THE AMERICAN SCENE

By Our American Editor

An American in Space

WITH considerable fanfare, the United States took their first small step on May 5 toward manned exploration of space. When Commander Alan B. Shepard, Jr., left Launch Pad 5 atop a "Redstone" missile, he was blazing a trail for American "astronauts" to follow—a trail that will lead to the moon and the planets. Behind him he left Government officials, members of Congress, scientists and a public at large still uncertain and debating over the objectives, value and urgency of man's exploring space. In comparison with the around-the-world space flight by Soviet "cosmonaut" Yuri A. Gagarin on April 12, the fifteen-minute flight by "astronaut" Shepard some 115 miles into space and 290 miles downrange from the launching pad was obviously a modest and belated jump into space. His launching rocket had only one-tenth the power of the Soviet missile, and his capsule was one-fifth as heavy. The flight was only one-sixth as long in time and about one-ninetieth in distance.

With the publicity build-up kindled by the American Government, Press, radio and television and the openness with which the launching was conducted, the manned "Mercury" flight tends to become magnified beyond its intrinsic importance. Perhaps inevitably, it was cast as America's answer to the Soviet feat, which it was not. Ironically, the enthusiastic public reaction to the Shepard flight tends to support the argument made by Wernher von Braun some three years ago, proposing that at times it is important to conduct space flights for primarily psychological and prestige reasons. It is an argument which thus far has found no favour within the National Aeronautics and Space Administration, which tends to emphasise strictly scientific and technical objectives for a space programme. Psychologically, it is obvious that no American space shot thus far has so captured and fired the public imagination as did the fifteen-minute flight of Commander Shepard. Symbolised on Launch Pad 5 was all the drama, heroism and uncertainty of exploration such as never can be conveyed by a scientific satellite sitting atop a missile. There was the drama of a young man staking his life against the workings of a complex machine, of personal heroism and courage in being rocketed out into space, of a gripping tension as a man sits alone for nearly three hours in a capsule waiting for a rocket, fuming with highly explosive fuels, to be fired, and then finally the feeling of relief and elation when the slim rocket soars straight up into space and the man some fifteen minutes later returns to earth. From a scientific and technological standpoint what was the significance of this first "Mercury" flight?

Scientifically, it proved little more than what was known from Major Gagarin's flight and flights of the United States X-15 rocket aircraft about man's ability to survive and function under the weightless conditions of space. In fact, when a flight similar to the present one was proposed by von Braun in 1958, it was dismissed by some of the present officials of the National Aeronautics and Space Administration as little more than a publicity stunt. The only basic difference from the original von Braun proposal is that the "Redstone" flight was conducted with a meticulously designed space capsule specifically designed for orbital missions. What then was the significance of the first Mercury flight? In an international context its unintended significance was to provide a further demonstration that the United States, handicapped by its lack of rocket power, was several years behind the Soviet Union. Quite naturally, American officials would prefer not to think of man-in-space as a race. But in historical perspective it seems evident that there is to-day as much of an international race for the new frontiers of space as there was four centuries ago to explore the New World. To American officials, the basic significance of the "Mercury" flight was that the United States had at least taken the first step toward manned exploration and military exploitation of space. In the next few months they will attempt to put an unmanned "Mercury" capsule into orbit around the earth, then try to fly the capsule in orbit with a monkey. And, hopefully, by the end of this year, one of the seven "Mercury" "astronauts" will ride in the capsule around the earth, first for three orbits and later for as many as eighteen. Technical details of the current American man-in-space programmes appeared in the April 21, 1961, issue of THE ENGINEER, pages 645 to 649. Following the "Mercury" flights will come the more advanced programme known as "Project Apollo." The "Apollo" capsule will carry three men for much longer periods in space. Initially, the plan is to place a manned "Apollo" vehicle in orbit around the earth for a week perhaps by 1966. Then as more powerful launching rockets, such as the "Saturn," become available, the "Apollo" capsule will be used, perhaps by 1969, for a manned trip around the moon and back.

The objective of the man-in-space programme, started in 1958 with Project "Mercury," is the manned exploration of the moon and planets such as Mars and Venus. It is an objective, however, which is yet to be enthusiastically endorsed within the Government and the scientific community or to be specifically defined in terms of time, cost and urgency. There is general agreement that ultimately man can and must go into space as a scientific observer and explorer of the vast stretches and bodies in the solar system. With his brain, which is still one of the best judgment computers ever designed, man can perform tasks in space which instruments never can. The preliminary exploration will be made by instruments, but ultimately it must be man who will make the detailed examination. Furthermore, it is becoming obvious that if the historic pattern is to be followed as space frontiers are pushed back, man may have to be ready with military missions in space, such as reconnaisance, repair of military satellites, observation and destruction of unfriendly military satellites. Because of the costs, risks, and uncertainties involved, however, there is no agreement among scientists, military officers and Government officials about how quickly the complex, costly ladder into space should be erected.

The objective and the urgency of the man-in-space programme have gone undefined in both the Eisenhower and Kennedy Administrations. In his final budget message, former President Dwight D. Eisenhower proposed that the construction of the "Apollo" capsule be postponed until the danger, cost and desirability of manned exploration of space could be more clearly assessed. President Kennedy, in effect, endorsed this decision by declining to request additional funds for the "Apollo" project. The initiative for spurring the space exploration effort is coming at this point not from the President but from Congress, where the House Space Committee just added 126,600,000 dollars to the Administration's space budget, with the bulk of the new funds going to the "Apollo" project. The continuing debate and the indecision over the future of man-in-space programmes spring partly from the enormous cost involved. One review conducted last year by the President's Science Advisory Committee showed that the cost of landing a manned expedition on the moon could run as high as 40,000 million dollars. Confronted with such costs, some influential scientists within the Government raise the question whether the money could not be more profitably spent on improving education or in other fields of scientific research. Combined with these cost factors, objections have been raised, particularly by the older scientists who still have an influential advisory part in Government, about the safety and scientific necessity of sending man to explore interplanetary space. They argue that at least for the foreseeable future far more information can be obtained about space, the moon and planets—and at far less cost—by sending instrumented vehicles rather than men. It also is argued that there is no assurance that once man ventures deep into space and beyond the protective blanket of the earth's magnetic field he can be safely shielded against the intense radiation emanating from the sun during solar storms.

Probably the best answer to these objections came in a recent report issued by the Space Science Board of the National Academy of Sciences. The board, composed of eighteen prominent scientists, conceded that "it is not likely that man can contribute much if anything to knowledge by simply orbiting about the earth or mere travel through interplanetary space." It is "most probable," the report said, "that instruments can do all that is necessary" with payloads

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that would be much lighter and cheaper than manned capsules. Nevertheless, the report continued, "man in orbit is worth pursuing" for the reason that "the ultimate exploration of the moon and planets will be done by man. This means that experience must be gained, step by step, and the orbiting of man is the first of this long sequence of steps." In the wake of Commander Shepard's flight and the more ambitious one by Major Gagarin, the policy questions confronting the Administration, Congress and the American public are: How fast can and should the United States climb these rungs into space and how much is it willing to pay for this admittedly expensive, difficult and yet most daring venture in man's search of the unknown? Ultimately, in view of the costs and hazards involved, the question may arise for both the United States and the Soviet Union of whether it would not be more logical to make the exploration of space an international effort—as proposed in broad terms by Presidents Eisenhower and Kennedy.

Yankee Atomic Power Station in Massachusetts

No. II—(*Continued from page* 802, *May* 12, 1961)

The Yankee nuclear power station of the Yankee Atomic Electric Company at Rowe, Massachusetts, commenced electric power generation on November 10, 1960, *and is scheduled to be in full commercial operation by July* 1. *The station will have an ultimate thermal output of* 485*MW and an ultimate net electrical capacity of* 136*MW. It was built by the Westinghouse Electric Corporation at a cost of about* 40,000,000 *dollars and employs the firm's pressurised light-water reactor. The reactor core comprises some* 25 *tons of* 3·4 *per cent enriched* UO_2 *pellets in stainless steel tubes. It is expected that the new station will eventually provide power at a cost of* 0·9 *cents per kilowatt-hour.*

THE joint between the vessel and closure head is designed to utilise either gaskets or seal welds to effect leak tightness; connections are provided to monitor any leakage past either gasket. The gaskets are self-energising, stainless steel O-rings plated with silver to provide good seating. The vessel will be operated initially with gaskets in order to obtain running experience. If leakage proves to be low, no seal welding will be employed.

The closure head is attached to the vessel with fifty-two 5¼in studs. These studs contain a central axial hole suitable for heaters and extend through the closure nut for applying stud tensioners as an alternative. A reduced-diameter closure joint was selected to cut down the weight and cost of the vessel and closure head. This choice improved vessel flange design and reduced the required bolting force, but it followed that the thermal shield must be fabricated in segments. These segments are bolted together inside the vessel. The weight of the reactor vessel is transmitted through twenty-eight support lugs to a ring girder which is an integral part of the neutron shield tank. The ring girder rests on the concrete primary shield surrounding the vessel and neutron shield tank. Each support lug rests on a fitted, radial pin for accurate location of the vertical centreline of the vessel. The pins permit radial expansion of the vessel while maintaining fixed centreline and levelness.

In order to obtain insurance on the plant, it was necessary to design, fabricate and test the reactor vessel in accordance with the A.S.M.E. Boiler and Pressure Vessel Code, Section VIII. Although the reactor vessel is designed for a maximum system pressure of 2500 lb per square inch absolute, it operates at a nominal system pressure of 2000 lb per square inch absolute. The margin between nominal operating pressure and design pressure allows for system pressure transients and safety and relief valve settings. The vessel and head are exposed to inlet coolant temperature, which should be no higher than 513·5 deg. Fah., but additional margin for temperature transients is provided, as the design temperature is 650 deg. Fah.

Only materials permitted by the A.S.M.E. Code were used to fabricate the vessel. The internal surfaces of the vessel are clad with austenitic stainless steel; the base material is carbon steel. The cylindrical section of the vessel is 7⅞in thick with 0·109in cladding; the hemispherical bottom head is 3⅝in thick with 0·109in cladding, and the closure head is 7in thick with 0·109in cladding. The internal height of the vessel is 31ft 6in with an inside diameter of 9ft 1in. The inside diameter of the primary coolant nozzles is 19¼in.

The only operational limits imposed on the vessel, other than maximum operating pressure and temperature, concern heating and cooling rates and minimum hydrostatic test temperature. If the vessel is heated from an ambient temperature of 70 deg. Fah. the maximum rate of heating must not exceed 50 deg. Fah. per hour up to a temperature of 250 deg. Fah. From a temperature of 250 deg. Fah. up to operating temperature the maximum rate of heating must not exceed 150 deg. Fah. per hour. The maximum permissible step increase in coolant temperature is 40 deg. Fah., when the vessel is in an isothermal condition. The vessel may be cooled at a maximum rate of 150 deg. Fah. per hour down to a temperature of 150 deg. Fah.; however, there may be some leakage past the gaskets when a rate of 50 deg. Fah. per hour is exceeded. The vessel cannot be subjected to a hydrostatic test unless the metal temperature is at least 90 deg. Fah. This limit was set by adding an adequate safety margin to the temperature at which the vessel material possessed a Charpy V-notch impact energy absorption of 30ft/lb.

A neutron shield tank around and under the reactor vessel contains a 36in thickness of water. Pie-shaped canned "Masonite" shield blocks cover the gap between the core vessel and shield tank at the top of the vessel so as to attenuate neutrons streaming upward between the vessel and tank. Beyond this shield tank there is a reactor or "primary" shield made of reinforced concrete that is 5ft 6in thick up to the vessel flange height, and 4ft 6in above. The concrete

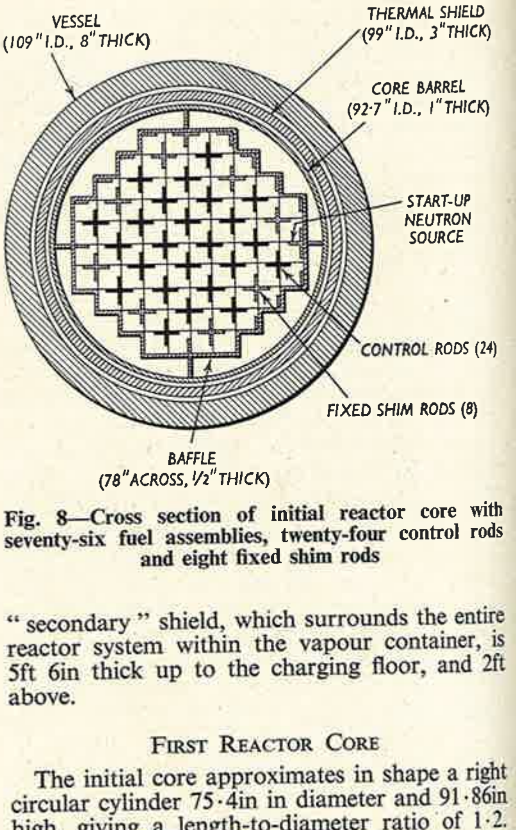

Fig. 8—Cross section of initial reactor core with seventy-six fuel assemblies, twenty-four control rods and eight fixed shim rods

"secondary" shield, which surrounds the entire reactor system within the vapour container, is 5ft 6in thick up to the charging floor, and 2ft above.

First Reactor Core

The initial core approximates in shape a right circular cylinder 75·4in in diameter and 91·86in high, giving a length-to-diameter ratio of 1·2. The core consists of seventy-six vertical fuel assemblies, twenty-four control rods and eight fixed shim rods. The fuel assemblies are essentially square in cross-section and are placed in a close-packed square lattice. The seventy-six individual, replaceable fuel assemblies are held in the core between the lower and the upper core support plates. Holes are provided in both support plates for the handling sockets which position the fuel assemblies and act as coolant inlets and discharge nozzles. These support plates are also provided with thirty-two cross-shaped slots to allow passage of the twenty-four cruciform control rods and the eight cruciform

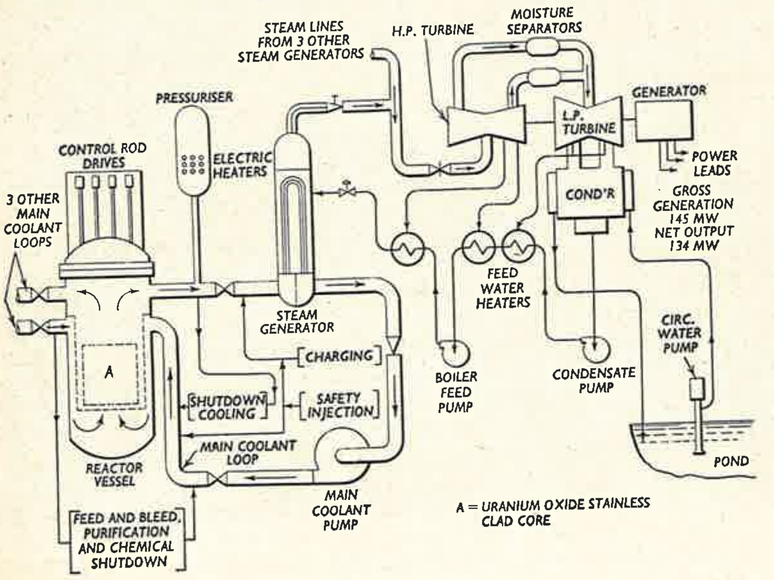

Fig. 7—Simplified flow diagram of the primary and secondary reactor systems