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BACKGROUND ON APOLLO WORK

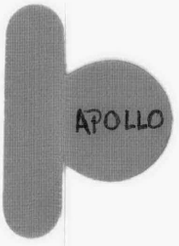
AT INSTRUMENTATION LABORATORY

1. General

In a three-story building at 75 Cambridge Parkway overlooking the Charles River in Cambridge, Mass., more than 300 engineers and scientists are teamed in an extensive mingling of government, industry and university talent to help send American explorers to the moon.

The team is engaged in designing the guidance and navigation system three U.S. astronauts will use to steer their National Aeronautics and Space Administration Project APOLLO spacecraft to the moon and back to earth.

More than 200 of the professional force are staff members at Massachusetts Institute of Technology's Instrumentation Laboratory, which -- as NASA's Associate Contractor for APOLLO Guidance and Navigation -- holds primary responsibility for system design, development, test and operational support.



Others on the team are on-site representatives of the Guidance and Control Division of the APOLLO Project Office at NASA's Manned Spacecraft Center at Houston, Tex., which directs the program, and on-site representatives of the APOLLO Participating Contractors for Guidance and Navigation which NASA selected to support Instrumentation Laboratory and eventually manufacture systems.

Participating contractors and their responsibilities are:

AC Spark Plug Division of General Motors Corporation, Milwaukee, Wis., and Wakefield, Mass., for inertial measurement units and associated displays and controls, for gyroscopes in the IMU, for total system integration and integration of all displays and controls, and for ground support equipment.

Kollsman Instrument Corporation, a subsidiary of Standard Kollsman Industries, Inc., Elmhurst, N.Y., and Syosset, N.Y., for the optical subsystem, the map and data viewer, and associated round support equipment.

Raytheon Company's Space and Information Systems Division, Bedford, Mass., and Sudbury, Mass., for the G&N digital computer and associated displays and controls.

Sperry Gyroscope Company division of Sperry Rand Corporation, Great Neck, N.Y., for pulsed integrating accelerometers used in the IMU.

Also on hand are engineering liaison representatives of other APOLLO contractors, including Space and Information Systems Division, North American Aviation, Inc., Downey, Calif., NASA's Principal Contractor for the APOLLO spacecraft, and Grumman Aircraft Engineering Corporation, Bethpage, N.Y., NASA's Associate Contractor for the APOLLO Lunar Excursion Module which will carry two of the three APOLLO astronauts from the orbiting main spacecraft to the moon surface and back.

The guidance and navigation system for the Lunar Excursion Module (LEM), the vehicle which makes the actual lunar descent, is expected to have many elements in common with the main spacecraft system. This common usage will provide substantial advantages in inflight repairs, astronaut familiarization and training, pre-launch logistics, and reduced development costs.

Supporting this fully-integrated government-industry-university design team are

another 300 Instrumentation Laboratory technicians, machinists and administrative personnel assigned to the APOLLO program.

The building that houses the design center is one of seven used by the Instrumentation Laboratory in Cambridge and was leased for the APOLLO program in late 1961 when the Laboratory accepted NASA's assignment to design the G&N system.

(The building formerly was occupied by an electronics firm, ITEK. It was originally built and for many years used as a warehouse and distribution center by a clothing firm, Brown Durrell Co., specializing in hosiery and underwear.)

2. Laboratory History

The Laboratory's founder and director is Dr. Charles Stark Draper, Professor and Head of the Department of Aeronautics and Astronautics at MIT and a pioneer in the development of inertial guidance, inertial navigation and inertial control systems for ships, submarines, airplanes, missiles and satellites.

Dr. Draper started the Laboratory just prior to World War II to develop lead-computing gyroscopic gunsights for Navy anti-aircraft guns. His Mark 14 gunsight was the first of its kind to reach the fleet and played an important role in naval engagements of World War II.

Toward the end of World War II, Dr. Draper and his associates developed gyro-stabilized gun-bomb-rocket sights for Air Force fighter planes and one of these saw extensive service in the Korean War aboard F-86 fighters.

Following World War II, Dr. Draper began applying knowledge of gyroscopic stabilization and feedback control to the original work done in this country on inertial navigation and guidance.

Essentially, these are systems that have a gyro-stabilized inner member on which force-measuring accelerometers are mounted. Information from the accelerometers, isolated from the vehicle by gyro and gimbal stabilization, is then computed into information about changes in speed, position and direction of movement, all without reliance on any information from outside the vehicle. Navigation systems read out this information, guidance systems control the vehicle automatically and guide it to a terminal or target.

Dr. Draper made his first inertial system transcontinental test in an airplance flight from Massachusetts to Los Angeles in 1953, demonstrating feasibility of such systems. Since then from the Laboratory have come designs and designs concepts for many now-operational systems. The Air Force THOR missile guidance system is based on Laboratory design concepts. The Laboratory designed and carried out engineering test of the inertial measuring unit in the Air Force TITAN missile guidance system. The Navy POLARIS missile guidance system also was designed, developed and tested by the Laboratory. And the first ship's inertial navigation system (SINS) was built, tested and demonstrated by the Laboratory. SINS are now used on nuclear submarines to enable them to remain submerged for long periods.

Laboratory research and development on advanced inertial guidance, navigation and control systems for military vehicles is continuing.

Many key Laboratory engineers now assigned to the APOLLO project worked earlier on such projects at TITAN and POLARIS.

Moreover, several Laboratory engineering groups now working on various phases of the APOLLO project also are working simultaneously on similar phases of other Laboratory projects.

In APOLLO, as in all of its programs, the Laboratory works closely with government-selected participating contractors in developing system designs, fabricating prototypes, carrying out engineering design tests and supporting operational use. System production and manufacturing, of course, is performed by industry. Of federal funds expeded for design, development, test and prcurement of these systems, the bulk goes to the participating industrial contractors for manufacture and fabrication, and only a small portion to support MIT's design, test and operational support efforts.

3. Laboratory APOLLO Organization

Assisting Dr. Draper in overall supervision of the Laboratory's design programs, including APOLLO, are the Laboratory's two deputy directors -- Roger B. Woodbury (of Weston), who was a principal engineer in development of inertial guidance systems from their early beginnings at the Laboratory, and Forrest E. Houston (of Westwood), a Laboratory leader in development of inertial navigation systems and who is a co-holder of patents on SINS.

Directing the specific APOLLO program at the Laboratory is Milton B. Trageser (of Winchester), who joined the Laboratory staff in 1951 following graduation from MIT. Mr. Trageser participated in development of THOR and TITAN systems and later conducted space guidance studies for the Laboratory.

Technical director of the Laboratory's APOLLO project is David G. Hoag (of Medway), who joined the Laboratory in 1946 following his graduation from MIT. Mr. Hoag worked on Navy antiaircraft gun fire control systems and Navy TERRIER and TARTAR fire control systems. From 1956 to his appointment to the APOLLO project, Mr. Hoag was technical director of the Laboratory's POLARIS guidance system development.

Management director of the Laboratory's APOLLO project is Perry K. Bryant (of Lynn), who joined the Laboratory in 1962 following retirement from the Air Force with the rank of Colonel. Mr. Bryant served with the Air Force Aeronautical Systems Division for several years with management assignments.

Key Laboratory officials leading important APOLLO development areas include:

Dr. Richard H. Battin (of Lexington) in charge of space guidance analysis for the Laboratory.

Philip N. Bowditch (of Cohasset) in charge of mechanical design of the APOLLO optical system. (Mr. Bowditch, a 1946 graduate of MIT., is the great great grandson of Nathaniel Bowditch, the pioneer 19th century navigator whose classic book, The American Practical Navigator, is still used, in updated form, by seafarers.)

Eldon C. Hall (of Wollaston) in charge of development of the APOLLO digital computer.

Edward J. Hall (of Lexington) in charge of development of the APOLLO gyros.

John R. McNeil (of Weston) in charge of electronics that make the Laboratory's pulsed integrating pendulum instrument into an accelerometer.

John B. Nugent (of Winthrop) in charge of mechanical design of the APOLLO inertial measurement unit.

Michele Sappupo (of Lawrence) in charge of development of the pulsed integrating pendulum instrument that forms the heart of the APOLLO accelerometers.

John E. Miller (of Weston) in charge of APOLLO inertial measurement unit integration and calibration.