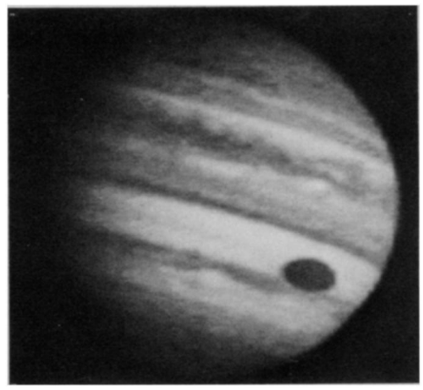
A pioneer view of Jupiter

The little spacecraft that could



"We're still alive!"

A long 46 minutes before, the Pioneer 10 spacecraft had flown within 81,000 miles of the titanic planet Jupiter, blazing a trail for future missions to the solar system's outer world. But it took that long, even at the speed of light, for data from the hurtling probe to cross the more than half a billion miles to earth and signal anxious scientists that Pioneer had survived Jupiter's fearsome radiation belt.

Jupiter is one of astronomy's great enigmas. It gives off more than twice as much heat as it receives from the sun. Its lingering 12-year year is fragmented into more than 100,000 brief, 10-hour days. Adjacent bands of brilliant color move at violently different speeds around its massive girth and a vast red spot, more than twice the span of the entire earth, rages and screams at the listening ears of radio telescopes. Yet for all the miles of data gathered by its 11 sensitive scientific instruments, Pioneer 10 has but confirmed that the mighty world is indeed a planet of mystery.

For from the outermost fringes of its influence, Jupiter confounded its explorers.

With almost 4.7 million miles yet to travel, 350,000 miles outside even the most expansive anticipation, on November 26 the spacecraft encountered a great shock wave where a million-mile-an-hour solar wind collides with the planet's magnetic field.

The sudden shock, Pioneer confirmed, deals the solar wind a mighty blow. Crossing the bow shock, the speed of the solar wind was cut in half. This suddenly released energy raised its temperature by 150 times to 1.5 million degrees C., sending the particles boiling off in violent, unpredictable turbulence. The number of energetic electrons jumped 20-fold across the shock front, as proton counts likewise skyrocketed.

Yet far stranger discoveries remain.

Some half a million miles later—twice the distance from the earth to the moon, a surprisingly small distance on Jupiter's vast scale—the spacecraft left the tumultuous magnetosheath and entered the magnetosphere proper, the main body of the planet's magnetic field. And here began one of the strangest puzzles since the flight was launched on March 2, 1972.

Once through the bow shock and magnetosheath, the scientists felt, they would soon encounter the regular structure of Jupiter's presumed dipole-shaped field. But it was not to be. For millions of miles Pioneer sped onward, while the numbers of particles fluctuated aimlessly back and forth and the magnetic field failed to grow or even assume a definite shape.

Hour after hour, day after day, magnetometer expert Edward J. Smith of Jet Propulsion Laboratory, plasma-watcher (and Pioneer project scientist) John H. Wolfe of NASA, radiation specialist James A. Van Allen of the University of Iowa and University of Chicago particle-physicist John A. Simpson peered at their gathering data, looking in vain for some sign that the force lines of Jupiter's powerful field were asserting themselves. As if to make the strangely vague field even more unearthly, Pioneer reported that it is backwards—a compass on Jupiter would point to the South Pole.

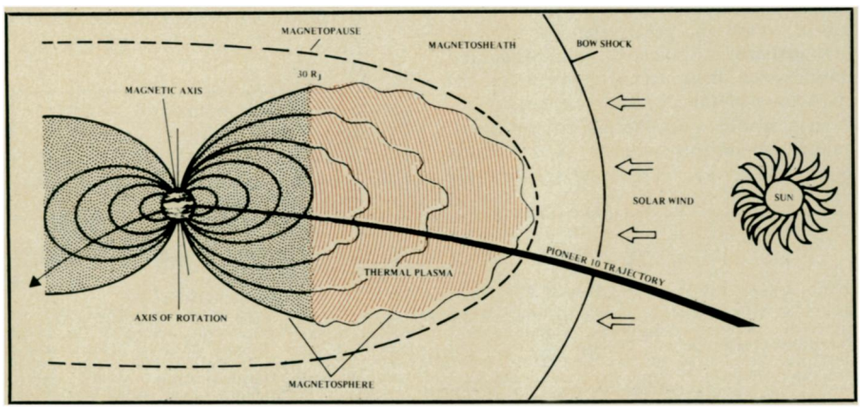
But even with millions of miles to go and questions arising faster than answers, the small (9 feet long, 570 pounds) but smart spacecraft was already fine-tuning the findings of earth-bound researchers. John D. Anderson of California Institute of Technology, Pioneer's chief trajectory analyst and celestial mechanician, discovered, four days into the magnetosphere, that the ponderous planet, some 300 times the mass of the earth was .0024 percent heavier than anticipated.

Farther and stranger. "It's a totally different ball game than we have on earth," said Van Allen of the feared radiation belt, potentially capable of crippling the spacecraft (SN: 11/24/73, p. 325). With all the bigness around, the radiation belts, he said, inexplicably appeared to be some 1.7 million miles smaller than comparison with earth's famed Van Allen belts would indicate.

Finally, four and a half days beyond the shock front, the instrument readouts began to climb. In perhaps an hour, the magnetic field grew from about five gammas up to 19. Particle counts rose by 500 percent. Anticipation reached a peak. Then the bottom fell out.

"At about 7:20 p.m. (PST), last night," announced Wolfe, "the spacecraft crossed back into the magnetosheath."

Pandemonium. Pioneer 10 certainly had not turned around and gone back whence it had come. What was going on? The field strength dropped back to six gammas, the energetic particles thinned out to the levels at the outer part of the magnetosphere, and there they stayed for more than 10 hours. James Warwick, who happened to be



Jupiter's magnetosphere, portrayed especially for SCIENCE NEWS by Pioneer chief scientist John H. Wolfe and NASA artist Chris Chizanskos. The magnetic lines of force in the dotted area are strong enough to pull trapped particles right around with Jupiter's 10-hour day, wobbling up and down because of the magnetosphere's tilt in relation to the planet's axis of rotation. The outer part (lined area), however, is weaker, so that, says Wolfe, it is not coupled to the planet, and any rotation of trapped particles is due only to a sort of "fluid drive" effect caused by the plasma.

Energy: the czar from Wall Street takes over

With its accustomed style and grace, the White House last week abruptly recycled its energy policy czars, amid growing outcry that the Administration was neglecting supplies of fuel and petroleum raw materials to providers of vital goods and services, including health care.

John A. Love, who resigned as governor of Colorado to head the White House Energy Policy Office, suddenly found himself and his office placed under a new agency, the Federal Energy Administration, to be headed by Deputy Treasury Secretary William E. Simon, whom Love had earlier replaced as the Administration's chief energy spokesman. Surprised and angered, Love and his assistant Charles G. DiBona promptly resigned.

Effects of the change could not be immediately determined, but Love had come under increasing criticism of late for alienating necessary allies and being generally indecisive (SN: 11/17/73, p. 308). Simon, a millionaire Wall Street investment banker, brings to his new job a reputation for being a no-nonsense "headcracker."

In addition to the well-publicized problems of how to apportion gasoline and heating oil fairly, Simon will soon have to face the more subtle, but potentially more dangerous problem of how to choose which specific petroleum users will be granted highest priority in order to keep the nation's goods and services flowing. Already, serious dislocations are appearing:

- Shortages have developed in the high volatility petroleum distillates, such as benzene and toluene, needed to produce pharmaceutical products. (Gasoline and heating oil—the so-called "middle distillates" that are volatilized at medium temperatures in oil refineries—are the only products subjected to special control so far.) The high volatility distillates are used to make everything from drugs and chemicals needed by doctors to the disposable tubes that carry blood during transfusions. Any decrease of these products could seriously affect health care in the country and already hospitals are scrambling to find substitutes.

The growing black market in benzene also helps illustrate what problems may be faced in other petroleum products shortly. SCIENCE NEWS has learned that some American pharmaceutical companies are having to purchase, from abroad, benzene produced in this country and sold abroad at higher prices. By the time the benzene makes the return trip, its price has more than tripled.

- The steel industry complains that it is using oil and natural gas at "an irreducible minimum," and that steel shortages have already begun to appear. Ironically, the shortages are appearing in precisely the areas that need steel in order to help the nation gain energy—drill bits, rail car wheels, roof and wall bolts for coal mines. A "serious shortage" of baling wire has been reported which could mean higher meat prices next year if hay can't be baled before it rots. So serious is the shortage of well casing and drill pipe for new oil wells that some oil companies are reportedly stripping old wells to recover the needed materials.
- The tourist industry may seem an expendable "frill" to some people, but some states are virtually unable to survive without it. Hawaii takes in $800 million a year from tourists; in Vermont, skiing alone is a $63 million a year business supporting 4 percent of the work force. The Department of Commerce already predicts a nationwide unemployment rate of between 8 and 14 percent next year, but some states will be hit much worse than others.

At his first press conference, Simon handled himself with aplomb. A firm decision on rationing, he said, would come by the end of the month. He had been assured direct access to the President—something John Love complained he lacked—and in a new spirit of openness, he promised weekly press briefings. Simon said he had not heard of the problem with high volatile distil-

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observing Jupiter's decametric radiations by radio telescope at the University of Colorado at the time, saw no signs of change.

The magnetic field of the earth is often pushed inward by temporary increases in the pressure of the solar wind, but the change is seldom more than 5 times the radius of the planet. Pioneer had apparently been passed by just such a push, except that the solar shove had covered at least 50 Jupiter radii.

Back in the stream again, the spacecraft flew on, yet the dipole remained elusive until, at last, on Sunday morning, with 30 radii to go, its traces finally appeared. A regular, ten-hour cycle became clearly visible, and the numbers of protons began climbing about 800 percent per hour, becoming almost as numerous as the electrons that had formerly outnumbered them 100 to 1.

As the planet loomed larger in the spacecraft's "camera," an imaging photopolarimeter transmitting hundreds of views of Jupiter and three of its twelve moons, concern for radiation damage became increasingly evident. "Everybody's really holding their breath," said Wolfe, barely an hour before the spacecraft would reach its nearest point to Jupiter. "It's going to be a cliff-hanger all the way to the end."

And so it was. The mysterious protons cannot be predicted or even reliably estimated from earth, and Jupiter had already shown countless unforeseeable surges that made extrapolations from measured data a risky business.

But, by the skin of its teeth, Pioneer 10 survived. Proton levels jumped by 2,000 times in less than 200,000 miles. One astrophysicist estimated that it could not have gone even a half a radius closer to the giant planet, and Wolfe's survival announcement was met with cheers from hundreds of assembled had been hope that some of the moons newsmen, scientists and VIP's. There particularly, Io, would sweep the deadly protons out of the way. Early analysis could not reveal whether the moons had made the difference. During its flyby, Pioneer was exposed to a radiation dose of some 500,000 rads, a thousand times the amount usually fatal to man.

Infrared measurements revealed an average global temperature of about 133 degrees below zero centigrade, along with yet another mystery: the apparent lack of a significant temperature difference between the planet's day and night sides. The moons Ganymede (recently discovered to show apparent traces of an atmosphere) and Callisto showed respective temperatures of minus 145 and minus 163 degrees centigrade.

Early signs were that Jupiter's magnetic field is about 4 gauss at the surface, some eight times as strong as earth's. The axis of the dipole appears to be tilted about 10 degrees, although it is apparently not far displaced from the planet's center. This is convenient for theorists although it seems to negate the radical southward displacement proposed by Warwick (SN: 5/19/73, p. 326).

The major outstanding question was whether Pioneer 11, following along a year behind its predecessor, could safely be retargeted toward Saturn, a maneuver which would require a much closer pass to Jupiter—about 25,000 miles—for a gravity-assisted swingaround. Certainly it could not survive such a near encounter at the near-equatorial magnetic latitude of Pioneer 10's path. The swingaround, however, would take the spacecraft past Jupiter at a much safer, more radiation free location, 45 degrees to the south of the equator.

The decision, or at least the confirmation of its possibility, awaits more refinement of the data. □