ROBERT M. POWERS

# PLANETARY ENCOUNTERS

original drawings by HELEN ZANE JENSEN

STACKPOLE BOOKS

1979

hemisphere must be "leaking" around to the other side. It did not quite occur to anyone to question the eighty-year-old assumption that Mercury rotates in eighty-eight days. If they had, the problem of the warm radio emissions would have been solved. If Mercury rotated in less than eighty-eight days, then the "dark" side was still warm because it had been in sunlight only two months earlier (with an eighty-eight-day rotation period, the same as the period of revolution around the sun, Mercury would in theory present only one face to the sun and the same one at all times).

The giant radio telescope at Arecibo, Puerto Rico, found the right solution in 1965. Measuring a radar echo reflected from the surface of Mercury, scientists found that it rotated in 58.4 to 58.9 days, which is exactly two-thirds of the time of revolution—the solar tides have locked the planet into this figure. Curiously, if astronomers had not been intent on looking for the eighty-eight-day period, they would have discovered the true rotation long before. An analysis of old drawings plus some of the best telescope photographs, after the fact, gave a figure of 58.65 days for the rotation period of Mercury.

Mercury had been observed for 1,800 years before the invention of the telescope, and we knew that it revolved around the sun in eighty-eight days, and after the sixteenth century we knew it was the closest planet to the sun. In the 350 years or so that telescopes and other instruments had been in use, we didn't even know the rotation period. We were fairly sure it didn't have an atmosphere, but weren't positive. It might or might not have mountains. Not much to say for "studying" a planet for almost 2,300 years.

In many ways, the knowledge of the planets can be divided into three categories: ancient (before telescopes), telescopic, and spacecraft. It isn't hard to see which has been the most successful. Compared to previous knowledge, spacecraft exploration is unbeatable—as the flight of *Mariner 10* to the planet Mercury showed.

*Mariner 10* became known as the "doughty little spacecraft that wouldn't quit," a public relations squib spawned after the second Mercury encounter and the "little spacecraft that *could*" (worse) somewhere else along the line. The spacecraft was, in fact, somewhat of a Phoenix. Even before it approached Mercury, there were doubts whether it would make the encounter with all or even most of its full faculties. It was down on antenna power, there were mysterious oscillations in the attitude control system which were unsolved, and the very precious supply of attitude control gas was low. Just before the third trajectory correction maneuver necessary for a reasonably close pass at the planet, the DSN (Deep Space Network which communicates with spacecraft) lost contact with *Mariner 10*.

The Mercury Mission was the first to use what would become a standard NASA practice to extend missions or push missions further out without having to design a new launch vehicle, or wait for the Space Shuttle to be ready to put interplanetary missions into orbit for further thrust into space by IUS, or a combination of the Interim Upper Stage and the Solar Electric Propulsion Stage (SEPS). *Mariner 10* tried out the "gravity assist" procedure and proved that it was not only workable but highly desirable. For a mission which was produced at the incredibly low fixed cost of 98 million dollars (a fixed cost mission is about equivalent to trying to hit the top draw in the Irish Sweepstakes and has about as much chance of being pulled off. Mariner won the draw), it actually made three trips to Mercury, photographed Venus, examined Comet Kohoutek, photographed the polar regions of the moon, and shot photos of the Earth as it departed sunward. The cost for all this information was about 60 cents per person per year in the United States for five years.

"Gravity assist" was first proposed by Arthur C. Clarke in a science fiction novel, *Sands of Mars*, in 1952. In the novel, it was used for a mission to Saturn with a gravity slingshot off Jupiter (Jupiter is still the favorite for slingshotting; it has the largest gravity pull—and greatest assist—of any of the planets. The sun, of course, is the big time for that one.) By1954, the *Journal of the British Interplanetary Society* was discussing the possibility (via an article by author Derek F. Lawden) of "perturbation maneuvers" to economize on fuel in interplanetary travel.

Work on gravity-assist trajectories was begun at Jet Propulsion Laboratories (JPL) in the early 1960s. Besides finding out all manner of interesting things about planetary orbits and trajectories (such as an Earth-Venus-Earth round trip by gravity assist), Michael A. Minovitch produced a mathematical technique to search for acceptable trajectories by computer. This led to the discovery of an Earth-Venus-Mercury gravity-assist possibility for 1970 and for 1973. The latter opportunity was used for *Mariner 10* on the outward-bound trip and for the spacecraft-return to Mercury for a second encounter. It was the gravity-assist technique which enabled NASA to plan many of the more interesting missions with savings in trip-time which equal money in support facilities and personnel savings and fuel. It is gravity assist which will enable *Voyager* (Chapter 7) to go to Jupiter and then to Saturn, Uranus, and possibly Pluto, a variation on the once proposed "Grand Tour of the Solar System" idea.

Nearly everything about *Mariner 10* was a gamble, from the designs of the radio equipment to the decision (based mainly on the fixed cost of the project) to launch only one spacecraft without back-up, in a blackjack or bust scene.

A little after 12:44 A.M., EST, November 3, 1973, the Atlas/Centaur No. 34 carrying *Mariner 10* lifted off the pad at Cape Canaveral, heading for Mercury by way of Venus. Less than fifteen minutes later it had made its parking orbit, unlike its ill-fated previous brother, *Mariner 8*. At 1:20 A.M., the engines of the Centaur stage were restarted successfully and the spacecraft accelerated to 25,456 miles-per-hour from an Earth orbital speed of 16,480 miles-per-hour. (25,456 miles-per-hour, called "second cosmic velocity" by the Russians, is the speed necessary to escape the gravitation field of the Earth and go into interplanetary space. It differs