Pioneer 1

NASA SPACE PROBE

"Pioneer"

Exceedingly fast preparation and execution of such an undertaking as the space probe demanded the participation and exceptional efforts of a vast number of industrial concerns as well as those of science and the military.

The project, which reached a climax when Pioneer was successfully launched the morning of October 11th, was initiated less than six months ago and has required the services of 52 scientific and industrial firms.

The National Aeronautics and Space Administration, directed by Dr. T. Keith Glennan, and the Air Force's Ballistic Missile Division, under the command of Maj. General B. A. Schriever, have assigned the major technical tasks in the Pioneer program to Space Technology Laboratories, Inc.

For this project, STL provided overall systems engineering and technical direction for the space probe vehicle and payload; for the design and operation of the world-wide tracking and communications network; carried out research and development of components and subsystems used in launch control and tracking equipment; and had development and hardware responsibility for the second, third, and terminal stages of the vehicle.

A breakdown of contractors by subsystem responsibility includes:

A. First Stage (Air Force Thor IRBM)

1. Propulsion systems -- Rocketdyne, a division of North American Aviation
2. Airframe, control, electrical, and instrumentation systems -- Douglas Aircraft Company

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3. Assembly, integration and checkout -- Douglas Aircraft
4. Systems engineering and technical direction -- Space Technology Laboratories

B. <u>Second Stage</u>

1. Propulsion system and tanks -- Aerojet-General
2. Control, electrical, instrumentation, accelerometer shutoff, and spin rocket systems -- Space Technology Laboratories
3. Assembly, integration, and checkout -- Space Technology Laboratories

C. <u>Third Stage</u>

1. Rocket motor -- Allegany Ballistics Laboratories
2. Structure and electrical -- Space Technology Laboratories
3. Assembly, integration and checkout -- Space Technology Laboratories

D. <u>Pioneer</u> -- Space Technology Laboratories

(Includes television camera and transmitter, and Thiokol rocket motor)

E. <u>Ground Stations</u>

1. Atlantic Missile Range -- Space Technology Laboratories
2. Hawaii -- Space Technology Laboratories
3. Singapore -- Space Technology Laboratories
4. Manchester -- Space Technology Laboratories, using Manchester University radio telescope antenna
5. Millstone -- Lincoln Laboratory Millstone radar, plus Space Technology Laboratories receiver

F. <u>AMR Launch Operations</u>

1. Test director -- Space Technology Laboratories
2. Test conductor -- Douglas Aircraft Company
3. Launch crew -- Aerojet-General
Douglas Aircraft Company
Rocketdyne
Space Technology Laboratories

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OBJECTIVES

The primary objective of the experiment was to penetrate the earth's atmosphere and put Pioneer in the vicinity of the moon. Instrumentation was designed to obtain the following scientific information:

a. temperature of the payload in space flight

b. micro-meteorite impacts

c. magnetic field measurements

d. radiation measurements

e. facsimile image of the surface of the moon (facsimile to be transmitted to earth by a TV scanning device)

Besides gathering scientific data, another objective was to demonstrate again the soundness of the design of a vehicle capable of performing a wide variety of space missions of scientific interest to the United States and the world, and also to demonstrate the soundness of the design of the world-wide tracking and communications network.

VEHICLE DESIGN

The short time allotted to develop a vehicle able to accomplish these prodigious tasks required the utilization of existing components wherever possible. Accordingly, the basic USAF Thor airframe and propulsion system, which weighs over 100,000 pounds, was chosen as the first stage. For this space mission, the structure of the Thor was slightly modified to accept the upper stages. Modification of the Thor also included removal of the vehicle's guidance system to decrease lift-off weight.

For the second stage, STL chose as the basic element the rocket which forms the second stage of the Vanguard vehicle. This basic liquid propellant unit, manufactured by Aerojet-General Corporation, was redesigned by STL to incorporate a proper orientation of the payload at all times and prevent tumbling motion. In addition, a unique dynamic damper device was incorporated to eliminate wobbling.

The instrumentation portion of the payload includes batteries, a telemetry system, an ion chamber to measure total radiation encountered, a cosmic ray telescope to measure cosmic ray density and energy and a newly-developed TV scanning device. Also, the number of meteorite impacts, the earth-moon magnetic field and the temperature of the payload are to be telemetered.

The instrumentation was designed by Space Technology Laboratories with the cooperation of AFCRC, State University of Iowa, and the University of Chicago.

The Doppler command receiver which controls the final velocity corrections and operates the retrorocket, weighs only 5.3 pounds including its batteries and will operate over very extreme ranges. It was designed and built in nine weeks by STL. The unit acts on six different commands, including the critical command for retrorocket firing, the key to actual placing of the vehicle in final orbit. The system also accepts commands from a ground station at Cape Canaveral to fire the vernier rockets for velocity corrections and to separate the payload from the third stage. The Doppler system can measure velocities to within an accuracy of 10 feet per second.

An important aspect of the total Pioneer program is the world-wide payload reception and communication system organized and operated by STL. Major portions of the equipment for the ground stations were provided by Hallamore Electronics and the Rantec Corporation. The five primary stations, at Cape Canaveral, Florida; Singapore; Manchester, England; Hawaii; and Westford, Mass., are controlled by a communications center located at STL in Los Angeles. The complete system was organized and placed in operation in approximately three months following project assignment to the Space Technology Laboratories.

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KEY PROJECT PERSONNEL

The Pioneer project was carried out under the over-all direction of Dr. Louis G. Dunn, President, and Dr. Ruben Mettler, Executive Vice President of Space Technology Laboratories, Inc.

Key STL personnel assigned to the Pioneer program included:

Electronics Laboratory

G. E. Mueller	Director, Electronics Laboratory	Pioneer Project Director
R. R. Bennett	Associate Director Electronics Laboratory	Electronic and Missile System Testing
G. J. Gleghorn	Manager, Controls Dept., Electronics Laboratory	Control Systems and Director of Flight Test Operations
H. A. Samulon	Manager, Techniques and Components Dept., Electronics Laboratory	Doppler System
L. A. Hoffman	Techniques and Sub-systems Section, Electronics Laboratory	Airborne System
R. C. Danta	Special Projects Group, Electronics Laboratory	Instrumentation
M. W. Bolton	Head, Missile Support Equipment Section Telecommunication Systems Laboratory	Electrical System and GSE
C. P. Sonett	Applied Physics, Electronics Laboratory	Instrumentation
R. C. Booton	Manager, Guidance and Navigation Systems, Electronics Laboratory	Assistant Manager of the Able-I Operations Center
A. Rosenbloom	Associate Manager, Guidance and Navigation Dept., Electronics Laboratory	Trajectories

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N. Pixley	Missile Support Equipment, Electronics Laboratory	Dynamics and Missile System Testing
H. Low	Controls Department, Electronics Laboratory	Control System
Y. Shibuya	Instrumentation Dept., Electronics Laboratory	Instrumentation
R. K. Whitford	Head, Control Section Electronics Laboratory	Control System

<u>Astrovehicles Laboratory</u>

A. F. Donovan	Director, Astrovehicles Laboratory	General Vehicle Engineering and Project Director
H. R. Lawrence	Associate Director, Astrovehicles Laboratory	General Vehicle Engineering
G. E. Solomon	Director, Astrosciences Laboratory	Propulsion and Structures Engineering
B. R. Adelman	Director, Vehicle Engineering Laboratory	Solid Propulsion Engineering
Richard D. DeLauer	Associate Director, Vehicle Engineering Laboratory	Propulsion and Associate Director of Flight Test Operations
P. Dergarabedian	Astrosciences Laboratory	Preliminary Design
P. N. Anderson	Vehicle Engineering Laboratory	Airframe Design
R. P. Lipkis	Hypersonics Group, Astrosciences Laboratory	Payload Thermodynamics
H. I. Leon	Applied Aerodynamics Astrovehicles Laboratory	Dynamic Stability
W. H. Schilling	Vehicle Engineering Laboratory	Ordnance Engineering
R. Droz	Vehicle Engineering Laboratory	Field Operations

Pioneer 1

J. E. Calkins	Applied Aerodynamics, Astrosciences Laboratory	Staff: airframe and propulsion
J. K. Kuhn	Project Management, Astrovehicles Laboratory	Liquid Engines
E. Moulton	STL Shops	Fabrication and Assembly

Thor Program Office

A. K. Thiel	Director, Thor Weapon System Program Office	Launch Operations
J. Rittersbacher	Thor Weapon System	Launch Planning
M. Ross	Head of Thor Project Group	Launch Operations
M. Goldman	Thor Project Group at AMR	Engines

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PROJECT ABLE I

LAUNCHING VEHICLE

The three-stage Able vehicle consisted of a modified Air Force Thor IRBM (liquid propellant, about 153,000 pounds of thrust) as the first stage. A liquid-propellant rocket engine powered the second stage (based on Vanguard design, thrust about 7500 pounds). A Vanguard-type solid-propellant unit was the third stage (116,500 lb sec total impulse). Total height, including nose fairing, 88.1 feet; gross liftoff weight, 112,000 pounds.

GENERAL SHAPE, WEIGHT, AND DIMENSIONS OF SPACECRAFT

A double toroid; total height of the two cone frustums and a thin cylindrical midsection was 30 inches; midsection diameter was 29 inches. The spacecraft had two additional propulsion assemblies: a ring of eight low-thrust, solid-propellant rockets for postlaunch velocity adjustment and an axially located solid-propellant injection rocket. The velocity-adjustment rocket assembly was jettisoned after use; the injection-rocket case was the main structural member of the spacecraft. Spacecraft total weight after vernier separation, 75.3 pounds; spacecraft total weight after firing injection rocket, 51.1 pounds; instrument package weight, 39.6 pounds. Shell composition: laminated plastic.

PROGRAM OBJECTIVES

To measure magnetic fields around earth or moon (at high and low amplitudes), density of micrometeoric particles, internal temperatures.

SPACECRAFT PAYLOAD

Instrumentation: facsimile television to scan moon; and sensor on injection rocket (to indicate it fired). *Antennas:* magnetic dipole (two rods, 16 inches long and ⅝ inch in diameter) transmitting at 108.09 megacycles. *Transmitters:* a) 108.06 megacycles at 300 milliwatts (telemetry and Doppler commands); b) 108.09 megacycles at 1 watt (television). *Power Supply:* nickel/cadmium batteries for ignition circuits of vernier and injection rockets, silver-cell batteries for television system, and mercury batteries for remaining circuits.

TEST RESULTS

Engine failure in first stage caused vehicle to blow up 77 seconds after launch, from Cape Canaveral. Date, August 17, 1958.

PARTICIPANTS

Air Force Ballistic Missile Division, Advanced Research Projects Agency, Space Technology Laboratories, Inc., Douglas Aircraft Company, Aerojet-General Corporation, Rocketdyne, Allegany Ballistics Laboratory, Thiokol Chemical Corporation.

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PIONEER I

LAUNCHING VEHICLE

The three-stage Thor-Able vehicle was comprised of a modified Air Force Thor IRBM (liquid propellant, thrust about 153,000 pounds) as the first stage. A liquid-propellant rocket engine powered the second stage (modified Vanguard second stage, thrust about 7500 pounds). The third stage was a solid-propellant unit based on Vanguard design, rated at 116,500 lb sec total impulse. Gross liftoff weight was more than 105,000 pounds, and total height was 90 feet.

GENERAL SHAPE, WEIGHT, AND DIMENSIONS OF SPACECRAFT

A double toroid; total height of the two cone frustums and a thin cylindrical midsection was 30 inches; midsection diameter was 29 inches. The spacecraft had two additional propulsion assemblies: a ring of eight low-thrust, solid-propellant rockets for postlaunch velocity adjustment and an axially located solid-propellant injection rocket. The velocity-adjustment rocket assembly was jettisoned after use; the injection-rocket case was the main structural member of the spacecraft. Spacecraft total weight after vernier separation, 75.3 pounds; spacecraft total weight after firing injection rocket, 51.1 pounds; instrument package weight, 39.6 pounds. Shell composition: laminated plastic.

SPACECRAFT PAYLOAD

Instrumentation: measurement of radiation in space (up to 1000 roentgens per hour, plus) with ionization chamber; determination of density of micrometeorite matter with a diaphragm/microphone assembly, measurement of magnetic fields around earth or moon (down to minimum of 5 microgauss) with a spin-coil magnetometer; study of moon's surface (to resolution of 1 milliradian) with an image-scanning infrared television system; recording of internal conditions with temperature-variable resistors. *Antennas:* a magnetic dipole for television system: an electric dipole for telemetry transmitter and for receiving ground commands at 115 megacycles. *Transmitters:* a) television system operated on 108.09 megacycles at peak power of 50 watts; b) telemetry transmitter on 108.06 megacycles at 300 milliwatts. *Power Supply:* nickel/cadmium batteries for ignition circuits of vernier and injection rockets, silver-cell batteries for television system, and mercury batteries for remaining circuits. *Transmission Duration:* stopped at re-entry.

TEST RESULTS

Pioneer I reached a peak altitude of 70,700 miles after launching from Cape Canaveral on October 11, 1958. Because of a slight error in burnout velocity and angle, this spacecraft did not reach the moon. It re-entered the atmosphere over the South Pacific on October 12, 1958. Important results were: a) determination of radial extent of radiation band, and first observation that radiation is a band; b) mapping of total ionizing flux; c) first observations of hydromagnetic oscillations of magnetic field from theoretical prediction; e) first determination of density of micrometeors in interplanetary space; f) first measurements of interplanetary magnetic field.

PARTICIPANTS

Air Force Ballistic Missile Division, National Aeronautics and Space Administration, Space Technology Laboratories, Inc., Douglas Aircraft Company, Aerojet-General Corporation, Rocketdyne, Allegany Ballistics Laboratory, Thiokol Chemical Corp., Naval Ordnance Test Station.

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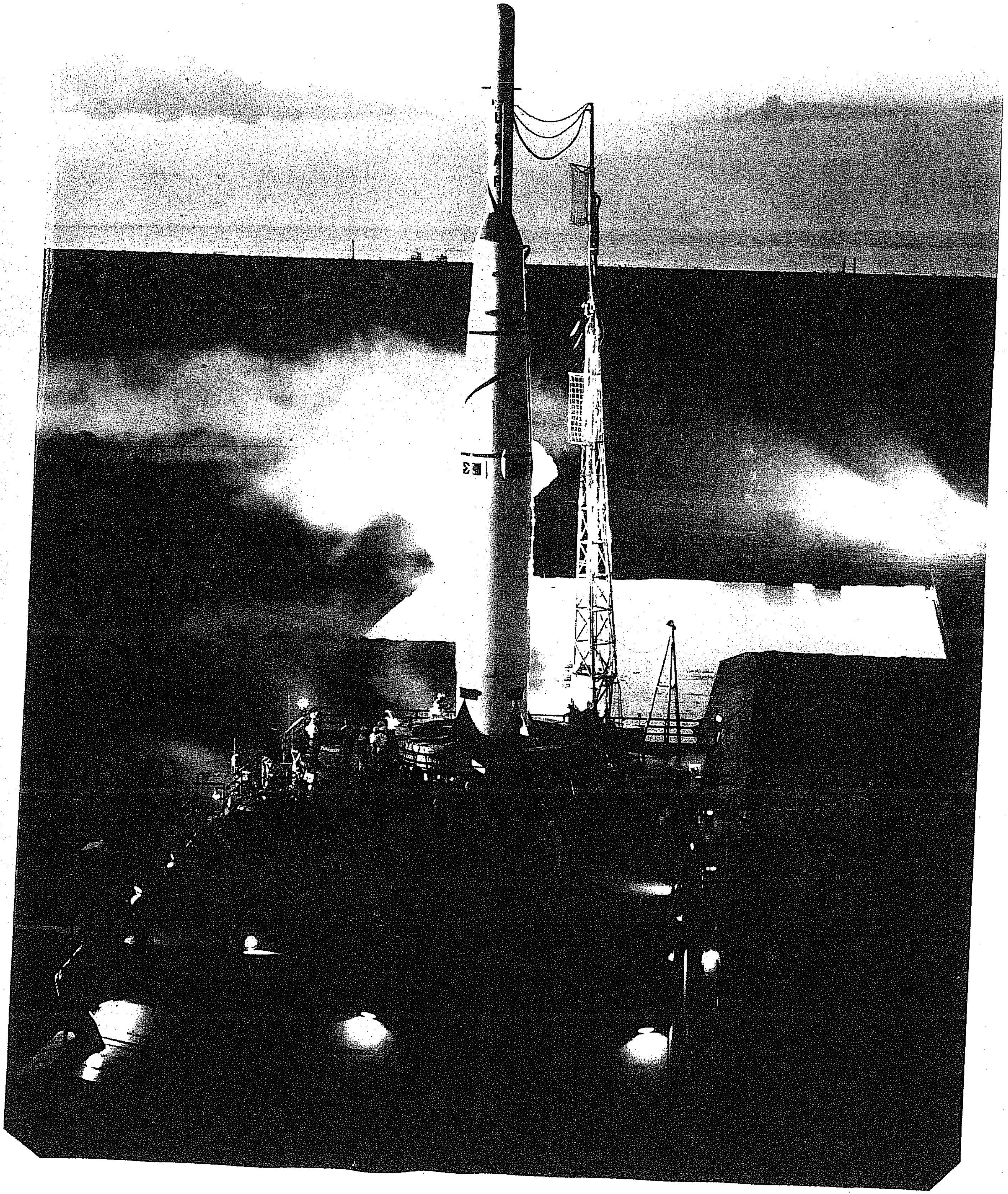
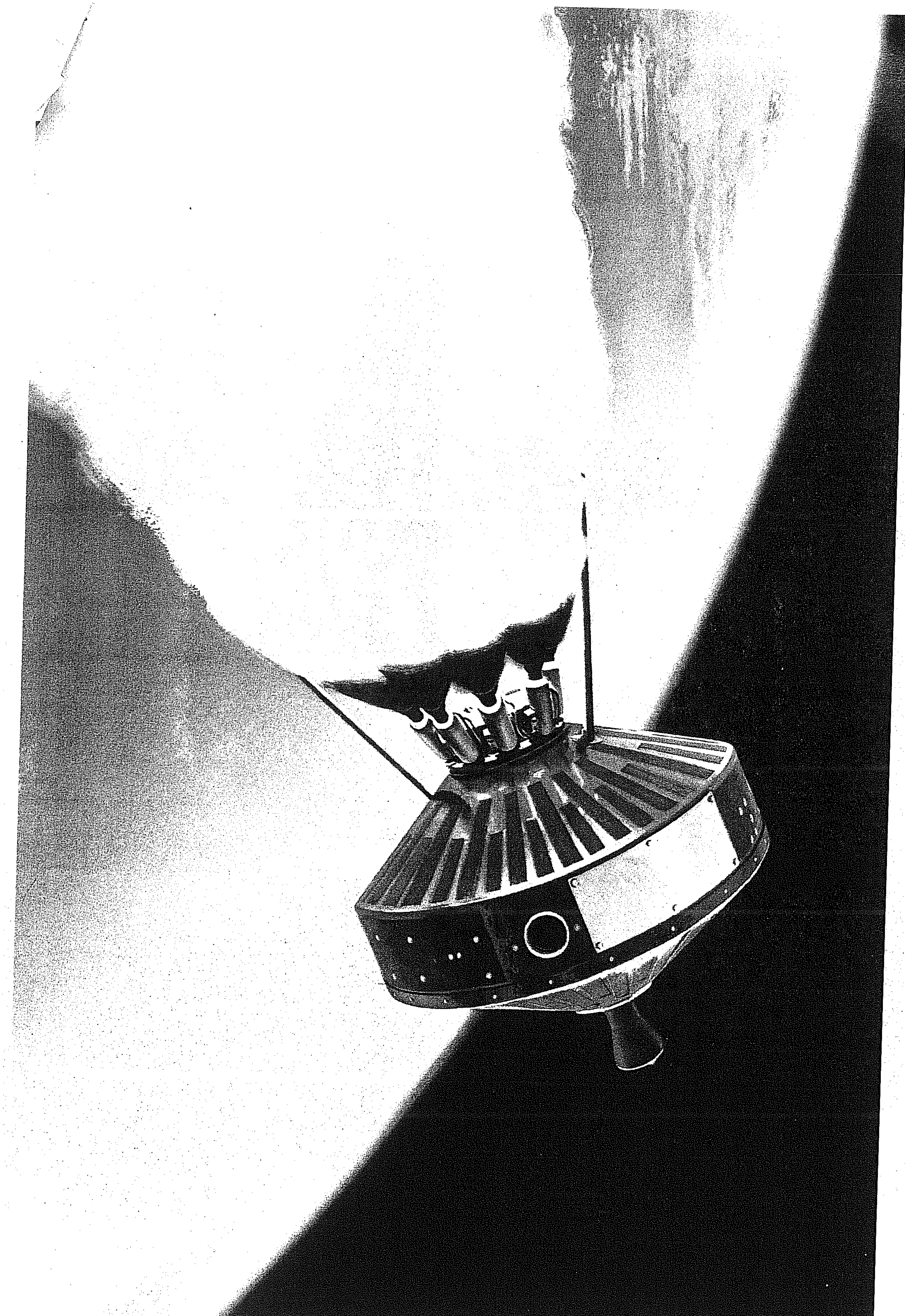
(Able-1)





DESTINATION SPACE -- Able-1, the nation's first space probe vehicle, blasts into the sky above Cape Canaveral, Florida. Designed, developed and instrumented by Space Technology Laboratories, Inc., Los Angeles, Able-1 thrust its payload, Pioneer, more than 70,000 miles into space. A forerunner of space ships that will some day travel to distant planets, Able-1 and its payload provided invaluable data needed to determine the environment man will encounter outside the earth's atmosphere. The Pioneer satellite, besides its many other "firsts", provided the feasibility and value of a communications satellite. During its two and a half day trip, signals were sent to Pioneer from Hawaii and Cape Canaveral which were picked up in England. This process was then reversed. It was the first time in history that such widely separated locations had been able to communicate directly with each other.

PIONEER I

Launched October 13, 1958

The free world's first successful deep space probe, Pioneer I attained an altitude of 71,700 miles. The spacecraft has just achieved separation from the third stage of its Thor-Able launch vehicle; the eight vernier rockets are being fired to adjust velocity.

TRIUMPH FROM A 'FAILURE'

After suspenseful launching, moon rocket's flawed space flight pays off

The last few seconds of the countdown built into an agony of tension for the little group of men locked in the blockhouse at Cape Canaveral. Quickly, quietly, by remote control, they took the last possible precautions to ensure perfection in their monstrous machine. Outside it stood poised on its concrete-decked launching pad, 88 feet of glistening rocket, the most complex, presumptuous vehicle ever crafted by the hand of man. If its 300,000 parts functioned perfectly, it might go to the moon.

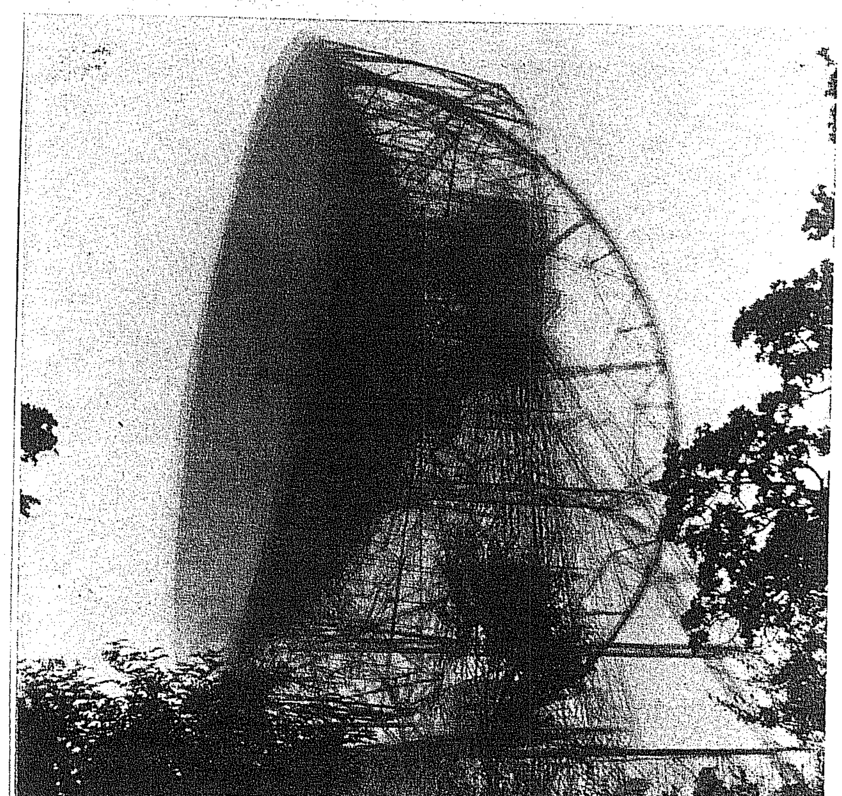
Weighing on the scientists in the blockhouse was the crushing knowledge of the vast and meticulous efforts that had been poured into the project by the best brains of the Air Force and U.S. industry. They knew that a priceless package of Lilliputian instruments fashioned for scientific measurements of the moon's environs had been installed with surgical cleanliness. And they knew the world was watching.

Inside this strange taut world which a shell of security shields from public gaze, John Bryson made a series of remarkable photographs for the Air Force which LIFE presents as a historic document. For though moon rocket Pioneer narrowly failed to go all the way, its record-setting flight (*pp. 124, 125*) must be counted not a failure but a major triumph of man.

SORTING THE DATA

As Pioneer sped off from earth its precipitous path was tracked by an elaborate global network of extraordinarily sensitive receiving antennas. As its clear signals were collected, a variety of data was transmitted almost instantaneously to a data reduction center in Hawthorne, Calif. There Pioneer's discoveries were fed into a massive computing machine. Then, within hours of launching, its findings were given to the world. They made news of tremendous importance—especially to potential spacemen.

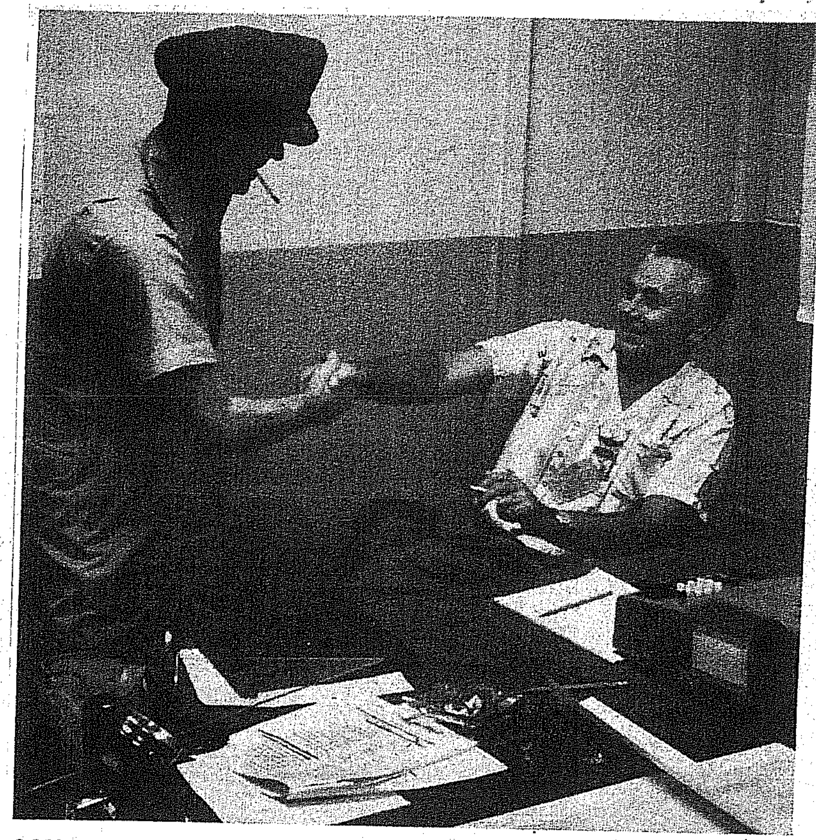
The deadly radiation belt already reported by three earth satellites turned out to have limitations (*see drawings, below right*). The implications were that spacemen, if they passed through it quickly enough, could survive the deadliest zone and break out into conditions of relative safety. But the vast extent of the perilous area could mean man must give up his dream of an inhabited earth-circling space platform which could serve as a jumping-off point for further penetration of space. The moon itself might turn out to be the most likely spot for that. So Pioneer, in its spectacular 43-hour flight, enhanced the moon's importance even though it missed the moon and met a flaming finish in the Pacific.



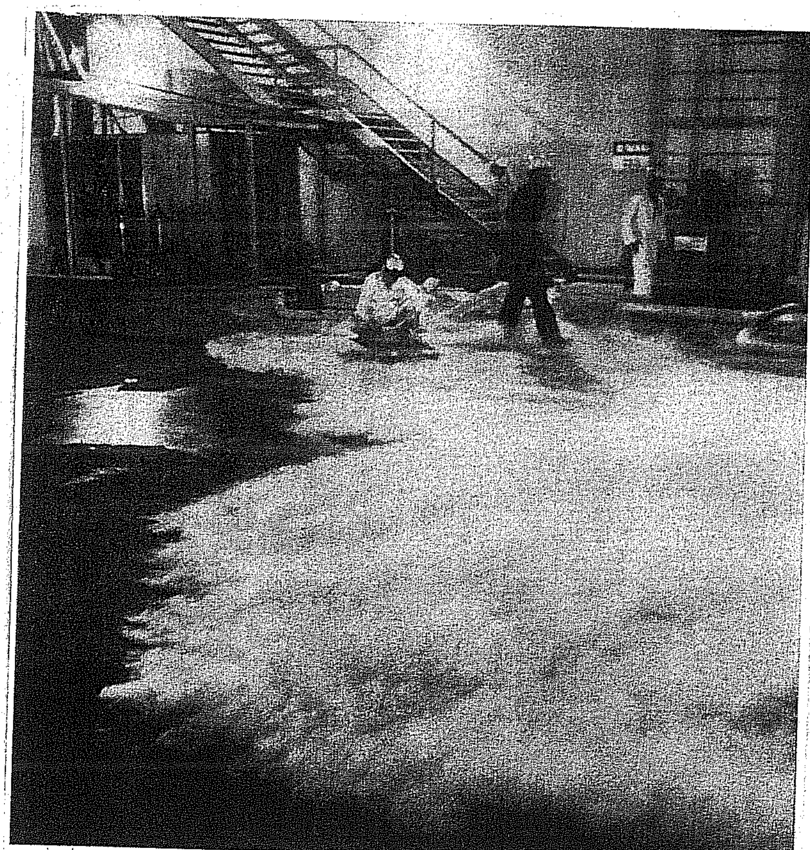
BLURRED IN MOVEMENT, RADIO TELESCOPE IN ENGLAND TRACKS PIONEER

Pioneer

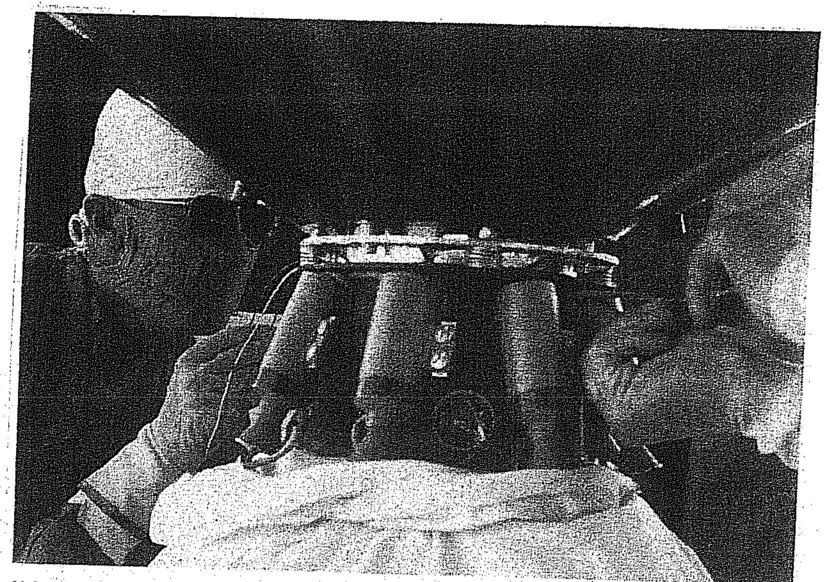
Pioneer



CONGRATULATIONS are extended to STL's Dr. Louis Dunn (*right*) by Air Force Brig. General O. J. Ritland when Pioneer seemed to rise perfectly.



CLOUDS OF OXYGEN in gaseous form, overflowing when first stage is fueled, pour out over launching pad. Liquid oxygen is used to ignite first-stage fuel.



WIRING SMALL ROCKETS which were to be used to raise Pioneer's velocity at the start of the fourth stage, engineers wear surgical gowns to keep the missile's instrument package (*top*) from carrying earth's germs to the moon.

The guidance systems of these missiles are so delicate that parts of them are assembled under conditions of almost surgical cleanliness, in a building where the draftsmen are forbidden to use erasers or to tear paper for fear of creating dust that might foul the mechanisms. The instruments in Pioneer's payload seemed doubly delicate because they were so infinitesimal. At first glance they looked as if they lay under a reducing glass. They belonged not to the world of miniaturization but of subminiaturization. Here were transistors as spindly as a water-striding insect, and thermistors (electrical thermometers) literally no bigger than a flea. Scores of such electronic minutiae—plus condensers, resistors, diodes, inductors and the necessary wiring—were fitted into an area that would cramp a match folder. The TV transmitter, weighing only 14 ounces, could fit into half a cigaret carton.

A further wonder is that such devices, seemingly so frail, could actually withstand environmental conditions of high heat, humidity and vacuum and stresses of vibration and acceleration. The little TV transmitter, for example, had been tested on a centrifuge for an acceleration of 30 Gs.

All these instruments, package after package of them, were arranged inside the Fiberglas shell and the shell was brought into perfect dynamic balance by means of counterweights. One last fact will illustrate the amazingly scrupulous attention that the payload received. Since it would be exposed to the harsh sunlight of space, unfiltered by atmospheric haze, it needed a paint that would keep the retro-rocket and instruments from getting too hot or too cold, yet would not absorb electrical energy from the telemetering system. It took scientists eight weeks of experiment to compose the right paint, and their calculations were so finely drawn that the shell would have been painted in a different pattern if lift-off had been on Oct. 12 instead of 11, to allow for a slightly changed angle of sunlight. Furthermore, again depending on the firing date, the heads of the rivets holding the instruments to the shell would be painted or left bare.

Even if both calculation and performance were perfect, a missile launched from Canaveral at the best possible instant would have about 70 chances in 100 of reaching the moon; fired one minute later, it would have 69 chances; 30 minutes later, 30 chances; 40 minutes later, almost no chance at all. At that, BMD's technicians could consider themselves relatively lucky. A moon rocket fired from a Russian site would face even stiffer odds because it would have to be launched still farther from the equator.

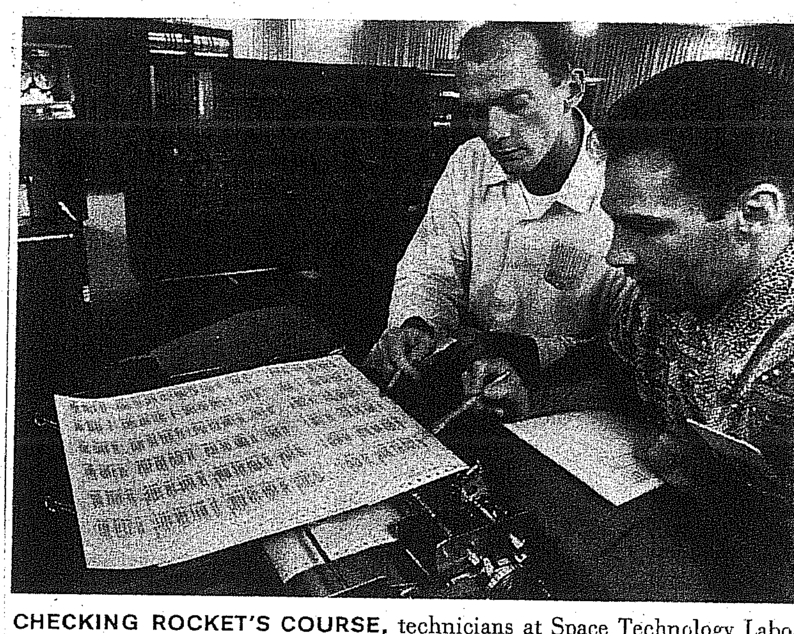
So the components met at Canaveral and were mated, and the lunar probe missile became an entity at last. The August deadline was met, but that first missile exploded after 77 seconds of flight. This month came the second of the Air Force's three authorized tries. When Pioneer rose with a deep, earth-shaking roar the men in the blockhouse shouted, "Go, Baby! Go! Go!"

"Baby" rose slightly, slowly, gathering speed. Thor's engine was gulping hundreds of pounds of fuel per second, and Pioneer began to soar. As far as anyone knew, it was flying according to plan. Canaveral was teletyping headquarters in California:

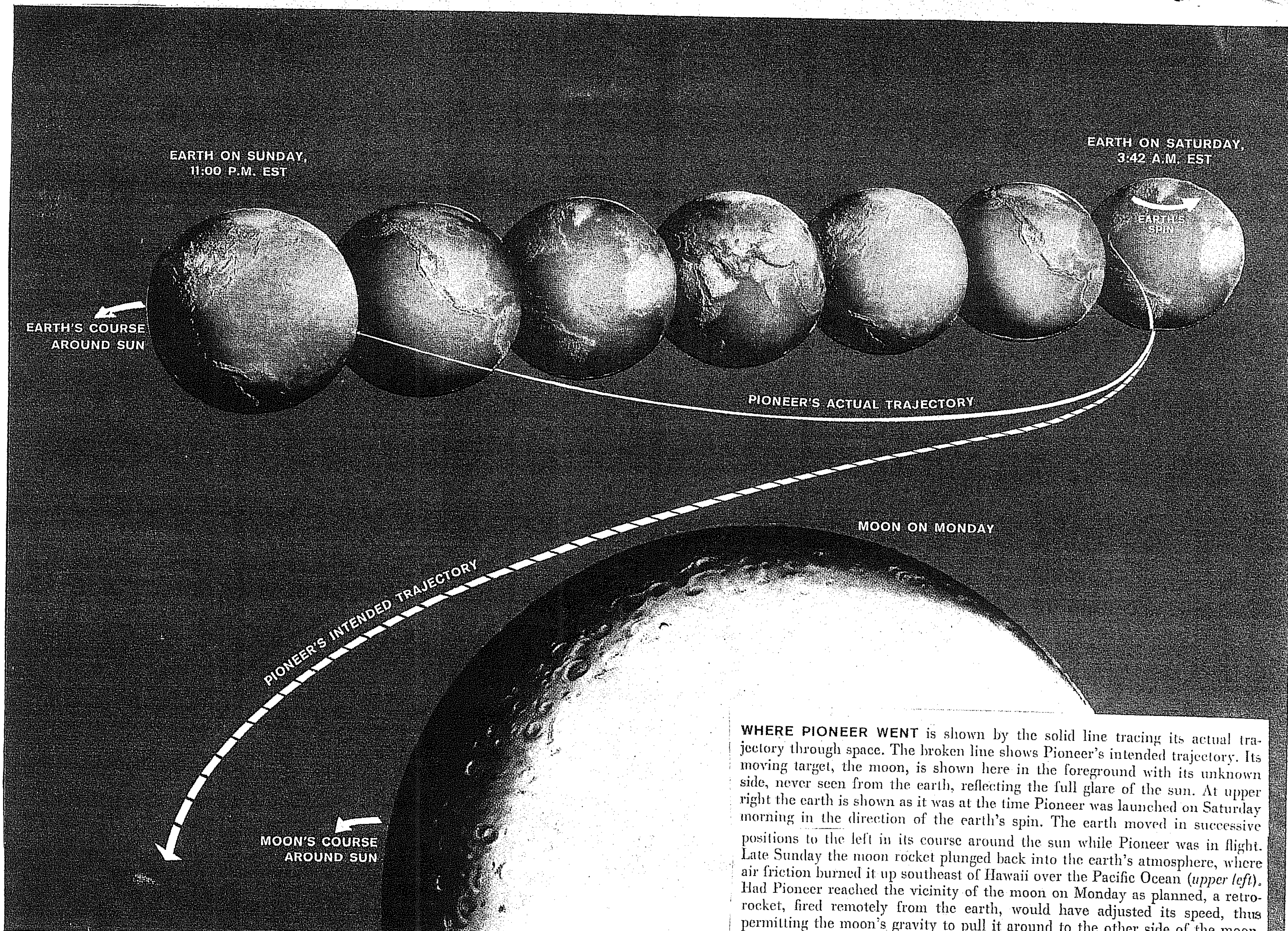
LOOKS GOOD LOOKING GOOD STILL GOING LOOKS REAL GOOD

But, in fact, Pioneer had already developed the trifling disability that would result in a broken rendezvous and a payload dragged back to earth.

The "disability" was not a malfunctioning. No tube or wire broke; no valve or circuit jammed. Everything functioned as planned and functioned within normal tolerances. The trouble was that the tolerances—the tiny variations in performance that are allowable in any mechanism—all happened to combine to set Pioneer on a trajectory that was a bit too high. In another launching these tolerances might cancel themselves out and Pioneer would head straight for the moon. Or they could add up to a trajectory that was too low. In this instance they combined to set Pioneer barely off course, and once launched there was no chance of correcting it. The guidance system in the standard Thor would have corrected it, but it had been removed from Pioneer to save weight. The slight change in trajectory made some of Pioneer's complicated relays and boosters function at the wrong time, and this was fatal. The engine of the second-stage rocket shut down

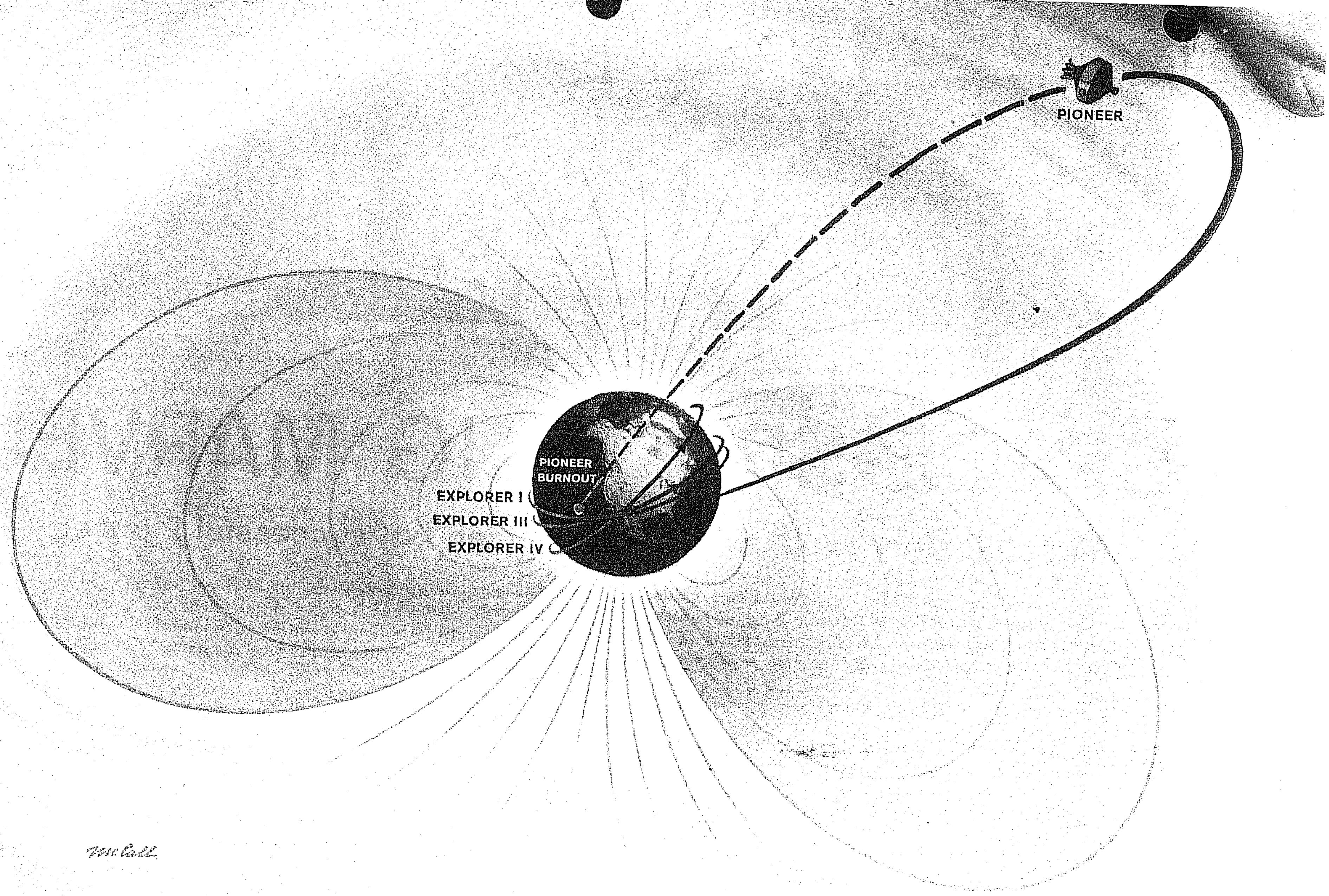


CHECKING ROCKET'S COURSE, technicians at Space Technology Laboratories look over data sheets showing Pioneer's velocity, trajectory, location.



WHERE PIONEER WENT is shown by the solid line tracing its actual trajectory through space. The broken line shows Pioneer's intended trajectory. Its moving target, the moon, is shown here in the foreground with its unknown side, never seen from the earth, reflecting the full glare of the sun. At upper right the earth is shown as it was at the time Pioneer was launched on Saturday morning in the direction of the earth's spin. The earth moved in successive positions to the left in its course around the sun while Pioneer was in flight. Late Sunday the moon rocket plunged back into the earth's atmosphere, where air friction burned it up southeast of Hawaii over the Pacific Ocean (*upper left*). Had Pioneer reached the vicinity of the moon on Monday as planned, a retro-rocket, fired remotely from the earth, would have adjusted its speed, thus permitting the moon's gravity to pull it around to the other side of the moon.

Pioneer



WHAT PIONEER FOUND was evidence that the belt of most deadly radiation, first encountered by Explorer satellites, has definite limitations and seems to take the shape of a doughnut around the earth. Beyond this, radiation peril continues but is less dangerous. This cutaway drawing, in which the front wedge of doughnut is removed, indicates radiation in shades of pink which grow darker as intensity increases. Red lines represent shape of earth's magnetic field which, scientists believe, is responsible for doughnut form because it collects, concentrates and holds radiation from more distant space. Over equatorial zone, Pioneer indicates the radiation intensity rises to a peak at about 7,000 miles, then drops off gradually, but remains highly lethal for at least 15,000 miles more (end of doughnut). Above magnetic poles (hole in doughnut) radiation should be lowest—even lower than that recorded by Pioneer at peak of flight, 79,120 miles.

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PIONEER II

LAUNCHING VEHICLE

Same as Pioneer I~~, page 18.~~

GENERAL SHAPE, WEIGHT, AND DIMENSIONS OF SPACECRAFT

Same as Pioneer I, except that total weight of payload after vernier-rocket separation was 86.3 pounds.

SPACECRAFT PAYLOAD

Same as Pioneer I, except: 1) STL image-scanning television system replaced that of Pioneer I; 2) a proportional counter (for radiation measurements) was added; and 3) the magnetic dipole was adapted to a 108.09-megacycle telemetry transmitter.

TEST RESULTS

Pioneer II was launched on November 8, 1958, from Cape Canaveral. Third-stage rocket failed to ignite. Re-entered atmosphere at 28.7°N and 1.9°E after reaching peak altitude of 963 miles. Highlights of flight were: 1) evidence that equatorial region about earth has higher flux and higher energy radiation than previously considered, and 2) suggestion that micrometeoric density is higher around earth than in space.

PARTICIPANTS

Same as Pioneer I.

Atlas-IV 9-6-6

ATLAS-ABLE IV
(ALSO KNOWN AS PROJECT ABLE IV)

LAUNCHING VEHICLE

A modified Atlas ICBM (20D) with a liquid-propellant rocket power plant of approximately 360,000 pounds of thrust was used as the first stage of a three-stage launching vehicle. The second stage was the typical Able AJ10-101 liquid-propellant rocket, adapted for this program. The third stage was a modification of earlier Able Model 248 solid-propellant rocket. Gross liftoff weight, 260,000 pounds plus; total height, 98 feet; major axis of elliptical base, 16 feet.

GENERAL SHAPE, WEIGHT, AND DIMENSIONS OF SPACECRAFT

Spheroid, 39 inches in diameter, with a rocket nozzle protruding from top and bottom, making a total height of 55 inches. Four solar-cell paddles were extended on arms from the equatorial plane of the spacecraft within an envelope diameter of 108 inches. Each surface of the paddles was covered by 1100 solar cells (8800 total). The spacecraft monopropellant rocket power plant, with a nozzle directed forward and another directed aft (along line of flight), could fire on ground command either nozzle to give short bursts of thrust for vernier velocity adjustment. The retrorocket thrust could also be used to decelerate the spacecraft as it approached the moon's orbit and thereby assist the weak lunar gravitational attraction in capturing the spacecraft. Each of these rocket engines delivered 20 pounds of thrust. Gross weight of spacecraft, 372 pounds.

PROGRAM OBJECTIVES

To obtain basic measurements of the lunar environment and to observe surface of the moon. Experiments: measurement of three specific energy levels of cosmic rays; relay of pictures of the lunar surface as scanned with a TV-like system; measurements of distribution and speed of micrometeorites encountered; measurements of magnetic fields around earth or moon by two types of magnetometers; study of radio waves.

SPACECRAFT PAYLOAD

Antennas: four aluminum dipole rods for the two transmitters and two receivers. *Transmitters:* two, 378 megacycles at 5 watts. *Power Supply:* nickel/cadmium batteries continuously charged by solar cells.

TEST RESULTS

The launch was made from Cape Canaveral on November 26, 1959. Countdown was normal, and liftoff occurred as scheduled. At 46 seconds after liftoff, second-stage guidance transponder no longer responded to interrogation. At 104 seconds, second-stage telemetry was lost. Atlas booster and sustainer operated as scheduled; however, about 45 seconds after launch, the plastic shroud covering the lunar probe came off. As the shroud fell away, the vehicle was approaching maximum atmospheric pressure loads. With the shroud gone, the payload was torn off. Radar indicated that the second stage ignited, but there was no indication that it separated. Telemetry record and reasons for the structural failure have not been released.

PARTICIPANTS

Air Force Ballistic Missile Division, National Aeronautics and Space Administration, Space Technology Laboratories, Inc., Convair, Aerojet-General Corporation, Allegany Ballistics Laboratory, Rocketdyne.

ATLAS ABLE-5A

LAUNCH VEHICLE

The three-stage Atlas-Able vehicle utilized a modified Atlas D ICBM (liquid-propellant, 360,000-pound-thrust) as the first stage. The second stage was a liquid-propellant adaptation of earlier Able vehicles capable of 7500-pound-thrust; the third stage was a solid-propellant modification from Able and Vanguard configurations, thrust about 3000 pounds. Liftoff weight, over 260,000 pounds; total height, 98 feet; base diameter, 10 feet.

GENERAL SHAPE, WEIGHT, AND DIMENSIONS OF SPACECRAFT

A 39-inch sphere with four solar-cell paddles extended on arms from the equator and rocket nozzles jutting from each pole. The thrust chamber at the payload's base was designed to increase spacecraft velocity, the chamber at the top to reduce velocity. Hydrazine-fueled, this was the first United States spacecraft with a self-contained propulsion system capable of operation many months after launch at great distances from earth. Weight, 387 pounds; shell composition, aluminum-alloy.

PROGRAM OBJECTIVES

To place a highly-instrumented probe in a moon orbit; thoroughly investigate the environment between the earth and the moon; develop a technology for controlling and maneuvering spacecraft from earth.

SPACECRAFT PAYLOAD

Instrumentation: 1) high-energy radiation counter, 2) ionization chamber and Geiger-Mueller tube for total radiation flux measurement, 3) scintillation counter to monitor low-energy radiation, 4) flux-gate magnetometer, search-coil magnetometer, and sun scanner for magnetic field measurement, 5) plasma probe to study the radiation effects of the solar wind and solar flares, 6) scintillation spectrometer to study the earth's radiation belt as well as possible trapped radiation about the moon, 7) micrometeorite spectrometer to measure the number and momentum of meteorites striking the spacecraft, 8) temperature control system utilizing 50 four-bladed fans designed to alternately expose light and dark patches of the satellite's skin to the sun. *Antennas:* two sets of dipole rods. *Transmitters:* two 1.5 watt UHF telemetry transmitters operated on 378 megacycles. *Power Supply:* 8800 silicon solar cells mounted on the four paddles charged nickel/cadmium batteries.

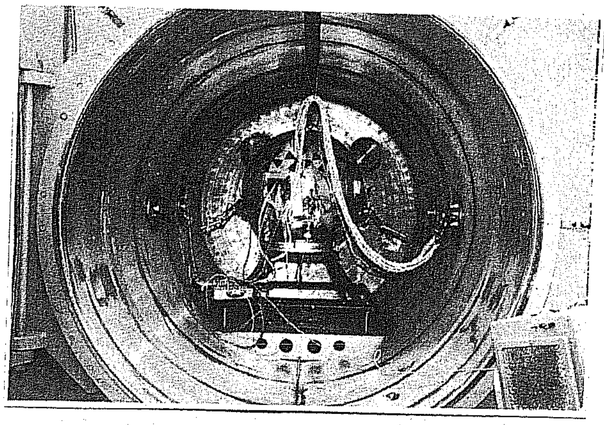
TEST RESULTS

Atlas Able-5A was launched from Cape Canaveral on September 25, 1960. The second stage failed, however, due to a malfunction in the oxidizer system. The vehicle re-entered and was destroyed.

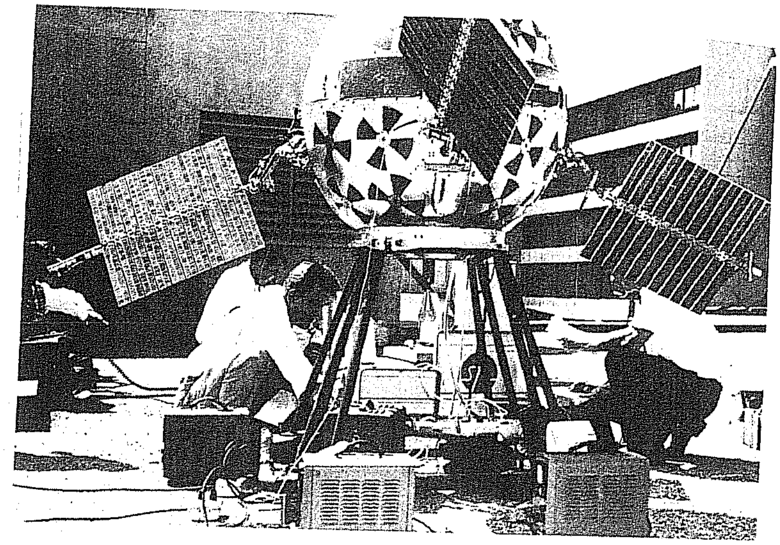
MAJOR PARTICIPANTS

National Aeronautics and Space Administration, Air Force Ballistic Missile Division, Space Technology Laboratories, Inc., General Dynamics/Astronautics, Rocketdyne, General Electric Company, Burroughs Corporation, Aerojet-General Corporation, Allegany Ballistics Laboratory, University of Chicago, University of Minnesota.

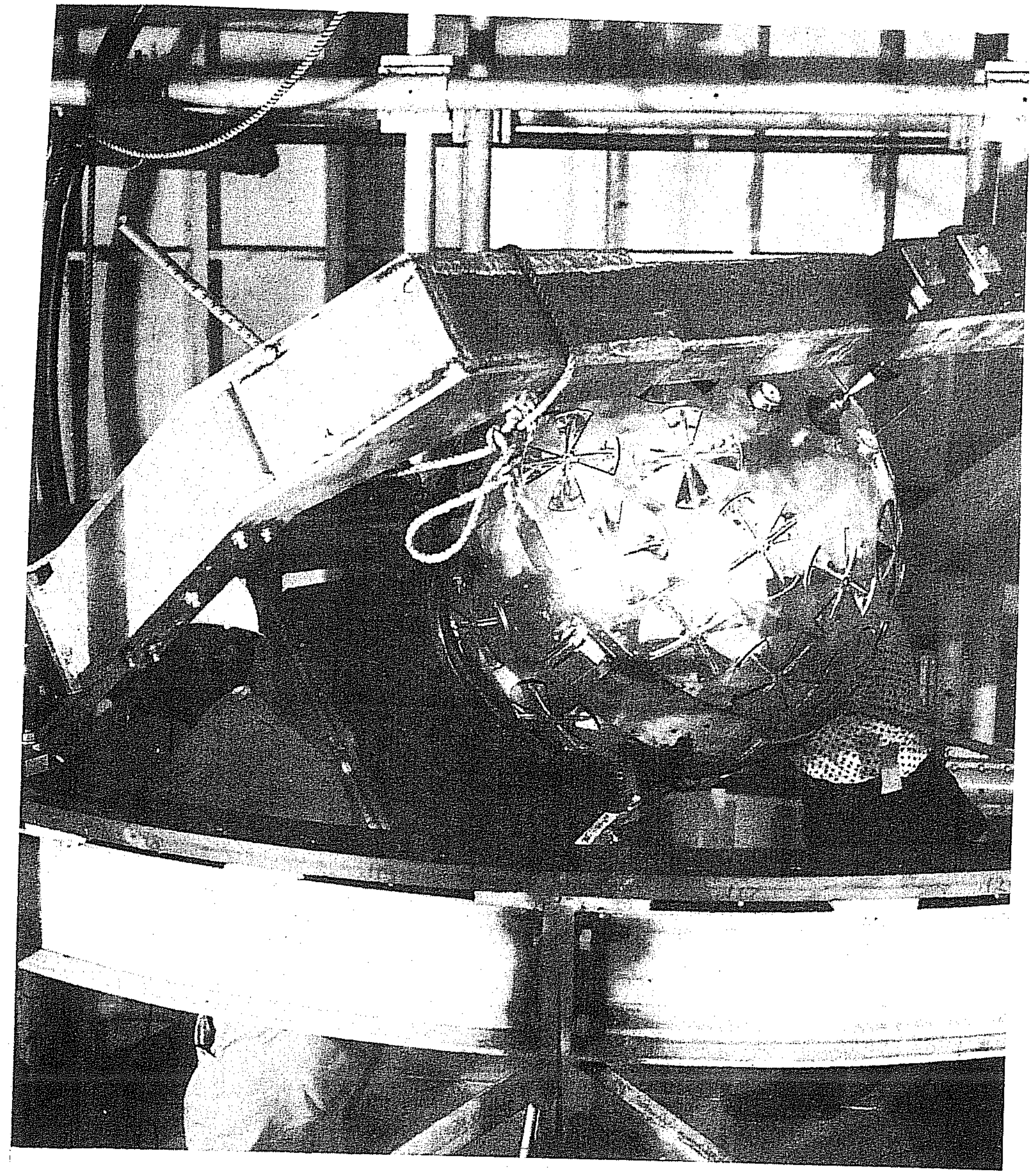
5·A



Looking inside of the STL large environmental test chamber. This facility was designed by Space Technology Laboratories, Inc. to subject satellites such as the Able 5B to simulated space conditions.



Checkout of the Atlas Able-5A's solar-cell paddles; each paddle contains 2200 solar cells. A second-stage malfunction prevented successful orbit of this lunar probe.



Close-up view of the Able V satellite, mounted in the gimbals that are part of the STL magnetic environment simulator. A portion of the coils of the world's largest Fanselau coil can be seen in background.

Atlas -, 5-B

ATLAS ABLE-5B

LAUNCH VEHICLE

Same as Atlas Able-5A, page 39.

GENERAL SHAPE, WEIGHT, AND DIMENSIONS OF SPACECRAFT

Same as Atlas Able-5A, page 39.

PROGRAM OBJECTIVES

Same as Atlas Able-5A, page 40.

SPACECRAFT PAYLOAD

Similar to Atlas Able-5A, page 40, except that a STL-designed rubidium frequency standard experiment was placed in a pod attached to the booster and a solid state detector sensitive to low energy protons added to the spacecraft.

TEST RESULTS

Atlas Able-5B was launched on December 15, 1960, from Cape Canaveral. The vehicle exploded at 40,000 feet, about 70 seconds after launch, due to a malfunction in the first stage.

MAJOR PARTICIPANTS

Same as Atlas Able-5A.