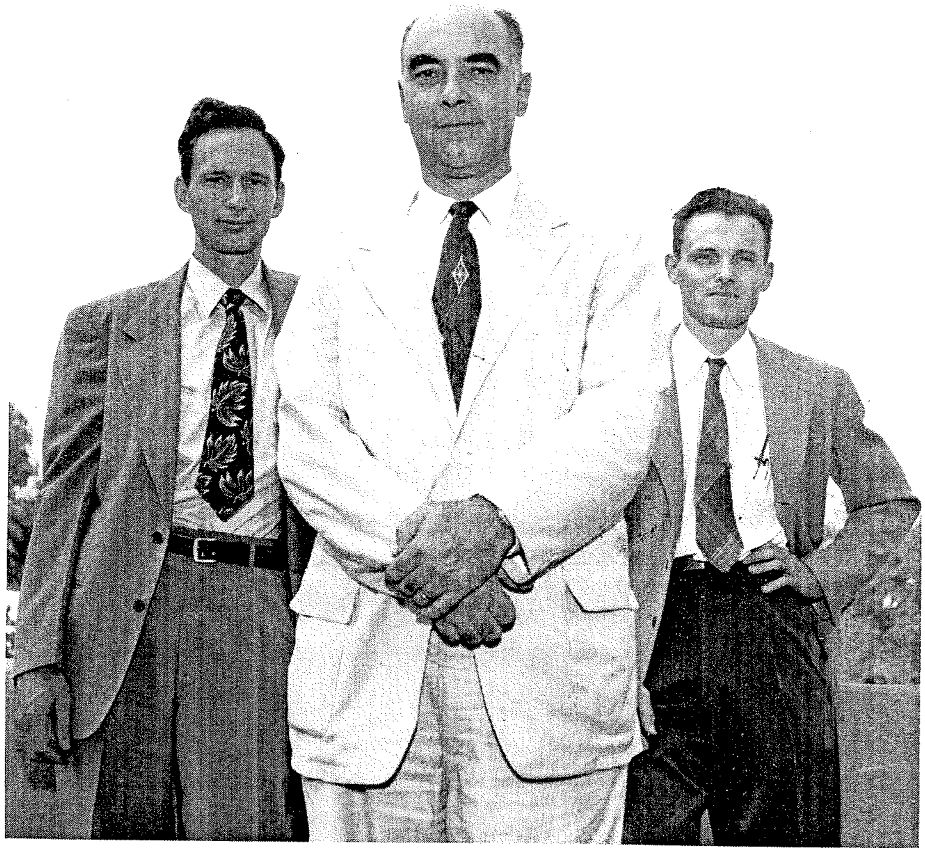


Carl Anderson, flanked by his co-workers in cosmic ray research — Eugene W. Cowan at the left, Robert B. Leighton on the right.

CARL ANDERSON

Some notes about his life and work at Caltech

IN 1932, Carl Anderson's discovery of the positron—one of the elementary building blocks of matter—was described by R. A. Millikan as "probably the most fundamental and far-reaching development in physics since the discovery in 1900 by Max Planck of the quantum of action."

Characteristically, Anderson took great pains to explain that the discovery was unexpected, and that it was by no means a one-man job, but a cooperative effort involving himself, Seth Neddermeyer (now Professor of Physics at the University of Washington) and R. A. Millikan.

Nevertheless the discovery won Anderson the Nobel Prize in Physics in 1936. He was one of the youngest men (31) ever to receive a Nobel award, the fourth American to receive the award in physics and the third member of the Caltech faculty to become a Nobel prize winner. Significantly, he shared the 1936 award with V. F. Hess, one of the "discoverers" of cosmic radiation in 1912. Anderson's discovery of the positron was made through studies of the cosmic rays.

Anderson, who was Assistant Professor of Physics at Caltech in 1936, was teaching a class when Robert A. Millikan broke in to tell him he had won the Nobel award. Anderson made the trip to Stockholm to receive it, and surprised King Gustav at the ceremonies by conversing with him in his native tongue.

Carl's parents were Swedish-born. They grew up on farms near Stockholm, and came to America in about 1900, when they were both in their twenties. They met in New York.

Carl was born in New York on September 3, 1905. The family moved to Los Angeles when he was seven years old. By the time he was graduated from the Los Angeles Polytechnic High School in 1923 Carl's chief, and practically only interest was electrical engineering. Not until 1925, when he was a sophomore at Caltech did he turn to physics, under the influence of R. A. Millikan.

In 1926 Carl Anderson won the annual Caltech travel prize for a six-month trip to Europe. After graduation in 1927 he stayed on at Caltech as a teaching fellow while doing graduate research on X-ray photoelectrons. In 1930 he received his Ph. D. *magna cum laude* and became a research fellow at the Institute, working under Millikan on cosmic ray studies.

Millikan and cosmic rays

Cosmic rays were given their name by R. A. Millikan shortly after the first World War. It was Millikan who first recognized that cosmic rays represented a very important field for investigation. He did more than anyone else to stimulate general interest in cosmic-ray research.

In these rays—coming from somewhere beyond the stars to bombard the earth like a continuous shower of invisible rain—scientists discovered that they had the sharpest tool possible for probing into the structure and composition of the nucleus of the atom. In the cosmic rays nature has provided us with the greatest concentration of energy known anywhere—higher than energies released in atomic fission, higher than any energies that can yet be produced by man-made "atom-smashing" machines. And these concentrations of energy are necessary for penetrating into the atomic nucleus.

Because the cosmic rays are invisible scientists have had to devise ingenious machines to record their presence. The most useful, in recent years, has been the Wilson cloud-chamber—a glass-windowed chamber filled with moisture-saturated gas. When a cosmic ray shoots through this chamber, it leaves a trail of charged fragments of air molecules. The vapor immediately condenses on these fragments, and a visible trail marks the passage of the invisible ray.

By 1932 scientists had identified two elementary particles of matter—the electron, with a negative electrical charge and a mass about 2,000 times less than the hydrogen atom, which is the lightest of all chemical atoms; and the proton, the positively charged nucleus of the hydrogen atom, and a constituent of all other chemical atoms.

In 1932 two more elementary particles were discovered—the neutron, which was immediately welcomed as a constituent of the nucleus, and the positron, or positive electron, which is identical with the electron in everything but charge.

Carl Anderson's discovery of the positron came during a series of experiments being performed for the purpose of measuring the energies of the particles produced by cosmic rays.

Under Millikan's direction, in 1932, Anderson built an apparatus designed to make the first direct measurements of the energy of cosmic rays. Weighing more than a ton, it included a giant electromagnet, a cloud chamber and an automatic arc light camera. Cosmic rays entering the steel chamber cylinder struck and shattered the atoms of the earth's atmosphere to fragments. The fragments, beating through the vapor chamber, caused droplets of moisture to condense along their paths. The magnetic field bent the positively charged particles to the right and the negatively charged particles to the left, while the arc light camera recorded the process.

It was expected that all particles with positive charges would be protons, while the negatively charged particles would be electrons, but when the photographs showed what appeared to be an electron, deflected to the *right*, Anderson realized he was on the track of a new particle.

The discovery of this new particle, the positron, represented the first instance in which it was recognized that an elementary particle of matter may have a transitory existence. In fact, the average life span of the positron is just a few *billionths* of a second; when a positive electron (or positron) and the negatively charged electron come close to each other they annihilate each other. In their place is found only radiation. In reverse, when the ultra-high energy particles in the cosmic rays strike an atomic nucleus, electrons and positrons are created out of the energy of the collision.

Discovery of the meson

In 1935 Carl Anderson and Seth Neddermeyer discovered two more fundamental particles of matter—the positive and the negative meson. This discovery was no quick accident, like that of the positron. It came after an exhaustive four-year search for the particle.

Public announcement of the discovery was made in 1936. By the time he received the Nobel award for his discovery of the positron, then, Carl Anderson had already gone on to discover two *more* of the fundamental particles of matter. It was proof enough that his original discovery—made, like most of the great discoveries in physics, when he was a very young man (26)—was no freak. At the time, it meant that Carl Anderson had to his credit the discovery of three of the six known particles of matter.

As the physicist I. I. Rabi once said, "Every time a scientific problem is solved it gives birth to twins." And the discovery of the meson created problems from the beginning—starting with its name.

Anderson had had name trouble with the positron too. When he decided to call the positive electron the positron, he suggested that the electron, with its negative charge, have its name changed to negatron. But 40 years usage was too much and the old name stuck.

Some British physicists with classical leanings thought the positron might better be called the oreston, on the grounds that this name would suggest its close relationship with the electron—since Orestes was the brother of Electra. And another group of British physicists, more sports minded, came up with an analogy to cricket. Since the positron came from cosmic ray tracks which seemed to be bent in the wrong direction, they were reminded of how, in cricket, the peculiar hops of a ball in front of a wicket were known as "googlies"—and so suggested that googlie would be an ideal name for the new particle.

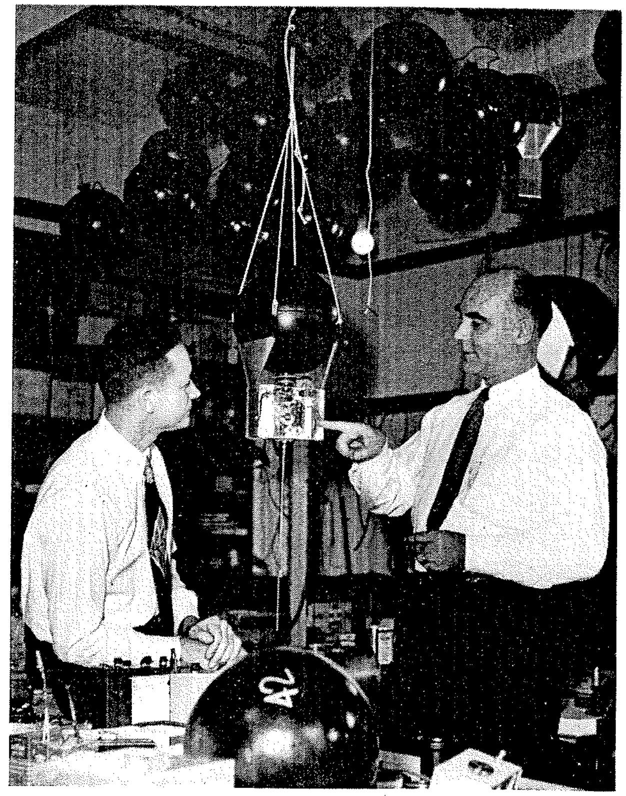
But the particle is still known as the positron. The meson was christened "mesotron" by Anderson and Neddermeyer but it's been knocked down to the simpler form by now.

Like the positron—which had been predicted in theory by the British physicist, Dirac, before its actual discovery by Anderson—the meson too had been predicted by the Japanese physicist, Yukawa. Again, it was a demonstration of the inevitability of scientific discovery. Many of the greatest discoverers of science are men who, looking over progress made by others, see a simple answer to a puzzle.

Like the positron, the meson proved to have a very short life expectancy—about two-millionths of a second, after which it disintegrated. Subsequently Anderson, working with Robert Leighton and Aaron Seriff, discovered that the disintegration of the meson resulted in the simultaneous production of an electron and two neutrinos. The neutrino, seventh of the known elementary particles, still exists only in theory. It has neither mass nor charge, but its existence is necessary to explain the balance of energy and momentum in the process in which an electron is produced when a radioactive nucleus decays.

It was becoming clear now that, when ultra-high-energy particles strike a nucleus, new particles come out which were not supposed to have been there in the first place.

Following the Anderson-Neddermeyer discovery of the meson, Powell and his co-workers in Bristol, England, discovered another type of meson, heavier than the Anderson-Neddermeyer particle. The particles then came to be known as light (mu) and heavy (pi) mesons. With the addition of the photon—which, like the neutrino, is not a material particle, in that it cannot be identified with any particle that can be observed at rest, but is identified only with radiation and radiant energy—there was, in 1949, a total of 12 known basic particles. The



Caltech colleagues Victor Neher and Carl Anderson check over equipment Neher used in high altitude cosmic ray research in Greenland this summer.

discovery at the University of California in 1950 of a neutral meson brought the total to 13.

But it was nothing like the end. Some four years ago, Rochester and Butler, at the University of Manchester in Great Britain, found in their cosmic ray studies single examples of two new particles. At Caltech Carl Anderson, now no longer one of "Millikan's young men," but with his own group of young men working with him—most particularly Eugene W. Cowan and Robert Leighton—began to run down these particles systematically.

By 1950 the group had proved the existence of the two new particles by finding some 35 examples of them. Subsequently the particles have been found by a number of other researchers. However, not much is known about the two new particles yet. They're still known as V-particles.

Where they fit into our present picture of the elementary particles we don't know. We do know, though, that there is something wrong with our fundamental concept of atomic nuclei. Our ideas about atomic structure, the motion of electrons, the forces that hold particles together in nuclei are going to have to be re-evaluated. It is possible that there may be still other particles in the atomic nucleus.

Carl Anderson and his co-workers are now engaged in an intensive study of the properties of the new V-particles, in an effort to gain a new understanding of elementary particles. Until recently this work has been carried on in two specially-built trailers, fitted out with cloud chambers, which were parked out behind the Aeronautics building on the Caltech campus. Now the trailers are being moved up to Mount Wilson, where there's a chance of getting three times as many of the V-particles, because of the greater intensity of the cosmic radiation at that height.

Another indication of Anderson's intensified research program is the new cosmic ray building, now under construction on the campus, between the two wings of Bridge. Here, Caltech's cosmic ray research work will be concentrated under one roof. A powerful new magnet is now under construction, and will be put into operation when work gets under way in the new building next year.

The fact that Caltech's synchrotron is under construction at the same time doesn't mean it will replace cosmic ray research in attempting to discover the secrets of atomic nuclei. In simple fact, it cannot replace cosmic ray research—nor can any machine yet devised. Some cosmic ray particles have energies up to 10 million billion volts—or a million times more than can be got in Caltech's new synchroton. The synchroton, however, has other important advantages and will complement the studies of the cosmic rays.

Tedium and excitement

Cosmic ray research is one of the most important branches of modern physics. In a way it's the most tedious—and in another the most exciting.

Carl Anderson's been in it most of his life. During the war years he took time off to serve as a rocket expert, and in 1944 he was flown to the European theater to aid in the first installations of aircraft rockets on Allied fighter planes. When the war ended he returned to his studies of cosmic radiation.

These studies have taken him, in some 20-odd years, half around the world—to the top of Pike's Peak, to Panama, in a B-29 up to 40,000 feet. On the record this sounds like the exciting part of the job. On the record the hours—and months, and years—in the laboratory sound like the tedious part. But to Anderson himself it's all as exciting and adventuresome as any exploration in a faraway jungle.

The job is not only all these things though. It is also exceedingly difficult.

"The atom can't be seen," Anderson once said, "yet its existence can be proved. And it is simple to prove that it can't *ever* be seen. It has to be studied by indirect evidence—and the technical difficulty has been compared to asking a man who has never seen a piano to describe a piano from the sound it would make falling downstairs in the dark."

Carl Anderson has been at Caltech since he entered it as a freshman in 1923. He's been Professor of Physics since 1939. The Anderson family—which includes eight-year-old Marshall and two-year-old David—lives in Arcadia. Though he's given up playing much tennis, Carl used to play a good game—modestly claiming he only played for exercise.

Anderson's first medal

Modesty is a habit with him however. When the Institute gave him a dinner at the Athenaeum after he had received the Nobel prize, and public praise was poured on him by everyone present—including Caltech's two other Nobel prize winners, Thomas Hunt Morgan and R. A. Millikan—Anderson took the occasion to tell about the *first* medal he'd ever won.

"I won it for physical achievement, while I was a freshman at Caltech," he explained. "I won it for the improvement I showed. To begin with I was the worst runner, broad-jumper and high-jumper of all, but at the end of the term I finished ahead of two or three of the others—so they thought I had improved so much that they gave me the prize."

The reason for the improvement was simple. When he took the physical achievement test at the start of the year, he was under the impression that it had something to do with ROTC, so he wore his heavy Army shoes. For the test at the end of the year he wore sneakers. The improvement, in comfort alone, was immense.

He's had some other prizes since. In 1935 he won the Gold Medal of the American Institute of the City of New York. In 1936 he was named one of America's Outstanding Young Men—along with Thomas Wolfe, Fred Astaire, Edward Stettinius and Lawson Little. In 1937 he won the Elliott Cresson Medal of the Franklin Institute of Philadelphia, received an Honorary Sc. D. from Colgate University and an LL.D. from Temple University. He is a member of the American Physical Society, the American Philosophical Society, the National Academy of Sciences, Tau Beta Pi and Sigma Xi—of which last he was president in 1948.

He keeps his Nobel award in a bureau drawer, underneath his stiff shirt.

This article is the first in a series of informal biographical sketches of the faculty of the California Institute of Technology