Accelerator Reveals Inner Space Secrets

(Editor's Note: Like the probing of outer space, the study of the inner universe, the atom, requires tremendous outlays of energy—and money. But, again as in space exploration, the rewards are as great as the costs.

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Rockets to explore outer space demand tremendous energy.

So also it takes tremendous energy to explore the inner universe of atoms, using protons and electrons as the main "rockets."

Speed them up with successive kicks of electricity and they can be sent crashing into atomic nuclei at nearly the speed of light. Electrons also can serve as a kind of microscope actually to "see" and measure individual particles in the nucleus.

Since World War II, physicists here, in Russia, Europe and elsewhere have built atom-smashers leapfrogging up to fabulous energies. Knowledge learned is freely shared.

The United States now has the most powerful accelerator at Brookhaven National Laboratory, firing protons at energies of 31 billion electron volts (BEV). This is triple Russia's strongest machine, but the Soviets propose one of 50 to 70 BEV. There are some reports they are already building it.

Rewards in knowledge are great. So are costs.

Through the Atomic Energy Commission and other agencies, the government this year is spending almost 60 million dollars in this research. Projected plans and machines call for 135 million by 1965—less than a third of the sum now spent annually to store surplus grain and far less than the costs of exploring outer space.

It can cost three to six million a year to operate one of the big brute machines, mostly for electric power, maintenance, special equipment and experimental devices.

Electronic Kick

One main way of accelerating particles is with a few big electrical kicks along a straight line tube—the linear accelerator.

The other is to whirl them around many thousands of times, slingshot fashion, with thousands of small electrical kicks. These are the synchrotrons and synchro-cyclotrons.

The particles race through hollow tubes, evacuated of air. Electromagnets around or beside the tube keep the particles curving within the tube until loosed upon the target.

The machines must produce millions and billions of "bullets" each second. Otherwise, trying to score a hit on the tiny atomic nucleus would be like firing a rifle bullet at a gnat miles away.

The first slingshot, the cyclotron, was developed early in the 1930s by the late Dr. Ernest O. Lawrence at the University of California. Its energy was only 80 thousand electron volts. (An electron volt is the energy one electron, or one proton, picks up in falling across one volt potential difference.)

Energies increased with new machines and designs. In 1952 came the 3 BEV Cosmotron at Brookhaven.

In 1954, the 6.2 BEV Bevatron whirred into action at the University of California. It, like the Cosmotron, was based on a new idea of Dr. Edwin McMillan of California for controlling electrical frequency to push the bullets to higher energy. Russia's V.I Veksler independently had the same conception.

The Bevatron pushed deeply into the nuclear frontier, finding among other knowledge the anti-proton, anti - neutron and anti-lambda particles.

Russia has a 10 BEV proton synchrotron, built with 36,000 tons of costly magnetic steel.

Brookhaven's new 31 BEV synchrotron, using a new principle of magnetic focusing, sends protons around a half-mile track 300,000 times within a second, yet its magnets weigh only 4,000 tons.

In Switzerland, a similar machine of 28 BEV has been operated nearly a year now by the 12-nation European Organization for Nuclear Research (CERN).

Both machines can produce all the particles of the nuclear zoo.

Most importantly, they can produce streams of them. So the newer particles can be studied intensely, or sent banging into other targets, to learn better what "cages" these "animals" belong in and how they relate to one another.

Building at Argonne National Laboratory near Chicago is a 42 million dollar 12.5 BEV machine which will produce a richer harvest of many of these particles.

Power For 70,000 Homes

Operated continuously, it would use enough electric power to light and run 70,000 homes. The great machines, in fact, often do run day and night, with experiments performed by professors and scientists from nearby universities and centers.

This opportunity for research strengthens universities, for top-notch teachers then are not so tempted to move to distant places where they can take part in this exciting research, Argonne's Dr. Albert Crewe points out.

Here and abroad, literally scores of accelerators are at work. Regardless of size, each can contribute vital facts concerning the inner universe.

Linear accelerators are equally workhorses of this research.

At Stanford, for example, electrons from the 1 BEV linear accelerator have been used as a microscope to determine the size, shape and other properties of the proton, neutron and electron in research by Dr. Robert Hofstadter and associates. Clues come from the manner in which electrons bounce off their infinitesmal targets.

From this work, protons appear to be like fuzzy peaches, soft on the outside, hard on the inside. Now with a $500,000 magnetic spectrometer, the scientists hope to push deeper into the cores of protons and neutrons, and check fundamental theories about the nucleus and its binding forces.

Stanford and Princeton scientists are cooperating in building a new device to make two electron beams collide and to check theories about laws governing atoms and the nucleus. Electrons from the present machine will collide with energies equivalent to that from a 1,000 BEV linear accelerator.

To open another frontier, Stanford scientists have proposed a two-mile long linear accelerator producing 10 to 45 BEV energies. It would cost about 107 million.

Beams in Collision

At the University of Wisconsin, the Midwestern Universities Research Assn. is building small models for a proposed 15 BEV synchrotron which would collide two beams of protons, at energy equivalent to one 540 BEV accelerator, to investigate deeper secrets of the proton.

In cosmic rays from space, nature showers down particles reaching energies of millions to a billion BEV. Balloons carrying special photographic plates are sent 20 miles or more high to record their hits and new data about the atomic nucleus.

At the California Institute of Technology, Dr. Carl D. Anderson and associates are constructing special new counters and cloud chambers to capture and study in the laboratory some of the explosive and revealing "events" created by cosmic rays.

With genius and tools, the search proceeds to make sense of all the particles, and four forces known so far to be involved in the inner universe. These forces are:

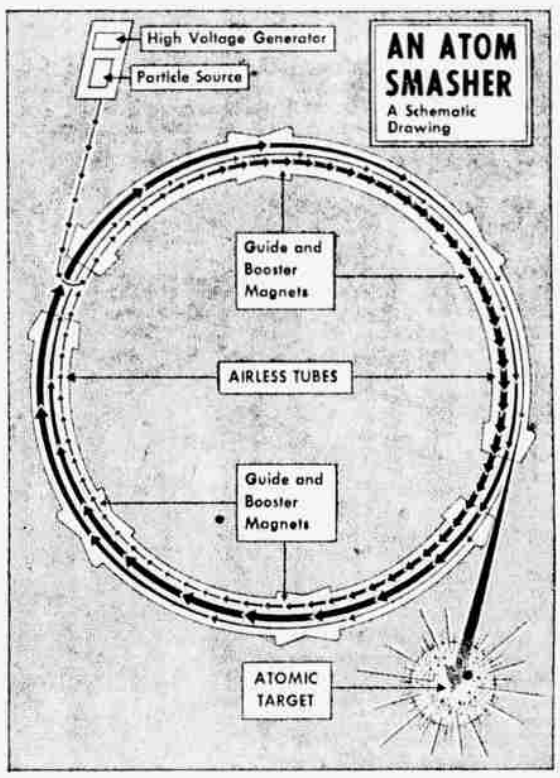
1. The "strong" forces binding atomic hearts together.
2. Electromagnetic forces within the atom, 100 times weaker.
3. The "weak" reactions which determine how any particle changes or decays into other particles—this is perhaps 10 billion times weaker than the electromagnetic forces.
4. Much weaker still, the gravitational force.

"Only through these four forces does any particle in the universe know anything about the presence of any other particle, and so to be influenced by it," Dr. Crewe explains.

But therein lies a key to the whole universe.

Nature probably is simpler in

(Continued on Page 12)



NUCLEAR SLINGSHOT: The steps to destruction of an atomic nucleus are diagrammed in this greatly simplified schematic drawing of an atom smasher. Particle "bullets" are fed into an airless tube, guided by electromagnets and accelerated by booster magnets to speeds approaching the speed of light. Then they are hurled at the atomic target, splitting its nucleus and releasing its tremendous power.