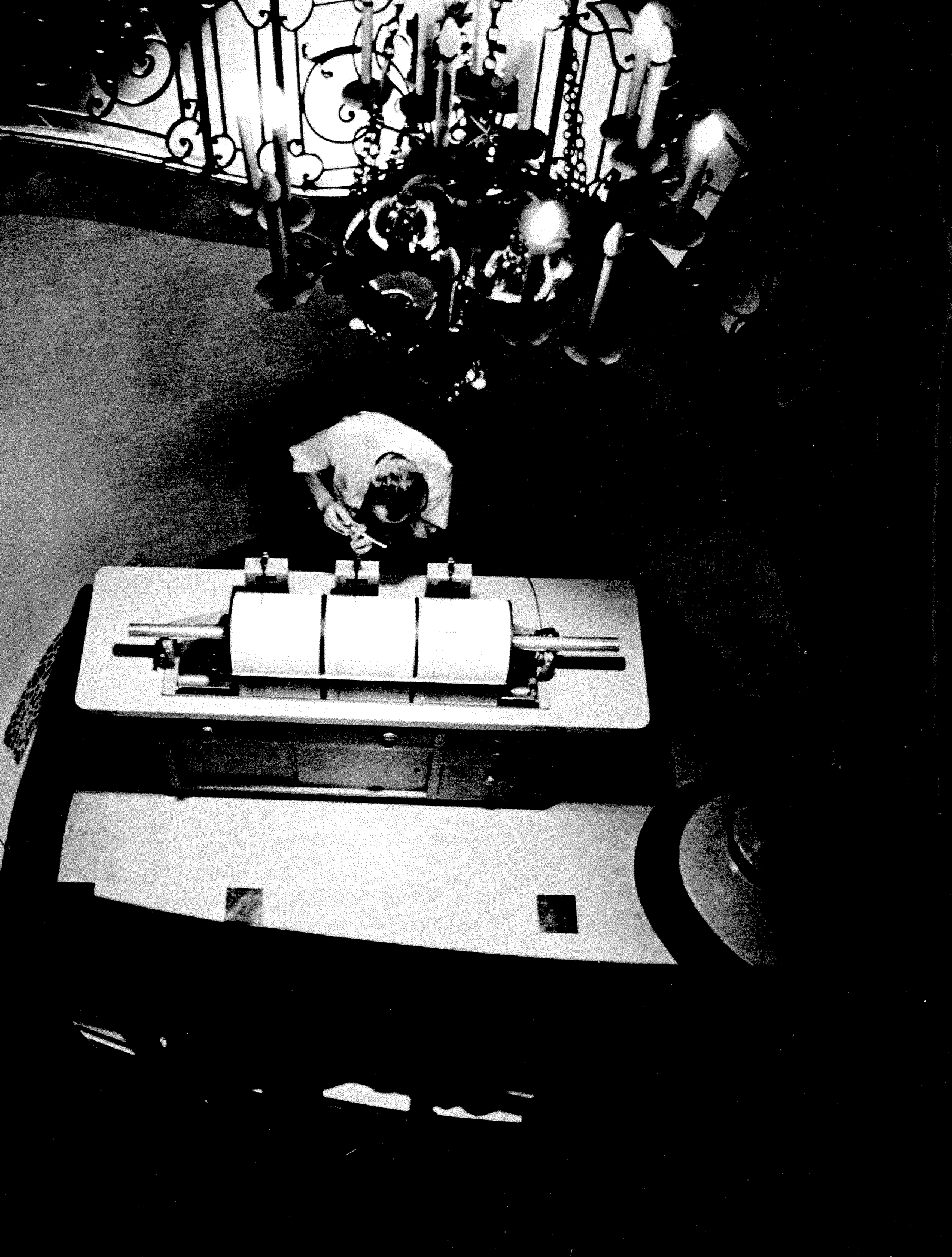


The Seismological Laboratory: Past and Future

DON L. ANDERSON

Moving into new and elaborate quarters is usually a matter of unqualified joy and anticipation. But anyone who has ever visited Caltech's Seismological Laboratory on North San Rafael Avenue will understand the mixed feelings with which the staff, students, and faculty recently left their home of 17 years.

With its long-time traditions, marble floors, paneled work areas, grand vistas, beautiful gardens, and private tennis court, working there had all the amenities of living in a mansion—including individual fireplaces and, at one time, private richly appointed bathrooms for each professor.

Slowly, however, the mansion was converted to more utilitarian scientific purposes. The sunporch and dressing room, originally attached to Hugo Benioff's office and complete with cedar closet and jewelry safe, were made into office space for Charles Archambeau and Hiroo Kanamori. The bathroom connected to Frank Press's office (formerly the master bedroom) was transformed into an office for a research fellow and a mathematician. Charles Richter's bathroom became a repository for reprints and journals, and Beno Gutenberg's bathroom became the ladies' room. A servants' bathroom became a student's office. At the end, of all the bathing facilities only the Director's shower remained, and many visitors were surprised to see a steady stream of tennis players in and out of his office around noontime.

Part of the inner patio was covered over to become the computer room. The kitchen was converted into a drafting room, and most of the larger closets became students' offices. The billiard room became a record-reading room. The walk-in silver safe in Clarence Allen's office was made into a storage vault for our ever expanding reprint collection. The garage became a high-pressure laboratory. Finally, we simply ran out of space. Even the hallways were full of seismic records and library overflow.

The environment, in fact, as well as the people, made the Seismological Laboratory a unique scientific facility—one to which many generations of geophysicists feel a great attachment. It provided an intellecually comfortable atmosphere that was conducive to productive thinking.

But its quarters and atmosphere were not the only unique aspects of what we now call—nostalgically already—the "Old Lab." In some respects it was a very high-class intellectual club. The students and faculty of the Seismological Laboratory have always formed a coherent group. The cohesion was partly an accident of history, the splendid setting of the Laboratory, and the common or intertwined research interests. Students have always been considered and treated as junior colleagues, differing from the faculty only in their experience and responsibilities. A strong *esprit de corps* exists, and there is some trepidation that this spirit cannot be transferred to our new surroundings. Our alumni in particular, who have gone off to more conventional environments, view the move as the end of an era rather than the beginning of one. I suspect they are all believers in Parkinson's laws.

Additionally, the staff and students of the Seismological Laboratory have always had a special responsibility to the public. Earthquakes (real or imagined), sonic booms, and announced or "felt" underground tests by the AEC generate floods of telephone calls from the press, the general public, and concerned public officials; and all of them must be dealt with promptly and diplomatically regardless of the press of other business.

In this sense we are a branch of the public relations office. This is a full-time responsibility since earthquakes occur during the night, weekends, and holidays, as well as in normal working hours. Even when things are quiet, records must be changed on the seismographs every day, and portable instruments must be ready to move on short notice. The financial and personnel ramifications of these responsibilities are obvious.

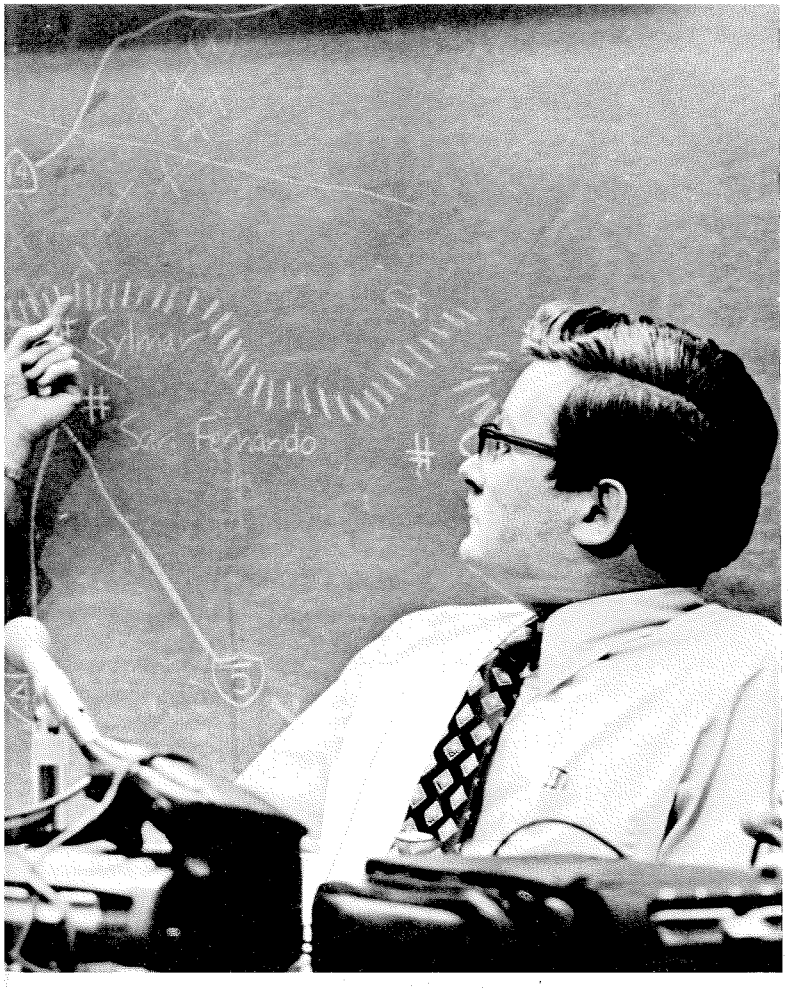
Even if we wanted to, we could not immerse ourselves completely in scholarly contemplation. This is "earthquake country," and the public wants, and needs, to know the information that exists only at our Lab—and this must be made available instantly. Students burning the pre-midnight oil are often the only immediate contact that a media representative has when he calls up to demand an interview for the 11 p.m. news regarding a 10:45 p.m. earthquake. Students mature quickly under this kind of pressure, and Caltech depends on them to give out accurate information and advice.

Since the Seismological Laboratory has been located off campus for so many years, many people are not aware of its activities or origins, except for what they read about in the newspapers or see on television. In fact, it is fair to say that local reporters and newscasters are more familiar with the environment at the old Laboratory than are most Caltech faculty. On the occasion of the dedication of the Seeley G. Mudd Building of Geophysics and Planetary Science, therefore, it seems appropriate to describe what the Seismological Laboratory is all about and where it is going.

The establishment and prospering of seismology and geophysics at Caltech are due in large measure to the vision and support of such men as George Ellery Hale, Robert Millikan, John P. Buwalda, Lee DuBridge, and Robert P. Sharp, all names well known to the Caltech community. (It is apparent that the importance of the study of earthquakes has been, and still is, recognized by astronomer, physicist, and geologist alike.)

One response to an earthquake is the invasion of the Seismological Laboratory by representatives of the media requesting information and reassurance from the experts, who in this case are . . .

The origins of the present Division of Geological and Planetary Sciences can be traced to Hale's desire to interest possible donors in giving money to build a Seismological Laboratory. He was motivated to secure funds for a central station for seismology in Pasadena by new instrumental developments which "seem to open up an entirely new field of research in geology, and may well be epoch-making in the development of that science." In his search for funds he concluded that "the only way in which an effective appeal can be made, however, is to plan a Department fully comparable in importance, both for advanced study and research, to the Departments of Physics and Chemistry; and donors would be especially attracted by the possibility of developing seismological research as a vital factor of the Department's study of the geology of Southern California."



These quotes are from a letter dated June 8, 1924, from Hale to John C. Merriam, president of the Carnegie Institution of Washington. Hale offered the cooperation of Millikan, and faculty members S. J. Barnett, A. A. Michelson, Paul Epstein, Harry Bateman, Richard Tolman, and A. A. Noyes, who could be called upon to conduct advanced courses and research in various branches of geophysics and the underlying mathematical problems. The division was established in 1926.

The Seismological Laboratory itself was founded in 1928 as a result of a 1921 study by the Carnegie Institution of Washington, a study based primarily on a 1916 report of H. O. Wood (at that time of the Hawaii Volcanic Observatory staff) on the desirability of establishing a network of seismic stations in southern California. Wood was placed in charge of the program and given the title of Research Associate, which he retained until his retirement. Wood's success in starting this program was helped considerably by the enthusiastic support of Hale, who was then director of the Mount Wilson Observatory. R. A. Millikan was a member of the Carnegie Advisory Committee and contributed to the establishment and maintenance of the headquarters at Pasadena.

In 1929 the Advisory Committee sponsored a conference at Caltech involving the ablest men working in seismology both in this country and in Europe. They were invited to evaluate the Carnegie program and chart the future course. The conference included Wood, Beno Gutenberg, Charles Richter, Hugo Benioff, Perry Byerly, James Macelwane, Sir Harold Jeffreys, and L. H. Adams. Shortly thereafter Gutenberg was brought to Caltech to work at the Seismological Laboratory, which was then still a Carnegie Institution endeavor with tenuous attachments to Caltech. Caltech provided the facilities, and Carnegie supplied all the funds and people.

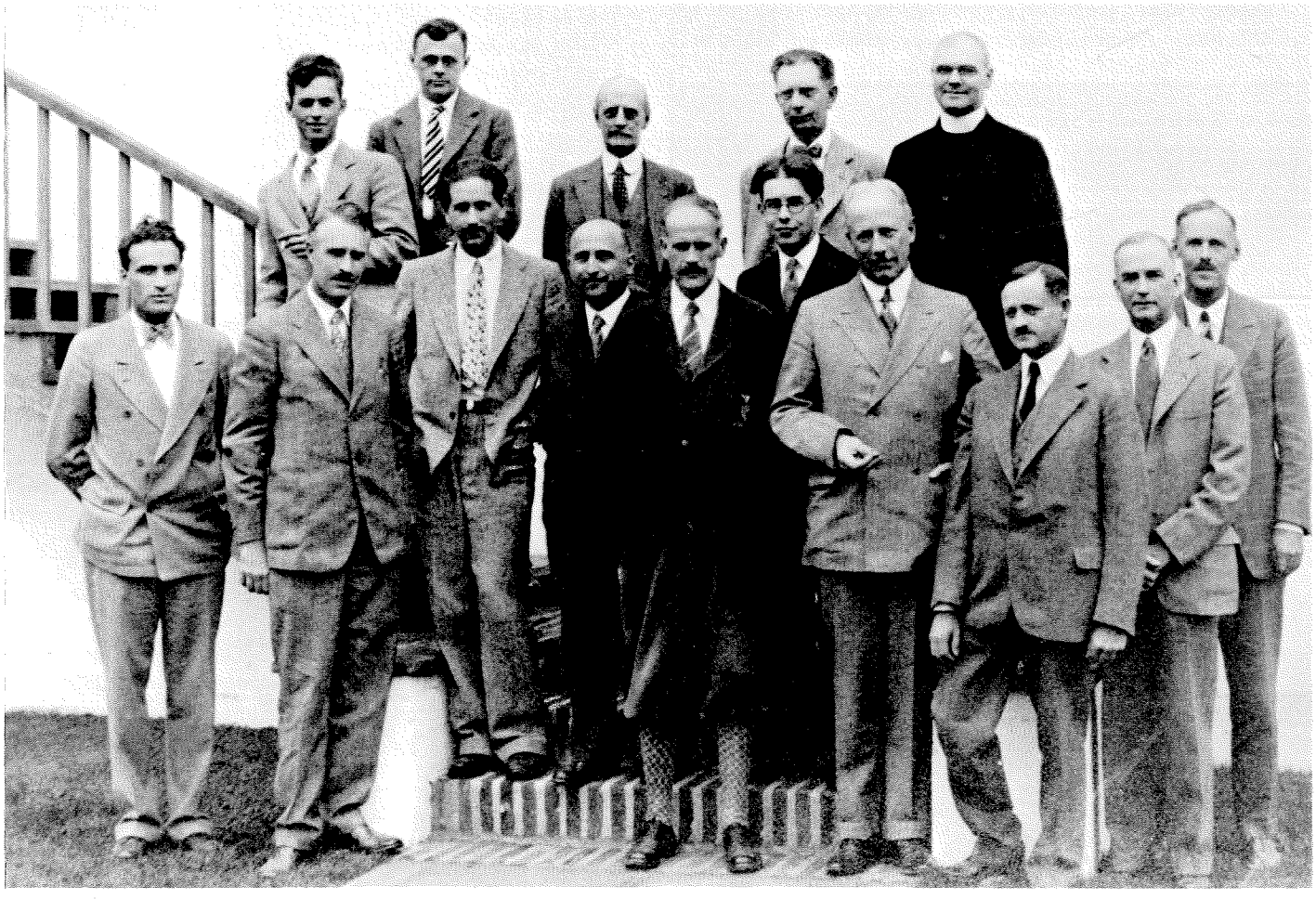
In the same year John Buwalda proposed to Millikan that half the staff of the Laboratory should be members of the Division of Geology (and Paleontology in those days). A new cooperative plan was worked out whereby the Lab

. . . Clarence Allen and Don Anderson. They are explaining what happened, and where, on February 9, 1971—and they're the first to credit everyone else at the Lab for turning out to help in the emergency.

was administered by a local joint committee of Caltech and Carnegie under the general direction of the Advisory Committee in Seismology. It was operated in this way by a committee of four from 1931 to 1937, at which time the administration was turned over to Caltech and Gutenberg was placed in charge. Carnegie decided to withdraw gradually from the operation and support of the Laboratory, but the general operation was still supervised by a committee in which Carnegie played a strong role.

In 1940 Millikan, Buwalda, and Vannevar Bush (then president of the Carnegie Institution) agreed that Gutenberg should be appointed executive officer of the Laboratory. He was named director in 1947 by Lee DuBridge, the new president of Caltech. Under Gutenberg's stewardship Pasadena became the world's center of seismological research.

By 1957 the staff had expanded from its original 4 to more than 20, and Robert Sharp, then chairman of the geology division, somehow managed to arrange purchase of an estate adjacent to the headquarters on San Rafael Avenue. This estate was complete with a 160-foot tunnel in bedrock in which to install seismic instrumentation, including Benioff's latest quartz strain meters. The two-laboratory setup—the original building renamed Kresge and the new one called Donnelley—continued to house the Seismological Laboratory until the recent move to campus.



These world authorities met at the Seismological Laboratory in 1929 to consider the status of seismology and to map worldwide research projects. Front row (left to right): Archie P. King; L. H. Adams; Hugo Benioff; Beno Gutenberg; Harold Jeffreys; Charles F. Richter; Arthur L. Day; Harry O. Wood; Ralph Arnold; John P. Buwalda. Top row: Alden C. Waite; Perry Byerly; Harry F. Reid; John A. Anderson; Father J. P. Macelwane.

Gutenberg retired as director in 1957, and Frank Press (now chairman of the Department of Earth and Planetary Sciences at MIT) was named the second official director of the Laboratory.

The publication record of the Laboratory really started in 1916 with H. O. Wood's two papers entitled "California Earthquakes—A Synthetic Study of Recorded Shocks" and "The Earthquake Problem in the Western United States." It was this latter paper that was to form the basis for the long-term plans which led eventually to the creation of the Seismological Laboratory and the network of seismic instruments. The Laboratory's techniques, procedures, instruments, and magnitude scales were adopted by the ever growing international community of seismologists. By 1940 the number of publications of the Laboratory had grown to 88; there were 170 by 1950; 370 by 1960; and 640 by 1970; and there are now in excess of 850. The published output has doubled approximately every ten years since 1935 and now includes contributions in lunar and planetary science, tectonics, behavior of materials at high pressure and temperature, and most other branches of geophysics.

Much of the present research at the Laboratory involves subdisciplines that did not even exist at the time of the move into the Donnelley Laboratory 17 years ago, or even in the transition period of the Gutenberg and Press eras. Some did not even exist at the time I became director in 1967. These subdisciplines include terrestrial spectroscopy, the study of the free oscillations of the earth after a great earthquake; strain and tilt seismology (long-term or permanent deformations of the earth); optical ultrasonics; solid state geophysics (the study of the properties of rocks and minerals at high temperature and pressure); lunar and planetary seismology; the science of synthetic seismology; plate tectonics; earthquake prediction (an old term but only recently a respectable science); dilatancy; earthquake physics (as opposed to earthquake mechanics or phenomenology); and inversion theory. Previous work such as development of wave propagation and dislocation theory, locations of earthquakes, and local and global tectonics, of course, continues.

Alumni of the Seismological Laboratory have dispersed across the country and around the world to start or strengthen geophysics departments in many universities. Recent graduates are on the professorial staffs of Harvard, Princeton, MIT, Columbia, Stanford, UC Berkeley, UCLA, UC Riverside, the University of Washington, Pennsylvania State, the University of Colorado, and the State University of New York.

All of these universities have outstanding programs in geophysics and, in fact, along with Caltech include the best departments or groups in the country. Other graduates have started programs in France, Chile, Turkey, and Israel. In recent years many of our graduates have gone into industry and to research labs in the U.S. government, most notably to the U.S. Geological Survey, which is in charge of the national program in earthquake prediction.

What does the future hold? Two articles in this issue explore the expansion of the Caltech Seismographic Network (the next step in monitoring southern California on the scale required for eventual earthquake prediction) and the anticipations of the new shock-wave facility. Other articles explain how more and more information about the earth and the earthquake source is being obtained from seismograms and the ultralong-period motion associated with faulting.

Space is too short to even itemize, much less detail, all the other research projects being undertaken by the staff and students of the Laboratory. However, some bear mentioning to complete the flavor and breadth of geophysics at Caltech. Recently several joint projects have been undertaken with JPL to apply space-age technology to tectonic problems. These include a program, using portable radio telescopes, to monitor deformations of the crust, and several laboratory and field projects to measure and understand changes in the physical properties of rocks just prior to failure. The seismometer that is to land on Mars in 1976 was designed at Caltech, and the seismic data it returns will be analyzed here. Much recent attention has been given to the origin, evolution, and internal structure of the moon and planets. We are trying to understand "deep mantle plumes," a recent concept that processes in the deep mantle ultimately control plate motions at the surface.

Breakthroughs cannot be anticipated, but the net result of the expanded and improved laboratory and field instrumentation, the continued evolution of new theories and techniques, and the continuous vigorous interaction of the transplanted geophysics group virtually assure that we will make even more rapid advances in understanding our earth and our neighbors in space than in the past. □