Nuclear Reactors for Rockets

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Almost as soon as it was realized that energy could be obtained from nuclear reactors, proposals were made to use nuclear energy to heat a working fluid which would propel a rocket. This seemed very attractive since there are many times the energy content of the best chemical fuels in fissionable materials. However, the exhaust velocities which can be obtained depend on the temperature to which the working fluid can be raised. These are limited by the temperatures at which the reactor can be maintained intact and by the temperature difference necessary to insure the heat transfer rates required. In the proposals which the author has seen so far, the limiting temperature has been the melting points (actually the somewhat lower softening temperatures) of the reactor materials. These are not very high for the materials used so far.[2]

This article contains a proposal for getting around these difficulties. The limiting temperature is the boiling point rather than the melting point of the fissionable material.

The rocket motor shown in Fig. 1 spins on the axis AB at as high a velocity as is practicable. The molten fissionable material C is held to the wall of the chamber by centrifugal force and operates as a fast neutron reactor. The working fluid, presumably hydrogen, is pumped into the chamber through many small holes in the lining so that it bubbles through the molten fissionable material. It enters cold and reaches its maximum temperature as it bubbles off the surface. Because the working fluid enters cold, the boundary between the fissionable material and the chamber wall is kept at a temperature well below that attained by the hydrogen at the surface of the reactor. Other exposed surfaces in the rocket motor can be protected either by circulating working fluid behind them or by letting working fluid pass through pores in the walls of the chamber.

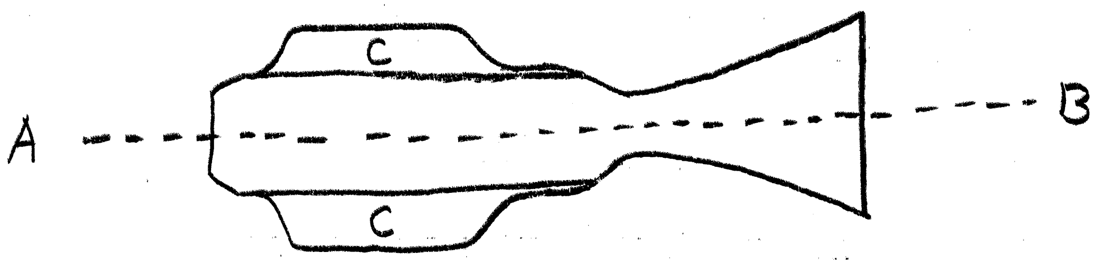

Fig. 1 Spinning Liquid Reactor

It is clear that the limiting temperature for this motor is the boiling point of the fissionable material. Uranium has a boiling point of about 2500 C, thorium has a boiling point of over 3000 C, while the boiling point of plutonium has not been published.

A number of different objections to this scheme come to mind.

1. It may be impossible to bubble enough hydrogen through the reactor without blowing it away, and moreover the working fluid might form a volatile compound with the fissionable material.

It is difficult to see how either of these questions can be settled short of experiment, though of course the experiments need not actually involve constructing a rocket motor. It may be pointed out that the centrifugal field can be much stronger than the earth's gravitational field and that this will help prevent blowing away the reactor.

2. The reactor may be impossible to control. The author has seen nothing on the control of fast neutron reactors, but doubts that the control problem will offer fundamental difficulties. One possible method is to make the reactor depend for its criticality on the exchange of neutrons through the wall of the chamber with a small amount of fissionable material kept at a low temperature and controlled by rods.

3. The mechanical difficulties of pumping the hydrogen through the molten material and keeping the motor spinning may be too great. To settle this a detailed design would be required. However, one possibility is to use vanes in the jet to keep the motor spinning, and to use the relative rotation of the motor and the rocket to run the hydrogen pumps.

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2. Uranium melts at 1100 C, thorium at 1845 C; the melting point of plutonium has apparently not been published though presumably it has been determined. If molten fissionable material is to be jacketed by higher melting substances, heat transfer difficulties will arise, and the jacketing materials must not absorb too many neutrons.