Propulsion for the 1980's

NERVA flight schedule is threatened by competing projects and budget cuts

by Everly Driscoll

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Hydrogen exhaust during power test.

The limitations on where man goes in space, what he takes with him and how much it costs have always been tied, one way or another, to adequate propulsion systems. These in turn depend on two factors: the amount of thrust they produce and the efficiency—in terms of fuel consumption—with which they produce it.

Thus far the path to space has been blazed by chemical-fueled rockets—solid or liquid—which are powerful enough to work against earth's gravity, but have relatively low efficiency. The specific impulse, the engineer's measure of propulsion efficiency, is the number of pounds of fuel per second that must be consumed to produce each pound of thrust. The specific impulse of the liquid rocket that took men to the moon was 450 seconds. The best solid-fuel rocket is even less efficient; its specific impulse is 230 seconds.

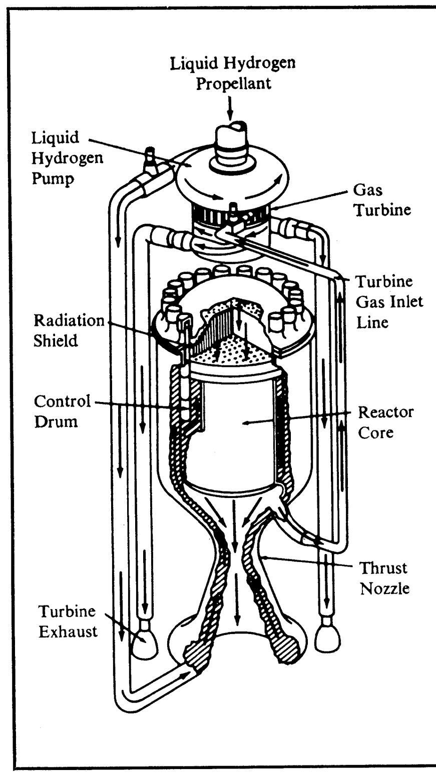
Nuclear rockets give promise of greater efficiency, but with less thrust. Thus they are natural for trips into deep space with heavy payloads, but they must be carried into orbit by the greater punch of chemicals.

The nuclear rocket was envisioned to double the efficiency of the liquid chemical. When work began on a nuclear rocket in 1955, engineers were not quite sure how to incorporate a fission reaction in a rocket. They considered the solid-core reactor the only feasible system. By 1963 such a system was being demonstrated. But two years before that, theorists had discovered a possible solution for an even better system—the gaseous-core reactor, which could double or quadruple the efficiency of the solid core.

In 1958 the National Aeronautics and Space Administration inherited the nuclear rocket work from the joint Air Force-Atomic Energy Commission ROVER project, which had begun in 1955. Since then, NERVA (Nuclear Engine for Rocket Vehicle Application) (SN: 5/2, p. 440) has made impressive progress at relatively low expenditures ($1.2 billion has been spent on the total technology development leading up to the current status). But even then its path was somewhat uncertain, partly because NERVA has had no specific or approved mission assigned to it.

Now competing projects and a diminished NASA budget loom—there are no funded space flights, manned or unmanned, after 1975. In addition, some engineers claim that the liquid chemical could do what NERVA would be doing. And others say that by the time NERVA is ready to fly, even more efficient systems will be demonstrated.

The rate of progress has depended on engineering and materials development, and NERVA has pioneered in this area. The basic graphite structure materials of the fuel element react rapidly



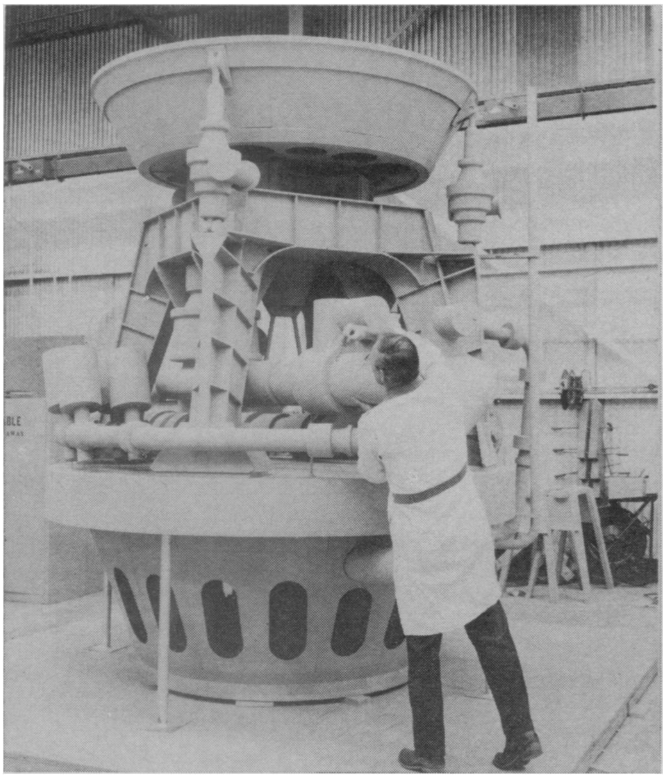
Westinghouse Electric Corp.

Design for a solid-core reactor.

with hydrogen at high temperatures (the materials have to stand 4,000 degrees F. without corrosion for extended periods of time). Improved coating technology and improved graphites and graphite carbide composite materials for the fuel element matrix have, in tests, reduced by a factor of two each year the average corrosion rate. (The Peewee-2 reactor, which will resume testing about Feb. 1, uses graphite containing a considerable amount of zirconium carbide.)

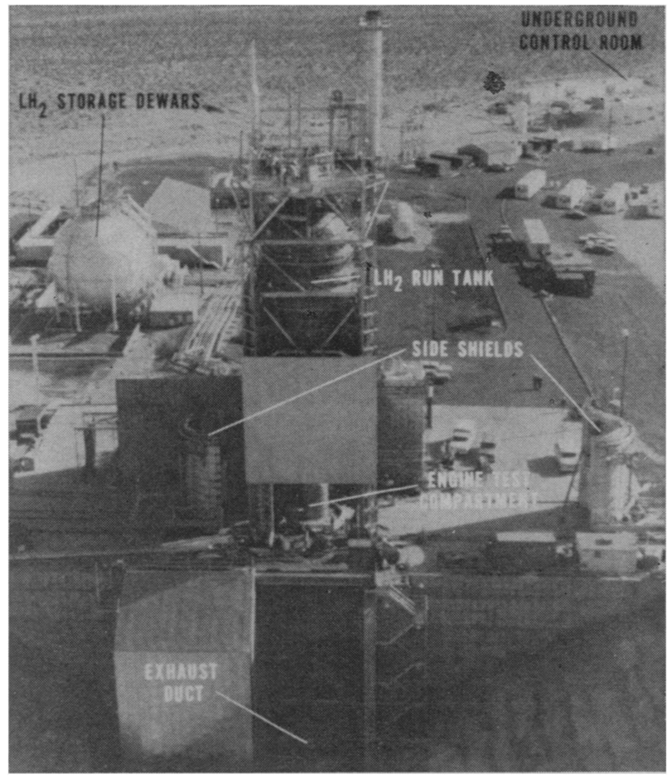
These advances have increased the specific impulse and operating time. In 1963, six experimental reactors had operated a total of 20 minutes, but not with steady-state power above 300 megawatts. Since then, 10 reactors have operated, some with up to 4,200 megawatts thermal power. The aim initially was for a specific impulse of 760 seconds; 850 seconds has been achieved and 900 seconds seems possible—twice that of the best liquid chemical. The goal for engine-operating time is 10 hours. So far, 14 hours have been accumulated, the longest being four hours at full design power. The goal for thrust on the NERVA rocket is 75,000 pounds.

The progress to date augurs well for the goal of flight tests in the late 1970's. But for this to become possible, something will have to give. NERVA's funding in the FY 1971 NASA budget was $38 million. The project receives equal funding from the AEC. But the modest estimate for completion is about $750 million, which means that the yearly allocations will have to increase if the



Aerojet Nuclear Systems Co.

Mockup of rocket thrust structure and propellant system.



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Nuclear rocket development station at Jackass Flats, Nev.

original flight schedule is to be maintained.

This poses definite problems for an agency whose yearly budget is going down: Over the past six years, the NASA budget has been reduced by 43 percent.

NASA believes it must develop the reusable rocket plane—the space shuttle (SN: 8/29, p. 178)—which will reduce costs of each launch. The shuttle would replace the expendable Saturn 5's, which initially were to place the NERVA into low earth orbit. With a shuttle, some NASA engineers argue, it would be possible to ferry fuel into orbit for chemical rockets, so that a nuclear rocket would be superfluous.

But proponents for continued NERVA development use the same argument as do those for the shuttle: it would constitute a reusable, economical system. They also say that unless the United States wants to support another crash program like Apollo, due to lack of steady progress on the liquid chemical rocket, the more advanced system must be gradually prepared so that when the need arises the system will be ready.

The NERVA craft will be able to carry out many tasks. It would be able to transport men and supplies from earth orbit to lunar orbit and from normal earth orbit to geosynchronous orbit—22,000 miles out. It could be used on complex unmanned flights, as well as interplanetary manned flights.

In Congressional testimony last February, Milton Klein, director of space nuclear systems for the NASA-AEC Space Nuclear Propulsion Office, compared nuclear rocket with liquid chemical rocket costs. NERVA, he said, could transport a lunar space station weighing 119,000 pounds to lunar orbit and return in one trip, unmanned. The chemical rocket capacity for the same mission is 38,000 pounds, which would require two or three trips. NERVA could carry 102,000 pounds to geosynchronous orbit; the chemical, 28,000 pounds.

A trip to the moon and back would use about 50 minutes of the total 10 hours operating time of the NERVA engine.

To adapt to shuttle use, the NERVA-AEC office is currently conducting studies for a modular NERVA craft that would be taken into low earth orbit by the shuttle and assembled there.

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Klein: Next step in propulsion.

There is little doubt that mankind has the potential to open up the solar system for interplanetary manned flight in this century. (Theorists are even producing figures for velocity and thrust for interstellar flight, though that is much further away.) Proponents claim that NERVA is the next step in propulsion efficiency.

As for more advanced systems such as the gaseous-core reactor, the NERVA office spends about 10 percent of its budget on such developments. But so far, even though the gaseous core is understood, and the problems outlined, its feasibility has yet to be demonstrated. (The NASA-AEC work, however, is only a small fraction of the total AEC work in both advanced fission and controlled fusion.) When it is proved feasible, it should have a propulsion efficiency two to four times as great as the solid-core reactor. This would give it a capability for even more complex flights.

Whether NASA can afford to continue with NERVA as well as initiate the shuttle development is a key question. At current budget levels such a program would probably eat into the other NASA projects. And the prospects of the NASA budget rising much above the fiscal 1971 level, $3.2 billion, are not good.

But NERVA has many powerful supporters who would not stand by while the solid-core nuclear work fizzled out. Thus NASA faces the prospect of eliminating or cutting down on other programs to accommodate NERVA. □