Project Galileo

A Return to Jupiter

The great Italian astronomer Galileo Galilei shocked the world in January 1610 when he announced his discovery of four satellites orbiting Jupiter. His discovery provided

proof to Nicolaus Copernicus' theory that Earth and the other planets orbit the Sun, and Earth is not the center of the universe. Galileo told the story of his discovery:

"On the seventh day of January in the present year 1610, at the first hour of the night, when I was viewing the heavenly bodies with a telescope, Jupiter presented itself to me; and because I had prepared a very excellent instrument for myself, I perceived (as I had not before, on account of the weakness of my previous instrument) that beside the planet there were three starlets, small indeed, but very bright."

Galileo thought those "starlets" were just more of the fixed stars that his telescope was allowing him to discover with astounding regularity. But the next night he saw they had changed position. The night after that was cloudy. Then, on January 10, he saw only two "starlets," the third having disappeared behind Jupiter.

On the 11th:

"I had now decided beyond all question that there existed in the heavens three stars wandering about Jupiter as do Mercury and Venus about the Sun, and this became plainer than daylight from observations on similar occasions that followed."

On January 13, 1610, Galileo spotted the fourth satellite.

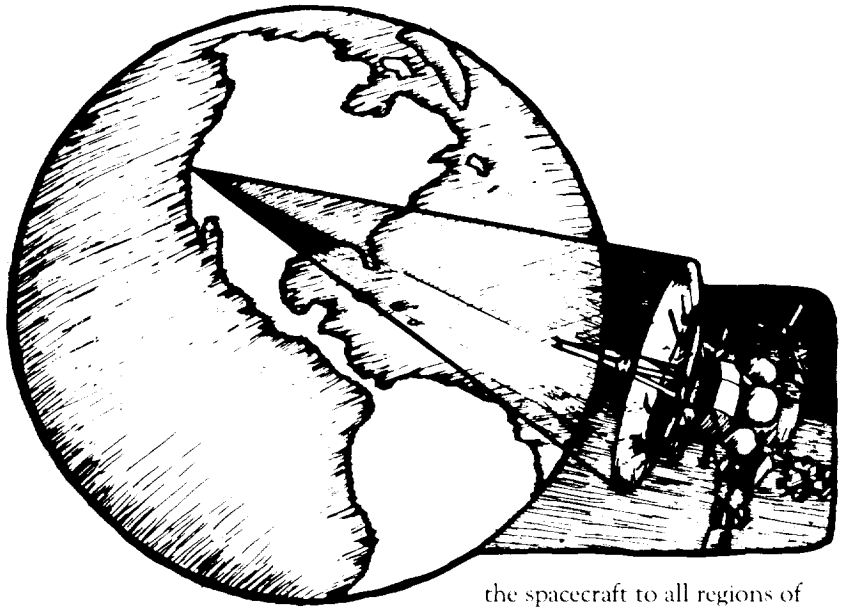
Although he nearly paid for his observations and later writings with his life, Galileo remained the most respected scientist of his time. Today, those four satellites—Io, Europa, Ganymede, and Callisto—are called the Galilean satellites in his honor.

A NASA project to orbit Jupiter and send an instrumented Probe into the giant planet's atmosphere is under way at the Jet Propulsion Laboratory. The mission, called

Project Galileo after the Italian astronomer, will begin an in-depth exploration of the Jovian system: Jupiter, the Galilean satellites, and the giant, invisible magnetosphere surrounding Jupiter. Scientists believe that Jupiter is made of the original material from which stars form, largely unmodified by nuclear processes. Close-range studies of Jupiter should provide important information about the beginning and development of our solar system and provide new insights into phenomena that directly relate to our understanding of all the planets.

Project Galileo was originally scheduled for launch in early 1982 as the scientific successor to the Voyager mission to Jupiter. The Galileo Probe was designed to be attached to the Orbiter, and the combination spacecraft was scheduled to be launched from an Earth-orbiting Space Shuttle. The relative positions of Earth, Mars, and Jupiter at that time make it possible to send a heavy spacecraft to Jupiter via Mars in a relatively short time. Problems in the Space Shuttle development, however, have delayed the Galileo launch until 1984, when Mars will again be in a useful position, although not as favorable as in 1982.

While the 1982 mission represented a more unified technical approach, the 1984 mission will still permit the original scientific objectives. But now two spacecraft will make the trip: an Orbiter spacecraft and an instrumented Probe flying aboard a Probe-Carrier spacecraft.



The current Orbiter is similar to the spacecraft designed for the 1982 launch, but will accommodate a larger rocket propulsion system for a maneuver at Mars.

The Orbiter is scheduled to be launched in February 1984 on a trajectory that will send it toward the planet Mars. One hundred days after launch, the Orbiter will fly within a few hundred kilometers of the surface of Mars. The Orbiter will use Mars' gravity and a long burn of its own rocket motor to boost it the rest of the way to Jupiter.

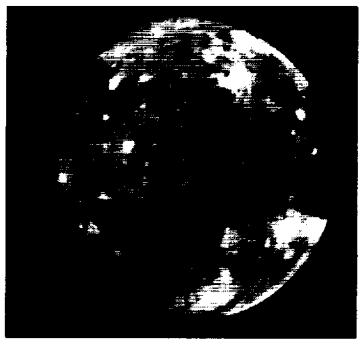
The Orbiter will arrive at Jupiter in mid-1986, about one year before the Probe. It will photograph the region where the Probe will enter to ensure achievement of the original mission's goals. As the Orbiter nears its closest approach to Jupiter, it will fire its retrorocket engine for about 50 minutes to slow the spacecraft and permit capture by the planet. Within a few hours of closest approach to Jupiter, the Orbiter will fly past the volcanic satellite, Io, for close scientific observation. Io's gravity will further slow the spacecraft.

At that point the spacecraft will be orbiting Jupiter in an elliptical path, ranging from more than 15 million kilometers (9.3 million miles) to 285,000 kilometers (178,000 miles) above Jupiter's cloud tops. Thereafter, the orbit will change through a series of elliptical paths to take the spacecraft to all regions of Jupiter's environment. That will be accomplished by using the gravity of the satellites to bend the orbit each time the spacecraft comes close to one of them. Eventually the orbit will be so altered that the spacecraft's closest approach to Jupiter will be 900,000 kilometers (560,000 miles) above Jupiter's cloud tops.

During at least one orbit, the spacecraft will fly through and study Jupiter's magnetotail—the portion of the magnetic region directly opposite the Sun—to a distance of 150 times the radius of Jupiter, more than 10 million kilometers (6.2 million miles) from the planet. Observations of the magnetotail are not possible from Earth or with flyby spacecraft because the spacecraft pass close to Jupiter, and their trajectories are too strongly deflected to reach that region.

The Orbiter will complete 11 orbits of Jupiter while making a close flyby of one Galilean satellite—Io, Europa, Ganymede, or Callisto—on each orbit. The Orbiter, carrying 11 scientific instruments and weighing about 2,660 kilograms (5,864 pounds) at launch, will transmit scientific and engineering data at rates up to 115,000 bits per second.

Meanwhile, the Probe will be launched one month after the Orbiter, in March 1984, and will be transported to Jupiter on a special Probe-Carrier spacecraft. Traveling on a longer trajectory that does not pass Mars, the



Ganymede

Probe and its Carrier will reach Jupiter one year later than the Orbiter, in the summer of 1987. After being released from the Probe-Carrier spacecraft, the Probe will descend toward Jupiter's thick atmosphere.

Scientists want the instrument-laden Probe to enter Jupiter's light-colored Equatorial Zone, between 1 and 5.5 degrees north or south latitude. They believe the topmost clouds of that portion of Jupiter's atmosphere consist primarily of ammonia. By entering at that location, the Probe should be able to measure Jupiter's important cloud layers.

As the Probe strikes the upper layers of Jupiter's atmosphere, it will slow so rapidly that it will feel the effects of 400 times Earth's gravity. Once the strongest deceleration forces have passed, the Probe will deploy a parachute. The descent module will begin to take atmospheric measurements and transmit its findings to the Probe-Carrier spacecraft for relay back to Earth. Forty minutes after entry, scientists expect the Probe to reach an atmospheric density of about 10 bars (10 times the atmospheric pressure at Earth's surface), below what are believed to be Jupiter's lowest water clouds.

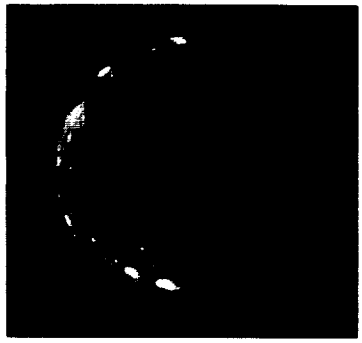
At the end of 60 minutes, the Probe will have penetrated 15 to 20 Earth atmospheres. Below that, increasing temperature and pressure—and weakening radio signals—will eventually bring the Probe mission to an end.

Meanwhile, the Probe-Carrier spacecraft will monitor radio signals from the Probe, picking up its scientific information and relaying it to Earth. The data also will be recorded on the Probe Carrier for later playback if needed.

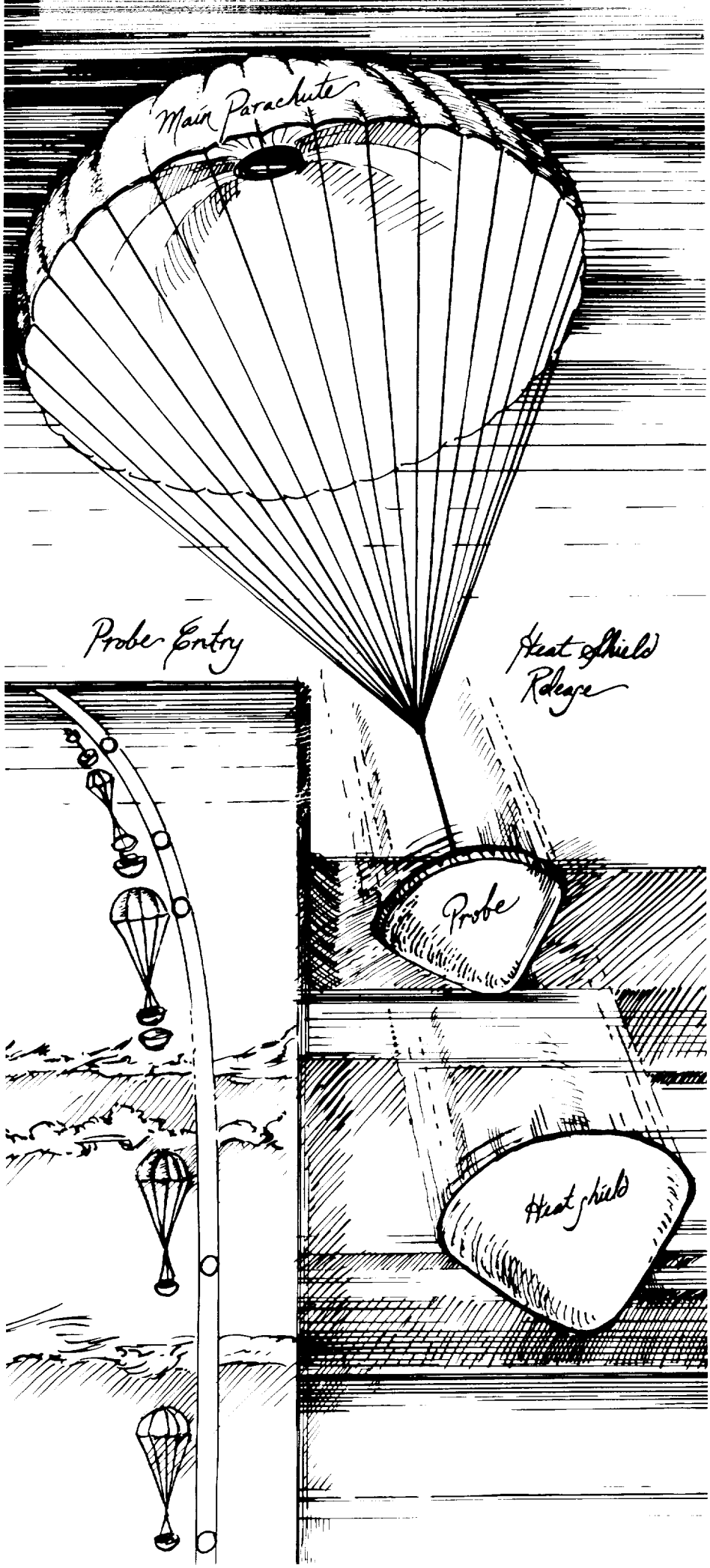
Once the Probe's work is done, the mission operations emphasis will revert to the Orbiter. The primary mission is scheduled to end about 20 months after Probe arrival at Jupiter.

Io

The Galileo Orbiter will incorporate a new dual-spin design. Part of the spacecraft will be three-axis stabilized so the camera and some other instruments can be accurately and steadily pointed. The other portion will spin so its instruments can sweep out space to make their measurements. Since Jupiter is too far from the Sun for solar cells to provide electric power, the Orbiter will use radioisotope thermoelectric generators similar to those flown on the two Voyager spacecraft.



Callisto

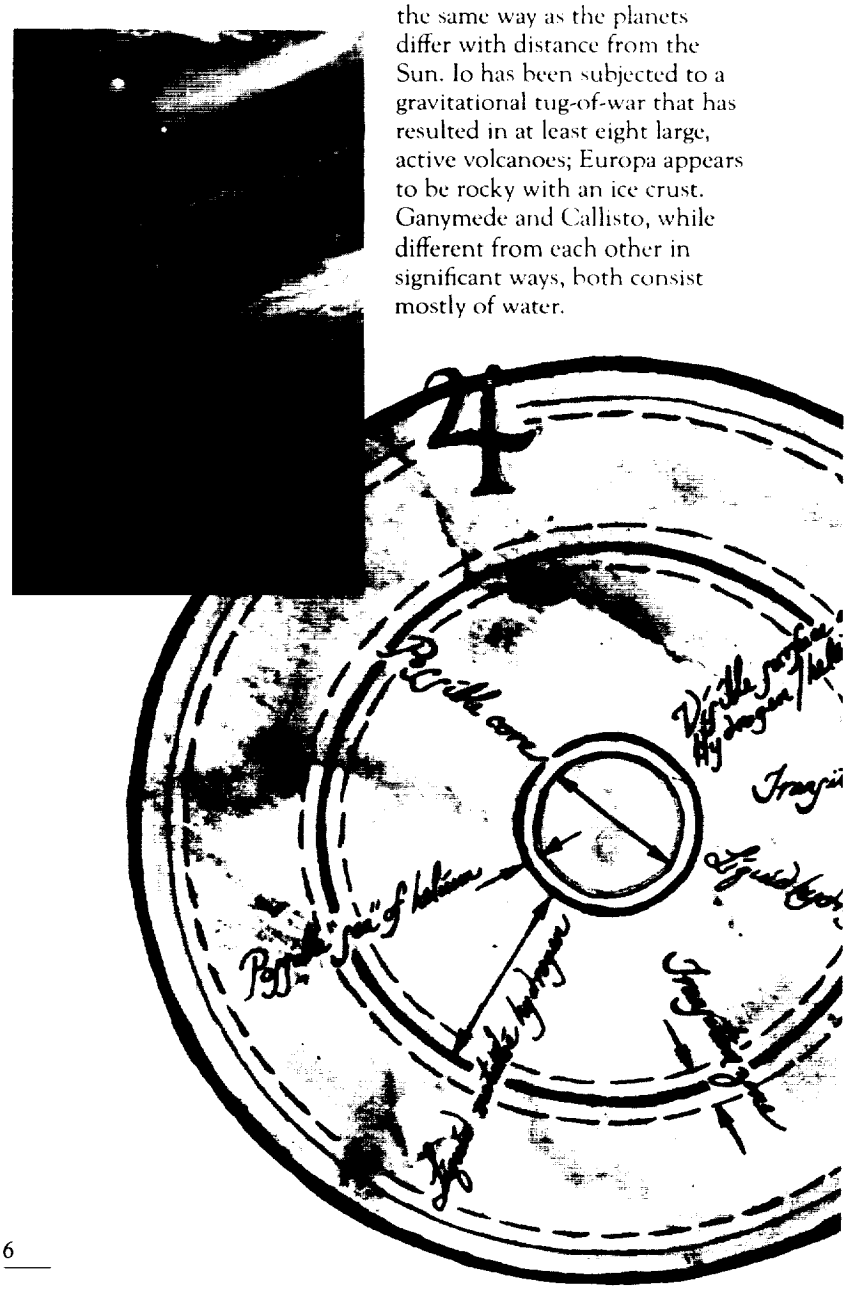

Main Parachute
Probe Entry
Heat Shield Release
Probe
Heat shield

Our scientists often refer to Jupiter and its 15 satellites as a "mini-solar system." They see a set of similarities between the solar system and the Jovian system within it.

Jupiter is drastically different from Earth and the other terrestrial planets—Mercury, Venus, and Mars. While the terrestrial planets are mostly rock, Jupiter's major constituents are hydrogen and helium, in about the same ratio as the Sun itself.

Jupiter is the noisiest source of radio signals, except the Sun, in our sky. Its magnetic field—the largest object in our solar system—is large enough to reach from Earth to Venus. Jupiter may not have a solid surface, but may change gradually from a gaseous, hydrogen-helium atmosphere to an interior of liquid metallic hydrogen. The tops of the clouds—all that can be seen of the planet—are wracked by huge storms that appear to well up from deep within Jupiter's interior.

The four Galilean satellites differ from each other in much the same way as the planets differ with distance from the Sun. Io has been subjected to a gravitational tug-of-war that has resulted in at least eight large, active volcanoes; Europa appears to be rocky with an ice crust. Ganymede and Callisto, while different from each other in significant ways, both consist mostly of water.



The Galileo 1984 Orbiter will carry instruments for all 11 scientific experiments originally selected, even though the change in launch date requires changes in the

Orbiter design. The design of the Probe and its seven instruments remains essentially unchanged.

The Orbiter is designed to

☆ Inspect the surfaces of the satellites (the cameras may see details as small as 30 meters, or 100 feet, across) to gain information about their composition, present state, and geological history.

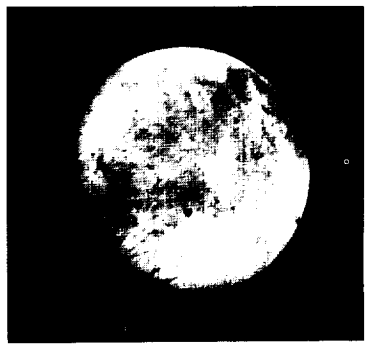
☆ Make comprehensive observations of Jupiter's weather.

☆ Study the magnetosphere—its size and shape and how it changes, how particles enter and leave it, and how Jupiter's satellites affect it.

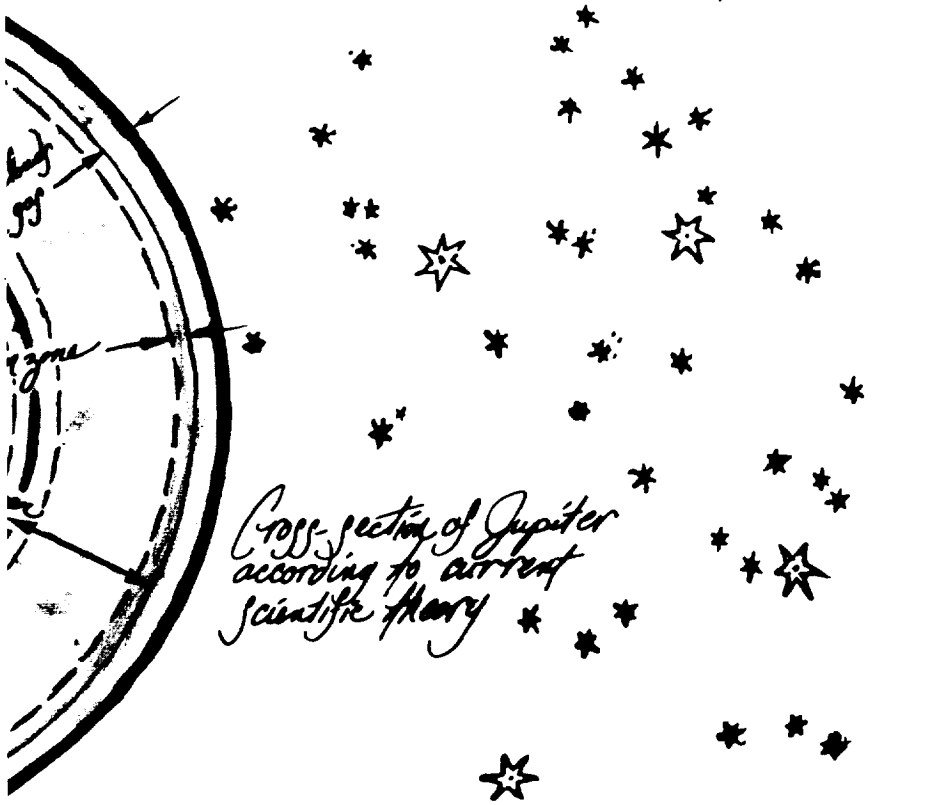
The Probe is designed to

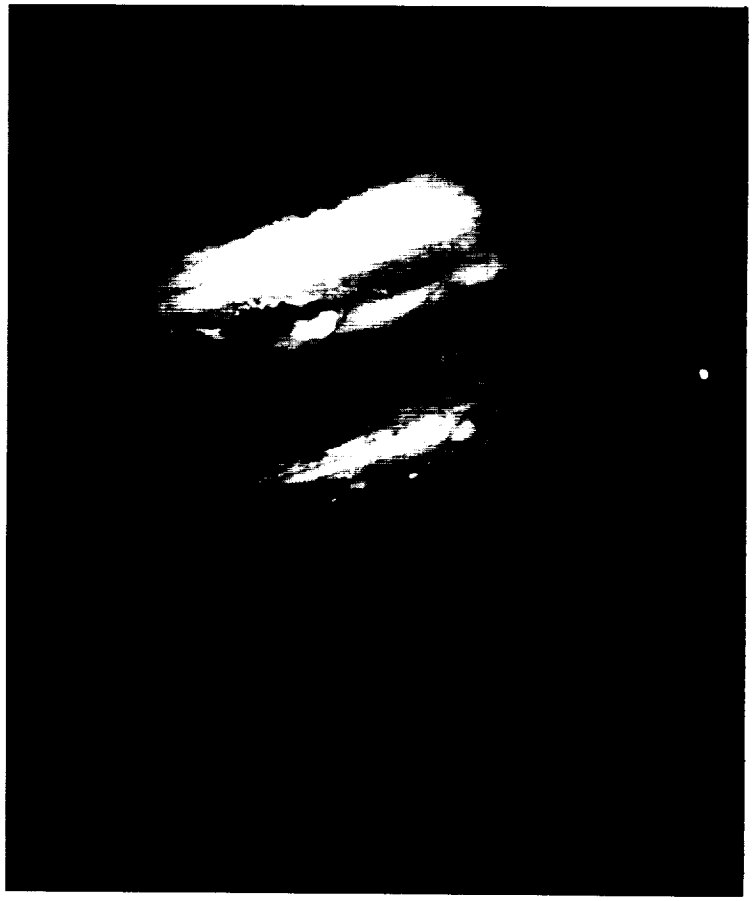
☆ Determine the temperature, pressure, density, and composition of the various levels of Jupiter's atmosphere down to a level at which pressure is about 10 times that at sea level on Earth, perhaps 129 kilometers (80 miles) below the cloud tops.

☆ Measure and compare the flows of energy through the atmosphere, inward from the Sun and outward from Jupiter's interior.



Europa





Even before the time of Galileo, people have been interested in Jupiter, our largest planet. More than 475 scientists—including 90 from 10 foreign countries—submitted proposals to participate in Project Galileo; 115 scientists were selected to form the Galileo science team.

Project Galileo will be the United States' fifth mission to Jupiter; predecessors include Pioneer 10 and 11, and Voyager 1 and 2. Pioneer 10 flew past Jupiter in December 1973, and Pioneer 11 arrived one year later. Voyager 1 passed Jupiter in March and Voyager 2 in July 1979, as the two spacecraft continue on to Saturn and beyond.

The Jet Propulsion Laboratory is the overall management center for Project Galileo and will build the Orbiter spacecraft. The Orbiter's rocket propulsion system will be provided by the Federal Republic of Germany. NASA's Ames Research Center will develop the Probe and Probe-Carrier spacecraft. Radio signals from the two spacecraft will be received on Earth by JPL's Deep Space Network.

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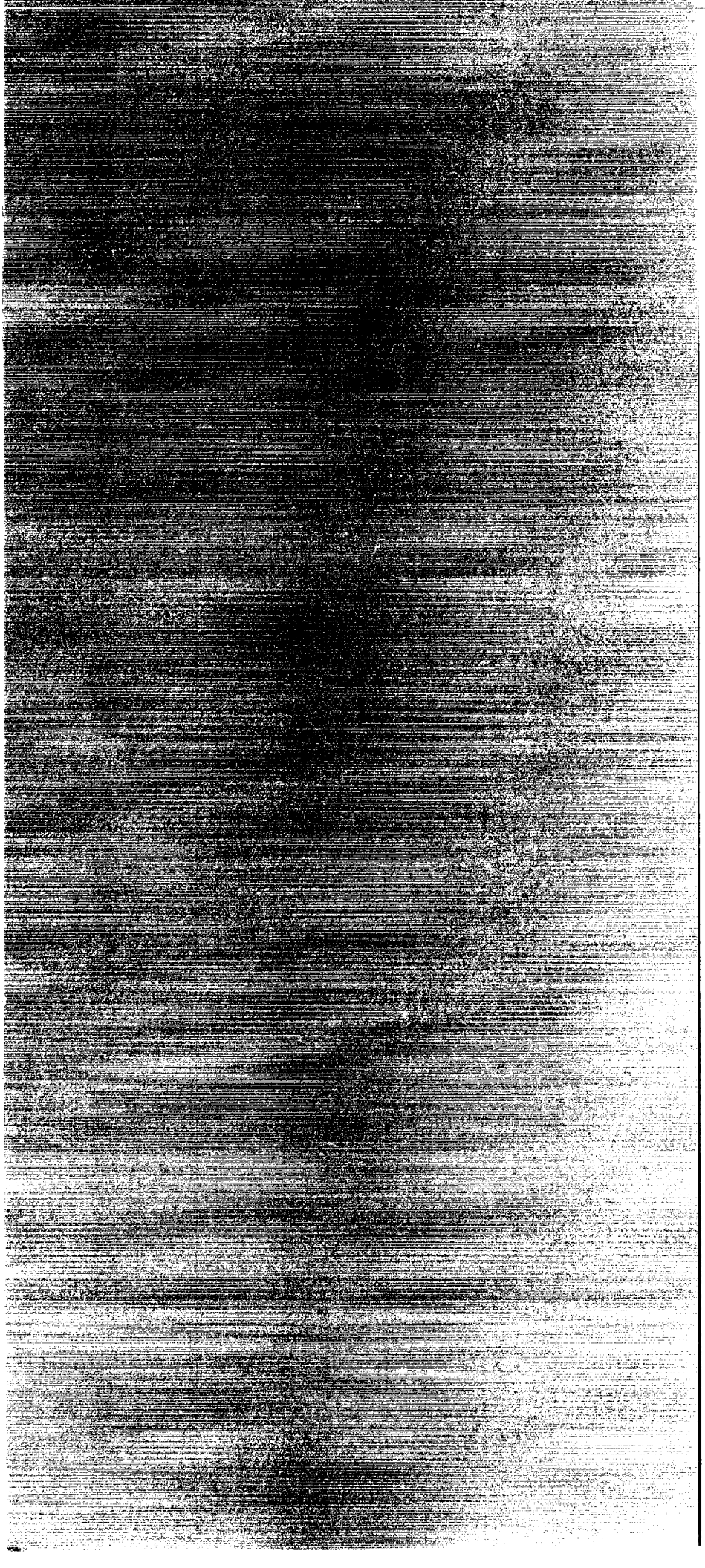

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