NUCLEAR ROCKETS

To Go to Mars

Space planners are battling Congressional doubts to set the stage for exploration beyond the moon.

by Carl Behrens

The U.S. may have no formal mission at present to go to Mars, but space people are already tooling up to build the machine that will get them there—the nuclear-powered rocket.

Recent success in the rocket program has stimulated President Johnson to ask Congress for $91 million this year (SN:3/11) to push the development of the interplanetary propulsion system.

The Administration's enthusiasm is not shared by all Congressmen. Representative Chet Holifield (D-Calif.), vice chairman of the Joint Atomic Energy Committee, says he is "getting cooler" about the whole space program, and particularly the nuclear rocket project. Senator John O. Pastore (D-R.I.), committee chairman, wonders if anything more than "intellectual curiosity" is behind the plans to spend $1.5 billion over the next 10 years on the interplanetary rocket.

The critics of the program are not challenging the idea of space exploration. As Representative Holifield puts it, the question is not whether to support the project, but whether to spend so much so soon on it—particularly when the Vietnam war is cutting into domestic programs which affect local politics.

The success of the program at present provides the answer to that question. With the feasibility of the concept all but proven, the Mars landing seems an inevitable next step, even if the mission has not yet been defined. That being the case, the smart thing, say the space planners, is to push the program ahead now, instead of waiting until the rocket is needed and then spending a lot more on a crash program.

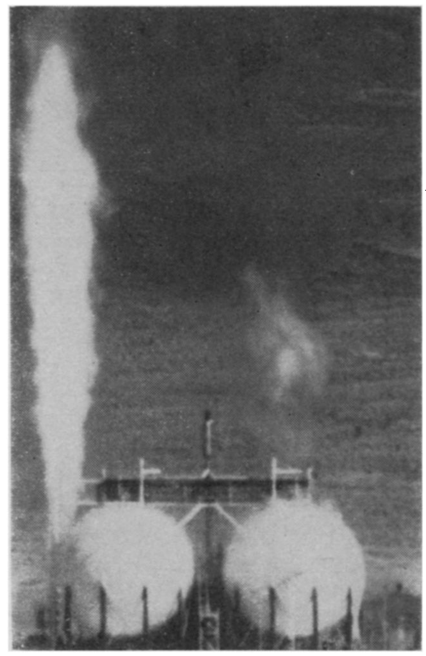
The nuclear rocket has not always looked like a sure thing. A few years back, in late 1962, one of the test rockets shook so much that its nuclear reactor core began to disintegrate and pieces of burning graphite shot out of the exhaust. It was 18 months before another rocket was fired.

When tests were resumed in 1964, though, the vibration problem had been solved, and no other serious ones have cropped up.

In February, a medium-sized test rocket, the Phoebus 1B, ran at full power, 1,500 megawatts, for 30 minutes—a startling length of time in rocket-burning circles. It was also started, stopped, and restarted a number of times.

The next step—for which Congress is now being asked to pay—will be a scaled-up version of the rocket, Phoebus II, which would produce 5,000 megawatts of power for the same 30 minutes. This is the rocket that could take men to Mars.

The main reason that rocket engineers are confident they can build the bigger machine is that there are no far-out theoretical problems to be solved. The nuclear rocket combines the technology gained in developing nuclear power reactors with the engineering principles involved in a conventional rocket. The only difficulty is that of making the two technologies compatible, and the tests so far have shown that this is possible.



NASA

Phoebus IB: going strong on earth.

The conventional chemical rocket works by pumping vast quantities of fuel and liquid oxygen into a nozzle, where the fuel burns. The tremendous heat produced gives the burned fuel molecules the energy to shoot out the end of the nozzle, giving a reaction boost in the opposite direction.

Major difficulties in building big rockets have been in developing materials and components, like valves and electronics, that could stand the extreme cold of liquid oxygen and the extreme heat of the thrust chamber. Another key component is the pump, usually powered by a turbine driven by hot gases, that has to dump the propellants into the thrust chamber in gargantuan gulps.

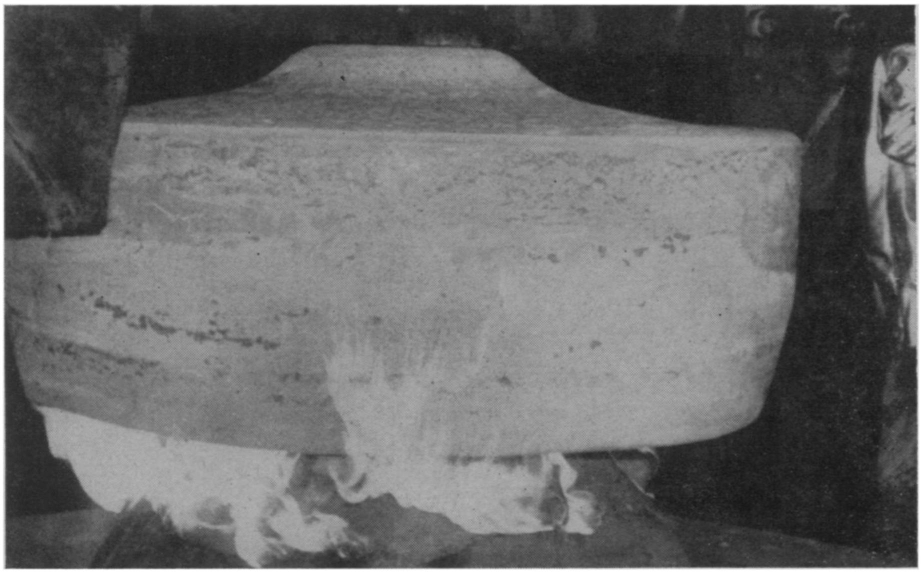
In the nuclear rocket, the fuel and oxygen are replaced by a single propellant, hydrogen, which is not burned, but instead is heated by being passed through the core of a nuclear reactor. The hydrogen is carried in liquid form in the rocket tanks. A turbine pump, like the one in a conventional rocket, pumps the hydrogen through the reactor. The controlled fission in the reactor gives off enough heat to raise the temperature of the hydrogen to 1,980 degrees C. By then an extremely energetic gas, the hydrogen shoots out of a thrust chamber, giving thrust to the rocket just as do the burned gases in a conventional rocket.

lant. On the other hand, the engine itself is much heavier than a chemical rocket. Where weight really counts—getting into orbit—the nuclear engine is outclassed by the lighter conventional burner.

But as a second or third stage, on longer interplanetary trips, the higher efficiency of the long-firing nuclear rocket comes into play importantly. It can produce a smaller amount of thrust—250,000 pounds for the yet-to-be-developed 5,000-megawatt Phoebus—for a half hour. The Saturn booster, in comparison, puts out 7.5 million pounds for only a few minutes.

Despite the success of the development program so far, a trip to another planet is not likely before the mid-1980's. It's a long road from test-firing a prototype model on the ground, with propellant tanks and other components separate and protected from the test engine, to putting everything into a package that will fly.

Although some of the experience gained in flying conventional rockets will be of use, the nuclear reactor is



Union Carbide

From the forge: 3-ton nozzle for Phoebus II, largest forging of special alloy.

It is the use of hydrogen that gives the nuclear rocket an advantage over chemical rockets in the payload it can carry. One measure of rocket efficiency, called specific impulse, is the amount of propellant—hydrogen in this case—that has to be ejected from the nozzle per second to get a given amount of force or thrust. The faster the propellant moves out of the nozzle, the bigger the specific impulse; and the lighter the propellant particles, the faster they move. Hydrogen, being the lightest element, can move out much faster than the hydrocarbon molecules that are used in chemical rockets.

The nuclear engine's good mileage means that it needs to carry less propellant.

bound to cause unexpected problems. For one thing, rocket components will have to be carefully shielded from reactor radioactivity. For another, the heavy reactor, with its shielding, will be unwieldy and unbalanced—the hydrogen tanks are light in comparison. More problems are caused by the greater temperature extremes—liquid hydrogen, in the nuclear rocket, is at minus 253 degrees C., compared to liquid oxygen in the chemical rocket, at minus 183 degrees C.

All of these problems—some of them solved, some not even near testing—mean that building a Mars rocket will be a long job. Which is why the space enthusiasts want to get started now.