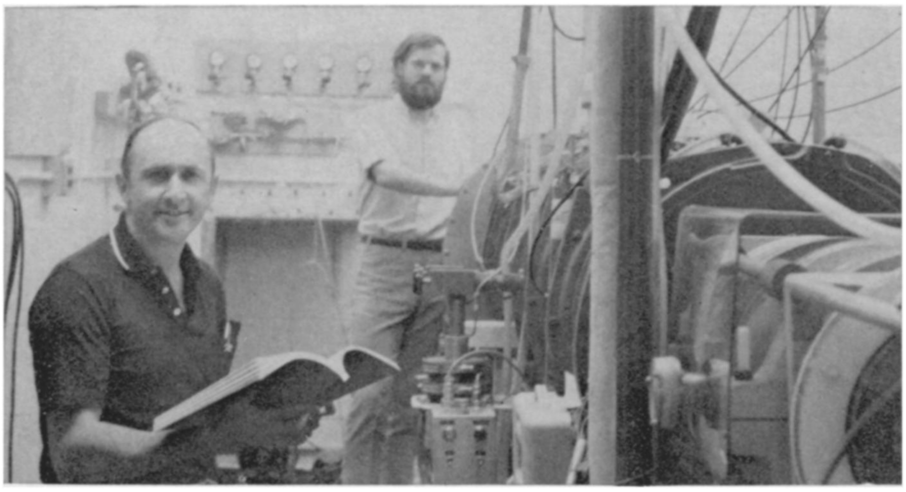
DENSE, HOT PLASMA

Mach 3,200 and fusion



Columbia Univ.

Gross, Halmoy, and shock tube: A thermonuclear plasma at Mach 3,200.

Experiments in controlled thermonuclear fusion can be divided into two classes. In one kind, called high beta, the hot plasma in which the fusion is to take place is quite dense, but it is harder to contain. In low-beta devices the plasma is less dense, reducing the possibility of fusions, but it is easier to hold the plasma together for longer periods.

Either variety may someday prove superior for use in power-producing reactors, or it may come about that one is superior for some applications and the other for other applications. Momentarily the low-beta plasmas have been getting most of the public attention, since the Tokamak devices, which use low-beta plasmas, have approached closer to the conditions for self-sustaining controlled fusion reactions than any other experiments (SN: 4/11, p. 373).

Now the high-beta side reports something new: a deuterium plasma heated by shock waves of Mach 3,200 or greater (speeds in excess of 100 million centimeters per second) in which thermonuclear fusions take place. The work was done by Drs. Robert A. Gross and Yung Gann Chen and graduate students Einar Halmoy and Pierre Moriette of Columbia University. According to Dr. Gross, it is the first time that a purely shock-heated plasma has shown evidence of thermonuclear fusions.

Shocks are one of the practical ways to heat high-beta plasmas, and they have been used for years in many experiments. The most common method is the so-called theta pinch, in which a magnetic field surrounding a plasma is suddenly compressed. This produces a shock followed by compression, and both shock and compression take part in the heating.

In contrast to the implosion shock of the theta pinch, the Columbia shock runs lengthwise down a 10-foot shock tube. An electric current up to 2 million amperes runs down a conductor in the middle of the tube and back up a conductor on the outside of it. This arrangement is called a coaxial geometry; in it, the current generates what Dr. Gross calls a kind of magnetic piston that runs down the tube, driving the deuterium plasma ahead of it.

The evidence that fusions take place within the shock plasma is that free neutrons come out of it. Such neutrons are a by-product of the fusion of two deuterium nuclei into a nucleus of helium 3.

Temperatures in the Columbia plasma run to 10 million degrees K. The shock plus compression in a theta pinch can produce temperatures to 50 million degrees K., and fusions take place in them too, but Dr. Gross's work, says Dr. Fred Ribe, who heads theta-pinch work at Los Alamos Scientific Laboratory, is the first reported success in getting thermonuclear temperatures in a shock-heated plasma in a coaxial geometry.

Dr. Ribe feels that the coaxial geometry will make the study of the physical characteristics and behavior of shock-heated thermonuclear plasmas easier than the implosion geometry of the theta pinch. He also sees a coaxial shock tube plus reflecting and focusing techniques as a way of injecting enough high-beta plasma into a toroidal confining chamber to do practical experiments. Toroids have an advantage over the straight tubes used in most theta-pinch experiments since they have no ends for the plasma to blow out.

To confine a Mach 3,200 plasma in a straight tube long enough to get a self-sustaining fusion reaction, one must stop it. Dr. Gross speaks of developing some sort of barrier to bring the plasma to rest at some point in the tube.

Whether in a toroid or a straight tube, a magnetic field appropriate to the physical characteristics of the plasma must be designed to contain it and hold it away from the walls of the tube, which would cool and neutralize it.

Another alternative, says Dr. Gross, is no confinement at all. It might be possible to make a pulsed fusion reactor that did not require the plasma confinement necessary for a steady power-producing reaction. Repeated shocks would produce plasma in spurts, and pulses of power would be drawn from the fusions taking place in the spurts.

Much more detailed knowledge of the physical properties of high-Mach plasmas is required to solve any of these problems. So far Dr. Gross and his associates have reported only some early data on magnetic fields inside the shock plasma. Profiles of temperatures, pressure, density and other properties are necessary and the group is working on these now. □

NITROGEN FIXATION

Starting with the simple

Enzymes are complex organic molecules that serve as catalysts in nearly every biochemical process. Man has managed to synthesize only one enzyme, ribonuclease (SN: 2/1/69, p. 112); the complexity of other enzymes so far has defied synthesis.

Two chemists at the University of California at San Diego report a new approach. Instead of synthesizing the enzyme itself, they have synthesized a functional model that is simpler than the enzyme but which does the same job—although in a less efficient way.

Dr. Gerhard N. Schrauzer and doctoral candidate Gordon Schlesinger have managed to produce a simple inorganic model of nitrogenase, the enzyme which certain bacteria and algae use to fix nitrogen from the air, a natural process that is the first step in the manufacture of proteins.

"Our approach is almost a new philosophy in biochemistry," says Dr. Schrauzer. "What we are doing is attempting to duplicate the natural evolution of the enzyme." He explains that nature very likely began with simple compounds and gradually worked up to the more complex ones that are today's enzymes. The efficiency increased with the greater complexity, but there had to be a simple and relatively inefficient beginning.

Dr. Schrauzer and Schlesinger say they have made such a beginning in