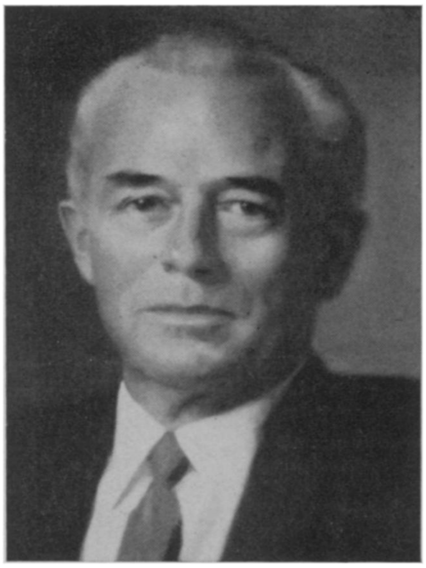


Wright

Pyramid of Chephren beside the Sphynx, scene of cosmic ray search for tomb.

Fifty-six-year search for answers

Mountains enlisted to filter particles that continue to defy understanding

by Ann Ewing

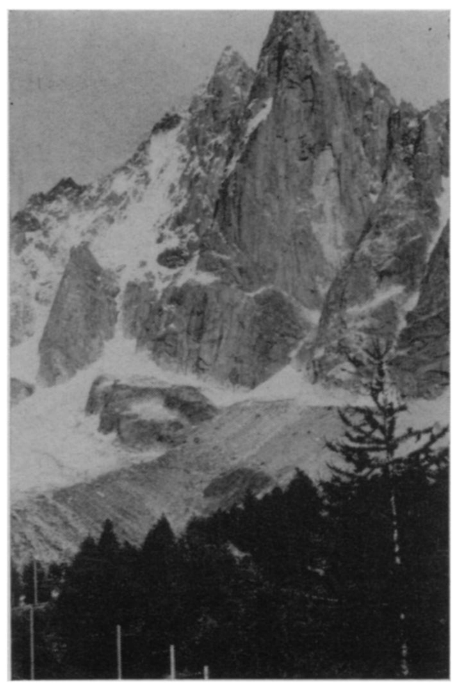
"The results of my observations are best explained by the assumption that a radiation of very great penetrating power enters our atmosphere from above." This was the conclusion of the late Victor F. Hess, based on his measurements of radiation made from a balloon flown over Europe at 13,000 to 16,000 feet on the morning of Aug. 7, 1912.

This statement opened the field of cosmic rays, now prized by the nuclear physicists as an unsurpassed source of high energy particles.

The most powerful rays produced by the world's largest atom smashers are far weaker than the cosmic rays raining everywhere on earth. As many as a hundred invisible particles pass through each square inch of this magazine—and its reader—every minute.

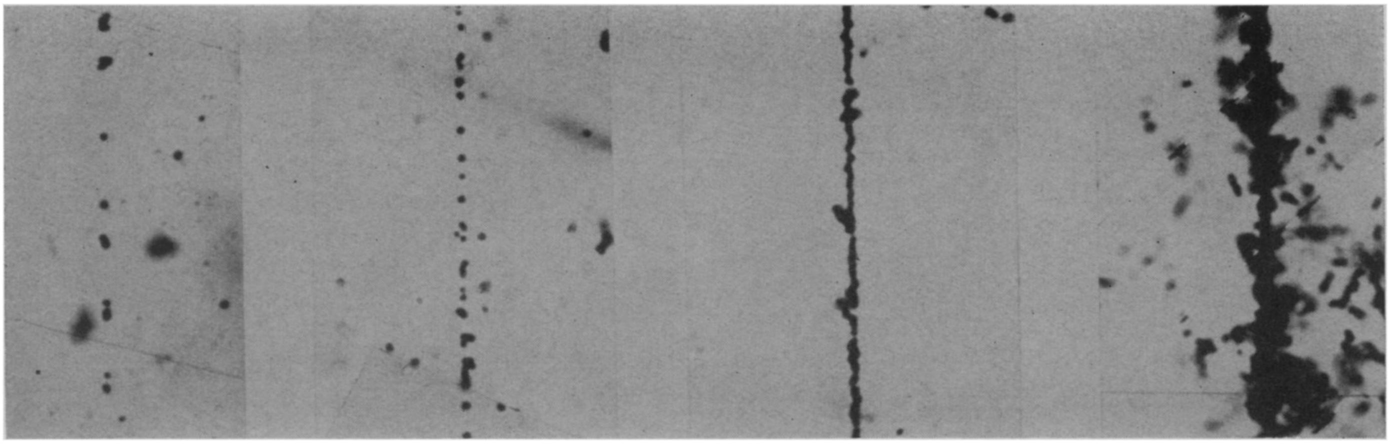
Ever since Hess's first experiment with balloon-borne electroscopes, scientists have been trying to find out where the cosmic rays come from, and how they become so powerful.

Increasingly sophisticated equipment has been brought to the job, and in-



French Tourist Bureau

Mont Blanc: filter for cosmic rays.



M. M. Shapiro, NRL

Hydrogen *Helium* *Nitrogen* *Calcium*

Cosmic ray tracks of various elements through photographic emulsion at the edge of the atmosphere.

creasingly expert experiments performed. Scientists now know more than Hess did. Whole mountains are being enlisted in the search for understanding, and cosmic radiation itself is becoming an archaeologist's tool. But there are still no solid answers as to what it is, or where it comes from.

It has long been evident that most of the radiation being detected within the atmosphere is secondary, resulting from collisions of the primary cosmic radiation with atoms of gas in the earth's atmosphere.

Primary cosmic rays consist of the nuclei of ordinary atoms stripped of their electrons and traveling at nearly the speed of light.

For every 1,000 incoming hydrogen nuclei there are about 150 helium nuclei and 17 of all the heavier ones, which become increasingly more rare as their weight climbs. Nevertheless, the abundance ratio of 17 does not signify a dearth of heavier elements but, on the contrary, a surplus, relative to the general distribution of elements in the universe. Accounting for that surplus is another problem plaguing cosmic ray experts.

One experiment to be started this spring to detect and sort out the higher energy cosmic rays will use Mont Blanc, highest mountain in the Alps, as a filter. Six tons of geiger counters, electronic components and the trucks needed to carry them will be parked in emergency garages at the sides of the highway tunnel linking French Savoy wth Italy's Valle d'Aosta.

The aim is to measure the intensity of cosmic rays that come from low angles above the horizon. Comparison of the horizontal arrival data with vertical arrival measurements which have already been made from deep underground mine shafts will yield important information about the nature of interactions well beyond 1,000 billion electron volts, and possibly help pinpoint a source for cosmic rays.

In a reverse twist of this kind of experiment, cosmic rays penetrating a pyramid will be used to test whether the building has a long-suspected hollow place, a burial chamber within the Chephren Pyramid at Giza.

Detectors have been set up by scientists from Ein Shams University in Cairo and the University of California in Berkeley at one end of a vault carved out of native rock beneath the pyramid. The more rock above these detectors, the fewer the detectable cosmic rays. Three months of observations are expected to show the directions from which the cosmic rays are arriving.

If the pyramid contains a hidden burial chamber, it would show up by the abundance of cosmic rays measured beneath it. Should such a site appear, the detectors will be moved to the other end of the vault where the observations will be repeated. This will give, by triangulation, the exact location of the chamber. U.S. participants returned to the site late last month, after Egyptian physicists on the site had completed test runs and reported the experiments ready to go.

In addition, satellites, both manned and unmanned, are being enlisted in the search for more understanding of cosmic rays. During the Gemini 11 flight in 1966, a record of cosmic ray arrival times was made in a slow-moving emulsion housed outside the space vehicle, then retrieved by Astronaut Richard Gordon during his pioneering space walk.

The tracks in this emulsion are being studied by scientists at the Naval Research Laboratory under the direction of Dr. Maurice M. Shapiro and at Goddard Space Flight Center under Dr. Carl Fichtel. Dr. Shapiro says the major significance of the Gemini findings is that the "important astrophysical information already deduced from earlier work with balloons has been confirmed by these observations above the atmosphere."

What was confirmed in the Gemini experiment is that the ratio of the light elements in cosmic rays—lithium, beryllium and boron—to all the heavier ones like iron is close to 20 percent. Since these light elements are virtually absent from the general abundance of elements in nature, their relative numbers in space provides a measure of the amount of material hit by cosmic rays in traveling from their sources. The lithium, beryllium, and boron are believed to arise as secondary cosmic rays, fragments from collisions.

The amount of material through which these light elements have passed is a clue to their ages, assuming a certain density for interstellar matter, which is mainly hydrogen. The experiments indicate that the average distance traveled by cosmic ray nuclei in their random paths from their sources to earth is as little as a few million light years.

This means they are generated within the Milky Way galaxy and not in far-distant galaxies, as some scientists have suggested.

However, the theory that all cosmic rays are produced in the Milky Way is seriously threatened by the results of measurements that have gradually pushed the upper limit of the cosmic ray spectrum to higher and higher energies. Primary cosmic rays with energies at least as high as ten billion billion electron volts have been detected. Particles of such extremely high energy would be unlikely to remain trapped by the magnetic field of the Milky Way galaxy and would, therefore, be visitors from intergalactic space.