plasma becomes high and instead of uniform heating, runaway electrons are produced. From this point on, heating is accomplished by transferring energy from magnetohydrodynamic motions to the particles in the plasma. This so-called magnetic pumping process bears a similarity to the acceleration of cosmic rays as described by Fermi. Unfortunately, in the stellarator as in the pinch a very considerable fraction of the energy is lost during the heating process. The heating derived from hydromagnetic shocks has been investigated by H. Grad at New York University, M. Rosenbluth at Los Alamos, and others.

In the evolution of the mirror machine the basic simplicity of the original design has been maintained. In addition to this advantage, the straight geometry makes it possible to operate in a relatively small volume.

An obvious disadvantage of the magnetic mirror machine is the loss of particles through the mirrors. In fact, all particles get lost whose motion includes a sufficiently small angle with the magnetic lines. In the course of time more and more particles will be scattered into these orbits and eventually all of the plasma escapes. Detailed calculations have shown that escape through the mirrors is a serious consideration but that it does not rule out the mirror machine as an effective thermonuclear energy generator. Furthermore, the end losses can in principle be reduced by inducing a rapid rotation of the plasma. The open ends of the machine also lead to an advantage: a simple possibility of injection. One can introduce a sufficient quantity of high-velocity ionized material through these ends and thus, in contrast with the other machines, circumvent the problem of heating a plasma which is already present. In injecting fast ion beams difficulties have appeared due to space-charge limitation in the injection mechanism.

A radically different system of injection is being tried at Oak Ridge National Laboratory. This system consists in bombarding the interior of the mirror machine with D_2^+ ions. Inside the mirror machine the molecular ions get disassociated and the more strongly curved D^+ ions are caught. This procedure has made considerable progress. It may lead to the establishment of a steady-state plasma which is suitable for detailed experimental investigation. In any case a completely satisfactory density and temperature need not at once be obtained by the injection in the mirror machine because simple strengthening of the magnetic fields will lead to an adiabatic compression of the plasma which will increase both the density and the temperature.

The homopolar, conceived by William Baker at Berkeley, is another machine based upon mirror containment — but an enhanced containment, due to the large induced rotation of the plasma. Similar work on rotating plasmas (Ixion) is being done by Keith Boyer at Los Alamos.

There is one additional design which has received serious consideration but on which no actual experimental work has proceeded. The name of this design is the picket fence or cusp geometry considered by J. Tuck and H. Grad. It consists of a series of magnetic field systems so arranged that the magnetic fields curve at each point away from the space which is enclosed and which contains the plasma. At the juncture of any two of these systems the magnetic fields have a cusp through which the plasma can escape. The difficulties

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