Cowan

TWO NEW RADIATION DETECTORS

Institute researchers develop a nonstop cloud chamber and a nonstop Geiger counter

by C. M. STEARNS

1. NONSTOP CLOUD CHAMBER

EUGENE W. COWAN, Assistant Professor of Physics working in Carl Anderson's group, has succeeded in making cosmic-ray tracks visible on a 24-hour basis. The standard "cloud chambers" that physicists use to make the tracks of subatomic particles visible are good for one set of tracks every few minutes; but the chamber has to have a rest between sets. Cowan's "continuously sensitive diffusion cloud chamber," on the other hand, can catch particle tracks one after another for considerable lengths of time without pause. Furthermore, Cowan's cloud chamber is small, inexpensive and simple (and this is a good thing, since it is at present more of a cosmic-ray demonstration device than a precision research instrument for which anyone would care to spend a large sum of money). It is so simple, in fact, that anyone with a reasonable amount of perseverance and a small supply of dry ice can set one up at home.

The new detector makes visible, as a thin line of cloud, the path of every electrically-charged subatomic particle that passes through it with sufficient energy. Such a particle may come from radioactive material, such as the radium on a watch dial; it may come from a particle accelerator, such as a cyclotron; or it may be a cosmic ray—either in the primary form of a particle coming in from outer space, or in the secondary form of a particle set in motion by the primary ray in a collision with some atom in the earth's atmosphere.

The particles that make up cosmic rays are the ones that most cloud chambers, including the new one, are designed to study. Dr. Cowan's new cloud chamber not only makes the tracks of such cosmic-ray particles continuously visible; but also "holds" each track long enough for easy visual inspection.

The new cloud chamber, in one form, is little more than a box, with transparent sides, sitting on a cake of ordinary "dry ice." The box is covered with a pad which has been soaked with slightly heated alcohol. The heated alcohol vaporizes and, under the temperature conditions that the heated top and cold bottom of the box dictate, diffuses downward inside the box. At this stage, since the alcohol vapor is an invisible gas, nothing can be seen inside the box.

If, now, a charged cosmic-ray particle such as an electron passes through the box, it disrupts the atoms in its path and leaves a trail of electrically-charged fragments behind it. The alcohol vapor condenses on these fragments to make visible droplets. The end result is a cloud trail—a thin thread of droplets, easily visible in a strong light, that marks the path taken by the cosmic ray.

Other cloud chambers rely on the same basic phenomenon—the condensation of vapor on the charged ions left in the wake of a speeding particle. But, to achieve the conditions that must exist for such condensation to occur, they require a sudden, large drop in pressure in the chamber; and this in turn requires, besides some fairly complex mechanical apparatus, a rest period ranging from one to several minutes between operations. Only the tracks of particles that pass through at or about the time of the pressure drop are made visible, and these tracks remain visible for only about one-tenth of a second. The continuous cloud chamber requires neither moving parts nor rest periods, and the tracks that appear in it remain visible for several seconds.

In its laboratory form, the continuous cloud chamber has many refinements. Electric elements heat its top, which supports a pad automatically supplied with methyl alcohol. The inert gas argon fills its interior. An electric field, energized briefly from time to time, pulls to the top or bottom the charged fragments that the passing rays have left, leaving the chamber more receptive to the next rays to come along.

But in its crudest form — one that can be set up with ease in any physics classroom and without much difficulty in any home — the continuous cloud chamber is a large glass jar filled with ordinary air, sitting on dry ice, in a strong light, with a pad soaked with pre-heated alcohol as its cover.

From the standpoint of cosmic-ray research, the continuous cloud chamber has (particularly in its present early stage of development) certain disadvantages. Some uses for it have already developed, however. One model will be tried out in the stream of electrons ejected by the billion-volt synchrotron now under construction on the Institute campus. The chamber has some promise in the field of investigation of "electron showers," cascades of thousands of high-speed electrons that cosmic rays sometimes produce. Other uses will undoubtedly be discovered to take advantage of the continuous operation of which the chamber is capable.

At present, the best use of the continuous cloud chamber is found in teaching and demonstration. It can, at a fraction of the cost of a classic cloud chamber, make available for study the tracks of many of the 20-odd cosmic-ray particles that strike every foot of ground at sea level every second, and thus provide an excellent and convincing demonstration of radiation otherwise completely invisible.

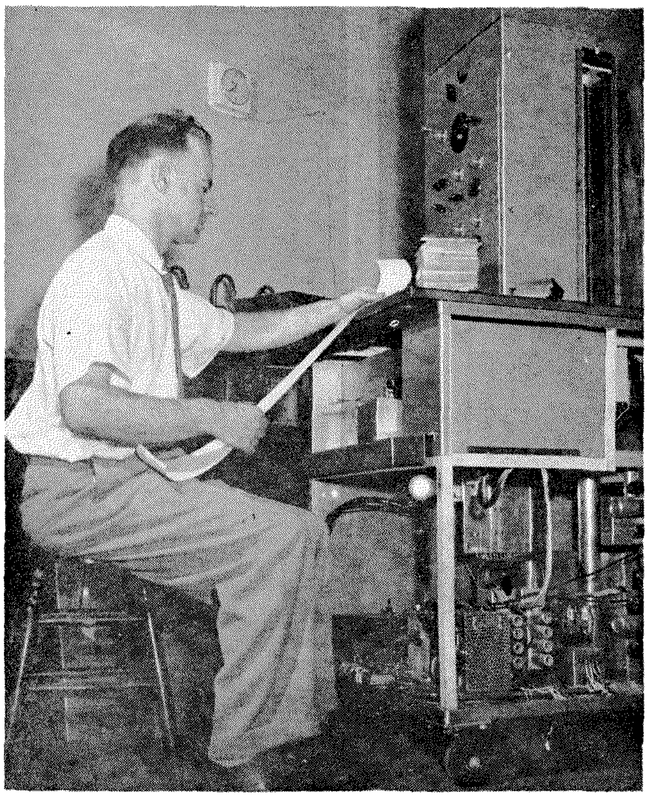
2. NONSTOP GEIGER COUNTER

While the Institute's Physics Division was busy making a nonstop cloud chamber, the better to watch one kind of radiation, the Biology Division was building a nonstop Geiger counter to measure another kind.

Dr. Geoffrey Keighley, concerned over the tedious hours spent by lab assistants in measuring the minute radiation emitted by the various materials resulting from "tagged atom" research, has finished an automatic counter that does most of the work without human assistance. It takes as many as 100 radioactive samples, examines the radioactivity of each for any preselected time between five minutes and one hour, and prints its findings on a paper tape. Though it is not the only device of its kind in existence, Keighley's counter has certain advantages over the few others that have been built; and its ability to work nights and weekends without supervision is of no mean value to Caltech's Biology laboratories, whose lights burn late enough as it is.

In biological research that relies on "tagged" atoms, or radioactive tracers, sample-counting is the final headache. It is difficult to incorporate radioactive atoms into the compounds that must be followed through a specific biological process. It is also difficult to obtain samples of the particular materials produced in the process that can reveal how far the tagged atoms have moved, chemically speaking. But these problems are fundamental problems of biology and chemistry. The "counting," on the other hand — the careful measurement of radioactivity that tells how many radioactive atoms have moved into various individual samples — is neither chemistry *nor* biology, but a tiresome and time-consuming chore.

Usually this "counting" involves putting each sample in a Geiger counter that measures, by responding to the particles ejected by each radioactive atom as it disintegrates, the number of radioactive atoms present in the sample. Then the operator must wait perhaps 30 minutes (but not 29 or 31) for the counter's report, note accurately the "count" (and often several hundred thousand atomic disintegrations are involved, even in a half-thimbleful of material), remove the sample, reset



Dr. Geoffrey Keighley's automatic counter measures minute radiation emitted by various materials resulting from "tagged atom" research. Samples move beneath a counting tube, which records reactions. These are transferred to a paper tape which can be read by the operator. The machine is currently being used to "count" radioactive samples obtained in a study of protein synthesis in the Institute's Biology Division.

the counter, put in another sample, and so on. Since many experiments produce fifty or more samples, it is easy to see why a machine to do this job automatically is welcomed by the Institute biologists.

The automatic counter itself is a combination of the mechanical and electrical improvisations that appear in any laboratory. An elevator raises samples (set in three-by-six-inch aluminum plates) on one side, receives and lowers them on the other; a conveyor slides them across the top of the machine beneath the counting tube itself. A dial, preset, determines the length of time that each sample remains under the tube. The tube's reactions are fed into a fairly complex assembly, called a scaler, which converts these reactions into numbers illuminated by small neon bulbs. A photocell reads off the illuminated numbers and operates the printing mechanism that puts the readings, suitably coded, onto a tape that the operator can read when the machine has finished its work.

If it is ever necessary, the counter can make one-hour counts of 100 samples, operating unattended for over four days and turning itself off at the end of the job. Since a 30-minute counting time is usually long enough, and since there are rarely as many as a full 100 samples, the machine will probably never take on a job that long; but a day or two of work may be expected from time to time.

So far, Keighley's counter has spent most of its time "counting" radioactive samples obtained in a study of protein synthesis. It has been known for many years that living systems somehow take a selection of the 24 complex chemical compounds known as amino acids and out of them make proteins — muscle, nerve, blood, germ-cell, bacteria, virus, depending on what system is doing the making. No one knows how the living systems do it. A most promising attack on this problem, an attack also being made in other laboratories all over the world, is to incorporate radioactive atoms (usually atoms of carbon, in their radioactive form of carbon 14 are used) into the various amino acids to see what the living systems do with each acid. The automatic counter, after the experiments have been run and samples obtained, provides the results for the scientists who are working on the protein-synthesis problem at the Institute.

A money saver too

Besides saving many tedious man-hours, the automatic counter should save money. Radioactive carbon 14 is obtained, in quantities adequate for research of this sort, only from the Oak Ridge nuclear reactor of the Atomic Energy Commission, and is expensive even though the A.E.C. provides it at as low a cost as is possible. Building carbon 14 into amino acids is an extremely complex, and therefore expensive, process. Yet, the less carbon 14 that is used in a given experiment, the longer each sample has to be counted—the less the radioactivity or the smaller the sample, the longer the time necessary to get a scientifically acceptable count. When men and women are doing the counting, this is important; when the automatic counter is doing it, time is no longer so important, and less of the expensive carbon 14 and carbon 14 compounds need be used.