INSTRUMENT LABORATORY

INSTRUMENT DEVELOPMENT BRANCH

CONTROL & INSTRUMENTATION DIVISION

TEST LABORATORY

MARSHALL SPACE FLIGHT CENTER

HUNTSVILLE, ALABAMA

MISSION AND FACILITIES
OF INSTRUMENT DEVELOPMENT BRANCH

The Instrument Development Branch is responsible for development, modification, prototype production, test, and calibration of measuring instrumentation, necessary to support the Test Laboratory's mission comprising static firing and development testing of launch vehicle systems, their components and ground equipment, providing evaluation of performance and recommendation of design criteria. This task requires that the Instrument Development Branch advances continuously in improving instrumentation to keep abreast of the requirements imposed by the ever increasing complexity of test programs. The advances in instrumentation are accomplished through research and development projects which are carried out either in-house or through private industry and research institutes.

Research, development, design, production, and calibration of specialized instrumentation can only be accomplished with the proper facilities. Therefore, planning was initiated several years ago to develop requirements for the proper building and equipment needed to carry out this function. The result of this planning is evident when one tours the Instrument Laboratory and views the complex systems contained in this facility. Some of these systems are unique and are available only at this Laboratory. A detailed description of the overall laboratory capability and functions is given in the following text.

The Instrument Development Branch consists of five sections:

1. Electronics Section
2. Flow and Level Section
3. Instrument Design and Shop Section
4. Pressure and Thrust Section
5. Temperature and Physics Section

The following is a brief description of the responsibilities, capabilities, and major facilities of each section. For easier understanding, the capacities of the calibration facilities are expressed in English Units. Some calibration facilities are engineered in Metric Units and the odd numbers for English Units are rounded off.

1. Electronics Section

The Electronics Section has the responsibility to assist the other sections of the Instrument Development Branch in some electronic part of their work and to develop, test, and calibrate various electronic instrumentation for all sections of Test Laboratory. This instrumentation includes accelerometers, microphones, displacement transducers, attitude indicators, seismic transducers, strip chart recorders, amplifiers, multiplex systems, liquid level readout systems, cathode followers, temperature rise indicators, etc.

The new Instrument Laboratory provides for this Section an Acoustics Laboratory (Rm 1) with calibration facilities for microphones from 1-150 cycles per second (cps) at 110-170 decibel sound level. The Anechoic Chamber (Rm 1A) contained in the Acoustics Laboratory is an extremely quiet room having no extraneous noises which might degrade the accuracy of microphone calibration. Besides microphone calibration, the Anechoic Chamber is of great value for research. Presently, it is being used for research to determine the effect of noise on human beings.

For precision electrical measurements, the Electronics Section has a shielded room (Rm 125) which is lined with a material that protects against radio frequency and other electrical noise influences.

Room 126 serves the development and calibration of accelerometers or vibration transducers. Special shakers and calibration systems provide the capability of calibrating over the range from 5 cps to 50,000 cps.

The previous Electronics Laboratory (Rm 123) will continue to serve as a general laboratory for development, manufacturing, and testing of electronic instruments and devices such as amplifiers, cathode followers, liquid level readout systems, seismic instruments, etc.

The Electronics Section is responsible for initiation and supervision of electronic type research contracts to private industry. Presently, such contracts include: damped piezoelectric accelerometers and high frequency calibration equipment;

two different contracts for development of digital data systems; and a study of cable characteristic for long distance data transmission.

2. Flow and Level Section

The Flow and Level Section has the responsibility of development, selection, procurement, modification, test, and calibration of flow and liquid level measuring instrumentation for Test Laboratory in support of all development and test programs.

The new Instrument Laboratory provides considerable increase and improvement to the development and calibration facilities of the Flow and Level Section. The liquid flow calibration facility in the High Bay uses as standards some discrete liquid level gages in 27 feet high cylindrical tanks. Three ranges for 125 gallons per minute (GPM), 750 GPM, and 3000 GPM are available. The readout and control console for this facility is in the main Flow Laboratory (Rm 12).

For less precision and more routine calibration, room 12 has also a completely self-contained commercial calibration system, using the time-weight principle. This calibrator has the capability of calibration at different temperatures, controlling the temperature of the fluid within $\pm 1^{\circ}F$ over a range of $50^{\circ}F$ to $150^{\circ}F$. The capacity of this calibrator is .6 GPM to 300 GPM and its accuracy is $\pm .1\%$.

For gas calibration, the main Flow Laboratory contains two small Prover Tanks with .42 cubic feet (ft^3) and 5 ft^3 volume for flowrates of .00035 cubic feet per minute (CFM) to 8.8 CFM. A larger Prover Tank of 200 ft^3 for flowrates up to 350 CFM is going to be added in the High Bay. A special gas calibration system in a sound and explosion proof room (Rms 13 and 13A) will provide calibrations up to 5000 CFM at 3,500 psi pressure. This facility will use critical flow nozzles as standards and additional measurements will be provided by turbine type gas flowmeters, pressure-volume-temperature (PVT) measurement in the supply tanks, and a water displacement method.

The accuracy of the Prover Tank systems is about 1/4 percent. The large gas calibration facility will be for air, nitrogen, and helium. Its accuracy will be about 1/2 percent and it is expected that the multiple sampling method, using several standards, will increase the accuracy to better than 1/4 percent.

In addition to the calibration facilities in the new Instrument Laboratory, a calibration stand for water, LOX, and LH_2 at flowrates up to 40,000 GPM and line sizes of 18 inches and 24 inches are being prepared in the test area.

The Flow and Level Section initiates and supervises research contracts to private industry and the National Bureau of Standards. These contracts include several contracts for the development of mass flowmeters; liquid level and quantity instrumentation; study of thermodynamic and transport properties of gases; and correlation of low pressure calibration for use in high pressure application.

3. Instrument Design and Shop Section

The Instrument Design and Shop Section is responsible for the design, fabrication, installation, and maintenance of special instrumentation and devices developed by the different sections of the Instrument Development Branch and used at test stands or for other research and development work of Test Laboratory.

The installation of the instrumentation in missiles, test stands, and laboratories is often very complex due to the sensitivity of the instruments and the critical locations of installation. Sometimes up to a hundred instruments, including resistance thermometers, thermocouples, calorimeters, and level gages have to be installed in missile tanks. Some of these tanks are up to sixty feet long. Many special adaptors and devices have to be designed and made for such installations.

The new building provides for the Instrument Makers Shop (Rm 2) the tools and machinery which are necessary for producing such instrumentation, devices, and facilities. Some of the major equipment contained in the Instrument Makers Shop includes: three precision 10" toolroom lathes, one 16" precision lathe, three universal milling machines, one toolroom surface grinder, precision high speed drill presses, jewellers lathes, and high precision measuring equipment used in insuring accuracy for manufacture of instruments.

The Instrument Design and Shop Section also supervises the mechanical design type research contracts with private industry. Presently, such contracts include: Lead-throughs for electrical connections into liquid hydrogen (LH_2) tanks or lines; design and construction of a high pressure tank with windows and optics for photographic studies of the LH_2 surface and the function of level gages at tank pressures above 1,000 psi; plummet, dead weight calibration and mounting of an internal weighing system for quantity measurements in an LH_2 tank; and improvement of the pressure balance and extending its range to a higher pressure.

4. Pressure and Thrust Section

The Pressure and Thrust Section is responsible for development, selection, modification, procurement, test and calibration of instrumentation required to measure pressure, force, weight, mass, stress and strain in support of the various test and development programs of Test Laboratory.

The evaluation of the many new pressure and force transducers produced by industry, combined with the acceptance testing and calibration of the large number of transducers, necessitated automatic test and calibration as much as possible. These automatic calibrations must still maintain precision in order to guarantee best accuracy and reliability of measurements. In a continuous R&D Program, test and calibration was accomplished with automatic, multichannel calibrators and automatic IBM Card Punch Systems

combined with high accuracy readout instrumentation and high speed data processing by the Computation Laboratory.

The Pressure and Thrust Section maintains the calibration standards for pressure and force measuring instrumentation and considerable other equipment and facilities for research, development, and testing.

The High Bay provides two new dead weight machines for testing and calibration of load cells or other force measuring devices. One unit has 500,000 lb. dead weights and the possibility to calibrate up to 5 million pounds, using load cells as transfer standards. The dead weight calibration has an accuracy of .006% and the load cell calibrator an accuracy of .02%. The use of two or three sets of load cells will increase this accuracy according to the multiple sampling theory. The other dead weight machine has a capacity of 50,000 lb. 165,000 lb. of portable mass in 20 lb. units are available for calibration or test of scales, cranes, elevators, etc. Other standards in the High Bay are: The old 60,000 lb. Tinius Olsen testing machine, using Proving Rings as secondary standards; a 120,000 psi Harwood dead weight pressure calibrator and a 4" pumping station vacuum system. For testing and evaluating instrumentation at simulated working conditions, the High Bay provides the following environmental test equipment: An environmental test chamber with a temperature range of -150°F to +500°F, a humidity range of 20 to 95% relative humidity and an ambient pressure variation, simulating altitudes up to 150,000 feet; a 6,000 force pound vibration system, capable of operating in the environmental chamber; a shock tube; and a sinusoidal pressure generator for pressure modulation of ±400 psi within a pressure range of 0-1000 psi at frequencies up to 1,000 cps. The generator works up to 10,000 cps but with lower amplitudes at higher frequencies.

The general laboratory (Rm 8) provides: The readout instrumentation for shaker and sinusoidal pressure generator; an automatic pressure calibrator with a small environmental chamber; strain gage application and general pressure calibration facilities.

Room 4 includes: A 12,000 psi Ruska dead weight tester; a 100 lb. equal arm balance; two mercury manometers; two air dead weight pressure testers and a precision differential pressure sensor using a floating piston with air bearings.

In addition to the above equipment in the new Instrument Laboratory, considerable instrumentation for test and calibration of pressure and force transducers is operated by support contractor personnel in Building 4746.

The Pressure and Thrust Section initiates and supervises research contracts to private industry and research institutes, including the following: Automatic pressure calibration system; automatic thrust calibration system; digital pressure transducers; ultra-high vacuum calibration system; sinusoidal pressure generator;

different load cell and thrust measuring studies and developments; weighing system; and part of a contract to study instruments and computers for determining the mass of space vehicles at take-off and during flight.

5. Temperature and Physics Section

The Temperature and Physics Section is responsible for development, selection, procurement, modification, test and calibration of instrumentation to measure temperature, heat flux, humidity, density, acceleration of gravity, composition of gases and other physical phenomena not included in the activities of the other sections.

To accomplish the above tasks and insure best measurement, accuracy and reliability, the Temperature and Physics Section maintains primary and working standards traceable to the National Bureau of Standards and numerous instrumentation and equipment required for research, development, and testing.

In the Temperature and Physics Laboratory (Rm 119) are: Freezing point standards with tin, lead, zinc, aluminum, silver, and copper, covering the range of 300 to 1800°F with an accuracy of .1°F; automatic thermocouple calibration facilities with printout, covering the range of ambient to 2500°F, using an NBS thermocouple as transfer standard with an accuracy of 1°F below 1500°F and increasing to about 3°F at higher temperatures; and a gravity meter with a repeatability of .0001 cm/sec^2. This precision gravity meter was used to determine for the Instrument Laboratory the true value of the local acceleration of gravity, referring to the station at the University of Alabama in Tuscaloosa, which had been established with the pendulum method by the U. S. Coast Geodetic Survey.

In Room 110 are: A heat flux calibration facility for calorimeters and radiometers providing a blackbody source for primary calibration and grey body for comparison in a range of 0 to 200 BTU/ft^2 · sec with a repeatability of ±3%; a humidity generator which facilitates calibration of water vapor monitors over the range of -100°F to 72°F dewpoint temperature; bridges for calibration of Platinum Resistance Thermometers at ice point and liquid nitrogen boiling point; and electronic instruments for nuclear measurements. Room 112 is specially prepared for storage of radioactive sources. Room 111 provides a hood for coating humidity measuring electrolytic cells.

About 525 feet behind the Instrument Laboratory is a small cell specially designed for use of liquid hydrogen. This cell contains the following calibration equipment: An LH_2 cryostat providing continuously adjustable temperatures from -440°F to -280°F with an accuracy of .05°F; boiling point systems for liquid oxygen, liquid nitrogen, and sublimation temperature of carbon dioxide, providing fixed points standards at low temperatures with an accuracy of .01°F. The LH_2 cell is also

used for testing level detectors in liquid hydrogen.

The Temperature and Physics Section initiates and supervises research contracts including: Development of point density gage for LH_2; development of cryogenic temperature measuring system; x-ray density gage for LH_2; nuclear type density gages for cryogenics; automatic thermocouple calibration system and automatic readout systems for resistance thermometers.