

Brookhaven National Laboratory

The desired event, a mu meson track in a spark chamber at Brookhaven.

Detecting nuclear particles

A host of instruments, ranging from the geiger counter to the computer, have been harnessed to study nuclear debris

As important as the size and intensity of a particle accelerator—some say even more important—is the auxiliary equipment that swallows 20 percent or more of the cost of an accelerator and operates with it to identify the nuclear debris resulting from particle bombardment. Refinements are constant; revolutions may well have to await the practical demands of spiraling energies.

The prize for the most exciting development of recent years still has to go to digital computers as an active and integral part of the experimental apparatus. The computer has become such an intrinsic element of the set-up that its rapid responses allow scientists to modify an experiment in progress. The technique is known as on-line computing.

Since particles cannot be detected by any of the known senses, scientists have devised ingenious ways to discover and study them. Particle detectors are of two basic types.

One kind is essentially a counter, such as the geiger counter or the scintillation counter.

The second type consists of track detectors, of which there are many varieties, including the now classic cloud chamber, the bubble chamber, the spark chamber and the wire chamber. The most recent entries in the field of track detectors are the streamer chambers,

the newest addition to the spark family, and the twin-shelled double bubble chamber.

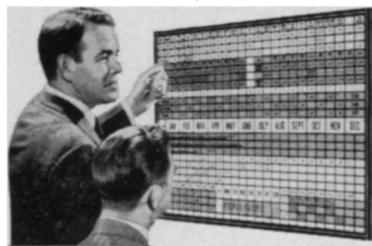
The cloud chamber is the ancestor of the many different types being used today. All of them operate by taking advantage of the fact that the bits of matter and energy called elementary particles leave in their wake a trail visible either to the camera or to the eye when they pass through matter.

This is because a charged particle, such as a proton or meson, disrupts one atom after another in its path, leaving behind a trail of electrically charged atoms called ions. Even though the sub-nuclear particle is much too small to be seen, its path is clear—just as when an invisible jet plane passes high overhead, the cloud of ice crystals formed in its wake is clearly visible.

The remaining and still very formidable task facing the modern physicist is to reconstruct, from the trails and from the clicks of counters, the nature of the elementary particles. This, according to Dr. Kenneth W. Ford of the University of California at Irvine, is roughly like reconstructing the design of a jet plane by studying its high-altitude wake.

A disadvantage of the gas-filled cloud chamber and of the liquid-filled bubble chamber is that the passage of charged

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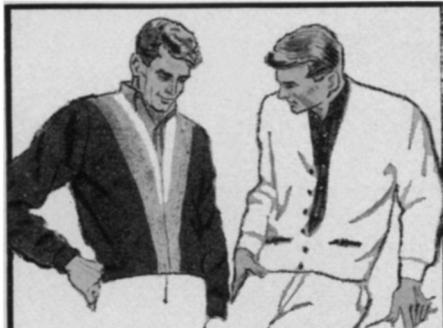


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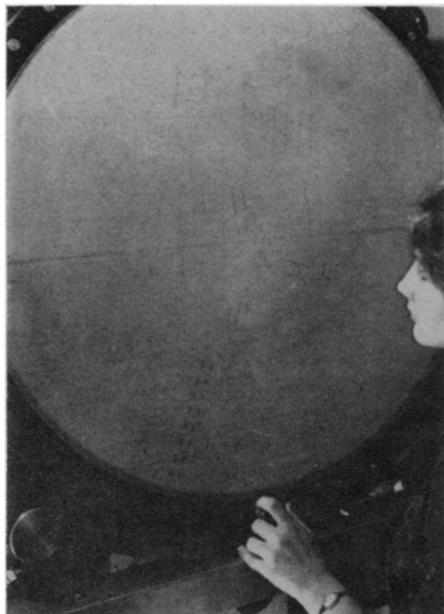
particles in great numbers results in a highly confused profusion of tracks.

The spark chamber linked with a computer allows selecting those of special interest, then making only the desired tracks visible.

The spark chamber complements but does not outmode the bubble chamber. It consists of a series of closely spaced metal strips, housed in an atmosphere of neon or other noble gas. The strips can be charged electrically so that, under certain conditions, sparks will flash between adjacent strips.

These sparks flash only when charged subatomic particles pass between the plates. If a pulse of voltage is applied immediately after a particle's passage, a series of sparks marks its wake.

By connecting an array of counters arranged along the outside of the spark chamber to a computer—the event selector—only those tracts of particular interest automatically actuate the spark chamber voltage pulse. The resulting sparks can be photographed for a permanent record; sometimes they are



Spark chamber photos measured. merely counted and their spatial distribution charted.

To analyze the photographs from many kinds of chambers, attempts are being made to replace human film scanners and measurers with automatic equipment. The most completely automated film scanners digitize the photograph, decide which events are significant and then measure them.

For those who once had to analyze hundred of photographs of nuclear reactions to find even one interesting event, the great delight in linking spark chambers and computers is that most uninteresting pictures are eliminated.

Nevertheless, bubble chambers have their place; they provide a target of pure hydrogen at the highest possible

density, with sensitive volumes as long as eight feet. Bubble chambers are thus invaluable for studying nuclear interactions of a type relatively easy to interpret, since the target particle is the simplest single nucleus, the proton.

Many different liquids can and are being used in bubble chambers, hydrogen and such heavy liquids as propane or freon being the most popular. The advantage of the heavier liquids is that particle tracks are much shorter; the disadvantage is that they are harder to sort out.

To combine the best properties of both light and heavier liquids, scientists from CERN and West Germany are experimenting with the twin-shelled chamber that is in fact one bubble chamber inside another. A target volume of hydrogen is set up, separately enclosed, within a chamber filled with a mixture of neon and hydrogen. This permits retaining the simple target, yet reducing overall track length.

The implications of this combination for use with the big chambers now in design stages (SN: 11/17/66) are under consideration both here and abroad even though much work remains to be done to perfect the idea in practice.

Taking advantage of the recent rapid progress in developing superconducting magnets, the new bubble and spark chambers are expected to produce magnetic fields that will be double the intensity of those now available, with no increase in size.

In the streamer chamber, the latest modification of the spark technique, the light output from the track caused by charged particles is very faint and must be intensified. This is accomplished by intensifying the weak streak with an image amplifier, such as those being used so successfully with astronomical telescopes (SN: 12/24/66).

As recently as five years ago, scientists who had finished analysis of their data, often long after the auxiliary equipment had been dismantled, commented, in effect, "now we know how the experiment should have been done."

Today, thanks to the on-line computer, the experimenter can be supplied with such information continuously throughout the test. He can remain an active element in the control loop, making decisions on the basis of information received, or he can allow the computer to operate the system.

"The use of on-line computer techniques, which combine electronic detector arrays with automatic data reduction by digital computers, will become the most important factor in experimental research for the high energy accelerators now contemplated—several hundred Bev or higher," says Dr. S. J. Lindenbaum of Brookhaven National Laboratory. *A.E.* ♦

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