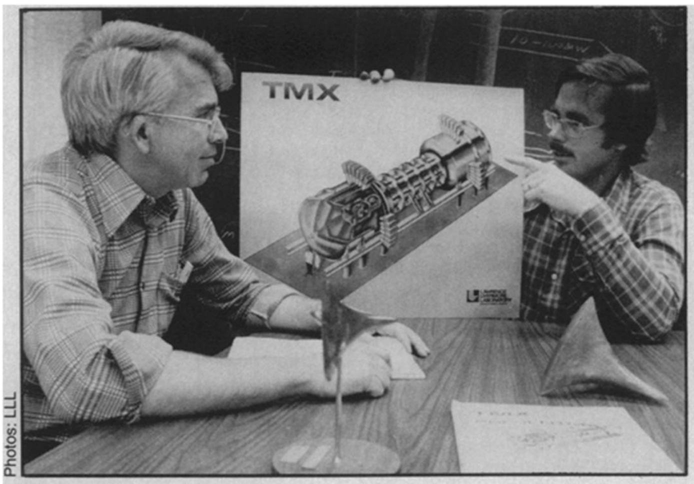
They Do It With Mirrors

Or at least they're hoping to. Some of the oldest ideas in fusion physics may become the basis of a future reactor.

BY DIETRICK E. THOMSEN



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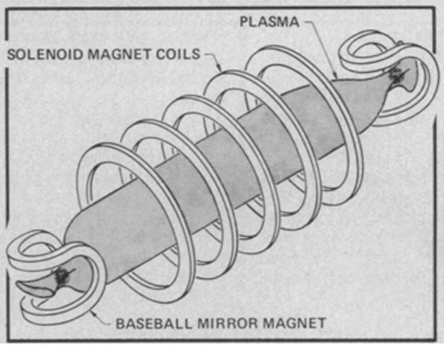
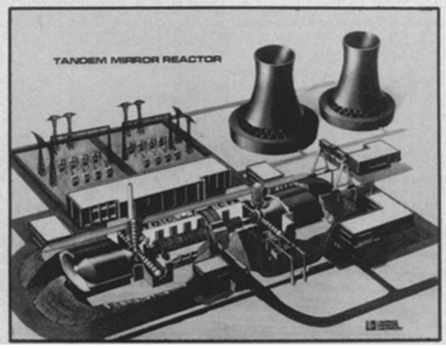
T. Kenneth Fowler and B. Grant Logan, the American originators of the tandem mirror concept for nuclear fusion exhibit a schematic of the TMX *machine (top). Its basic feature will be a solenoidal plasma plugged at both ends by "baseball" magnets (bottom left). Ultimately it may lead to power plants (bottom right).*





In controlled thermonuclear fusion experiments involving magnetic confinement of the atomic nuclei to be fused, the most serious problem has always been keeping the nuclei confined in the magnetic field. The people who work on laser fusion always talk about how many fusions they have managed to cause by their latest blitzing of a fuel pellet with laser light. The magnetic fusion people usually chart their milestones by confinement time. (Temperature is also a necessary concern, but temperature without confinement is not much use.)

Among the first ways physicists thought to confine atomic nuclei in magnetic fields was the magnetic mirror, and so good an idea has it been that after 30 years it pervades the latest concept, as T. Kenneth Fowler of the Lawrence Livermore Laboratory reported at the American Physical Society Meeting in Washington in April. In fact, nature thought of the magnetic mirror first. It is the form of the trapped radiation belts around the earth and other planets. Electrically charged particles (atomic nuclei, electrons, etc.) tend to follow corkscrew paths along the lines of a magnetic field. When they reach a point where the field strength grows appreciably, the particles reverse direction. These reversals take place near the poles of the planet, and so there is a constant back and forth motion of charged particles along the planetary field lines.

It works fairly well over thousands of kilometers of planetary magnetosphere. It works rather less fairly over thousands of millimeters of laboratory tube. The planetary fields have closed field lines that come together and go to ground at the magnetic poles. It proved impossible to set up that kind of field in a straight tube in the laboratory. The best that could be achieved was a certain amount of pinching at the ends. There was still an opening through which the plasma (the mixture of nuclei and electrons that was to be held) could escape, and escape it did.

So people went to other ideas and configurations, the most important general alteration being to bend the tube into a torus and so eliminate the ends. But the linear mirror device, the solenoid, continued to exercise a fascination, especially on those who were thinking of future thermonuclear fusion reactors. The attraction of a linear geometry for a reactor is that a linear device can be made in any length that satisfies the needs of a particular power requirement, and if it is built of separable components, like a train of cars, it has advantages for routine maintenance. So out of considerations of what a future reactor should be grew the tandem mirror, as it is now being called at Livermore, Novosibirsk and other places where it is being worked on.

Fowler spoke at a symposium in memory of Gersh Istkovich Budker, one of the most brilliant and versatile of the physicists at the Akademgorodok at Novosibirsk. The tandem mirror concept, Fowler says, "was developed at Novosibirsk though not specifically a Budker idea." It was developed also at Livermore and discussed at a conference in Novosibirsk in 1975. These things led to the current status of the effort. At Livermore they expect construction of a tandem mirror device called TMX to be complete by fall. Besides Novosibirsk, work is also underway in Japan. "Toshiba built one in nine months flat," Fowler says to illustrate how fast it can be done.

To make a tandem mirror, it's not how long you make it, but how you make it long. What you do is plug the ends of the leaky solenoid with two "baseball" machines, which are another kind of magnetic mirror. Baseball machines get their name from the shape of the coils that produce the magnetic field in them; the coils look like the seams of a baseball. It might be more fashionable to call it tennis ball, but baseball was in the works almost 20 years ago, before it became mellow to be mellow. The magnetic field that the baseball coils produce has the shape of a "twisted bow tie," as Fowler describes it. In the middle of the field is a volume, a kind of magnetic well, where the plasma will sit fairly stably. A very dense plasma can be built up in the middle of the baseball; indeed, the demonstration of this "gave some confidence that mirror machines were on the right track," Fowler says. Two baseball machines with their very dense plasma are a method of plugging the ends of the solenoid. In fact, the arrangement adds electric to magnetic confinement. Since the mirror does not confine electrons as well as ions, a small charge imbalance builds up that makes a positive electric potential at the ends of the solenoid that helps to bounce the ions back.

With the ends now plugged by the dense baseball plasma, the plasma in the solenoid can now go about its fusion business. Or such is the principle. Several nations seem to be betting at least a little on the practice. □