GEORGE W. HOUSNER

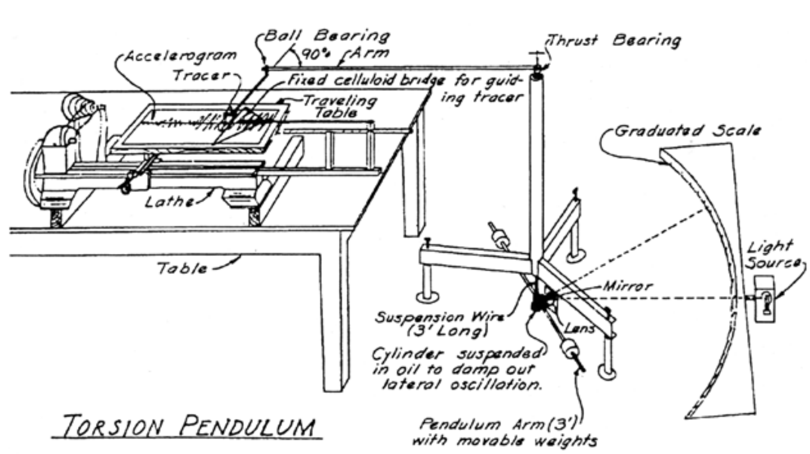
1910-2008

George W. Housner, the Braun Professor of Engineering, Emeritus, often considered the father of earthquake engineering, died on November 10 of natural causes. He was 97.

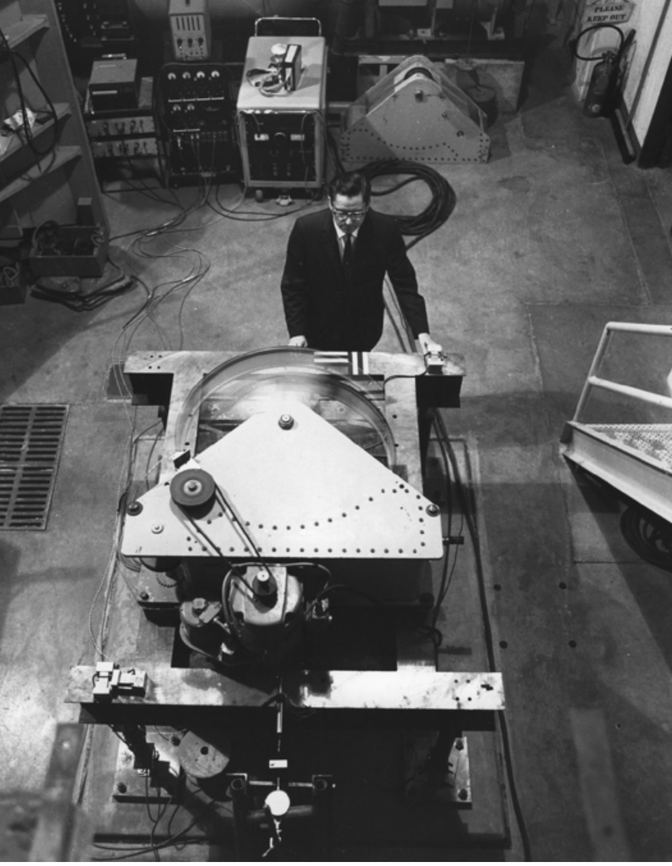
Born in Saginaw, Michigan, in 1910, Housner received his bachelor's degree in civil engineering from the University of Michigan–Ann Arbor in 1933. He earned his MS at Caltech in 1934, and then took five years off to work as an engineer, designing bridges, schools, and dams. His interest in making buildings earthquake-resistant began during this stint in the workaday world—the magnitude-6.4 Long Beach quake had rocked the Southland just months before his arrival, killing 115 people and causing some $40 million in damage.

Housner returned to campus in 1939, earning his PhD in 1941 under Romeo Martel, who became interested in the earthquake-resistant design of buildings after the magnitude-8+ Great Kanto Quake and firestorm leveled Tokyo in 1923. Housner's thesis, *An Investigation of the Effects of Earthquakes on Buildings*, "is so fundamental that nobody ever cites it explicitly any more," says John Hall, professor of civil engineering. It was indeed the seed of a new field. In his oral history, Housner recalls the task of trying to convert an earthquake accelerogram—a paper record of the ground motion at a specific site—into a "response spectrum," which predicts how a building of a given height at that location would behave upon experiencing that shaking. "I first did that for my thesis. And the very first time we calculated it—we did it by pencil and paper, which involved drawing the accelerogram and multiplying and integrating—it took about a day for one point on the spectrum . . . . [The torsion pendulum] speeded it up from one day to about 15 minutes. Well, that was a big advance, about 30 times. But then later we developed an electrical way of doing it and we'd get a point in maybe 15 seconds. Now [in 1984], 15 seconds on the digital computer, and we get 500 points."

Housner put aside his calculations to advise the Army Air Forces during World War II. As a civilian member of the National Research Council, he was in North Africa and Italy from 1943 to 1945. His first act upon arrival was to help retrain the bomber crews' machine gunners, who were being taught to "lead" enemy fighters as if shooting at a formation of Canada geese from a blind. But from a speeding aircraft, says Hall, "you usually have to aim behind the target, which is not intuitive. You can increase the hit rate by an order of magnitude." The booklet Housner's group prepared, entitled *Get That Fighter*, became standard issue. "They even had charts posted on the walls of the planes," says Hall. Soon after, Housner got involved in planning the bombing raid on Ploiesti, Romania—Nazi Germany's only oil field, and the most heavily defended target in the Reich. The defenses included barrage balloons, tethered by steel cables at an altitude of about 2,000 feet. The idea was that low-flying bombers would hit the cables and spin out of control, but Housner's analysis of the stress waves that would run up and down the cable when a wing hit it proved that the cable would snap instantly above a certain impact velocity. Reassured, the pilots flew—and inspections of the returning planes showed grooves gouged into the wings where cables had been hit without the pilots knowing it. Later, in Italy, Housner read an intelligence report on a list of standard equipment available to the German engineers in charge of rebuilding bombed-out bridges, and he noticed that the longest available I-beam was 15 meters. He persuaded



Housner built this device for his PhD work. The torsion pendulum, standing in for a building, is set in motion by manually tracing an earthquake accelerogram placed on a table moved at constant speed by a lathe motor.



Housner with a rooftop-shaking machine in a 1966 photo. Dino Morelli's design consisted of two off-center baskets that counterrotated on a common vertical axis at a speed precisely set by Tom Caughey's controllers. With the baskets loaded with several hundred pounds of lead weights, and the machine set to match Millikan Library's .85-second resonance period, it moved the building back and forth a quarter of an inch.

the operations planners to target bridges whose spans between piers were longer than 15 meters, as they would be impossible to repair without building a new pier in the middle of the bombed-out span to support the I-beams. This, in turn, would keep the bridges out of service for a much longer time. For this and many other contributions, he was given the Distinguished Civilian Service Award by the War Department.

Returning to Caltech as an assistant professor of applied mechanics in 1945, Housner coauthored two textbooks on mechanics with professor Donald Hudson (BS '38, MS '39, PhD '42) and a book on stresses and strains with professor Thad Vreeland (BS '49, MS '50, PhD '52). Though now out of print, they live on. "They were some of the best-written texts ever," says Hall, with "clear and concise explanations that dealt with complex issues. A lot of the modern texts borrow his ideas, and even his problems."

During those early postwar years, Housner established his reputation as an intellectual leader in applied-mechanics research. He tackled such problems as flow-induced vibrations in pipelines, the sloshing of fluids in large storage tanks, and hydrodynamic pressure on dams during earthquakes.

"He was a fundamental, independent, and creative thinker, with great intuition and practicality," Hall said. "Solving problems was what he was designed to do. He'd look at a problem, quantify it in some way, and come up with a solution."

This attribute would come into full flower in the 1950s, when he and mechanical engineer Hudson started developing instruments to measure how buildings responded to being shaken—work funded, oddly enough, by the Office of Naval Research. These strong-motion accelerographs, when installed on several floors of a tall building, allowed the engineers to determine the building's natural vibrational modes and how those modes damped themselves out. Some of this information could be gleaned from the small jitters of a building at rest, but to really put a building through its paces, it needed to be moved on command. To this end, Housner, Hudson, and professors Tom Caughey (PhD '54) and Dino Morelli (MS '45, PhD '46) built a rooftop-mounted shaking machine. Modern versions of these machines—one of which sits atop Caltech's nine-story Millikan Library—are now in use all over the world.

These studies first saw practical application in early 1960s, with the design of the 40-story Union Bank building in downtown Los Angeles. The Connecticut General Life Insurance Company, which built the building, instructed the architect to go to Caltech for advice on earthquake-resistant design. Housner and Paul Jennings (MS '60, PhD '63, now professor of civil engineering and applied mechanics, emeritus) took inventory of the known faults in the vicinity, and estimated the ground shaking at the building site that would result from a plausible earthquake on each fault. As Housner remarked in his oral history for the Caltech Archives, "We then showed them how to calculate how the building would respond [to that shaking]. And we helped them make the design. After that, all the high-rise buildings in Los Angeles were done in the same way."

"Working with George on this important, practical project was a great learning experience for a young professor," Jennings recalls. Housner and Jennings later went on to consult on the design of the twin 52-story ARCO towers, the 55-story Security Pacific Bank building, and many other structures. "In a sense," said Housner, "those buildings had experienced some four or five [strong] earthquakes before they were built."

Even before construction on the Union Bank tower began in 1965, the wisdom of this approach became self-evident. On March 27, 1964, a magnitude-9.2 temblor made the high-rises in Anchorage, Alaska—all four of them; two of 14 stories, and one each of 8 and 10 floors—uninhabitable, along with innumerable lesser structures. Housner was appointed chair of a National Academy of Sciences engineering committee to evaluate the damage. The entire NAS report—the first such comprehensive scientific study of a natural disaster—filled nine volumes, with the engineering book running 1,190 pages.

The nation's attention was now focused on earthquakes, and the head of the Building and Safety Department for the city of Los Angeles, John Monning (BS '33), seized the op-

Housner received the National Medal of Science from President Ronald Reagan in a White House ceremony in 1988 for his "profound and decisive influence on the development of earthquake engineering worldwide."

portunity to persuade the city council to require that all new buildings of 10 stories or higher be equipped, at the owner's expense, with three strong-motion accelerographs at basement, roof, and mid height. (Housner and Hudson had drawn up specs for a design that could be built cheaply, and had persuaded Teledyne, a local geophysical instrument maker, to manufacture it—more than 10,000 of its successors have now been sold worldwide.)

Thus, when the magnitude-6.6 San Fernando quake struck on February 9, 1971, Housner recalled, "we were able to get all sorts of records. We got more records on that earthquake than out of all the earthquakes in the world before that." And with mainframe computers having become capable of some serious number crunching, they were able to validate his and Jennings' high-rise design methods against the accelerograms obtained in the earthquake. "The Building Department in L.A. said, 'Well, that's good enough for us. We can now force through the requirement that all buildings over 16 stories be designed on a dynamic basis'"—that is, to resist the dynamic lateral forces of an earthquake rather than a static "equivalent" lateral load (a very strong wind, essentially, which was the best proxy previously available), as previous versions of the code had specified. Where Los Angeles leads, others follow, and this is now standard practice for the codes governing the design of tall buildings in seismic areas everywhere.

Housner was keenly interested in other types of structures as well, consulting over the years on San Francisco's Bay Area Rapid Transit system, the Trans-Arabian Pipeline, nuclear facilities, ports, and offshore oil platforms. In the 1950s, the California State Water Project—a sprawling undertaking that brings water from the rivers of Northern California and the high Sierra to the thirsty cities and farms of the rest of the state—was being launched. The project includes some 20 big dams, a dozen or so large pumping stations—several of them near the San Andreas fault—to hoist the water over the mountains, and the California Aqueduct itself, which crosses the fault three times. Lobbying by Housner and others led to the creation of a seismic safety advisory board, chaired by Housner, in 1962. "We prepared a recommendation based on my research and told them what the strong shaking would likely be and what they should do. And they adopted the procedure. That was the first time such modern procedures had been used on dams and pumping plants. So we set a precedent; now all over the world they do that the way we recommended it."

Housner also spent a lot of time abroad, and in correspondence with foreign colleagues. "I don't think it's fully appreciated how much he worked for international cooperation," says Hall. "I came on him in the copier room once, wrapping up this parcel of books from his own collection to send to this guy he'd been writing to at the University of Bohol, in the Philippines. And I thought to myself, there he is, sowing another seed in the world. Encouraging somebody. Most of us would be too busy to bother."

Housner began a very active retirement in 1981, coming out of it to chair yet another disaster inquiry, this one of the magnitude-6.9 Loma Prieta quake of 1989 that caused the collapse of the San Francisco–Oakland Bay Bridge and several segments of the Nimitz Freeway (I-880) in Oakland. "The resulting report, *Competing Against Time*, was very effective, and serves as a model for such post-earthquake inquiries," says Jennings.

A lifelong bachelor who had always enjoyed teaching, Housner began to disburse his estate to the Institute after retirement. He established an endowment for grad students and postdocs in earthquake engineering, followed by the Housner Student Discovery Fund to support undergrads in essentially any scholarly endeavor. Next came an unrestricted endowment to the Caltech Y. His will contains a bequest to endow a chair in any field, and his collection of some 200 rare books, amassed on his world travels and mostly engineering- or science-related, is now in the Caltech Archives. He also supported local musical and artistic organizations, particularly the Coleman Chamber Concert Series.

Housner was a member of the National Academy of Engineering, the National Academy of Sciences, and the American Academy of Arts and Sciences. He was a founding member of the Earthquake Engineering Research Institute, which annually awards a medal in his name, and was instrumental in the formation of the International Association for Earthquake Engineering and Caltech's Earthquake Research Affiliates. In 1981, he was given the Harry Fielding Reid Medal from the Seismological Society of America, and in 1988, the National Medal of Science. He was named a Caltech Distinguished Alumnus in 2006. —*DS* e&s

JACQUELYN DOE BONNER

1917-2008

Jackie Bonner, former editor of *Engineering & Science*, died in Pasadena on November 21 at the age of 91. A longtime member of the Caltech community, Jackie was born in Clifton, Arizona, and grew up in Arizona, Idaho, and California. She attended Idaho State University, and later was a student at UC Berkeley.

In 1939 Jackie married Wesley Hershey, and the couple moved to Pasadena in 1946, when he was hired to serve as executive secretary of the Caltech Y. As Mrs. Hershey, she hosted hundreds of Caltech Y events and social gatherings.

Jackie began paid employment at Caltech in 1962 as an editorial assistant in the Industrial Relations Center and joined the Publications staff in 1965. She became associate editor of *E&S* in 1968 and managing editor three years later. When legendary *E&S* editor Ed Hutchings retired in 1979 (he had been hired as the magazine's first professional editor in 1948), Jackie was the natural successor, and for the next five years produced a publication that continued Ed's style of clear, straightforward writing, careful editing, and tenacity in nagging faculty to explain their work in simple English—a legacy that she, in turn, bequeathed to those who succeeded her. Her close attention to editing, in particular, influenced many of her colleagues. She left her own creative mark in the section of *E&S* called Random Walk—her title—which she started in 1981, and which, though it has migrated from the back to the front of the magazine, still exists.

In 1973 Jackie had married her second husband, Lyman Bonner (PhD '35), a rocket propellant expert and Caltech administrator, and in 1984 she and Lyman decided to take less demanding, half-time positions at the Institute. She continued working as a senior editor on the Publications staff until she retired in 1988.

Jackie was an avid reader throughout her life and a long-standing member of the Neighborhood Church and the League of Women Voters. She was predeceased by both of her husbands and is survived by her daughters, Kay Hershey Loughman, Margaret Hershey Lester, and Susan Hershey; stepchildren Allen and Philip Bonner and Lynn Bonner Bernstein; and eight grandchildren and stepgrandchildren. e&s

KITAEV WINS "GENIUS" AWARD

Alexei Kitaev, professor of theoretical physics and computer science, has been named a MacArthur Fellow. Often referred to as the "genius" awards, the five-year, $500,000 grants are awarded annually to 25 creative, original individuals.

Kitaev has made important theoretical contributions to a wide array of topics within condensed-matter physics, including quasicrystals and quantum chaos. More recently, he has devoted considerable attention to the uses of quantum physics in computation. Though his work focuses mainly on the conceptual level, he also participates in "hands-on" efforts to develop working quantum computers.

Kitaev says he was "very surprised" when he learned of the honor. "I didn't know what the award was at first," admits Kitaev, who was born and educated in Russia. "But then I looked up the names of people who have previously received a MacArthur award, and saw that they are very good scientists. I am excited and honored to be in the same group with them."

"We are thrilled that Alexei has received this well-deserved honor," says Andrew Lange, the Goldberger Professor of Physics and chair of the Division of Physics, Mathematics and Astronomy. "He is a stunningly original thinker who has made profound theoretical contributions to both quantum computing and condensed-matter physics." —*LO* e&s