JPL

Scarp runs 185 miles across surface.

sun side of Mercury. If, as it appears at first glance, the planet's influence is present there, it may show up in the magnetic field as well. The main goal of the second encounter, however, was the pictures. Next March, the third and final pass, on the planet's darkside again, will be largely devoted to the infrared, ultraviolet and other instruments, looking from as close as 2,360 kilometers. There is some concern about whether Mariner's reserve of control gas is adequate for the journey—"I think it'll have some of the element of 'the Perils of Pauline,' " says Project Manager Gene Giberson—but officials are cautiously optimistic. "As far as I'm concerned," says Program Manager William Cunningham, "we're on our way to 'Mercury 3' right now." □

'Jupiter effect': Mixed reaction

The planets of the solar system are moving surely and inevitably toward a configuration that happens only once in 179 years. In 1982 there will come a moment when all the planets are in line with each other on the same side of the sun.

A newly published book, *The Jupiter Effect* by John Gribbin and Stephen Plagemann (New York: Walker and Co., 1974), foresees disastrous effects for that planetary imbalance. Gribbin and Plagemann predict increased seismic activity in the years around 1982 and specifically a major earthquake for the Los Angeles area.

Due to stories about it in the past two weeks by United Press International and Newsweek, the Jupiter effect theory is getting considerable public attention, including a formal query from a U.S. Senator. But the theory is receiving, at best, mixed reviews by scientists.

The two authors propose this chain of events: The planets exert tidal forces on the sun, and with all planets lined up on the same side of the sun such forces reach a maximum. The maximum force triggers an overabundance of sunspots. More sunspots mean more solar particles reaching the earth's upper atmosphere. The particles trigger unusual movements of large air masses. These movements affect the earth's rate

The Colombo Connection: How Mariner was brought back

"Looking back on things like this, you kind of kick yourself," says Joseph G. Beerer, "but sometimes you just can't see the forest for the trees." He wasn't the only one. In 1970, Beerer was the trajectory analyst helping to plan Mariner 10's flight past Venus and Mercury. His gentle self-chastisement is for his failure to realize the significance of a number buried in a computer printout on his desk, showing that Mariner could easily be aimed to pass close to Mercury two, three, and a virtually infinite number of times. And almost for free.

The math was easy. It would almost inevitably have occurred to someone sooner or later. As it happened the brainstorm was that of Italian astrophysicist Giuseppe Colombo, whose work in 1966 had helped to explain the newly discovered 3:2 ratio between Mercury's rotational and orbital periods.

Early in February of 1970, a group of scientists met at the California Institute of Technology to discuss Mercury, including the upcoming flyby. The launch date had already been chosen to minimize the energy required for the flight, and an arrival date had been picked to give a proper lighting angle for photography on the single visit that was then planned. Mission officials had also decided because of some of the experiments to aim for the planet's "dual-occultation zone," a region where Mercury would block both the earth and the sun from the spacecraft's view. Even with these stipulations, however, there was a range of available aiming points, each of which would take Mariner 10 into a different solar orbit after leaving Mercury.

It was at this meeting that Colombo tugged on the jacket of Caltech's Bruce Murray, who would be Mariner's chief picture analyst, and exclaimed, "The spacecraft will return! The spacecraft will return!" Queried by Murray, Colombo pointed out that among the range of possible post-Mercury solar orbits there seemed to be one with a period of 176 days, exactly twice the 88-day period of the planet. Couldn't this orbit be fine-tuned so that every two trips around the sun Mercury would find the spacecraft waiting for it?

Murray asked Beerer to find out. Sure enough, already on Beerer's desk was a computer listing of alternatives including one in which Mariner would move around the sun an average of 2.04 degrees per day. Divided into the number of days in a year, it came out just right for repeated encounters—extra flybys for free.

Well, not quite. A few changes had to be made in the spacecraft design, and time was short since the contracts with the builder (Boeing) had to be signed that autumn. Valves were adapted from Apollo so that Mariner's engine could be restarted the required number of times. Pioneer contributed a larger tank to hold an increased amount of control gas. Solar panels had to be made movable for better cooling, and an antenna was pivoted so that it could aim at earth while the spacecraft was behind the sun between encounters.

And it all had to be done while adding neither cost nor weight. Fortunately (and atypically), Mariner 10 came in about $750,000 under budget, thanks largely to its NASA project, program and spacecraft managers, respectively, Gene Giberson, William Cunningham and John Casani, and the spacecraft program manager at Boeing, Edward Czarnecki. The weight miraculously took care of itself: The conservatively rated Atlas-Centaur rocket turned out to be able to handle the load.

The cost of keeping data analysts and others around for the second encounter had added only about two percent to Mariner 10's $98 million budget, with another 1.7 percent for "Mercury 3" next March 16, but that comes out of more recent budgets. Altogether, the Colombo Connection, with Beerer, Giberson, Cunningham and colleagues, has been one of the better investments in NASA's planetary research program. □