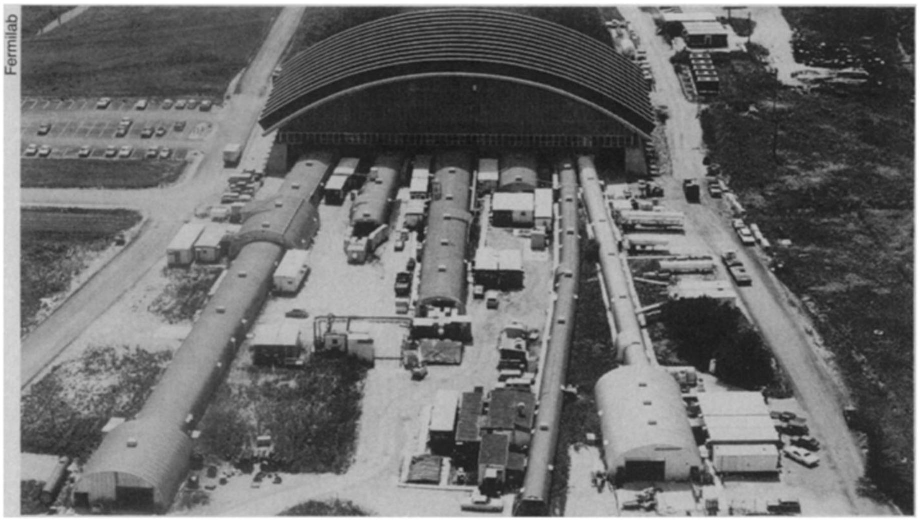
Commentary


Fermilab

The meson detector building at Fermilab, where some of the new higher energy physics will be carried out.

Physics Lives!

Physics is alive and well and living, surprisingly enough, in the United States. A scant few years ago it seemed politicians were ready to bury physics rather than to praise it. It looked as if no initiative for new equipment for experimental physics would ever again get off the ground in the United States. Physicists themselves were asking who would be the last to turn out the light. Theoretical physicists, at least, thought they had everything well understood, and all that was needed was a mopping-up operation (SN: 10/4/80, p. 220).

All that has changed. The science now seems resurrected and rejuvenated. (It was never really closed, but there was for a while a tremendous sense of complacency.) Now theorists admit to bafflement, something they are by temperament reluctant to do. "They look at experimental results," says an experimentalist, Leon Lederman, director of the Fermi National Accelerator Laboratory in Batavia, Ill. "and beg us to build new accelerators." As one theorist, Chris Quigg of Fermilab puts it, the theory that worked so marvelously at the energy levels where physicists have been working up to now has to change. They are not sure how it will change, so there is a sense of open excitement about the prospects of finding out. "[The theorists] need more facts," says Lederman.

They are likely to get them. This summer of content for American physics has seen the authorization of the first major accelerator project in nearly a decade, the Stanford Linear Collider (SN: 7/30/83, p. 71). In addition, the National Electron Accelerator Laboratory (NEAL) to be built in Newport News, Va., is all but authorized. At the recent 12th International Conference on High Energy Accelerators, held at Fermilab, a start was actually made toward the realization of what had heretofore been a pipe dream, the giant Super Superconducting Collider, which would put 40 trillion electron-volts of energy at the disposal of experimenters. (SN: 8/20/83, p. 118). Also at the conference, plans were aired for machines that would accelerate beams of ions (atomic nuclei) and collide them with each other. (This equipment at long last would be something that could accurately be called "atom smashers.")

And the excitement is not just more of the same. After a long period in which theory so accurately predicted experimental results that the whole enterprise was in danger of becoming boring, physicists are now on the border of territory where they have much vaguer ideas of what to expect. It is "the desert," "no man's land" — perhaps even a bit of the twilight zone?

A couple of years ago Lederman made a remark about the tremendous amount of energy stored in a drop of water, binding together the quarks that make up the neutrons and protons in the atomic nuclei of the water. He has lived to regret that statement, as it hit page one all over North America — usually without the qualifier that according to physics as known up to now, there is no way to get that energy out. Quarks are perpetually confined inside the neutrons and protons, which for them are "bags" they cannot escape.

Quarks are one thing that will come under the scrutiny of researchers using the new equipment. Are they truly the elemental building blocks of nature or are they, too, composites? How do they behave with one another? And (especially with NEAL and the ion accelerators) how do they behave when they are contained in atomic nuclei? There are already hints that in nuclei quarks don't stay in their proper bags. There are even hints that a state called a quark-gluon plasma can exist, in which the identities of neutrons and protons are totally destroyed, and all that is left is a collection of quarks and what binds them together, the gluons.

If a quark-gluon plasma can exist, the study of its physics will be both exciting and necessary for a proper understanding of matter. Maybe it will turn out that the quarks are not as irretrievably bound as they have seemed. And maybe — this is the vibration of the whisper of a hint — some of their binding energy can be available to the outside world.

Quarks and gluons are part of a theoretical physics based on symmetry and on a kind of dialectic tension between symmetry and asymmetry. Symmetry here means basically sameness. It is the basis of the existence of things, but for distinctions to exist between different kinds of particles or different kinds of force, the symmetry must be slightly broken. The breaks cannot be so great, however, as to destroy our perception of the underlying symmetry.

Usually the breaks are small, a matter of a few percent in the masses of different particles that otherwise would be identical, but at the heart of one of the recent great successes, the unified theory of electromagnetism and the weak interaction, is a rather large break: Two particles, the photon and the Z^0, have the same function, the mediation of forces that do not change the electric charge of the particles they act on ("neutral weak currents" is the technical term), but the Z^0's mass is 100 billion electron volts, the photon's mass is zero. That this big break can exist is a result of a theoretical mechanism worked out by Peter Higgs of the University of Edinburgh. It involves particularly the existence of certain particles called Higgs particles.

Do Higgs particles exist? Does the Higgs mechanism work at high energies? Some physicists are wondering. Are quarks what we think they are? Do they behave the way we have thought? Again questions have arisen and there are vague hints and suggestions. So, if Congress agrees, it will be out of the trenches of well-known physics and into the no man's land. The great excitement of now in physics is that ideas unthinkable a few years ago now hang in the air waiting to see whether new discoveries will clothe them with reality.

— D.E. Thomsen