- and Materials Conference, Palm Springs, Calif., Mar. 29–31, 1967.
- S. I. Solomon, "Mathematical Techniques of Operations Research for Management," *Operations Research Course, American Management Association*, New York N.Y., Mar. 31, 1967.
- J. R. Apel, "Non-Linear Effects in Beam Plasma Interactions," *Plasma Physics Seminar, University of Maryland*, College Park, Md., Apr. 4, 1967.
- P. M. Bainum and D. L. Mackison, "Gravity-Gradient Stabilization of Synchronous Orbiting Satellites," *British Interplanetary Society Spring Meeting, Loughborough University of Technology*, Loughborough, England, Apr. 4–6, 1967.
- C. H. Pollow, "Navy Navigation Satellite System," *Naval Air Reserve Training Units WEPTU 661 and 662 (Washington, D.C.) and Units 911 and 912 (South Weymouth, Mass.)*, Naval Air Facility, Washington, D.C., Apr. 8, 1967.
- R. M. Fristrom, "Flame Chemistry and Fire," *Chesapeake Chapter of the Society of Fire Protection Engineers*, College Park, Md., Apr. 13, 1967.
- F. J. Adrian, "Guidelines for Interpreting Electron Spin Resonance Spectra of Paramagnetic Species Adsorbed on Surfaces," *1967 Meeting of the American Chemical Society*, Miami, Fla., Apr. 14, 1967.
- C. J. O'Brien, "The Johns Hopkins University Applied Physics Laboratory and Its Work," *Department of Adult Education, Navy Ship Research and Development Center*, Carderock, Md., Apr. 17, 1967.
- A. J. Zmuda, W. E. Radford, F. T. Heuring, and P. Verzariu, "The Scalar Magnetic Intensity at 1100 km at Middle and Low Latitudes," *48th Annual Meeting of the American Geophysical Union*, Washington, D.C., Apr. 17, 1967.
- J. C. Murphy, "An ESR Survey of Some Transition Metal Tartrate Crystals," *Washington Area Magnetic Resonance Seminar*, Gaithersburg, Md., Apr. 19, 1967.
- J. R. Apel, "Unstable Waves in Multi-Stream Plasmas," *Plasma Physics Seminar, Columbia University*, New York, N.Y., Mar. 31, 1967; and *General Physics Colloquium, University of Massachusetts*, Amherst, Mass., Apr. 20, 1967.
- W. E. Wilson, "A Critical Review of the Combustion Reactions of the Hydroxyl Radical," *Western States Section of the Combustion Institute*, San Diego, Calif., Apr. 24, 1967.
- D. G. Grant, "Principles of Holography," *Biological Photographers Association Monthly Meeting, Applied Physics Laboratory*, Howard County, Md., Apr. 25, 1967.
- G. L. Dugger, "Ramjets," *Department of Space Science and Applied Physics, Catholic University*, Washington, D.C., Apr. 27, 1967.

## PUBLICATIONS

The following list is a compilation of recently published technical articles written by APL staff members.

- L. W. Ehrlich, "A Modified Newton Method for Polynomials," *Commun. Assoc. Computing Machinery*, 10, No. 2, Feb. 1967.
- T. Jerardi, "Geodesy," *Drexel Tech. J.*, XXIX, No. 3, Feb. 1967, 12–17.
- F. J. Adrian, "ESR Spectrum and Structure of O<sub>2</sub>F," *J. Chem. Phys.*, 46, No. 5, Mar. 1, 1967, 1543–1550.
- W. E. Wilson, "Rate Constant for the Reaction  $N + O_2 \rightarrow NO + O$ ," *J. Chem. Phys.*, 46, No. 5, Mar. 1, 1967, 2017–2018.
- N. Rubinstein, "On the Cesari-Cavalieri Area of a Surface," *Duke Math. J.*, 34, No. 1, Mar. 1967, 73–84.
- J. Frank, J. H. Kuck, and C. A.

Shiple, "Latching Ferrite Shifter for Phased Arrays," *Microwave J.*, Mar. 1967, 1–6.

H. Querido, J. Frank, and T. C. Cheston, "Wide Band Phase Shifters," *IEEE Trans. Antennas and Propagation*, AP-15, No. 2, Mar. 1967, 300.

## APL COLLOQUIA

Mar. 3—"The Use of Computers in Designing Electronic Circuits," by W. W. Happ, NASA Electronics Research Center.

Mar. 10—"The Trapping and Acceleration of Ions in Electron Plasmas," by G. S. Janes, Avco-Everett Research Laboratory.

Mar. 17—"The Gunn Effect—Status and Prospects," by L. S. Eastman, Cornell University.

Mar. 24—"Whiskers and Fibers," by M. J. Salkind, United Aircraft Corporation Research Laboratory.

Mar. 31—"Fluidic Missile Control," by A. B. Holmes, Harry Diamond Laboratory.

Apr. 7—"The Cosmic Background Radiation and the Primeval Fireball," by R. B. Partridge, Princeton University.

Apr. 14—"Measurement of  $2e/h$  Using the ac Josephson Effect, and its Implications for Knowledge of the Fundamental Physical Constants," by W. H. Parker, University of Pennsylvania.

Apr. 21—"Structure and Variations of the Upper Atmosphere," by L. G. Jacchia, Smithsonian Astrophysical Observatory.

Apr. 28—"The Photographic System of Lunar Orbiter," by W. Feldman, Eastman Kodak Corporation.

## WITH THE AUTHORS



*S. A. Taylor*, co-author of "Digital Pulse Compression Radar Receiver," was born in Washington, D.C., and attended the University of Maryland, George Washington University, and the University of Virginia. A specialist in circuitry as applied to radar techniques, Mr. Taylor joined the Laboratory in 1952. His first assignment, in the Transistor Circuits Group, included fabrication and test of electronic equipment used in the evaluation of missile prototypes. Presently, as a member of the Radar Techniques Group, he is responsible for the design of various signal processors, including multi-frequency receivers and post detection interpretation and pulse compression equipment.

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Evening College. Prior to his association with APL in 1963, Mr. Hicks was employed by the Martin

Company where he was engaged in electronic packaging and product design. At APL, Mr. Hicks assisted in the development of the ministick packaging technique, and in the package design of satellite memory systems. A specialist in advance packaging and process techniques, he is concerned with the use of thin-film materials for current and future applications. Mr. Hicks is a member of the Institute of Electrical and Electronics Engineers.



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