TWO NEW PARTICLES

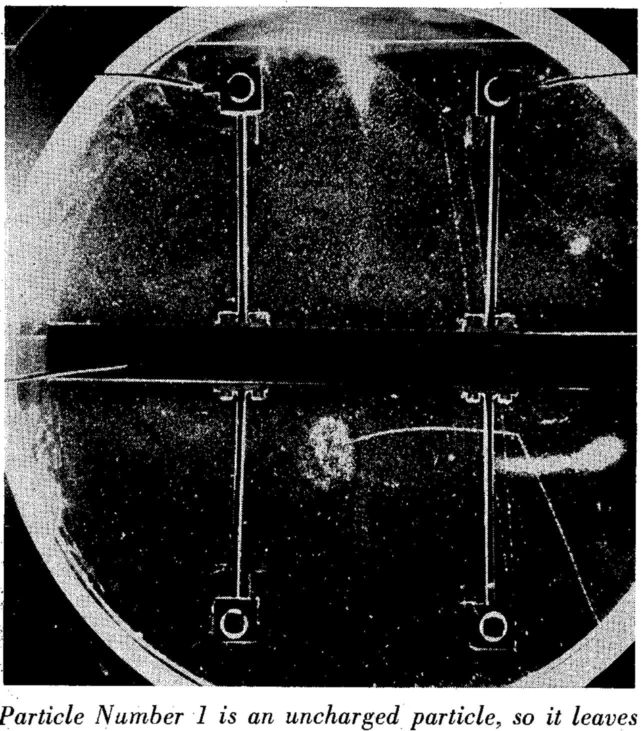
by C. M. STEARNS

Caltech researchers re-discover two elementary particles of matter—but, far from simplifying our understanding of nature, the discovery makes it even more difficult

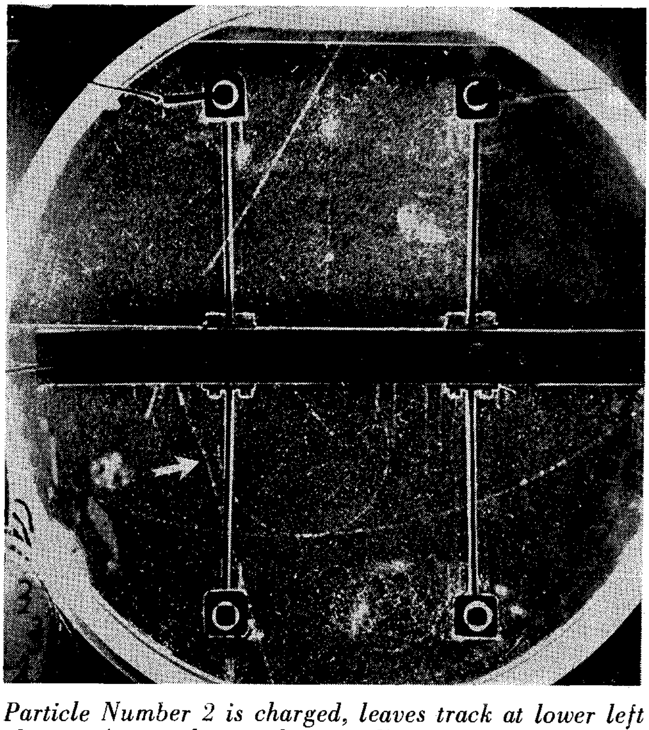
A GROUP OF PHYSICISTS at the Institute has found definite evidence for the existence of two new elementary particles. These particles have been on the "possible" list ever since 1947, when G. D. Rochester and C. C. Butler of England's University of Manchester first found them on two photographs taken in the course of studies of cosmic rays; now Aaron J. Seriff, Robert B. Leighton, Robert C. Hsaio, Eugene W. Cowan, and Carl D. Anderson have virtually proved that the particles do exist.

In all, the Institute physicists have 34 pieces of evidence pointing to the new particles—30 pointing to one of them, and 4 pointing to the other. In each case, the evidence is a photograph of a cloud chamber in which the particles left their tell-tale traces. Some of the photographs were made on the Institute campus; the rest at an elevation of about 10,500 feet on California's White Mountain, where the cosmic rays that produce the particles are somewhat more plentiful.

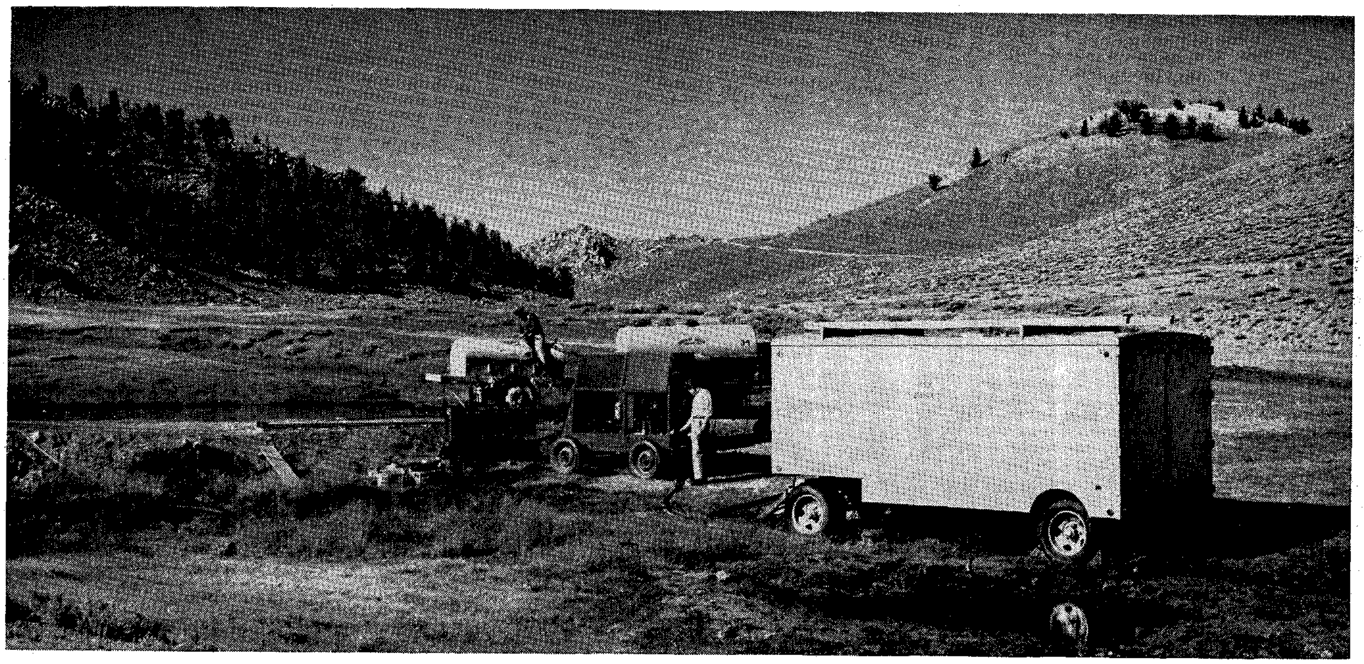
Each of the 30 photographs that apply to the first of the new particles shows two tracks that form an inverted "V" in the cloud chamber. It is the electrical charge on any such particle that causes a vapor-trail in a cloud chamber; and since this first new particle has no charge, it leaves no trace above the V. But when it disintegrates into two *other* particles—both of them charged—which make the tracks that form the V, the V proves that the original particle must have been there to disintegrate. Particle Number 1, then, is an uncharged, unstable particle that suddenly turns into



Particle Number 1 is an uncharged particle, so it leaves no track in the cloud chamber photograph above. But it reveals its presence by suddenly turning into two charged particles—whose tracks form inverted V at lower right.



Particle Number 2 is charged, leaves track at lower left above. Arrow shows where it disintegrates into a secondary charged particle—which continues track at a new angle—and an uncharged particle, which leaves no track.



Cloud chamber, mounted in this trailer, was taken to the top of White Mountain (10,500 ft.) in the scientists' attempts to verify the existence of the new particles. Of 11,000 cosmic ray photographs taken, 34 showed the particles.

two charged particles—quite possibly into mesons of a type already known.

By studying the tracks that form the V, the physicists have learned a few things about Particle Number 1. First, of course, is the fact that it has no charge; this they know because the particle leaves no trail in the cloud chamber. Furthermore, by studying the thickness of the tracks that form the V, their curvature in a magnetic field and various other factors, the physicists have got some idea of the mass and energy represented by the particles that make the tracks—and therefore some idea of the mass and energy represented by the parent, Particle Number 1, that gave birth to them. They have concluded that Particle Number 1 is more massive than any similar particle previously discovered among the cosmic rays; it is at least twice as heavy—and possibly seven times as heavy—as its predecessors.

Particle Number 2

The photographs that apply to Particle Number 2 show a different picture: a track not like a V, but like a dog's hind leg—a track coming down from above and then bending off at a new angle. Obviously, the investigators say, the track coming down is Particle Number 2 itself, and it must have a charge or the track would not be there. The bend means that Particle Number 2 disintegrates into a charged particle, which continues the track on a new angle; and into an uncharged particle, which of course leaves no track.

Since there are fewer photographs relating to Particle Number 2 than to Particle Number 1, fewer conclusions can be made about Number 2. It is, though, a charged particle, and again differs from any particles discovered earlier.

The two new particles bring the total number of known elementary particles to 13. Of the previously discovered 11, it is the mesons which give the best clue to what the newcomers may be.

Among the elementary particles of the universe, the mesons fall in a class apart. For one thing, mesons appear only where enormous amounts of energy are involved. Electrons take part in the day-to-day chemical activities of the world—the burning of coal, the use of food by living organisms, the explosion of gasoline or gunpowder. These are all, relatively speaking, *low-energy* events. Neutrons and protrons, the foundation blocks that make up the heart of each atom, do not become involved until more violent activities are reached, activities such as that of the sun or of an atomic bomb. These are *high-energy* affairs. Mesons, however, are found only in connection with activities more violent still. They are to be found only in the atomic rubble left when a cosmic-ray projectile from space (or, more recently, from one of the more powerful atom-smashing machines) plows into a piece of the earth or the atmosphere. Mesons, in short, are involved in events that are so violent, even if on a submicroscopic scale, that they can best be described as of *enormously high energy.*

That is one way of separating mesons from their neighbors in the table of elementary particles. A second turns on the idea of stability.

Stability is a clue

Left to their own devices, the best-known of the elementary particles are relatively stable. A proton, unless it gets in the way of a cosmic ray or finds itself a part of one of a few radioactive atoms, remains a proton. A neutron, even when away from its normal home in the heart of an atom, remains a neutron for an average of 20 minutes. An electron is similarly stable under ordinary conditions. But mesons are unwilling inhabitants of the physicists' world; they live only a few billionths (or, at most, millionths) of a second before decaying into something else, or disappearing into some nearby nucleus.

Such are the mesons—the ones so far recognized; and the two new particles clearly have some things in common with them. Like mesons, the new particles are found associated with cosmic-ray projectiles carrying enormously high energies (there is no way of knowing when man-made machines will be able to produce the new particles as they have recently produced the older, more familiar mesons). Like mesons, the new particles disintegrate into something else after a short and violent life (there would be time for three billion of them to be born, to live, and to die, one after another, in the passage of one second). The new particles were not predicted by any recognized theory—and, again like mesons, they find no theory that explains them adequately.

The two new particles *differ* from mesons, however, in life expectancy. Theirs is generally shorter, being about three ten-billionths of a second in the case of Particle Number 1 and probably still less in the case of Particle Number 2. Only the neutral meson, just pinned down at the University of California, has a shorter life span. The new particles also differ from mesons in their mass, which is still unknown, but which, in the case of Particle Number 1, is probably either about 600 or about 2200 times that of an electron. So the new particles should probably not be called mesons. But the word "meson" has already been stretched into a sort of catch-all name for mysterious new particles, and the two new ones may be added to the batch until the physicists know enough to give each meson a proper and individual name.

What is the significance of the two new particles? It is of course too early to say. However, whether or not they actually turn out to be variations on the meson theme, they share the importance that mesons have in physics—which is considerable. The study of mesons and related "events" in cosmic-ray phenomena has changed basically the physicists' concept of the elementary particles of matter. Physicists no longer think of these particles as permanent objects which always preserve their identity, and which serve only as building blocks of matter by joining together in groups to form the more complex chemical atoms. The unstable particles have changed that. One must recognize, instead, the fact that an elementary particle may have only a transitory existence. Today the universe seems composed of elusive units capable of changing from solid mass to radiant energy and back again billions of times a second.

If the universe is made up of a few basic building blocks, where in all this shifting scene do those blocks appear? And, above all, what holds them together in atoms with a force that, once released, can level a city?

It may be that meson-like particles hold the key to both riddles. The only theory today available to account for mesons holds that they are, in some way, pieces of the force that holds atoms together. The name "cosmic glue" has been applied to them, and is as good as any.

It may be, then, that inside an atom a meson—either a piece of energy, or perhaps a wildly-oscillating abstraction that is energy one instant, and solid the next—helps to hold things together; but that when that atom, or any part of it, is hit hard enough by the super-projectiles found in cosmic rays and cyclotrons, the meson is knocked loose, and is momentarily observable as a solid particle.

Such specific description of a meson may make a physicist wince, since far too little is known about the meson as yet to detail its behavior. Still less is known at this point about the two new particles. However, this picture of meson-like particles as solid bits of cosmic glue may very well turn out to be close to the truth; and it is certainly difficult to account for mesons in any other terms.

The two new particles, then, may join with the mesons that preceded them to help physicists explain once and for all how things are put together.

ELEMENTARY PARTICLES

Particle	Charge	Mass	Existence Recognized	Key Figures
Electron	—	1	1890-1900	J. J. Thompson
Proton	+	1836	1890-1920	Several
Photon	0	0	1900-1905	Several
Neutrino	0	0 (?)	1925-	Pauli, Fermi
Neutron	0	1836	1932	Chadwick
Positron	+	1	1932	Anderson
Mu meson	+, —	215	1936	Anderson, Neddermeyer
Pi meson	+, —	284	1946	Powell
Neutral meson	+, —	about 280	1950	York, Moyer, Panotsky, Steinberger
New Particle #1	0	600-2200	1947-1950	Rochester, Butler; Seriff, Leighton, Hsaio, Cowan, Anderson
New Particle #2	+, — ?	?	1947-1950	