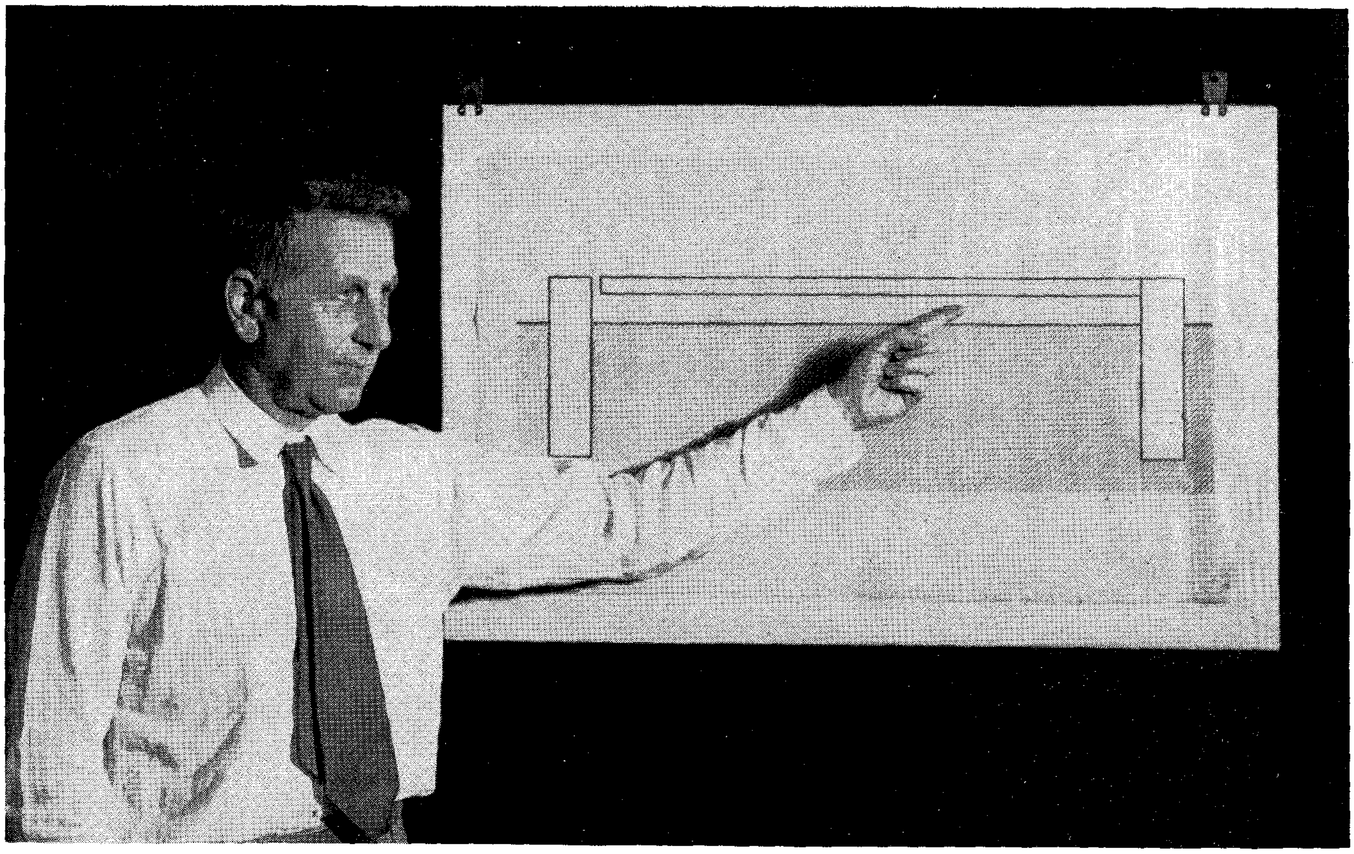

*Hugo Benioff and schematic drawing of his linear strain seismograph which measures squeezing and stretching in earth's crust. Instrument consists of two piers sunk in rock, almost—but not quite—joined by 100-foot fused quartz tube.*

# EARTHQUAKES

**Seismologists move a step closer to one of their elusive goals: earthquake forecasting. They've designed a sensitive new instrument to measure the strains in the earth's crust that produce quakes.**

THE CALTECH SEISMOLOGICAL LABORATORY will start construction of a sensitive new seismograph this fall, designed to record strains in the earth's crust of the order of one part in 100 million. Roughly, this means it should record a 1/1000th-of-an-inch compression in two miles of rock—or a one-inch squeeze between the Atlantic Coast and the Pacific Coast.

The instrument will be used primarily to record and measure secular (or long-term) strains in the earth's crust which produce earthquakes. This will be the first attempt anywhere at precise measurement of these strain patterns. If the experiment is successful the foundations of the science of seismology will be strengthened. At some distant date (maybe even centuries from now) these measurements—combined with the kind of intensive study that the Seismological Laboratory launched on the 1952 earthquakes in Kern County (*E&S*—October 1952)—may bring seismologists within reach of one of their elusive goals: earthquake forecasting.

Dr. Hugo Benioff, Professor of Seismology, has been awarded a $10,200 grant by the Geological Society of America for development and construction of the new instrument, which is known as a secular linear strain seismograph.

Secular strains, unlike the short-duration strains created during earthquakes, may take years or centuries

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to develop. Such strains, for instance, have been building up along the northern portion of California's great San Andreas Fault since the 1906 San Francisco quake, and along the southern portion since the Fort Tejon quake of 1857. These are the strains that lead Caltech seismologists to expect the fault to slip again some day in the indeterminate future.

Secular strains accumulate when the two faces of a fault—a dynamic fracture in the earth's crust—lock by friction or "cementing" along the fault line. When enough strain energy is stored in the crustal rocks so that the resulting force breaks the obstruction, a vast, abrupt movement of rock masses occurs—in one direction on one side of the fault, and in the opposite direction on the other. This is an earthquake.

So far no instruments have been set up elsewhere to measure secular strains. The Benioff linear strain meter is intended to provide precise information on the amount of squeezing or stretching over a wide area. It will be installed in an abandoned tunnel in the San Gabriel Mountains near Big Dalton Reservoir, about 5 miles northeast of Glendora—and about 25 miles from the San Andreas Fault. The tunnel, which extends for more than 100 feet into the granite mountainside, is the property of the Los Angeles County Flood Control District. It was originally bored to determine the nature of the rock structure to which Big Dalton Dam was to be attached.

## Seismograph network

If tests with this new instrument are successful, Dr. Benioff hopes eventually to establish a network of such meters throughout central and southern California. Recordings from the network would make it possible to get an overall picture of the strain pattern and its development in the area.

Seismologists then may determine the source of the basic stresses causing earthquake-producing strains. They would still not be able to predict when or where an earthquake may occur—although they would move a step closer to that distant possibility. When they have enough data to determine the amount of strain in a particular area and sufficient earthquake history to know at what strain level the fault slips, according to Dr. Benioff, it may be possible to estimate roughly when a quake can be expected. This, however, will require decades—maybe centuries—of study.

The new instrument also will be used to measure tidal strains of the earth produced by the gravitational attraction of the sun and moon. These bodies cause a slow throbbing or ground swell, just as they cause ocean tides. The period of the swell, like that of the tides, is about twelve hours. In other words, the earth's crust is pulled slightly out of shape, reaches its maximum distortion and returns to its original position over a period of one-half day.

Geophysicists have been able to determine tidal *movements* of the solid crust—finding, for instance, that the earth pulsates about eight inches at the equator—but not the tidal *strains*. These are the squeeze and stretch which produce such movements. Knowledge of the amount of tidal strain will give geologists a better idea of the structure and rigidity of the earth.

## Extending the range

A third purpose of the linear strain meter is to measure and record long-period seismic waves beyond the range possible with existing instruments. Such waves are generated by large earthquakes. An early Benioff strain seismograph recorded long waves from the 1933 Japanese quake with a period of three to four minutes and later registered some with a seven-minute period from the 1950 Assam quake. Longer period waves may exist but cannot be recorded with existing instruments.

Waves of these periods provide information about the nature of the faulting at the epicenter and may indicate the duration of the processes at the source as well as the extent of faulting. They also may reveal facts about the structure of the earth's mantle down to 600 miles or more below the surface.

The new instrument will be a modification of existing ones at the Seismological Laboratory in Pasadena and at its auxiliary station on Palomar Mountain (*E&S*—November 1951). The existing instruments are designed to measure only shorter-term squeezing and stretching of the earth's crust, observed during earthquakes and their aftershocks.

## Far from the madding crowd

The tunnel site will remove the new strain meter from human disturbance. (A person standing on the floor of the Laboratory in Pasadena squashes the granite bed below the building enough to record on the instrument there). Furthermore, the new meter will be well protected from temperature change. It will be made of fused quartz, which responds less to temperature variation than the steel used in earlier models at the Laboratory. And, in its tunnel location, temperature will vary less than one degree throughout the year.

The new meter will consist of a 100-foot length of two-inch fused quartz tubing rigidly fastened to a pier sunk in the rock. It will be held up by a number of flexible supports. Mounted on another pier at the free end of the tube will be specially designed electronic apparatus to measure displacement of that end with respect to the pier.

If the instrument is proved in the forthcoming test and the findings of a network of such machines are backed up by a wealth of tediously-acquired earthquake history, then it may be found that earthquakes, like all future events, may cast a *recognizable* shadow before them.