Containment above the Melting Point of the Container

It occurred to me that it might be possible to contain substances at high temperatures in *liquid* containers—that is, in a "liquid pipe" or "liquid crucible." The practical problem was solved, in principle, in 1950 (*4, 23*) through use of a centrifugal chemical reactor, shown schematically (to scale) in Fig. 5. In this reactor, liquid aluminum metal was boiled at about 2700°K in a container of *liquid* aluminum oxide (melting point, 2320°K).

In this particular case the reactor, consisting essentially of a large steel cylinder lined with aluminum oxide bricks, was rotated horizontally at a few hundred rotations per minute. Aluminum metal, in the form of a rod, was fed, together with oxygen gas, through the stuffing box at right, where it burned in the free cylinder, with a dazzling flame and the evolution of great heat, to aluminum oxide at a temperature of about 3800°K.

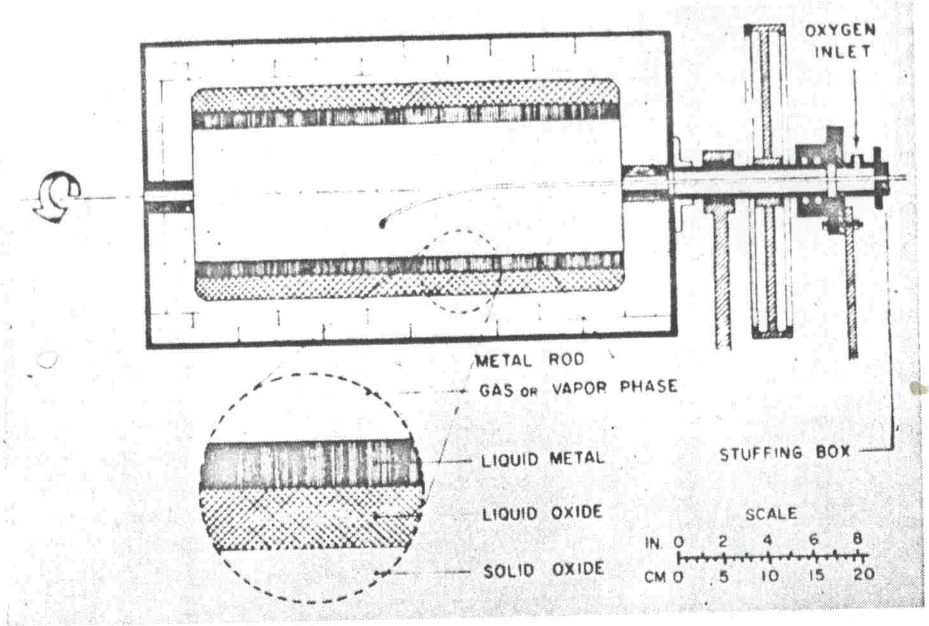

Fig. 5. Schematic diagram of the centrifugal chemical reactor.

In the centrifugal reactor, liquid boiling aluminum in the form of a pipe, burning in oxygen, floats on the surface of the heavier liquid aluminum oxide [also in the form of a pipe (see Fig. 5)], which in turn is supported on solid aluminum oxide. The melting surface gradually recedes toward the walls of the steel pipe. The number of rotations per minute should be sufficient to produce "rimming" (*24*) of the liquid aluminum and liquid aluminum oxide.

The whole free volume (except in the vicinity of the side plates) is at a temperature of about 3800°K; most of the combustion product (aluminum oxide) boils out through the open port at left. The operation can be carried out for periods up to 1 hour without special cooling. The reaction can be carried out with an excess either of aluminum or of oxygen. The thickness of the liquid-aluminum pipe can be varied at will from about 1 millimeter to about 2.0 centimeters or more.

The density of liquid aluminum oxide was recently found to be 3.053 g/cm^3 at the melting point (2288°K) and 2.569 g/cm^3 at 2720° (*25*); the density of liquid aluminum is estimated, according to the method reported for magnesium (*26*), to be 2.050 g/cm^3 at the normal boiling point (2720°K). Thus, liquid aluminum always floats, as a perfectly separate, clearly defined phase, on liquid aluminum oxide.

A true "liquid crucible" was produced by rotating liquid aluminum oxide *vertically*, thus producing a paraboloid of revolution, and by introducing aluminum rod and oxygen into this paraboloid through a tube of solid aluminum oxide placed, from the top, along the axis of rotation. The boiling aluminum (also in the shape of a paraboloid) was burned in the crucible thus formed. A limiting disadvantage of such chemical centrifugal furnaces is the fact that their operation requires exothermic chemical reactions. Thus, no chemical reaction can be studied except the one actually taking place.

It recently occurred to me (*27*) to utilize a high-temperature plasma jet (*15, 28*) operating in the range 5000° to 17,500°K as a centrifugal furnace, with a noble gas such as helium or argon as a source of heat. Such a furnace has now been operated successfully. It is shown schematically in cross section in Fig. 6.

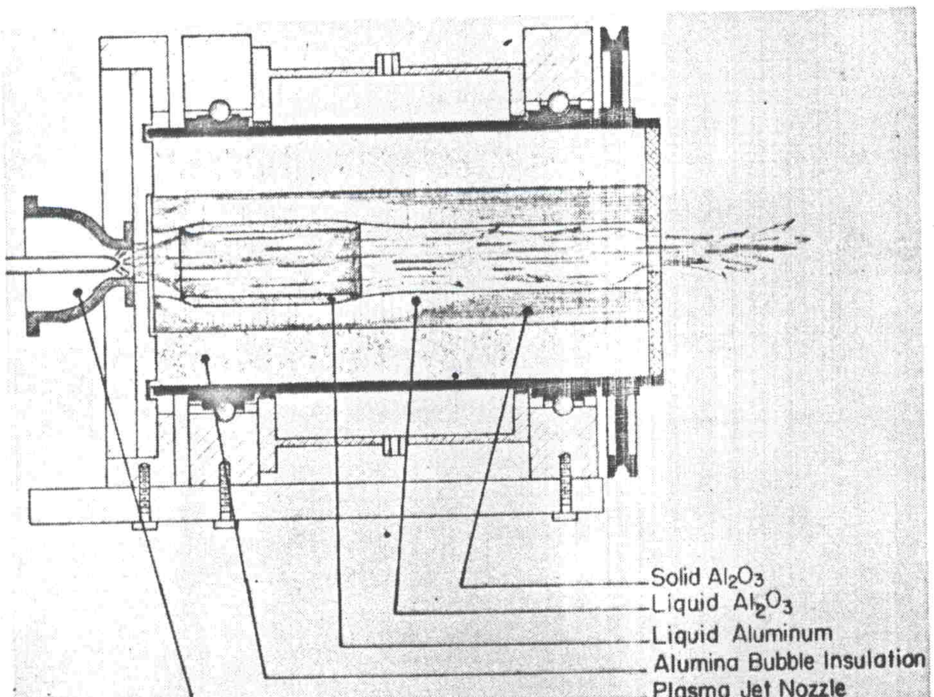

Fig. 6. Schematic diagram of the plasma jet centrifugal furnace.