Research Notes

Reports on recent developments in seismology, computer programming, and information science at Caltech.

PREDICTING CREEP

Caltech seismologists have now successfully predicted ground movement along a major earthquake fault—thus coming one step closer to the prediction of large earthquakes. Max Wyss, a graduate research assistant in geophysics, and Stewart W. Smith, associate professor of geophysics, have discovered that episodes of movement along a restless section of California's San Andreas fault occur at regular intervals. The motion they are studying is called "creep," the gradual movement that may occur along a fault, usually over a period of several days—not the sudden, violent displacement associated with earthquakes.

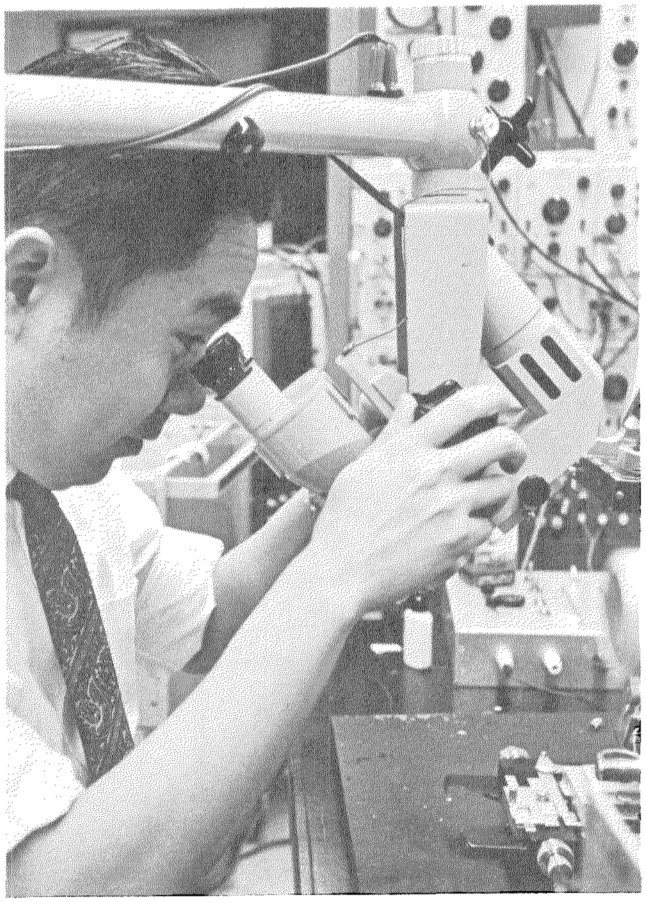
Wyss predicted early last summer that the section of the San Andreas fault near the town of Parkfield would show creep on August 15. It actually occurred within a week of the time specified. Calculations also indicated that creep would occur again around Christmas Day. This prediction was only accurate to within three weeks due to a small error in a field report. The creep occurred in the first week of December. The seismologists have now forecast that the fault will move again about April 8.

The San Andreas fault is a deep fracture in the earth's crust that extends diagonally 600 miles across California from the Mendocino County coast southeast into the Gulf of California. Land on the west side of this crack has been moving north in relation to the eastern side at about two inches per year for millions of years. The stress created by this movement—and the sudden release of such stress when rock layers break and slip—results in earthquakes.

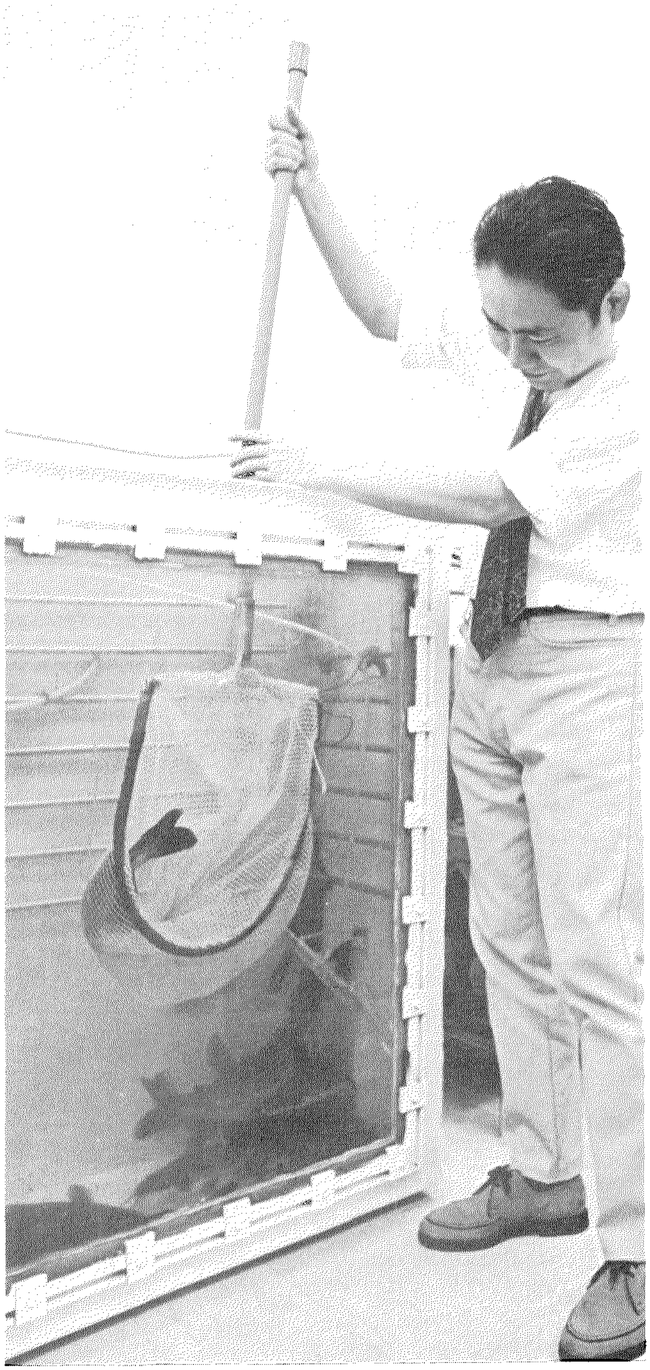
The creep that Wyss and Smith are observing began with an earthquake of 5.6 magnitude two years ago. Since then the western side of the fault has moved north 25 centimeters in relation to the eastern side. This movement has become very regular—about two millimeters every few months. In the Parkfield area the fault is an extremely weak, low-friction surface, much weaker than the surrounding rock. This can explain the high concentration of seismic activity along the narrow zone.

In monitoring the earthquake that occurred near Parkfield in 1966 it was observed that, after the main shock, slow slippage of the fault began to occur. Slippage along the fault during the tremor must have been much greater below than at the surface. All the evidence points to a buried fault that underwent a considerable amount of slip. Little or no slip occurred in the surface layer during the earthquake, but substantial slippage occurred over the next few months. This suggests a causal relationship between the earthquake and the creep that followed it. Since the main shock didn't cause immediate slippage on the surface, the layer between the deep region and the surface became highly stressed. The response at the surface has been fault creep.

Wyss and Smith have noted not only that the creep episodes occur at very regular intervals but that each interval is a precise amount of time longer than the preceding one. The amount of creep in each episode is less than one-tenth of an inch and accumulates over a period of up to five days. This amazing regularity makes it possible to predict with confidence the occurrence of creep.



Ken-Ichi Naka tests the catfish eye for reaction to light.



Naka's office equipment includes a unique feature—an aquarium stocked with research subjects.

THE EYE OF THE CATFISH

The study of living nervous systems through the use of high speed digital computers is one of the major research projects in Caltech's information science program. Because the visual system is the most important subset of the entire nervous system, a primary emphasis of the study is the examination of visual systems of various creatures—flies, frogs, crayfish, pigeons, and humans. Now a new subject has been added to this list—the common catfish—which is ideal for this research because it has a relatively simple eye.

In these experiments Ken-Ichi Naka, research associate in biology and applied science, removes the iris from the eye of the fish and implants submicroscopic glass probes (1/50 of a micron in diameter) into the retina. Then, by flashing lights at the eye, he tests the responses of the different types of retinal cells to various light intensities, patterns, and colors. The information is transmitted to the computer as the experiment proceeds and is stored for future analysis.

There are three major layers of sensory cells between the retina and the optic nerve, which connects with the brain; the rod-and-cone, the S-cell (horizontal-cell), and the ganglion layers. Naka is especially interested in the horizontal cells, which lie between the other two. The evidence he has found indicates that these S-cells are intermediaries between the rod-cone cells and the ganglion cells, and modify the responses of the other cells according to the light conditions. He has discovered that the voltage potential of the S-cells (which are relatively large compared to the other sensory cells) varies according to the intensity of light that is flashed to them from the retina through the rod-cone cell layer. The S-cells, connected to the other layers by hunderds of neurons, communicate basic information to the ganglion layer—information about average light levels, movement, patterns, and other light conditions.

In this way these cells act as a warning signal to the other cells about changes in brightness, allowing the other cells to adapt their receptor sensitivity. This is a function similar to that of the iris; however, the S-cells respond much more quickly than those of the iris.

The next step in Naka's studies will be to observe two layers of sensory cells simultaneously in order to learn how the S-cells modify the signals from the rods and cones. Eventually he intends to probe several points of sensory systems simultaneously.

THE COMPUTER LEARNS ENGLISH

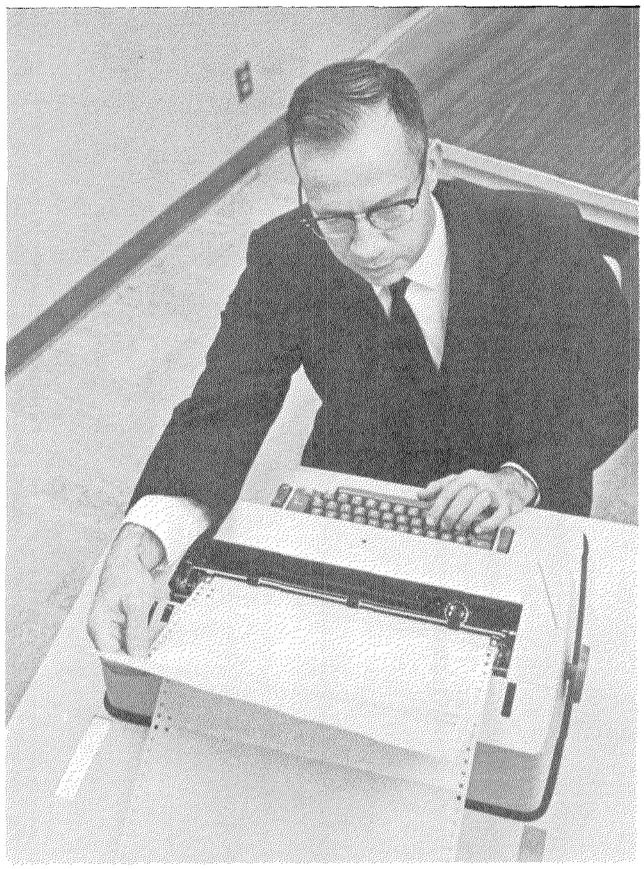
It used to be that the only people who could communicate with computers were those who had mastered a special language like FORTRAN or CITRAN. Now Frederick Thompson, professor of philosophy and applied science at Caltech, is breaking this communications barrier with a new system that makes it possible for everyone from businessmen to high school students to talk to computers in ordinary English.

Dr. Thompson and his colleagues in the project—Peter C. Lockemann, senior research fellow in engineering; and Bozena H. Dostert, lecturer in humanities and an associate scientist in information science—call the new system the Rapidly Extensible Language (REL) system. As in other systems, communication with the computer is through ordinary electric typewriters tied to the computer over the telephone lines. But in the REL system the user simply types his questions to the computer in English. REL understands almost all English constructions, including verbs, tenses, and subordinate clauses. Of course the ability of the machine to answer still depends upon what information is stored in its memory. If it doesn't have the answer, it informs you of that fact.

One of the most important aspects of REL is its ability to rapidly extend the informational capabilities of the computer. In other systems new information must be processed from cards and tapes at the computing center in order to be available. In the REL system the computer can be provided, directly from the console, with new facts and definitions of new concepts which can be used immediately—and stored for future use as well.

To demonstrate his new system Dr. Thompson is using some 60 basic facts about 144 countries of the world—including population, gross national product, working-age population, life expectancy, defense expenditures, unemployment, number of physicians, and TV and radio distribution. From this data base a myriad of questions can be answered—questions as complex as, "What underdeveloped American nations have a ratio of industrial employment to working-age population of less than one-tenth?"

Vast archives of social and economic data that is now available in forms readily understood by computers could, through the REL system, be obtained by anyone who can ask a question in the English language. With REL other bodies of data—voting records of congressmen, census figures, stock market records, sports statistics—would be as accessible as the services of the public library.



Frederick Thompson experiments with his new Rapidly Extensible Language system on the computer console.