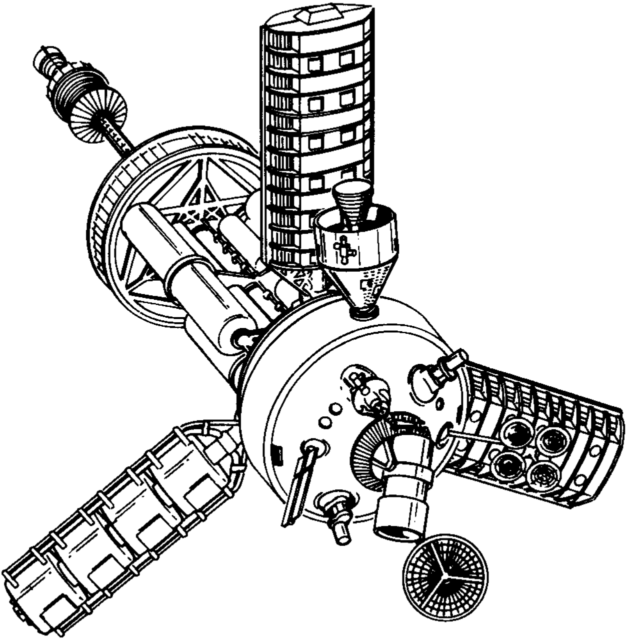
MODEL PRODUCTS

PILGRIM OBSERVER



SPACE NEWS RELEASE
MANNED SPACECRAFT CENTER, HOUSTON, TEXAS

For release: Wednesday, March 7, 1979

PILGRIM I LAUNCH MARCH 21

Pilgrim I, the first United States manned planetary exploration vehicle, will be launched into near-Earth orbit from J. F. Kennedy Space Center, Florida, on Wednesday, March 21, 1979 to inaugurate this nation's manned planetary exploration program.

The flight of Pilgrim I will be divided into two mission phases: earth-orbit systems verification (EOSV) and multi-planet exploration and probing (MPEP). Pilgrim I is designed as a long-life multi-mission space vehicle capable of deep space operation for 5 years or more.

The launch of Pilgrim I will take place from Launch Complex 39B with an augmented Saturn-V. Pilgrim I will rendezvous in a 200 nautical mile circular orbit with the Saturn Workshop (USOC, orbited 1972). Pilgrim I will be launched unmanned.

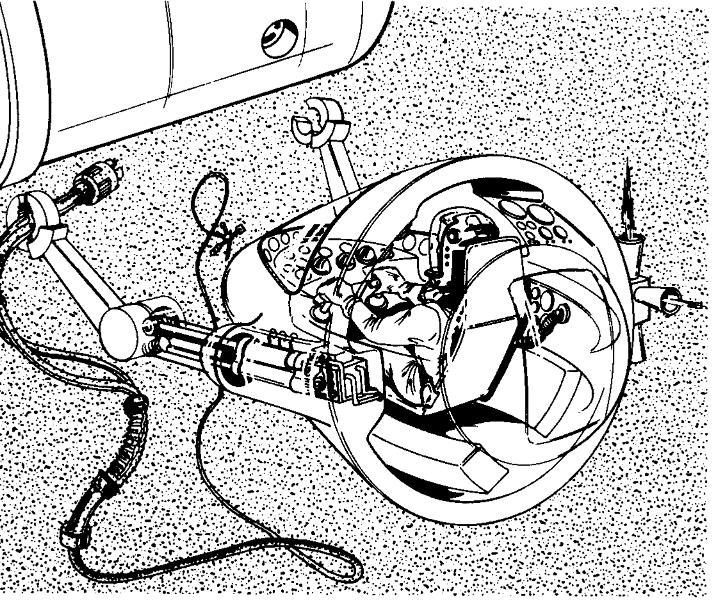
Rendezvous target is a point one nautical mile from the USOC trailing in the same orbit. Once station keeping has been established, the crew of 10 astronauts will be lofted to the Pilgrim I by the space shuttle S.S. WILLY LEY on Friday, March 23, 1979. The EOSV phase of the mission will then commence, and should be in full operation by the end of March.

VEHICLE DESCRIPTION

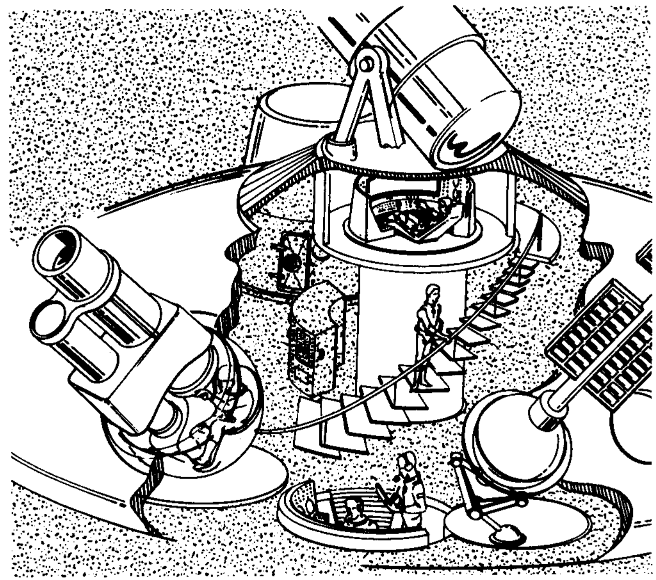
The Pilgrim spacecraft is a 10-man exploration vehicle intended for long-duration space voyages with travel times of up to 5 years without refurbishment. The United States' ability to place very large payloads into near-earth orbit, the economy of the Space Pioneer Class of reusable space shuttles, and the establishment of a permanently-manned earth-orbiting station (USOC) makes possible a completely new approach to the problems of economical interplanetary missions.

Pilgrim I is the first of a series of true space ships capable of traveling to any part of the Solar System out to the orbit of Saturn and designed to be used over and over again by orbital refurbishment. Pilgrim I will never touch the surface of a planet again, and it is expected to be useful for interplanetary exploration until 1990—or even longer with uprating and modification of its systems as space technology progresses. The Pilgrim Class of space ships are scheduled for future use as (1) an earth-orbital space station for earth resources observations and studies, (2) an earth-orbital space station in synchronous orbit approximately 22,300 miles above the surface for use in meteorological and communications services, (3) a lunar orbital space station for logistical support of the Lunar Surface Laboratory, (4) an interplanetary exploration ship capable of carrying manned planetary lander modules to initiate and support the manned Mars landing program.

Pilgrim I is the interplanetary manned probe mission (observer) configuration. It is 100 feet long and 33 feet in diameter in launch configuration in order to mate with the second stage (S-II) of the Saturn launch vehicle. The three modular systems arms are deployed in orbit to achieve a 3-spoke configuration with a tip diameter of approximately 150 feet. After deployment, the three-arm assembly will rotate about the long axis of the spacecraft like a helicopter rotor. Because of human factors limits — the ability of the astronauts to maintain orientation in a spinning craft —the arms will rotate at approximately 2 revolutions per minute to produce centrifugal force equal to about one-tenth of earth gravity at the tips of the arms. The remainder of the Pilgrim spacecraft consisting of the Main Control Center at the hub of the rotating arms and the Service Section consisting of the propulsion system and consumables storage bays will maintain a stabilized inertial reference to provide a fixed attitude with respect to the stars. As such, the Main Control Center will be in a zero-gravity condition and will provide a stabilized platform for astronomical observations, scientific experiments, and communications operations. Transfer between the rotating arms and the stabilized hub will be made through a special transfer cabin inside the Main Control Center structure.

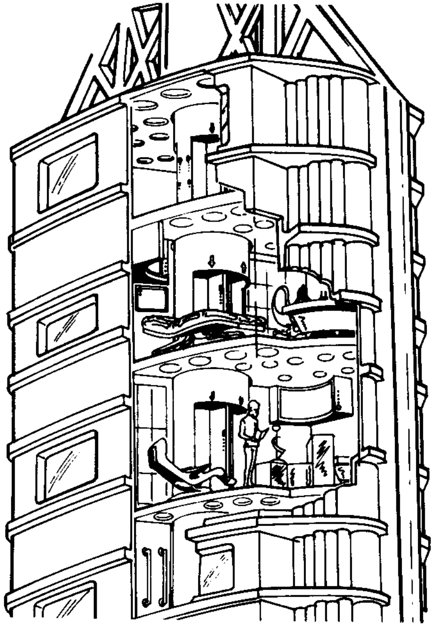


Two auxiliary spacecraft are carried by Pilgrim I. The Modified Apollo Command and Service Module (Apollo-M) can be used during EOSV as a shuttle between Pilgrim I and Freehold and during MPEP as a carrier for scientific experiments that require separation from the main space ship. The Apollo-M will also be used for close-in inspection of objects encountered in space that are in a trajectory approximating that of Pilgrim I and that are within the velocity-change (delta-V) capabilities of the Apollo-M. The One-Man EVA craft (OMEVAC), also called Astrotug or "Little Toot" is used to perform routine or emergency inspection and repair of the external components and systems of Pilgrim I. Astrotug will be able to check for micrometeor damage, locate and repair leaks in consumable plumbing, implace and retrieve scientific experiment packages on the external structure of Pilgrim I, and will be capable of performing maintenance and repair tasks if required. Both the Apollo-M and the Astrotug are docked to the Pilgrim I through the Universal Docking Adapter (UDA) which also permits the docking of the Space Pioneer Class shuttle craft as well as allowing soft-suited astronaut IVA ingress and egress.



The Main Control Center of Pilgrim I contains all command, communications, control, and scientific experiment functions of Pilgrim I. Mounted on the MCC are the various antennas for communications, telemetry, and navigation. Several types of optical and radio telescopes will also be mounted for the MPEP phase of the Pilgrim I mission.

One of the three rotating arms contains the crew living quarters for a maximum of 10 men in Pilgrim I. Spinning these living quarters to provide artificial gravity ranging up to one-tenth earth-normal gravity at the tip of the arm will provide a means to counter some of the long-term detrimental physiological effects of weightlessness that have been suspected for some time but which cannot be confirmed until medical scientists have the opportunity to study men who have been exposed to weightless conditions for years. Providing artificial gravity in the living quarters eliminates the need for elaborate zero-g living facilities for preparing food, providing for personal hygiene, handling biological wastes, storing equipment, and restraining astronauts during sleep periods.



The second rotating arm contains the hydroponic farm that is an important link in the closed ecological life support system that is being pioneered aboard Pilgrim I. Because it is impractical to carry along all of the oxygen and other life support consumables for long-duration space voyages, space technologists have had to develop life support systems that will re-process or re-use oxygen, water, and other biological materials. The result is the "closed ecological" life support system that is a miniature version of the Planet Earth. As on Earth, pollution control is a mandatory requirement. Human beings need oxygen, water and food, and in turn produce carbon dioxide, water, and waste. Plants take carbon dioxide, water, and human waste and, in the presence of light energy, convert them into oxygen and food. Thus, the hydroponic farm where plants are grown in chemical solutions acts to balance the ecology and permit long-duration space voyages with less required weight for consumables.

The primary requirements for the plants in the hydroponic farm are large leaf areas and ability to produce carbohydrates. Rapid growth to maturity is also desirable. Initial experiments in Pilgrim I during EOSV phase will involve the use of pumpkin plants. Since pumpkin plants are vines, they exhibit little if any geotropism or gravity-seeking instincts; they will be planted in the close-in sections of the hydroponic arm where lower artificial gravity prevails. The outer levels of the hyroponic arm will be given over to experiments with various food plants that also meet the criteria of large leaf area.

The third rotating arm contains the nuclear electric power plant that will provide the electrical energy necessary to operate onboard equipment. This nuclear power plant is an advanced version of the various SNAP (Space Nuclear Auxiliary Power) devices that have been orbited on spacecraft since the days of the Nimbus-III and have been emplaced on the lunar surface since Apollo-12. The Pilgrim I power plant involves no novel technology since it is a "stack" or combination of Brayton cycle nuclear power units that have previously been well-proven on earth-orbiting spacecraft. Solar cell arrays such as were used on earlier interplanetary spacecraft and on space stations were not practical for Pilgrim I because of the large surface areas that would be required for flights beyond Mars and because of the technical difficulty of bracing or stowing them during periods of acceleration for trajectory alterations.

The propulsion system of Pilgrim I consists of three up-rated J-2 250,000-lb-thrust rocket engines using liquid hydrogen and liquid oxygen as propellants. In addition to the conventional liquid propellant J-2 engines, Pilgrim I is equipped with one Nerva 2B nuclear rocket engine for in-flight burns to correct trajectories, provide thrust for shaping orbits, and increase velocities where possible in order to reduce transit times. The primary working fluid for the Nerva 2B is liquid hydrogen.

Various attitude control and ullage rockets are located on the Pilgrim I. Burning hypergolic propellants, they perform such functions as adjusting spin on the rotating compartments, stabilizing the Main Control Center, and making small changes in velocity vectors.

MISSION PROFILE:

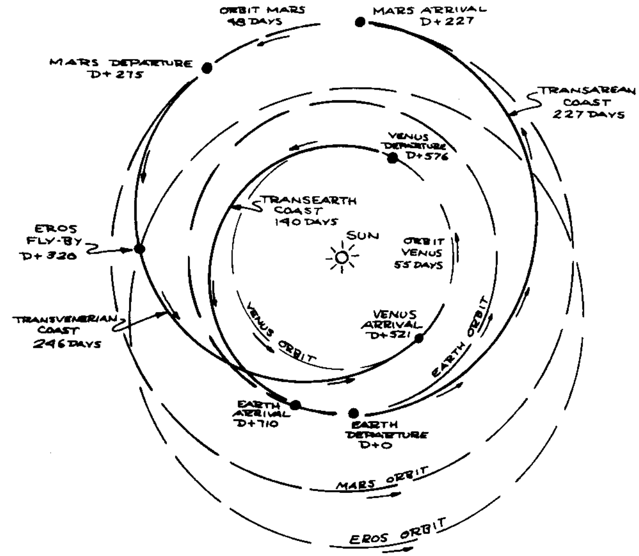
The Earth Orbit Systems Development (EOSV) phase of the Pilgrim I mission will take place over a period of two months from time of original insertion into earth orbit. The Pilgrim I EOSV will utilize the spacecraft itself to develop, prove, and man-rate the various long-duration systems required for Pilgrim deep space interplanetary missions. Preliminary proving was done during Saturn Workshop missions. During this development phase when there are more likely to be in-flight failures of new equipment or changes required to improve performance, new, modified, or replacement equipment can be quickly brought to Pilgrim I. In addition, should some failure require it, Pilgrim I can be egressed rapidly or assistance quickly provided from the nearby Saturn Workshop.

Primary mission objectives during EOSV phase are:

1. Verify Nuclear Electric Power Plant reliability, performance and long-life capability.
2. Verify and develop techniques for operating and balancing the Pilgrim closed ecological cycle life support system.
3. Develop and perfect the artificial gravity techniques and equipment suitable for long-duration space missions.
4. Develop and check-out on-board navigation, communications, and scientific equipment in the space environment.
5. Evaluate man's ability to adapt and function within the Pilgrim spacecraft environment for extended periods of time.
6. Test fire the Nerva 2B engine for check-out.

The Pilgrim I EOSV phase is scheduled for approximately two months but is considered to be open-ended with respect to verification of reliability of equipment. All consumables will be replenished by shuttlecraft prior to the start of the MPHEP phase.

If all goes according to schedule, the Pilgrim I MPEP phase will commence in June 1979. The initial interplanetary mission chosen for Pilgrim I is an Earth-Mars-Venus-Earth orbiting mission with short orbiting periods around Mars and Venus. The mission will also include a fortuitous fly-by of the asteroid Eros on the Mars-to-Venus segment.



The Earth-Mars-Venus-Earth swing-by mission was chosen for Pilgrim I because the positions of the three planets will permit the total trip time to be 710 days. This is less than the total round-trip time of approximately 971 days required for a Mars orbiting round trip alone, and can be accomplished well within the delta-v capabilities of the Pilgrim spacecraft with the Nerva 2B propulsion system.

The Pilgrim spacecraft will be manned by a team of ten astronauts, four of whom are technical specialists in spacecraft operations and maintenance and the remaining six of whom are scientist-explorers to conduct or supervise the on-board experiments.

As presently conceived, the mission will begin with an orbital plane change to put Pilgrim I into a 200 n.m. circular earth orbit inclined 23°27′, or co-planar with the ecliptic. Transaerean insertion burn will be made with the three J-2 engines. At that point, the Pilgrim I becomes the Pilgrim-Observer space vehicle. Transarean coast will last approximately 227 days culminating in a retrograde burn of the Nerva 2B engine to achieve a circumarean orbit (Martian orbit) with a periapsis of 500 n.m. and a high point of 5,800 miles.

Phasing of the orbit will permit one or more close approaches to the Martian satellite Phobos. The Pilgrim Observer will spend approximately 48 days in Martian orbit before the Nerva 2B engine is started to thrust the spacecraft into a transvenerian trajectory. This Mars-to-Venus coast will take 246 days and will include a close-approach and fly-by of the asteroid Eros 145 days after transvenerian injection. This will be of particular interest to astronomers because of the unusual variation of brightness of that asteroid which has led to the theory that Eros has a highly irregular shape and may be elongated like a football. Close-approach photographs and real-time television relay to Earth should provide answers to this astronomical puzzle.

Insertion into circumvenerian orbit (Venus orbit) will be made with a burn of the Nerva 2B engine, and the Pilgrim Observer will circle Venus in a 500 n.m. orbit for 55 days while scientific measurements are made of the Venerean environment and of solar phenomena.

Transearth injection will place the Pilgrim Observer into a 140-day transearth coast, terminating the mission with a final burn of the Nerva 2B to insert the Pilgrim Observer into the 200 n.m. earth-orbit phased with the Saturn Workshop. The crew will be outshipped by a shuttle craft following extensive debriefing.

Primary Mission Objectives of the MPEP phase of the Pilgrim voyage include:

1. Perform planetary exploration photography and conduct remote atmospheric and surface sampling of both Venus and Mars.

2. Investigate and photograph, the Martian moon Phobos to determine size, density, and chemical composition.

3. Perform a fly-by of the asteroid Eros to determine reasons for wide variations in brightness, its shape, and its appearance.

4. Measure solar phenomena and characteristics in interplanetary space between the orbits of Venus and Mars.

5. Search for evidence of extra-terrestrial life.

6. Provide precursor flight data for subsequent Pilgrim Lander flights to Mars scheduled in the 1980 time period.

7. Verify the concept of the economy of multi-mission modular interplanetary space vehicles exemplified in the Pilgrim spacecraft.

8. Confirm all systems and equipment design and operation for future flights as far as the orbit of Saturn.

9. Conduct long-term medical and biological studies of human physiological processes subjected to conditions of the space environment, and assess psychological and social factors involved with long duration voyages in space.

SCIENTIFIC EXPERIMENTS

On-board scientific experiments and investigations currently planned for Pilgrim Observer include:

1. Planetary Atmospheric and Surface Experiment Package (PASEP) which will be small, unmanned, instrumented, remotely controlled entry and landing probes that will be launched from Pilgrim Observer while in orbit around Mars and Venus. PASEP will telemeter data on atmospheric temperatures and pressures during entry and descent as well as assess the chemical composition of the planetary atmosphere and surface materials. PASEP contains a color television camera and transmitter that will send pictures back to Pilgrim Observer during descent and after landing; these color TV pictures will be recorded on board and also transmitted back to Earth. PASEP contains a seismometer for measuring surface disturbances, a magnetometer for measuring magnetic field intensity, a Discriminating Radiation and Particle Recorder (DRAPR), and a SNAP nuclear power source for providing the electrical power. Estimated useful life of PASEP on the surface of Mars is 2 years; it will continue to send telemetry data up to an opera relay satellite left in circum-Martian orbit by Pilgrim Observer, and this relay satellite will re-transmit the signals to Earth. The PASEP Venus-landers may have a useful life of less than 2 years due to the extreme heat and pressure on the surface of Venus; the actual lifetimes of the Venus PASEPs will provide technical data on designing future Venus landing probes.

2. Orbiting Planetary Environmental Relay Apparatus (OPERA) will be left in orbit around Mars, Phobos, and Venus to relay to Earth the telemetry signals from the landed PASEPs and to measure near-planetary environmental factors such as particle radiation, magnetic fields, and planetary albedo. Useful lifetimes of the OPERA units are anticipated to be in excess of 5 years. The OPERA units are similar to the highly reliable, economical Modular Probe Craft (MPC) now orbiting the moon.

3. Companion Orbiting Laboratory of Eros (COLE), a satellite package that will be rendezvoused with the asteroid Eros and placed in orbit around it to continue to monitor the Eros albedo, magnetic field, and gravitational field as well as providing data on interplanetary space environmental factors along the orbit of a cis-Martian asteroid. COLE contains a small telemetry transmitter and an omni-directional antenna that will broadcast scientific data back to the deep space antenna complex at Freehold.

4. Deep space laser communications techniques will be studied using the 24-inch reflecting telescope on the Pilgrim Observer as both a transmitter and a receiver.

5. Over 150 astronomical observations are experiments and are expected to provide enormous advance in our understanding of the Solar System. Many of these experiments and others that will be programmed during the next 18-months prior to Pilgrim Observer's transarean injection and earth departure will be open-ended and under the complete control of the two scientist-explorers aboard who will be responsible for astronomical experiments.

6. Pilgrim I is the first spacecraft to carry a completely-equipped sick bay. Two medical specialists on the scientist-explorer team will keep complete records of regularly-scheduled on-board physical examinations programmed for the entire 10-man crew. Regular medical and psychological de-briefings will be conducted, recorded, and transmitted to Earth. Unlike early space flights, biomedical data will not be continuously monitored.

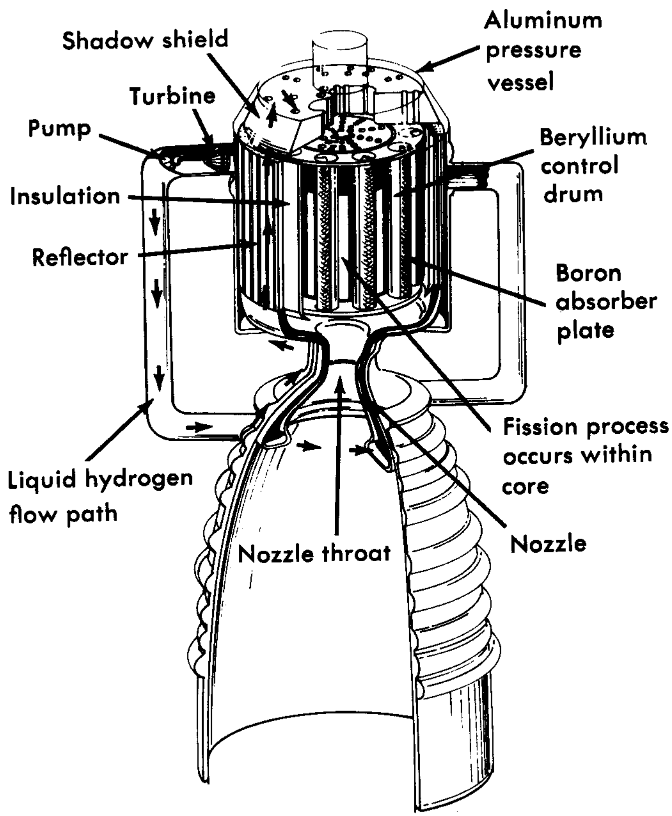
NERVA 2B NUCLEAR ENGINE

The Nerva 2B nuclear rocket engine is the key to making the Pilgrim Observer mission possible. This "atomic" rocket engine, under development since the early 1960's, delivers about 2½ times as much thrust per pound of rocket propellant as the J-2 rocket engines which depend upon the chemical combustion of liquid hydrogen and liquid oxygen. In rocket engineering terminology, the specific impulse of the Nerva 2B is 850 pounds thrust per pound per second propellant flow. The total engine weight, including nuclear reactor, is 35,000 pounds, and it is capable of producing a maximum thrust of 250,000 pounds.

Basically, the method of operation of the Nerva 2B is simple. A nuclear reactor is used to heat hydrogen which is then expelled through a Delaval-type convergent-divergent rocket nozzle to produce thrust.

Liquid hydrogen is used as the "reactive mass" or "working fluid"' of Nerva 2B, and is stored in large insulated tanks in the Pilgrim consumables sector. It flows to the Nerva 2B engine first through a centrifugal pump. It is then piped to the base or skirt of the exhaust nozzle of the engine where it is permitted to flow through the double-walled nozzle; this recirculating cooling system is also used on conventional rocket engines and prevents the nozzle from melting while the engine is operating. The liquid hydrogen is "boiled" by the heat of the nozzle to produce gaseous hydrogen, and part of this is directed to the turbine portion of the turbo-pump assembly which pumps the liquid hydrogen from the tank to the engine. Thus, the Nerva 2B appears to operate by "lifting itself by its own bootstraps."

The hydrogen then flows through tubes in the nuclear reactor core which rapidly heats it to approximately 4500°F. This hot gas is expelled through the rocket nozzle to produce thrust.



In practice, the construction of the reactor core is quite complex. It is composed of uranium and graphite. Like the nuclear reactors of electric power plants on earth, the Nerva 2B reactor produces heat by the fission of uranium. The core of the reactor is surrounded by an insulating shell of beryllium which acts as a reflector of neutrons generated in the fission process. Within the core are 12 rotable drums made of beryllium except for a coating of boral on about ⅓rd of their surfaces. Boral acts to absorb neutrons and thus slow down a nuclear fission reaction. By rotating the 12 core drums, the amount of neutrons reflected or absorbed can be controlled, and thus the fission process in the reactor core can be controlled.

A dome-shaped "shadow shield" is placed on the front of the core to provide some of the radiation shielding for the Pilgrim I structure and crew. The entire nuclear power unit is encased in an aluminum pressure vessel which is attached to the rocket nozzle.

Radiation hazard, once thought to be a major problem with nuclear rocket engines, has been solved by the use of three design features: (1) the engine has the large shadow shield in front of the reactor core which "shadows" the spacecraft ahead, greatly reducing the radiation directed toward the spacecraft and crew; (2) the spacecraft structure already includes protective shielding to protect the crew against radiation that streams from the Sun due to solar flares, and this shielding also helps protect the crew from the Nerva 2B radiation.

FLIGHT SCHEDULE PILGRIM OBSERVER

Transarean injection (Earth departure)	D + 0
Transarean coast = 227 days	
Mars arrival	D + 227
Orbit Mars = 48 days	
Transvenerian injection (Mars departure)	D + 275
Transvenerian coast = 246 days	
Eros encounter and fly-by-145 days into TVC	D + 320
Venus arrival	D + 521
Orbit Venus = 55 days	
Transearth injection (Venus departure	D + 576
Transearth coast = 140 days	
Earth arrival	D + 710

A NOTE FROM MPC: While the Pilgrim Observer spacecraft is at this time speculative, it has been designed with the help of astronautic engineers so that it would operate if built. The Nerva nuclear rocket engine is undergoing ground tests in Nevada. The on-moard nuclear power supply is under test in smaller versions in earthbound laboratories. The Pilgrim Observer has been fictionally worked into the actual NASA space program for the 1970-1980 time period as announced. The mission profile of the interplanetary flight to Mars, Venus and return is real and could be carried out.

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