# Research Notes

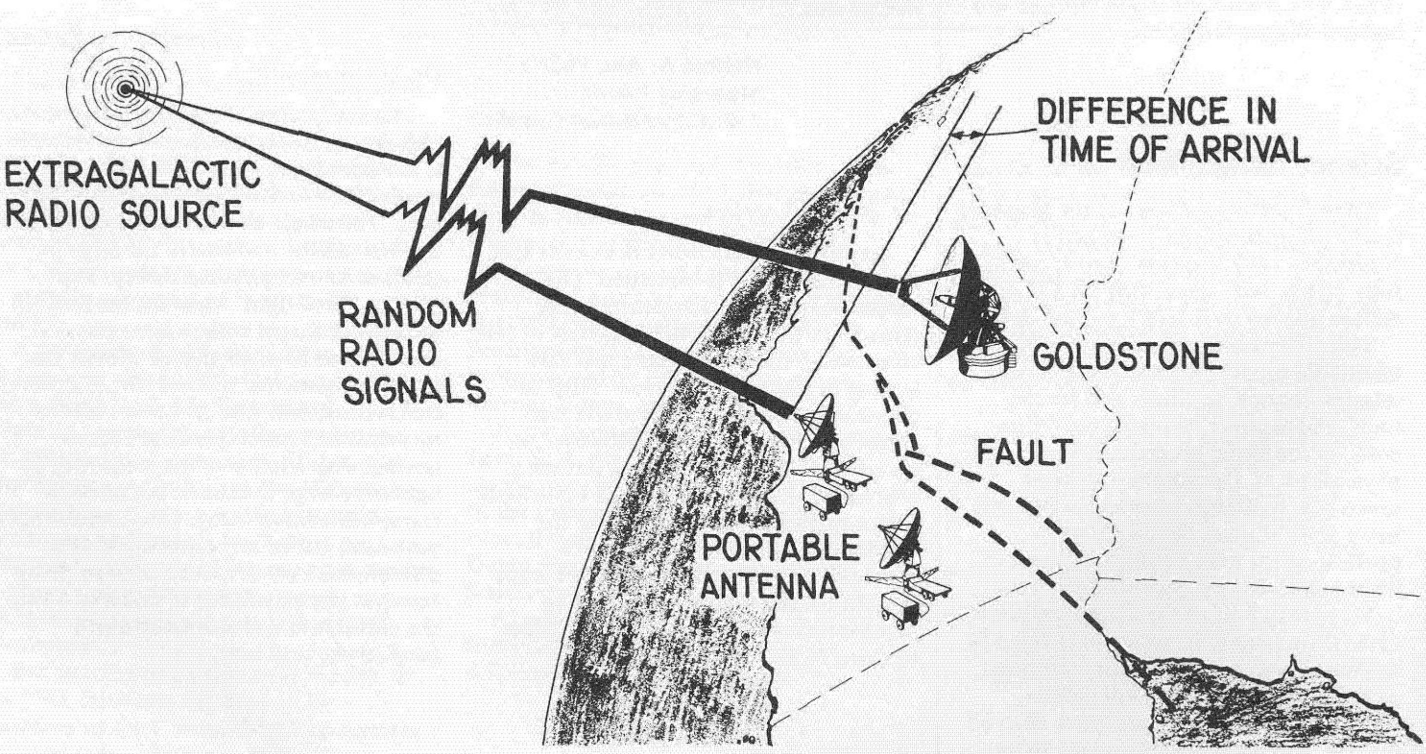
## Quasars and Quakes

A team of scientists and engineers at Caltech's Jet Propulsion and Seismological Laboratories is using quasars to measure movements along the earthquake-prone San Andreas fault. Quasars are so far away that their positions in the sky appear to remain fixed, making them extremely stable points of reference for measurements on earth.

The team includes Peter F. MacDoran, John L. Fanselow, J. B. Thomas, and Donovan Spitzmesser from JPL and James H. Whitcomb, a graduate student in geophysics, from the Seismological Laboratory. They are conducting experiments to test the new technique called ARIES (Astronomical Radio Interferometric Earth Surveying) using 64- and 26-meter-diameter antennas of the Deep Space Complex at Goldstone, near Barstow, California, and a smaller, transportable antenna. Basically the system involves measuring the difference in the time of arrival at two or more antennas of indentical radio signals from the same quasars. High-speed computers are then used to calculate the distance between the antennas, which can be separated by a space as short as a few miles or as long as between continents.

The ARIES concept was given a big boost when experiments in 1971 showed that measurements between antennas as much as 8,000 kilometers apart were accurate to within 1.5 meters. A series of experiments in 1972 with two Goldstone tracking antennas 16 kilometers apart refined the distance-measuring accuracy to 4 centimeters. The goal of the team's research is to measure movements of a centimeter or less along the entire 800-kilometer length of the San Andreas fault.

Measurements of this accuracy are important in determining the true rate of motion and energy buildup along the San Andreas fault—the line of contact

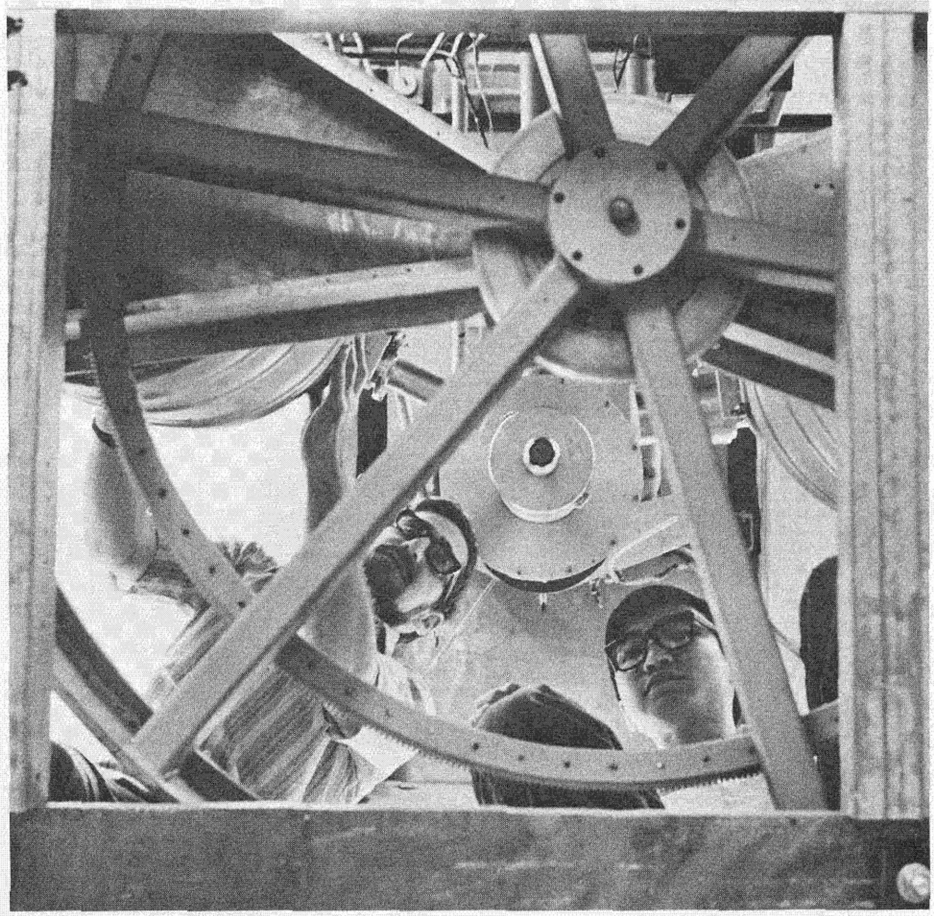



*Using signals received from quasars outside our galaxy, scientists at JPL and Caltech hope to use space tracking antennas positioned along the 500-mile length of the San Andreas fault to help determine its rate of creep—a critical factor in predicting the occurrence of earthquakes.*

between two of the world's major tectonic plates, the North Pacific and the North American. The North Pacific plate is believed to move north relative to the North American plate at 2 to 6 centimeters a year—and it is crucial in the study of earthquakes to know which figure is more accurate. For example, the San Francisco earthquake in 1906 was produced by a 4-meter slip along the San Andreas fault in northern California. Since then, that section of the fault has been moving, storing strain energy. If the rate of storage is 2 centimeters a year, it is not likely that an earthquake the size of the 1906 one would occur until about the year 2100. But if the rate is 6 centimeters a year, such an earthquake could occur at any time.

In order to determine the rate of buildup, geophysicists have developed a number of techniques to study motions near and across fault lines. They are accurate only for distances up to about 40 kilometers because the systems are line-of-sight limited; that is, they cannot measure beyond the horizon. Measurements of motions over several hundred miles of a fault as long as the San Andreas have been calculated by adding short measurements together. But this method gives inconclusive information about fault movements because of the effect of accumulated error in connecting the short line of-sight measurements.

ARIES, its developers believe, provides a good way of accurately measuring motions between points several hundred miles or more apart. They would like to start by using five or six movable dish antennas in conjunction with one of the large-diameter Goldstone dishes. The movable dishes would be set up on a network of reference points in California and the western United States. By making measurements of the distance between antennas at least once a year it should be possible to determine the general character and scale of the motion along the San Andreas fault in two or three years. Several extragalactic sources would be used as reference points: three quasars, 3C-273, 3C-279, and 3C-345, each of which is apparently about a billion light years away; and two quasar-like radio galaxies, 3C-120 and 3C-84, which are about 100 million light years from earth.



*Eri Cohen and N. K. Cheung work to position delicate particle detectors close to the base of a supercold "dilution refrigerator." The device is being used to test various aspects of the symmetry rule of physics.*

## Deep Freeze

The coldest place on the Caltech campus may no longer be the low temperature physics laboratory where researchers bring substances to within a few degrees of absolute zero. An even colder place is inside the specially designed "dilution refrigerator" in the nuclear spectroscopy laboratory of Felix Boehm, professor of physics.

Boehm—with Eri Cohen, research fellow in physics, and graduate student N. K. Cheung—uses the refrigerator to maintain radioactive nuclei at temperatures just a few tenths of a degree above absolute zero in a very strong magnetic field. In a 10-foot-high tapered cylindrical chamber, liquid nitrogen is used to insulate helium while it is cooled from a gaseous state to a liquid state about one degree above absolute zero. Cooling to the necessary few tenths of a degree above absolute zero is done by diluting one isotope, helium-3, by another isotope, helium-4, in a mixing chamber at the tip of the tapered cylinder. An iron disk about a fourth of an inch in diameter, impregnated with radioactive material, is introduced into this chamber and cooled to the proper temperatures. The system is set up to allow the experimenters to position instruments closer to the radioactive source than in other similar devices, which cuts down the amount of error.

Boehm, who was one of the first to discover the breakdown of the left-right symmetry in the weak interacting nuclear forces, is using the device to test another aspect of the symmetry principle—that of time-reversal invariance; that is, whether the physical laws governing a subatomic event would be invariant whether the interaction is run in reverse or not.

## Moving In On Neurons

Gilbert McCann, professor of applied science, has developed a new technique that should accelerate research on the brain and nervous system.

For many years scientists have studied the brain and nervous system in a variety of organisms—from insects to man—by studying the unit common to them all, the nerve cell or neuron.

These studies have yielded a good deal of important information, but no basic understanding of how the brain works will emerge until we learn more about the function of neurons as an integrated system.

This is not easy to do. The human brain and nervous system contain billions of neurons. Even the nervous system of the common housefly has about 1,500,000 neurons of about 350 different kinds. Until recently, it has been possible to study only about 10 of these different classes of neurons at one time. With the new concept he has developed, McCann has now studied, recorded, and analyzed 108 of the 350 classes of neurons in the housefly.

Using an on-line computer, McCann can record and analyze electrical impulses from the neurons in a living fly. Microscopic glass or steel electroprobes, linked by hair-thin wires to the computer, are inserted near a neuron. Usually several microprobes are used at the same time in one area. The computer's cathode ray tube shows the impulses emitted as a series of sharp waves or "spikes." Each variety of neuron has its own characteristic spike pattern. The computer sorts out each spike "fingerprint" from the jumble of signals that are recorded on magnetic tape and displays three-dimensional graphs on a cathode ray tube. The computer can change the orientation of the graph, using the dimensionality of the picture to help separate the spike patterns.

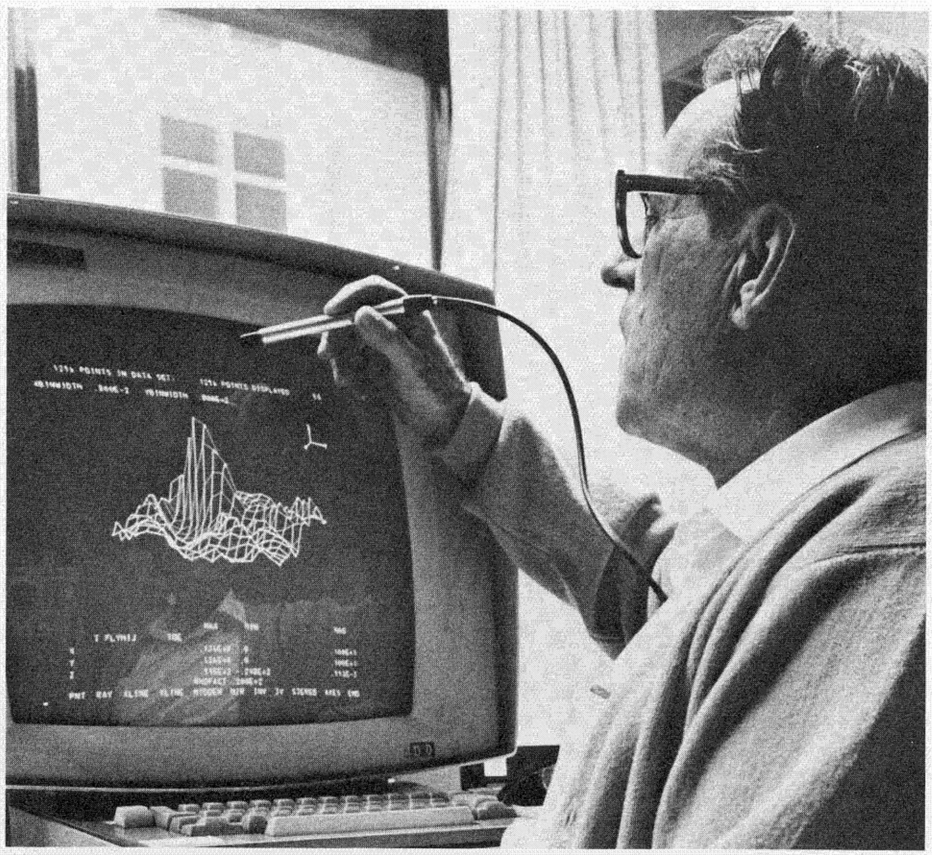
Once this is done, the spikes can be classified according to the type of neuron that emitted them. The computer's memory has a store of characteristic neuron-spike firing patterns recorded in response to test stimuli or visual patterns that represent each of the different neuron classifications. Matching the neuron's "handwriting" with that of one from the memory bank completes the classification.

The system allows a researcher at any time to quickly insert a substitute experiment to clarify new data or follow a new lead, or to design complex experiments that require computer modeling.

A particularly important function made possible by the system is to inhibit the activity of selected neurons to determine the effects on nervous-system functions. This activity of the computer is vital to a complete understanding of the principles of intelligence.

One of the most frustrating problems in studying a living nervous system is that you destroy it if you take it apart piece by piece for analysis. The new technique makes it possible, in effect, to take a nervous system apart without permanently altering it.

The research is supported by the National Institutes of Health.



*Using a light pencil and a computer terminal screen, Gilbert McCann, professor of applied science, alters a three-dimensional graph of a spike pattern that represents signals from a single neuron of the one and a half million present in a fly's brain. McCann has designed a computer system that can analyze and "fingerprint" these neurons.*