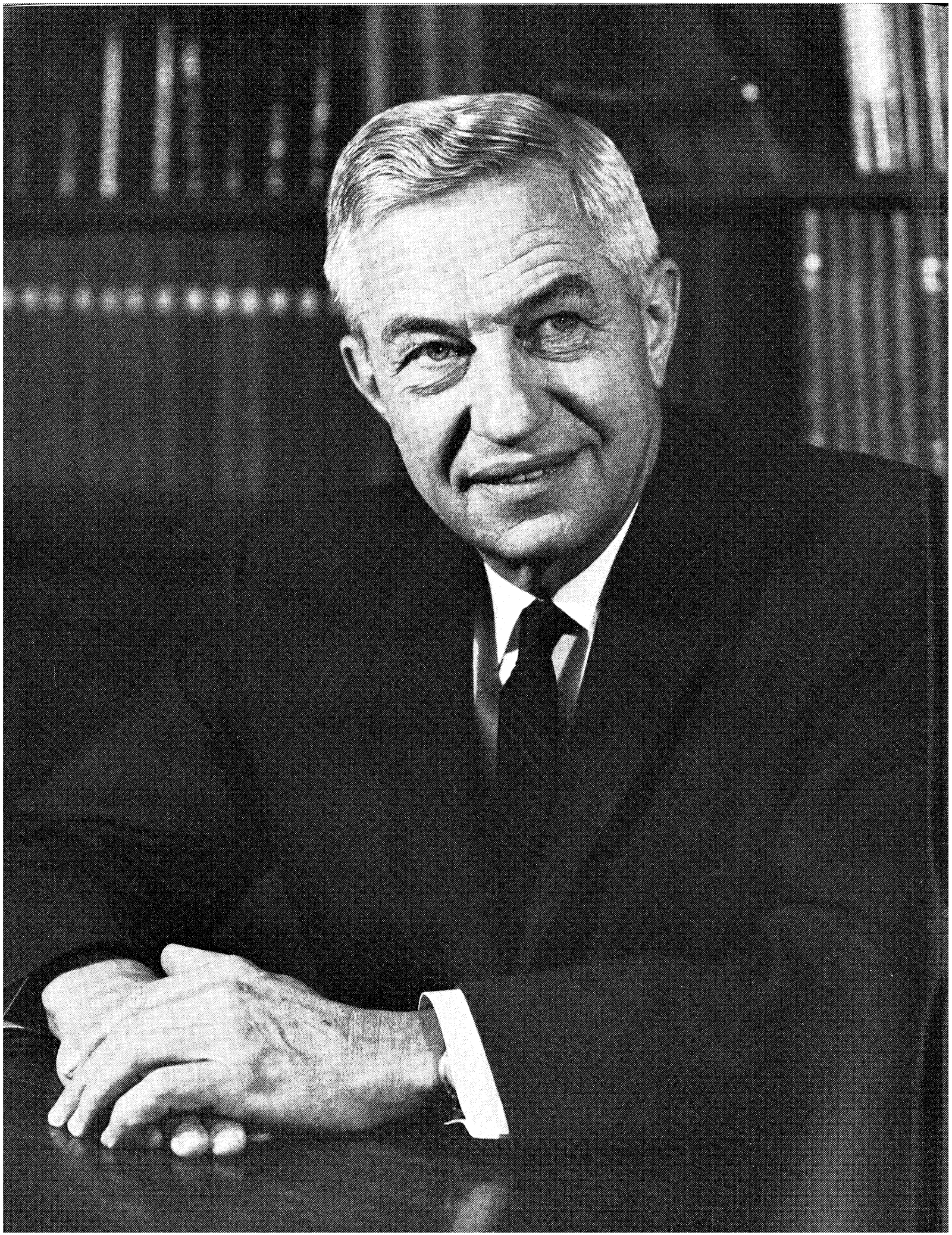
75

CALIFORNIA INSTITUTE OF TECHNOLOGY

PICTORIAL HIGHLIGHTS

1891–1966

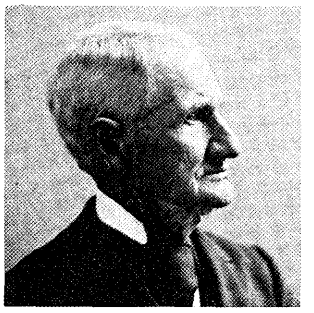


SEVENTY-FIFTH ANNIVERSARY
1891 · 1966

Seventy-five years have passed since the 1891 opening of "Throop University," a school of arts and crafts that has evolved into the preeminent institution that is today's California Institute of Technology. This anniversary serves as an occasion to look back at our beginnings and to assess our future. It is rewarding to note the continuity of the past 75 years, to emphasize this continuity, and to recognize that changes in the Institute have always accompanied and have often preceded changes in the community and in the country. In presenting this pictorial account of the Institute's development, I would point out with pride that for 75 years Caltech has served the present and anticipated the future—a challenge that will always be our goal.

L. A. DuBridge
PRESIDENT
CALIFORNIA INSTITUTE OF TECHNOLOGY
October 24, 1966

THE EARLY YEARS



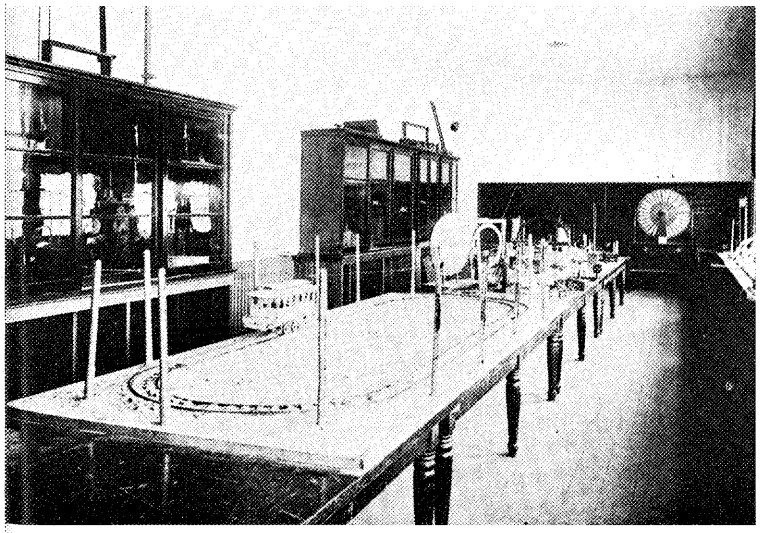
Father Throop

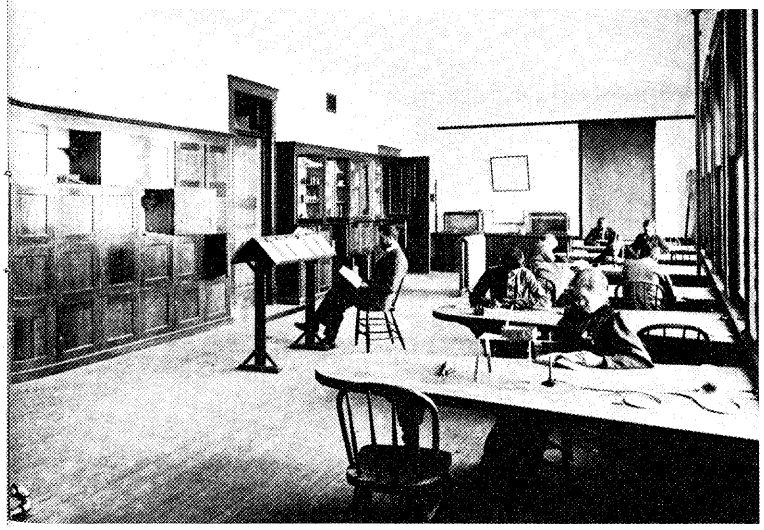
The center of Pasadena in 1891—Colorado Street near Fair Oaks

The Throop University, forerunner of the California Institute of Technology, opened its doors to students for the first time on November 2, 1891. Its founder was Amos G. Throop, a retired Chicago businessman who had moved to California at the age of 70. Father Throop (as he was called by everyone in Pasadena) believed that the standard American education of his time was far too bookish. He proposed a practical education, a school where students would learn by doing, and, at the age of 80, he organized and endowed what was to become one of the country's pioneer schools of manual training.

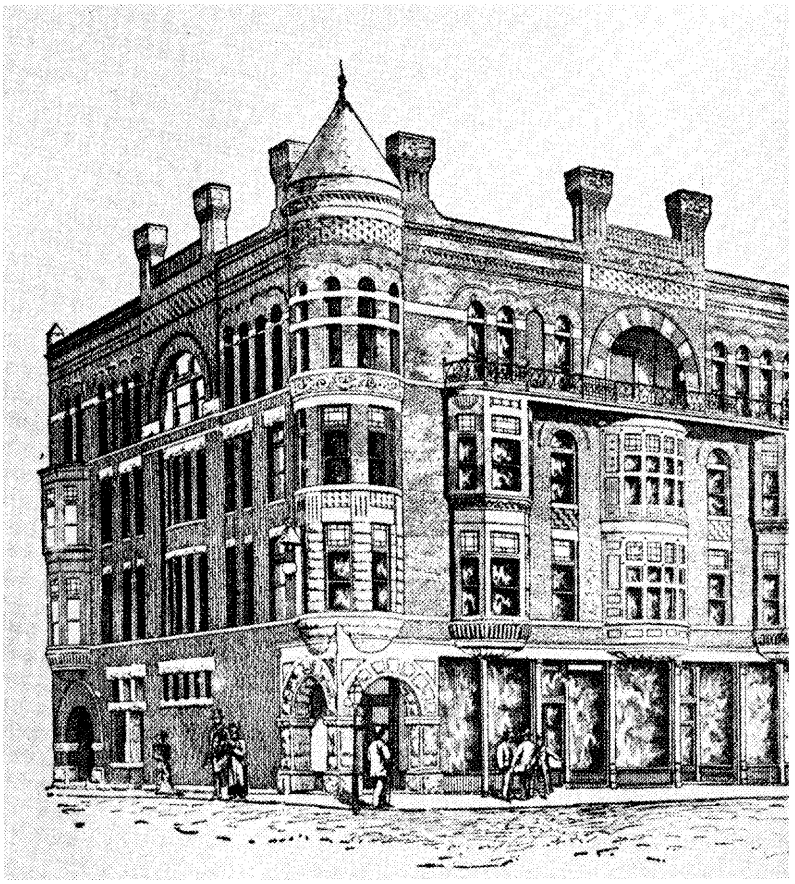
The school, later called Throop Polytechnic Institute, opened with a student body of 35, ranging in age from 7 to 20. Its main emphasis was on vocational training, and in this role it served its community for nearly two decades.

The Throop physics laboratory displays a model of the electric streetcar that was soon to replace the horsecar as Pasadena's rapid transit system.



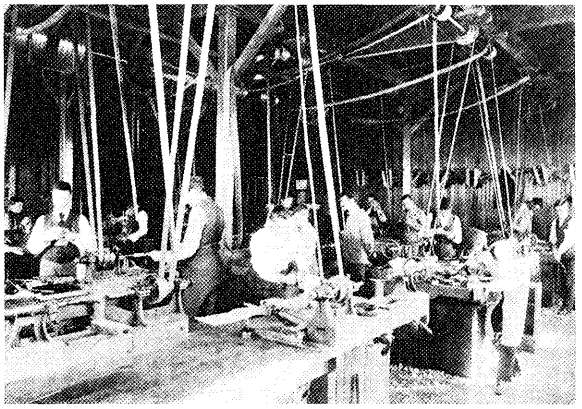


Throop University's first home was in this "commodious and elegant structure," now part of the Green Hotel. The school moved to new quarters in 1892.



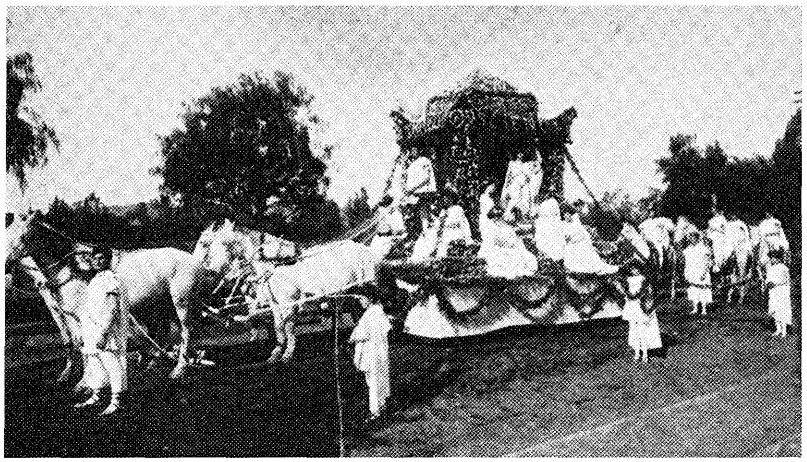
The biology lab has plenty of bunsen burners, if not much else. Throop gave his $200,000 fortune to endow the school.

Woodworking is an important part of the curriculum. Shop has "appliances for joinery, turning, inlaying and scroll sawing."

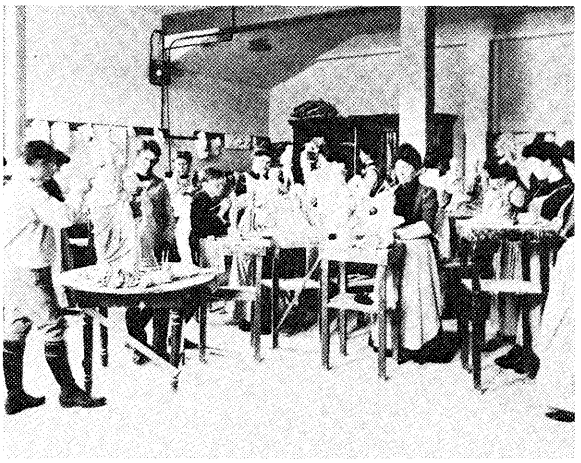


A coeducational cooking class demonstrates the Throop Institute motto: "Learn to Do by Doing."

Fourteen football lettermen engage in a studio skirmish to immortalize Throop's championship team of 1895.



Throop students create a float for the Rose Parade of 1904. "Science" is written in flowers on top of the pagoda.



Modeling class includes students of all ages. Throop also offered training in piano, voice, painting, and drawing.

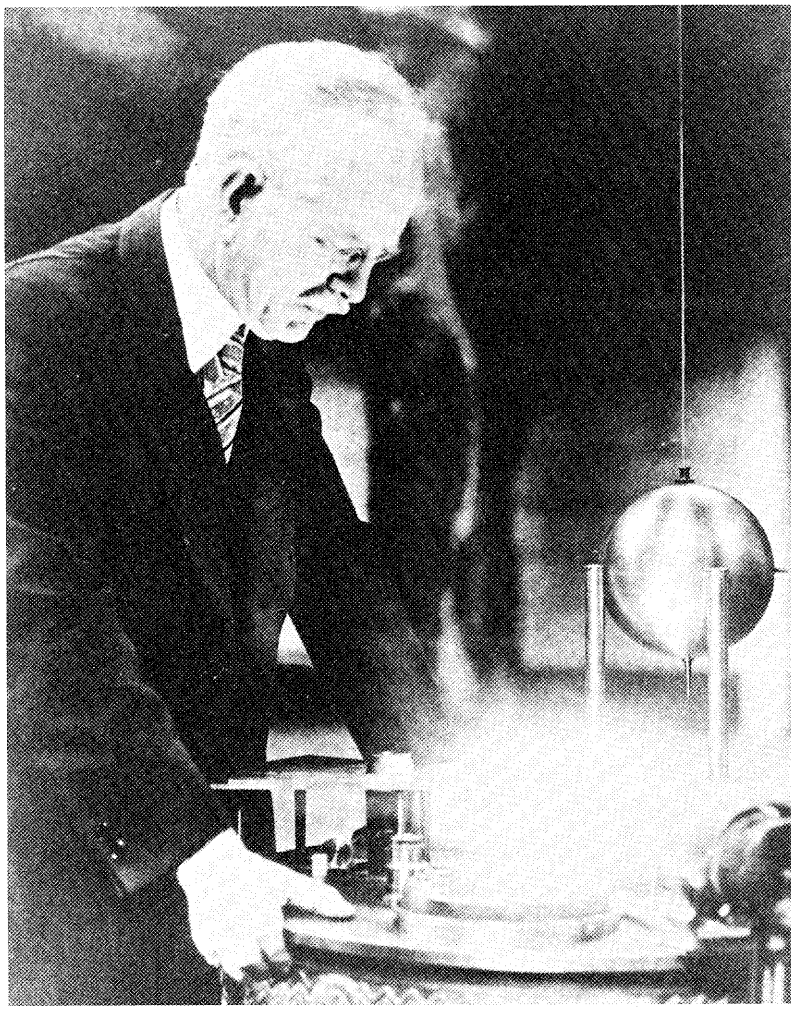
"A COLLEGE THE EQUAL OF ANY IN THE COUNTRY"

In its annual catalog for 1907, Throop Polytechnic Institute announced plans to become a "technical school of college rank the equal of any in the country." These brave words reflected the vision of George Ellery Hale, astronomer and first director of the Mount Wilson Observatory, who was to shape the future course of the Institute.

By the early 1900's, the doctrine of manual training pioneered by Throop had been absorbed by the public schools, and the time had come for new directions. Hale foresaw the enormous scientific and industrial growth of California and, in Throop, the germ of a first-rate college to meet the needs of that growth. Joining the board of trustees in 1907, he persuaded Throop to drop its grammar and high schools and concentrate on becoming a worthy western rival to MIT.

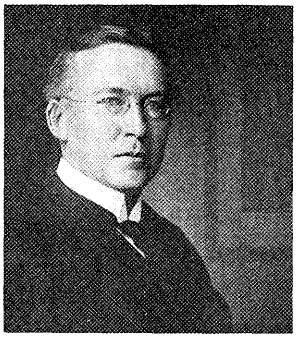
By 1908, the trustees of Throop included Hale, Dr. Norman Bridge, Arthur H. Fleming, Henry M. Robinson, J. A. Culbertson, and C. W. Gates. It was the dedication of these men—of their time, talents, and fortunes—that transformed the modest vocational school into a world center of scientific research.

But it was George Ellery Hale who supplied the philosophical framework for the new college: to choose a few things and do them well; to concentrate on research; to get the best man available for every position; to offer a broad cultural program.

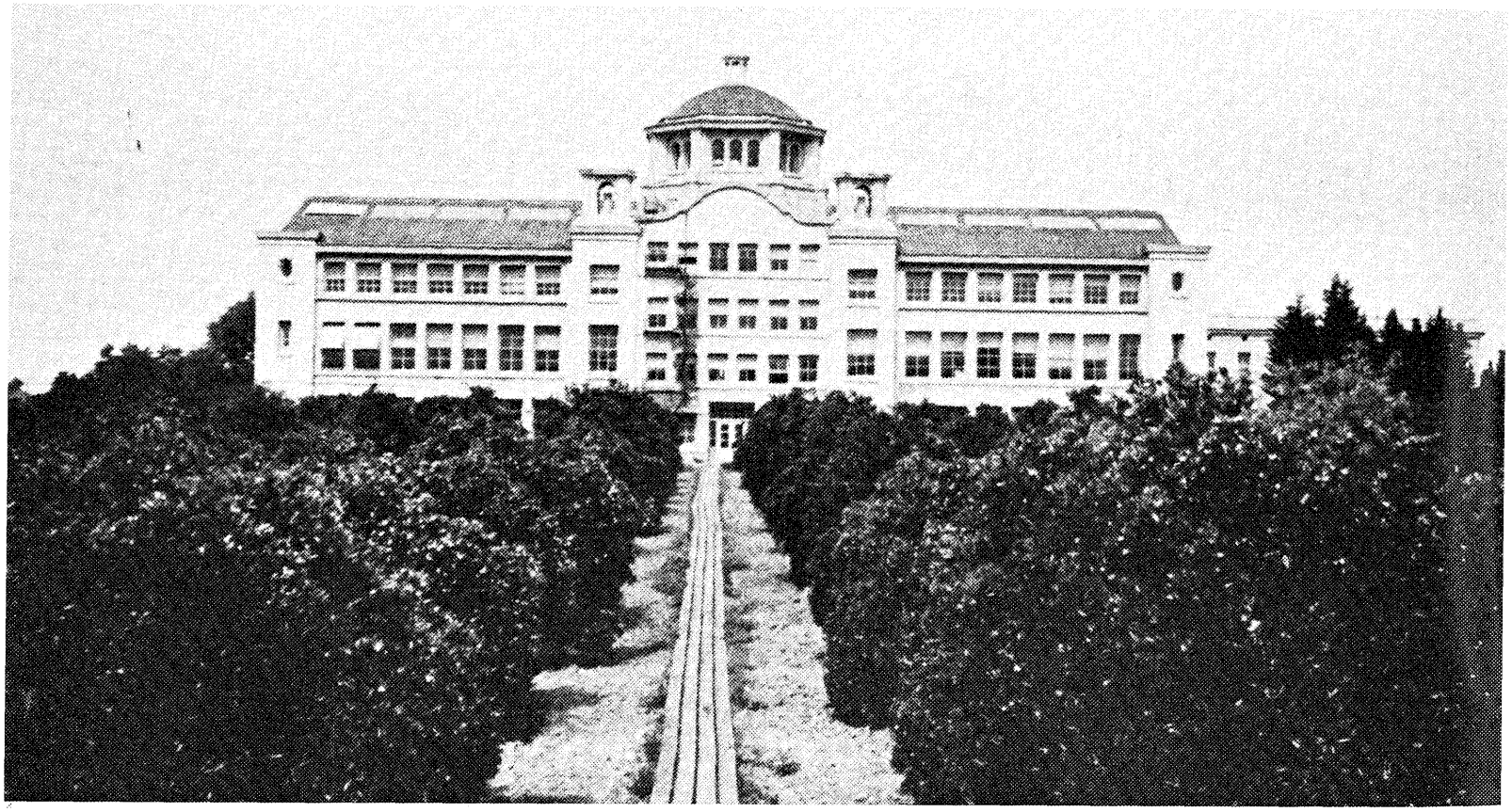


"The greatest engineer," Hale wrote, "is not the man who is trained merely to understand machines and apply formulae, but the man who, while knowing these things, has not failed to develop his breadth of view and the highest qualities of his imagination."

In 1910 the new college moved to a new campus—the site of the present Caltech—and started classes with a student body that had been pared down from 600 to a select 31. This "contraction of numbers in the face of a great expansion of plan" has been called "probably the boldest step ever taken by an American educational institution."



James A. B. Scherer, president of Newberry College in South Carolina, was hired by Hale to be the first president of the "new Throop." He served from 1908 to 1920.

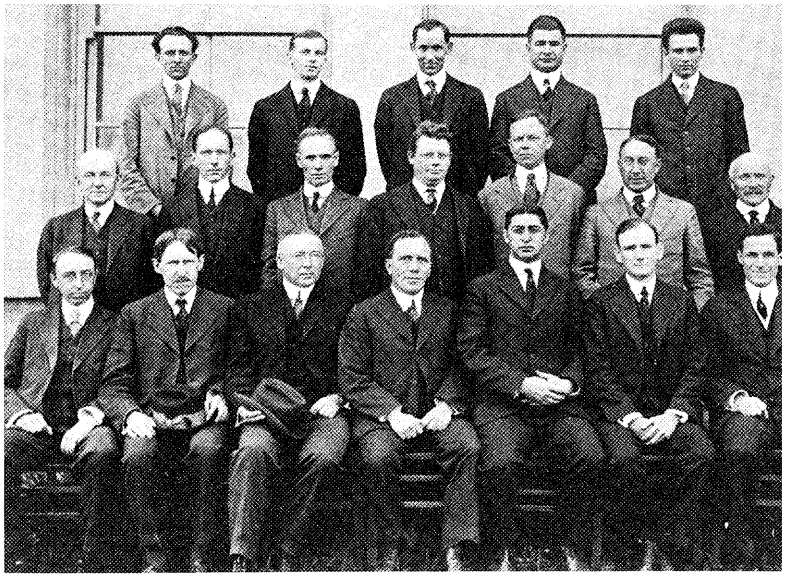


By 1910 the Institute had a new 22-acre campus, gift of Arthur Fleming, and one building—Pasadena (now Throop) Hall—gift of the citizens of Pasadena.

On March 21, 1911, one year after Throop moved to its new campus, Theodore Roosevelt delivered an address at the Institute.

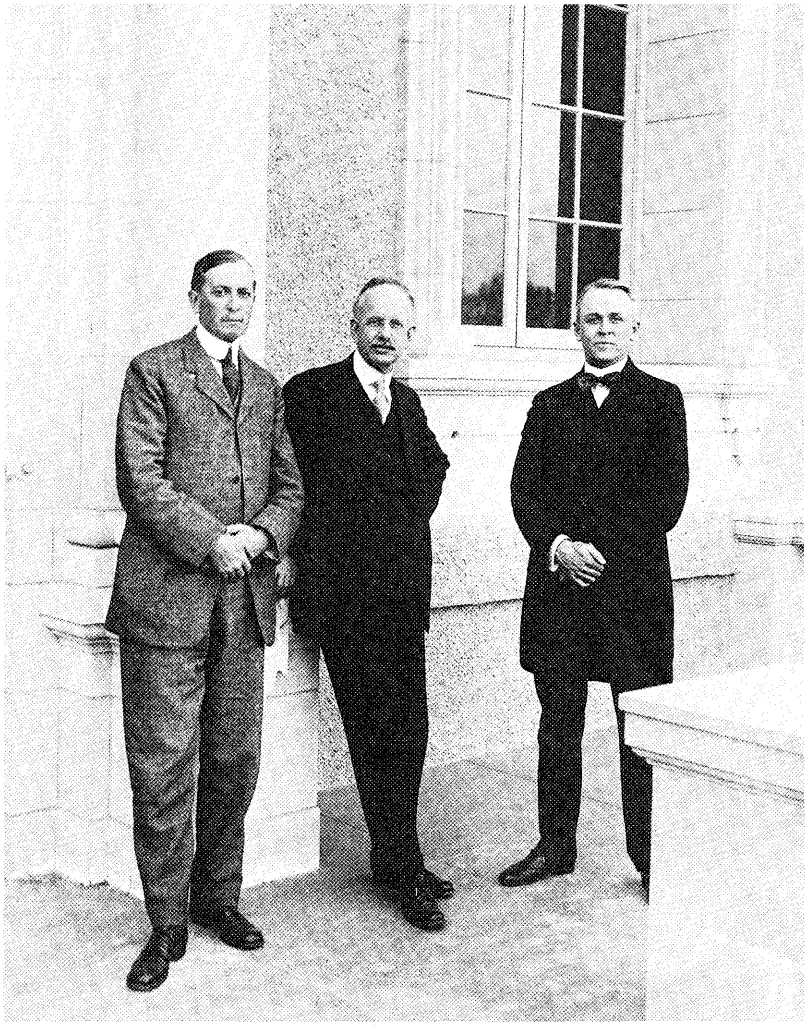
"I want to see institutions like Throop turn out perhaps ninety-nine out of every hundred students as men who are able to do given pieces of industrial work better than anyone else can do them," he said, "...and the one-hundredth man I want to see with the kind of cultural scientific training that will make him and his fellows the matrix out of which you can occasionally develop a man like your great astronomer, George Ellery Hale."

Theodore Roosevelt, former President of the United States, tours the new campus of Throop Polytechnic Institute with President James A. B. Scherer on March 21, 1911.



Entire Throop faculty in 1916. Top row: Frederick H. Kennedy, Stuart J. Bates, Howard J. Lucas, Andrew W. Smith, Robert S. Ferguson. Middle row: Lucien H. Gilmore, Edward C. Barrett, W. Howard Clapp, Royal W. Sorensen, Clinton K. Judy, Alexander Enenkel, Frederick E. Beckmann. Bottom row: Harry C. Van Buskirk, Robert E. Ford, James A. B. Scherer, George A. Damon, Walter H. Adams, Franklin Thomas, Seward C. Simons.

THREE MEN OF VISION



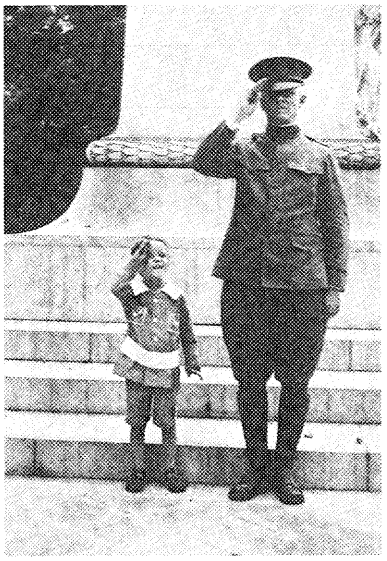
Noyes, Hale, and Millikan

Throop College of Technology, as the school was called after 1913, offered Bachelor of Science degrees in electrical, mechanical, and civil engineering. But George Ellery Hale, holding fast to his dream of a center for pure science, was combing the country for distinguished scientists to lead the school into graduate study and research.

Hale's first triumph came in persuading his old friend, Arthur Amos Noyes, professor of chemistry and former acting president of MIT, to join Throop's faculty on a part-time basis in 1913. In 1919 Noyes resigned from MIT to become full-time director of chemical research at Throop.

With Noyes firmly established in the Gates Laboratory of Chemistry, the first research laboratory on campus, Hale next turned his enormous persuasive powers on the country's foremost physicist, Robert Andrews Millikan of the University of Chicago. In 1917 Millikan agreed to spend a few months of each year at Throop as director of physical research.

WORLD WAR I



Major Robert A. Millikan of the Army Signal Corps, and son Max.

Throop's plans for expansion were temporarily halted by World War I, when most students were in uniform as members of the Student Army Training Corps. Robert A. Millikan moved to Washington to lead the nation's wartime scientific effort. As head of the National Research Council, which he and Hale had helped to establish, he was the nation's leading civilian scientist. At the same time, Millikan served as director of research for the Army Signal Corps, with the rank of major and later lieutenant colonel. He lived in Washington until October 1919, when he returned to the University of Chicago.

Members of the Student Army Training Corps attack sandbagged trenches on campus and lay siege to Throop Hall.

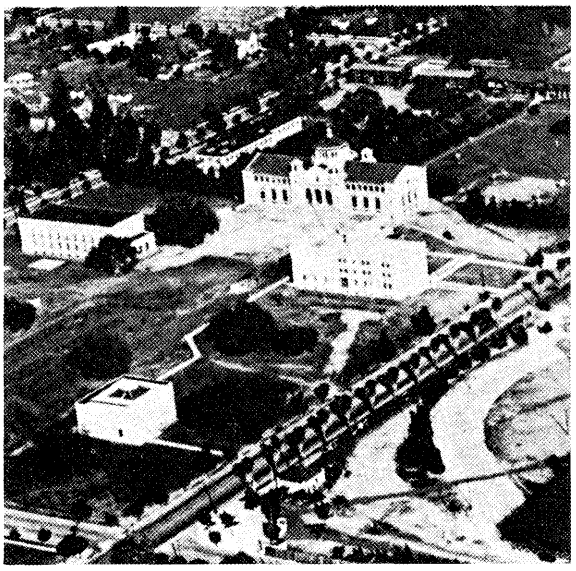
THE MILLIKAN YEARS

Robert A. Millikan was persuaded by his old friends Hale and Noyes to become administrative head of the newly renamed California Institute of Technology in 1920, upon the retirement of ailing president Scherer. He took up his duties in the fall of 1921, and the Institute's great days began.

When he came to Caltech, Millikan was 53 years old, and already world-renowned as a scientist, educator, and public servant. In the next 35 years at the Institute, he pursued three careers simultaneously: building an outstanding department of physics, conducting research on the nature and origin of cosmic rays, and leading the Institute to a position of world preeminence in scientific education and research.

Millikan never accepted the title of president but served as chairman of the executive council—an eight-man governing board established to share some of the administrative duties. But he was in every sense a president. He recruited great men to the faculty, captured the enthusiastic support of the community, stabilized the Institute's financial position, and followed every research project on the campus with personal interest.

In the words of Lee A. DuBridge, "Few institutions in the nation are so completely the shadow of one man . . . for 35 years Dr. Millikan was Mr. Caltech, and Caltech will always be his monument."



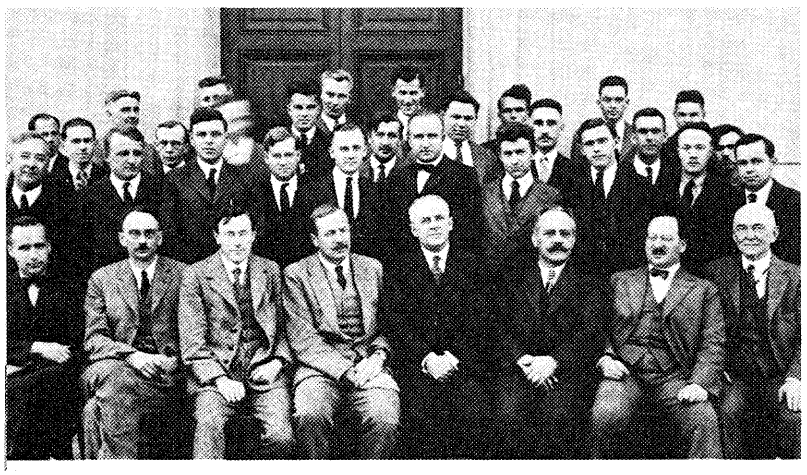
The 1922 campus had Throop Hall for engineering, Gates (left) for chemistry, East Bridge (right) for physics, and Culbertson (foreground) for an auditorium.

Campus plan drawn up by Bertram B. Goodhue in 1920 has been generally followed in the development of the present campus. The central building here, which dwarfs Throop Hall, is a library. More than 40 years have passed, and the design is different, but a general library is going up at this location.

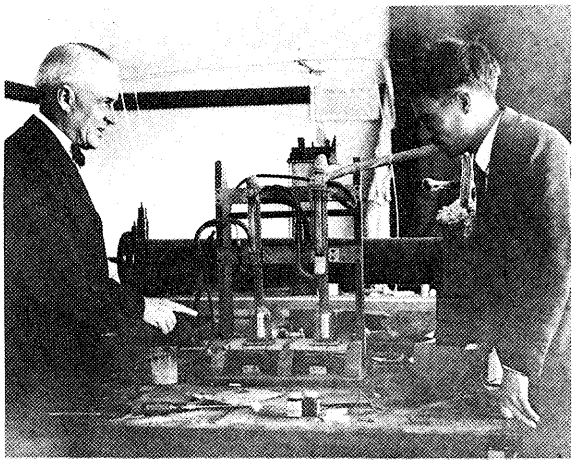
PHYSICS

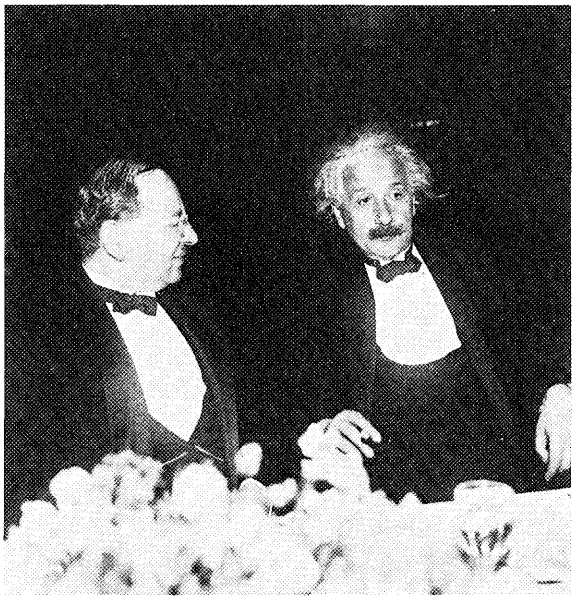
Millikan devoted most of his first three years at the Institute to building a division of physics. An expert recruiter, with a broad acquaintance among scientists all over the world, he brought to Caltech the most eminent physicists of his day. In 1923 his prestige received another boost when he was awarded the Nobel Prize in physics. Under Millikan's leadership, the Norman Bridge Laboratory became, almost overnight, a world center of physical research.

From Chicago, Millikan brought his graduate-student assistant, Ira S. Bowen, who worked with him on spectroscopy and cosmic ray research.



Physics staff in 1923. Front row: Earnest Watson, Richard Tolman, Harry Bateman, Charles Darwin II, R. A. Millikan, Arnold Sommerfeld, Paul Epstein, L. H. Gilmore.

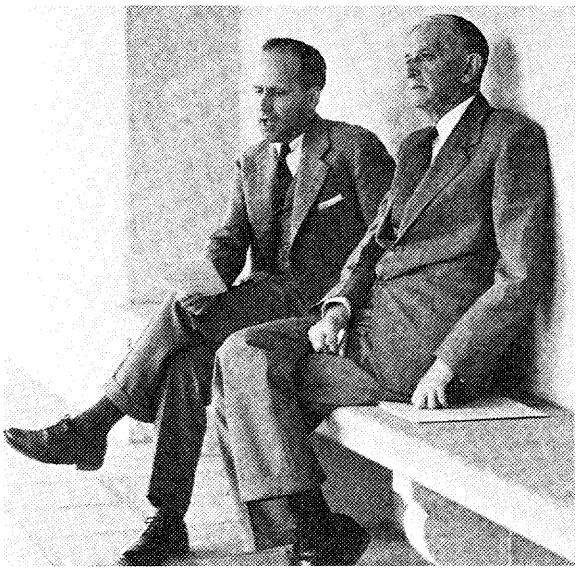




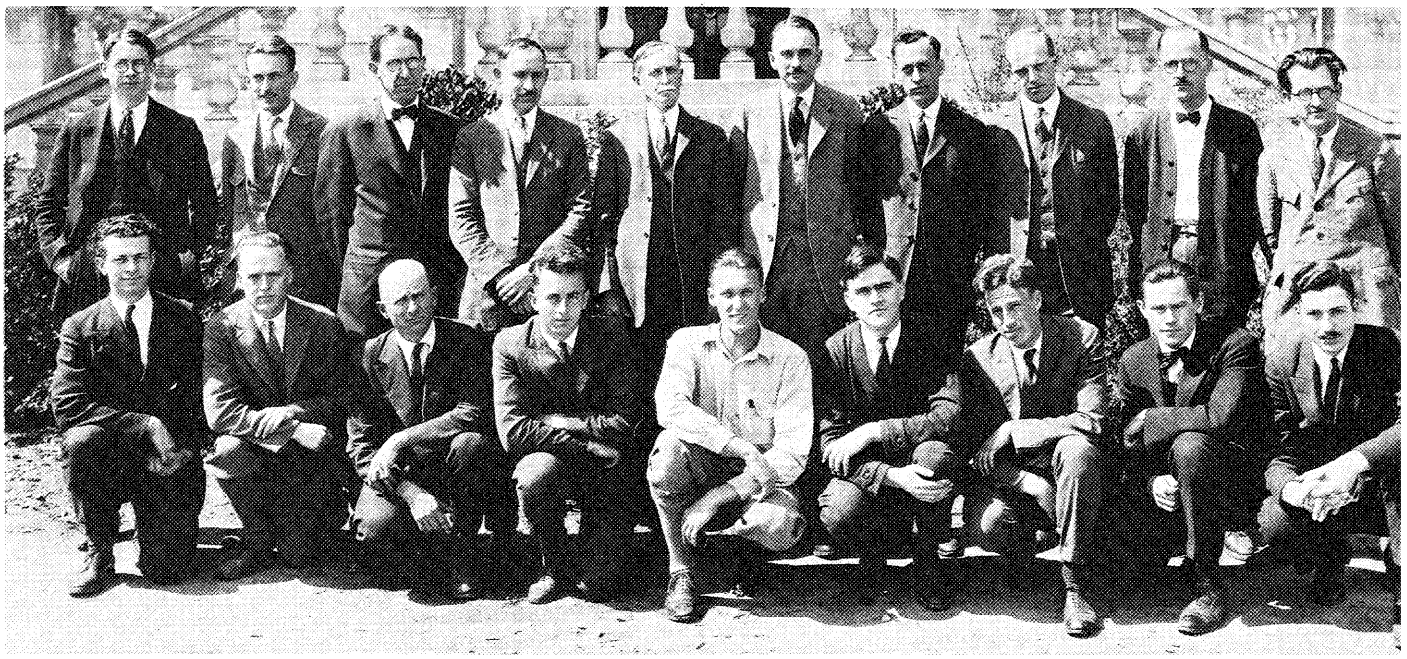
Theoretical physicist Paul S. Epstein, shown here with Albert Einstein, was one of Millikan's first appointments to the physics faculty in 1921.

CHEMISTRY

Arthur Amos Noyes came to Throop as director of research of chemistry in 1917, a position he held until his death in 1936. By 1923 the chemistry division had several distinguished faculty members and a total of 19 graduate students.



A. A. Noyes, shown here with physicist Earnest Watson, was particularly noted for his inspirational direction of undergraduate research.



The chemistry staff in 1923. Front row: Linus Pauling, Ernest White, Reinhardt Schuhmann, William Holton, Joseph Mayer, Paul Emmett, Vincent Manchee, Oliver Wulf, L. Merle Kirkpatrick. Top row: Charles Prescott, Richard Badger, James Bell, Howard Lucas, Arthur A. Noyes, Richard Tolman, William Lacey, Stuart Bates, Ernest Swift, Roscoe Dickinson.

Ernest H. Swift, an analytical chemist, joined the chemistry staff as a teaching fellow in 1919, served as division chairman from 1958 to 1963.

BIOLOGY

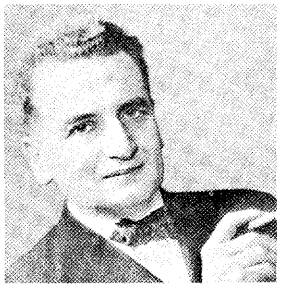
In line with Hale's policy to "choose a few things and do them well," the Institute added new departments only when they could match the standards established in physics and chemistry.

In 1928 the great geneticist, Thomas Hunt Morgan (right), whose work led to the modern chromosome theory of heredity, came to start a division of biology. Morgan, too, attracted top scientists and graduate students, and the Kerckhoff Laboratories became another outstanding research center.

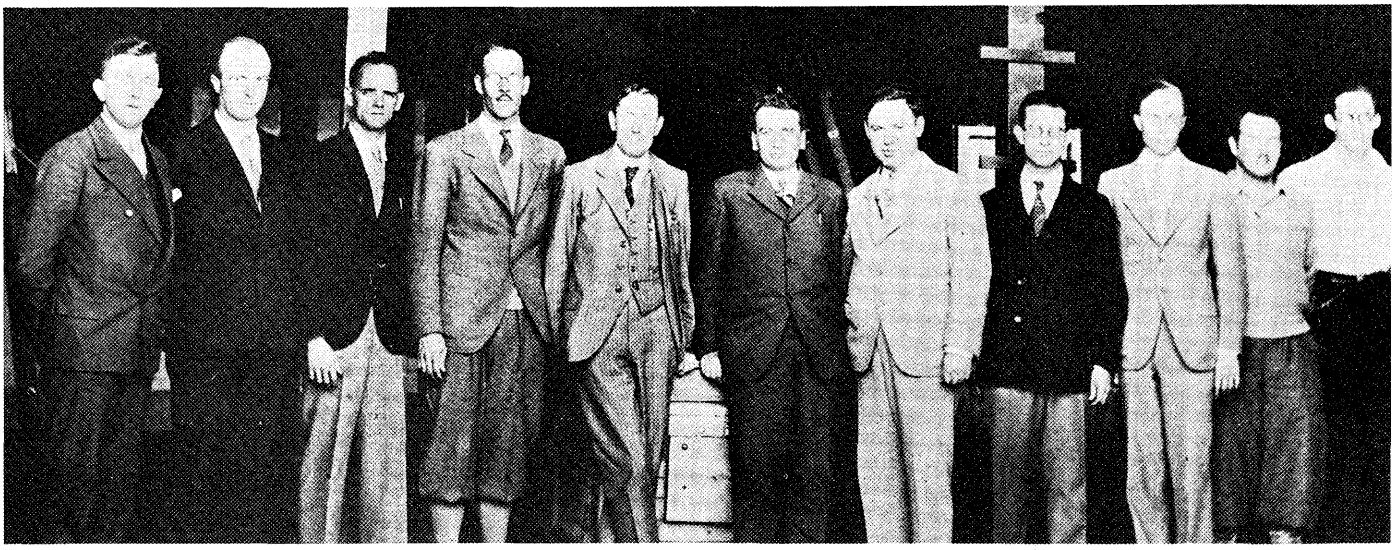
The biology staff in 1931. Seated: Henry Borsook, Herman E. Dolk, Henry S. Sims, A. H. Sturtevant, Sterling Emerson, Hugh M. Huffman, Thomas Hunt Morgan. Standing: Hermann F. Schott, Charles R. Burnham, Walter E. Lammerts, Kaj Linderstrom-Lang, Emory L. Ellis, Geoffrey Keighley, James Bonner, Albert Tyler, George W. Beadle, Jack Schultz.

AERONAUTICS

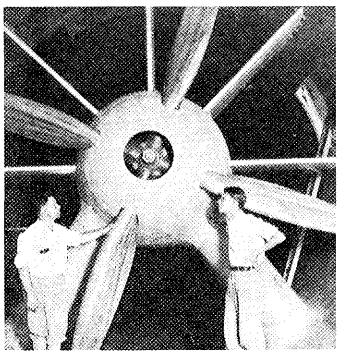
A graduate school of aeronautics was founded in 1926. Under the leadership of Theodore von Kármán, Galcit (Guggenheim Aeronautical Laboratory C.I.T.) soon became supreme in its field, and for many years supplied most of the highly trained aeronautical engineers in the country.



Theodore von Kármán (right) probably had more to do with the growth of aviation than any other man of his century. His work ranged from early improvements in airplane design to the development of supersonic flight. He proved the feasibility of jet-assisted take-offs for airplanes (JATO) and founded the Jet Propulsion Laboratory as a center for rocket research.



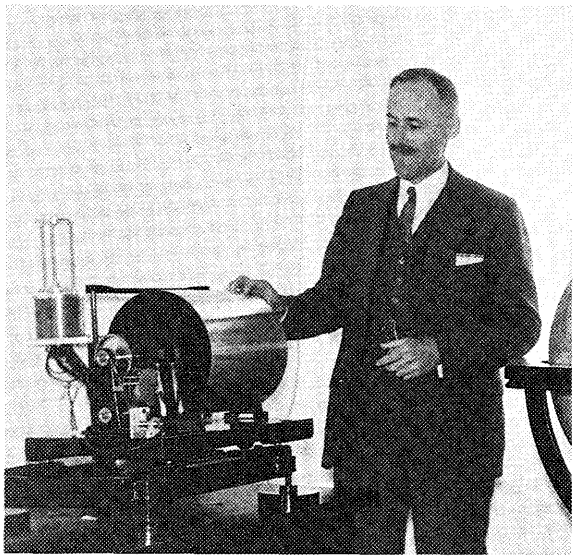
The aeronautics staff in 1930: W. Tollmien and R. Seifert (visiting professors from Göttingen), William Bowen, Clark B. Millikan, Harry Bateman, Theodore von Kármán, Arthur L. Klein, Ernest E. Sechler, W. B. Oswald, F. F. McFadden, Frank Moyers.

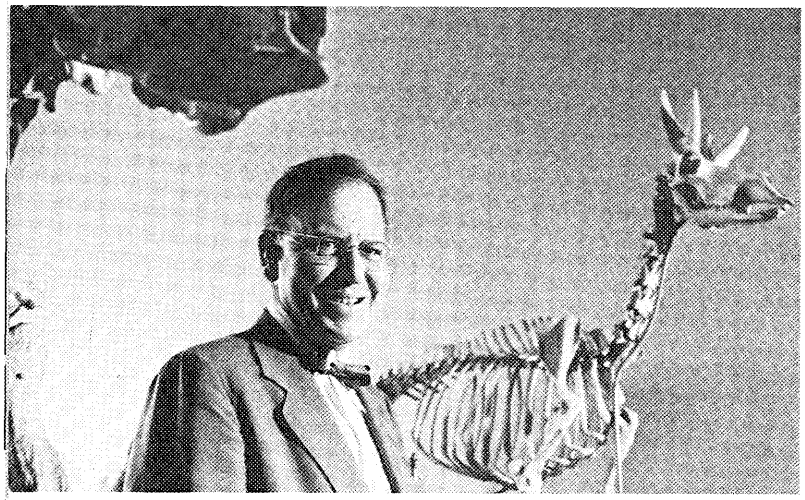


The 200-mph, 10-foot wind tunnel, designed by Arthur L. Klein (left) and Clark Millikan. Completed in 1929, it became a vital tool of the growing aircraft industry. Millikan was director of Galcit from 1949 to 1966.

GEOLOGY

Caltech's geology division was established in 1926 with an initial emphasis on structural geology and paleontology, and in 1928 the new Seismological Laboratory began operations. Important work of the division in the next two decades included geological studies for routing the Metropolitan Aqueduct from Boulder Dam to Los Angeles, the universal earthquake magnitude scale (the Richter scale), and basic contributions to the geological history of western North America.

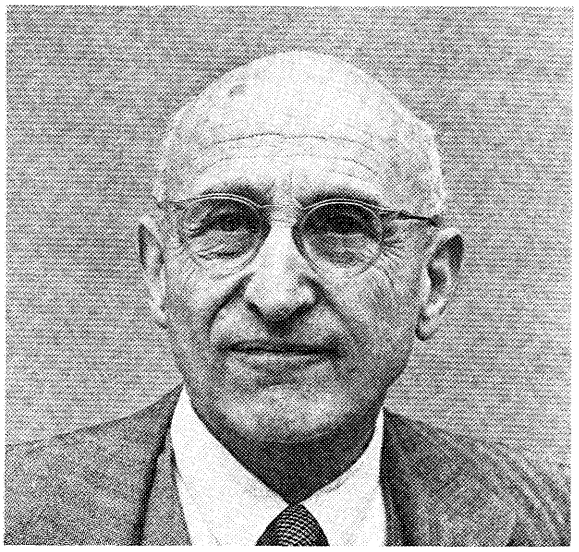




John P. Buwalda (above) founded the Caltech geology division and was its chairman until 1947. A distinguished structural geologist, he worked for 30 years to convince Californians of the necessity of earthquake-resistant construction.

Chester Stock (left) came to Caltech as professor of paleontology in 1926, was chairman of the division from 1947 until his death in 1950. His work on fossil mammals helped to establish the principles of mammalian evolution.

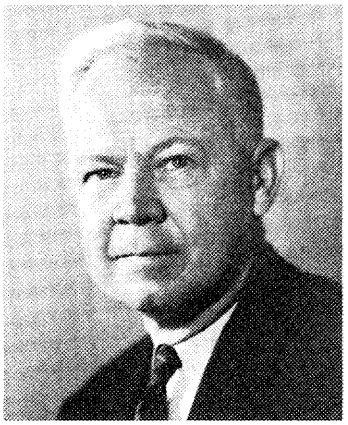
Beno Gutenberg's decision in 1930 to join the Seismological Laboratory probably did more than anything else to shift the center of seismological research from Germany to the United States. His contributions included the first correct determination of the earth's core, the mechanism and energy of earthquakes, and the structure of the earth's crust.



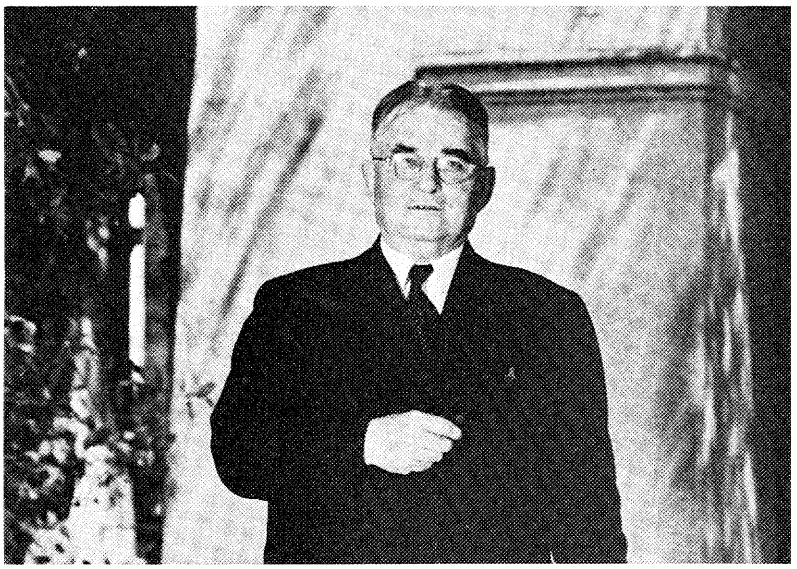
HUMANITIES

A strong emphasis on liberal arts, a tradition dating back to Throop College days, was reaffirmed when Hale, Noyes, and Millikan created the modern Caltech. The educational policies formulated by them in 1921 established the requirement—unique in any engineering college at that time—of four consecutive years of study in the humanities for all undergraduates.

The humanities program developed under the leadership of Clinton Judy, division chairman from 1923 to 1949, and William B. Munro, former chairman of the division of history, government, and economics at Harvard. Munro joined the Caltech faculty in 1927, served on the executive council, board of trustees, and as Institute treasurer.



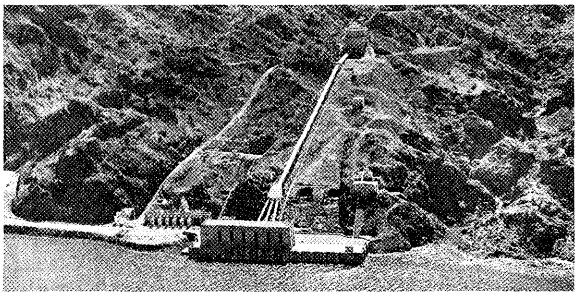
Clinton K. Judy joined Throop faculty as professor of English in 1909, retired as chairman of humanities in 1949.

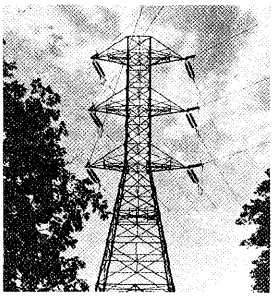


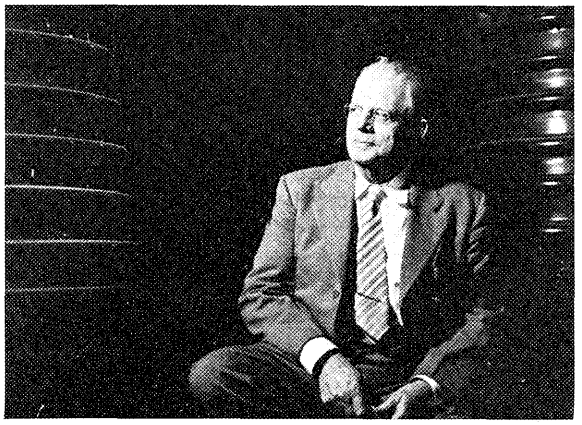
William B. Munro, professor of history, secured endowment for humanities, directed the early building program.

Wallace Sterling, now president of Stanford University, was on the Caltech humanities staff from 1937-48.

ENGINEERING







Within a few years after Throop's change in 1908 to a technical college, the basic courses in civil, electrical, and mechanical engineering were set. They were remarkably similar in principle to those given today, with an emphasis on fundamental science and mathematics, a substantial amount of time devoted to humanities, and a minimum of specialized courses.

Franklin Thomas (left), who developed Caltech's civil engineering department after he came in 1913, probably did more than any other individual to get Colorado River water for southern California. He was chairman of the division of civil and mechanical engineering, aeronautics, and meteorology from 1924 to 1944, and dean of students from 1944 until his death in 1952.

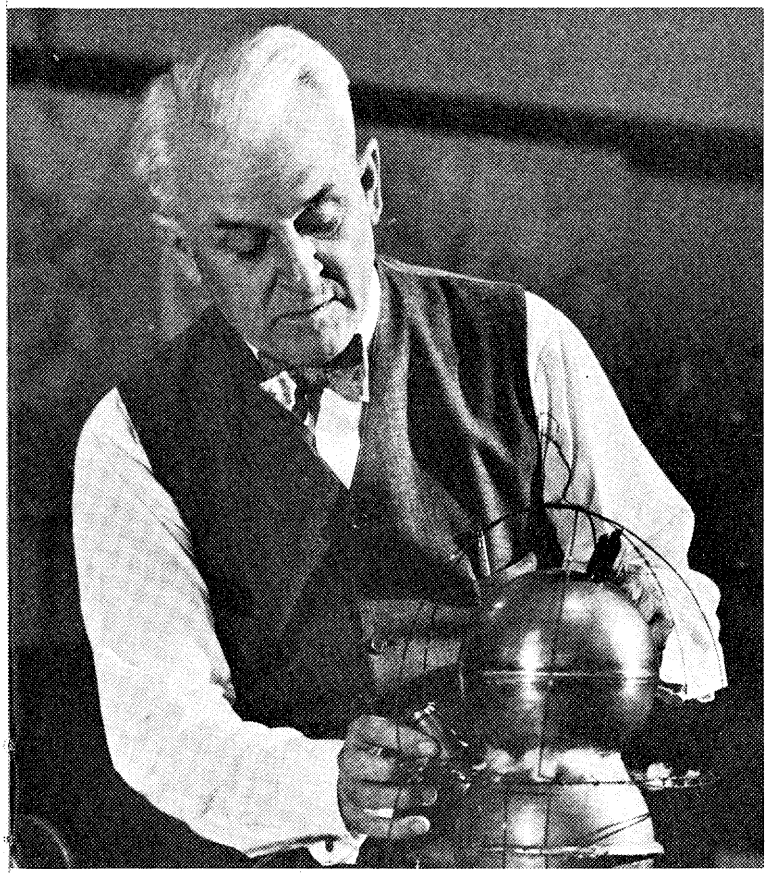
Royal Sorensen (right) came to Throop in 1910 to organize an electrical engineering program and stayed to develop it into one of the best in the world. He designed Caltech's high-voltage laboratory, the first 1,000,000-volt high-power facility in the country. The research he directed there played a significant part in the development of high-voltage transmission systems, and the industrialization of southern California.

WORLD CENTER OF RESEARCH 1921–1941

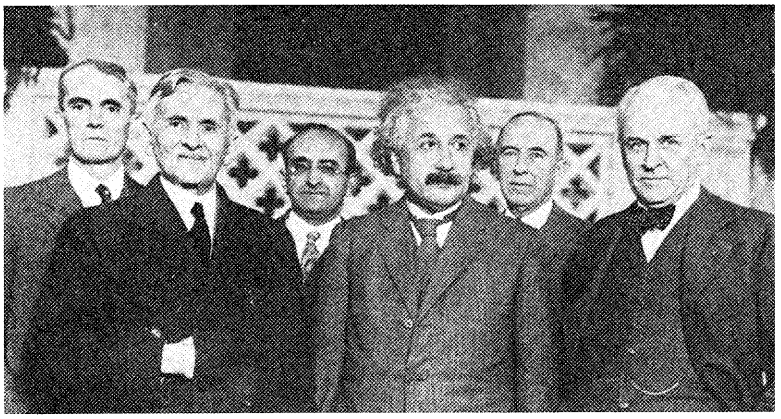
By 1928, only seven years after Millikan's arrival, the modern Caltech had taken shape. It had established six academic divisions—the number the Institute has today—and the educational standards and policies that still govern its operation.

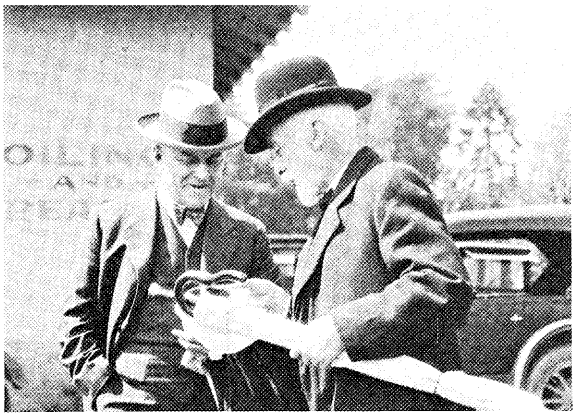
During the 20 years leading to World War II, the Institute attracted distinguished scientists from all over the world to its faculty and research laboratories. A few of these men, and their work, are shown in the following pages.

Distinguished physicists at Caltech, 1931. Front row: A. A. Michelson, first American to win the Nobel Prize in physics; Albert Einstein; R. A. Millikan. Back row: Walter S. Adams, director, Mt. Wilson Observatory; Einstein's secretary, A. A. Meyer; Max Farrand, director, Huntington Library.



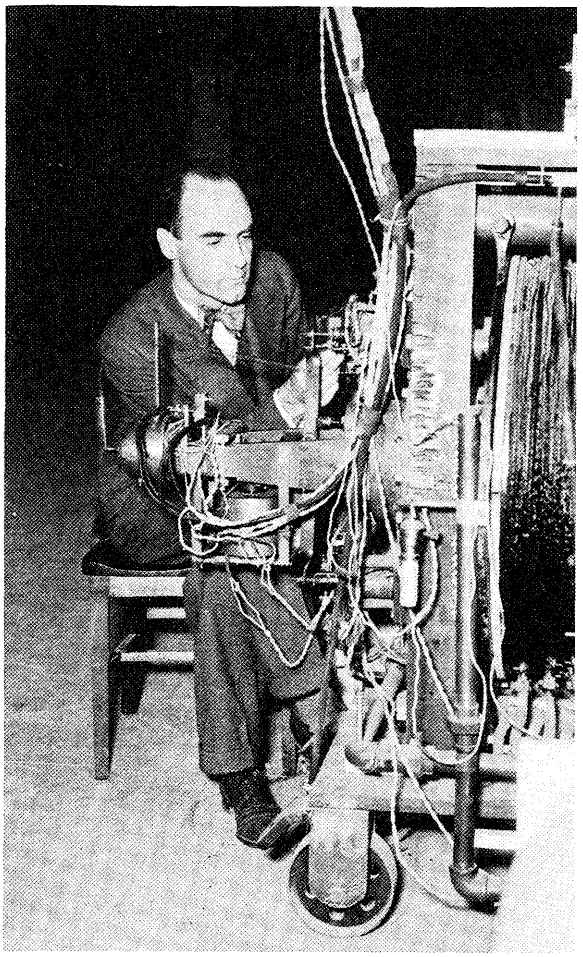
R. A. Millikan (above) and Victor Neher designed and built this instrument, used to measure cosmic rays in selected areas around the world at altitudes up to 95,000 feet.



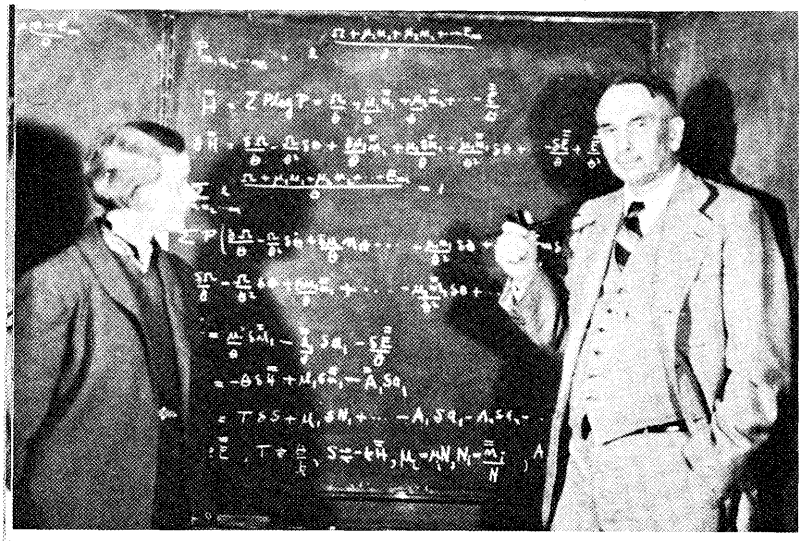


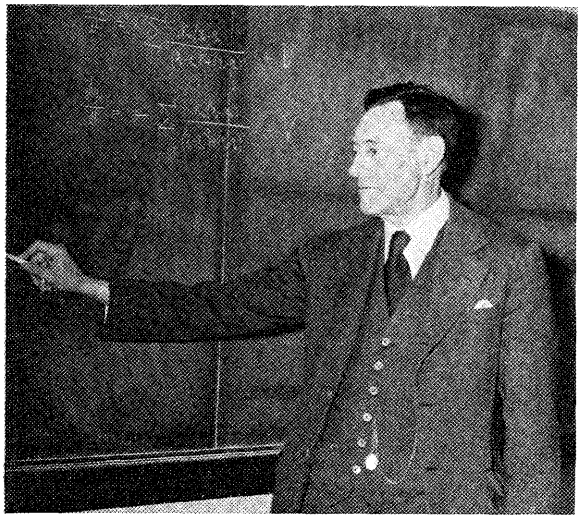
H. A. Lorentz, Dutch winner of the 1902 Nobel Prize in physics, had been doing brilliant research in theoretical physics for 60 years when Millikan persuaded him to lecture at Caltech in 1922-23.

Carl Anderson discovered the positron in 1932, using a Wilson cloud chamber placed between the poles of this magnet. Work earned him Nobel Prize.

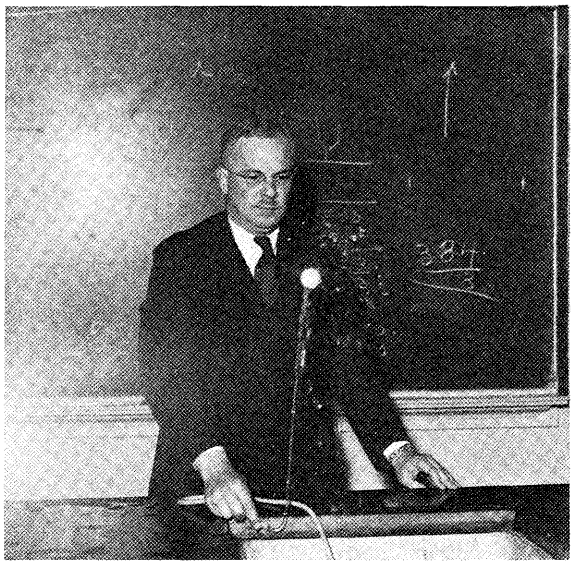


Richard Tolman with his wife Ruth. His versatility accorded him expert status in cosmology, relativity, atomic energy, thermodynamics, statistical mechanics, chemistry, and mathematical physics.



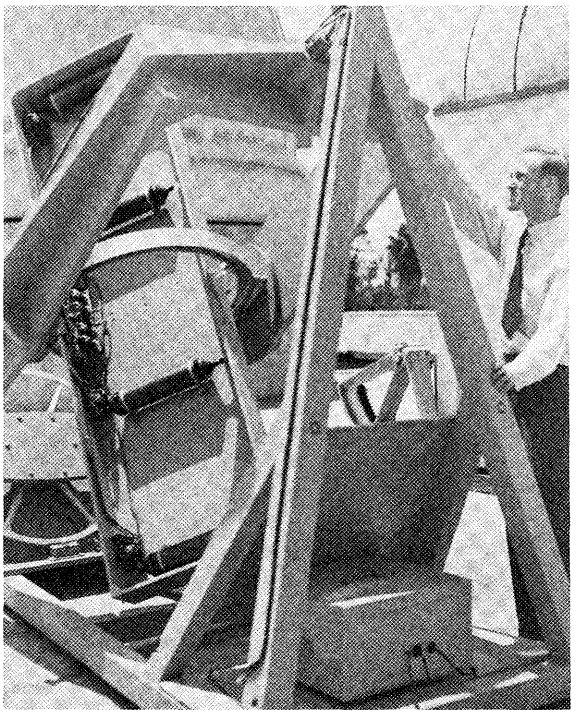


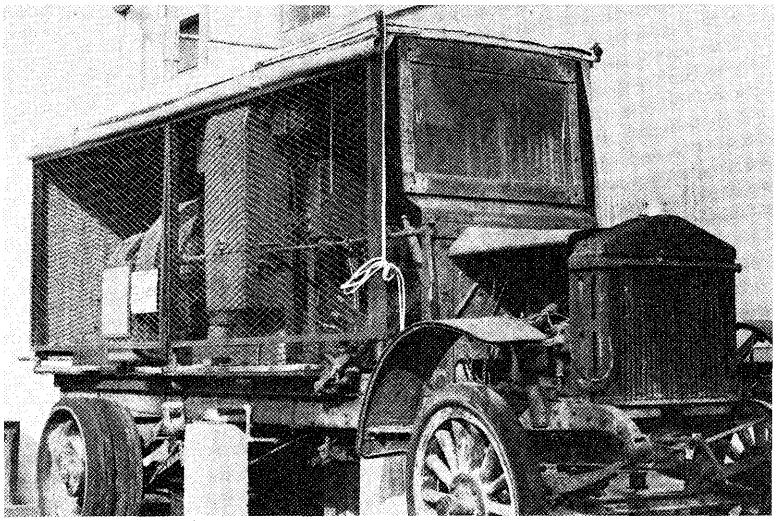
Harry Bateman held full professorships in mathematics, physics, and aeronautics. He collaborated with, and actually came close to anticipating, Einstein on his general theory of relativity.

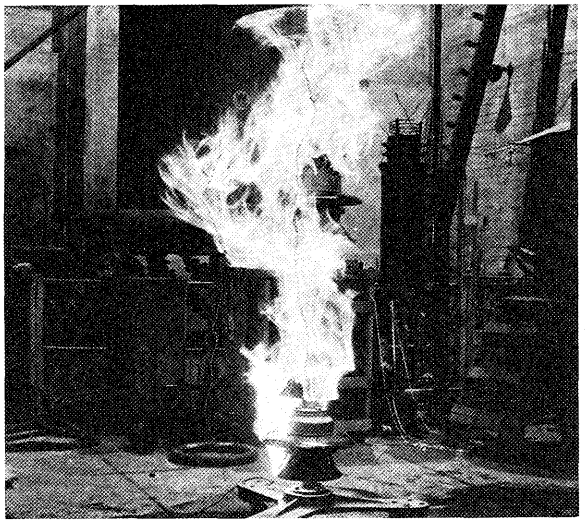


Robert L. Daugherty, lecturing here on fundamentals of hydraulics, came to Caltech in 1919 to head the mechanical engineering department, did important work on pump design for Grand Coulee and Colorado River projects.

This converted 1912 Pierce-Arrow, once used to supply power for movies on location, served Carl Anderson in his cosmic ray research for almost 30 years.

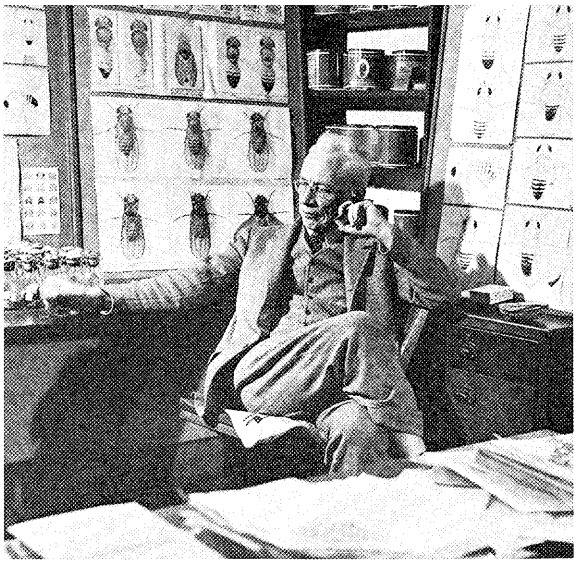






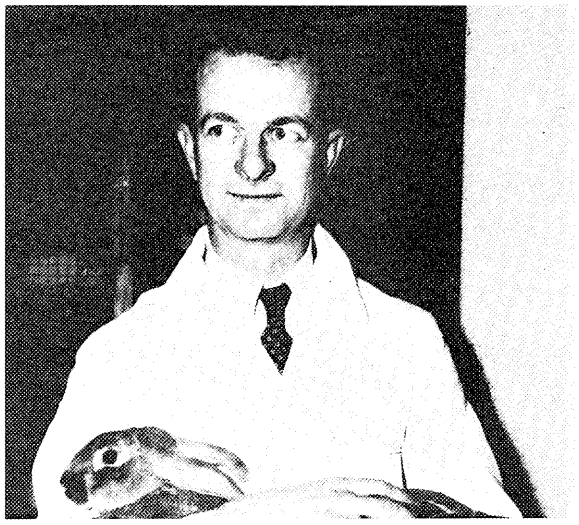
W. H. Pickering (now Jet Propulsion Laboratory director) with cosmic ray telescope he built for research with R. A. Millikan in the 1930's.

Work in the high-voltage lab (right) led in 1928 to C. C. Lauritsen's million-volt x-ray tube, the "father" of all high-potential vacuum devices.

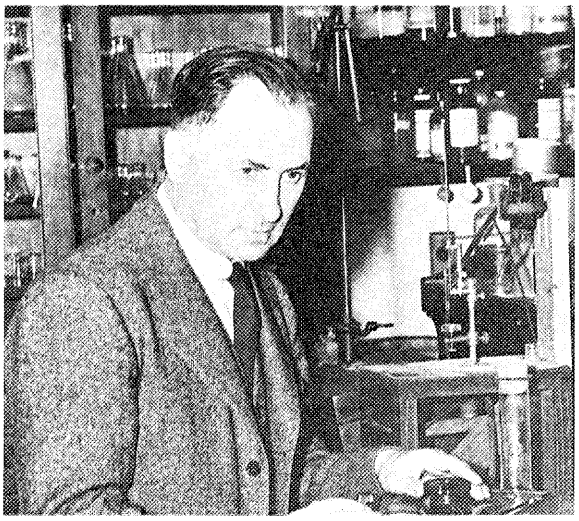


A. H. Sturtevant came to Caltech with Thomas Hunt Morgan in 1928, was discoverer of the linear arrangement of genes in the chromosome.

A. J. Haagen-Smit (left) was brought to Caltech by T. H. Morgan (right) in 1937 to do research in flavor chemistry, later made pioneer studies of smog.



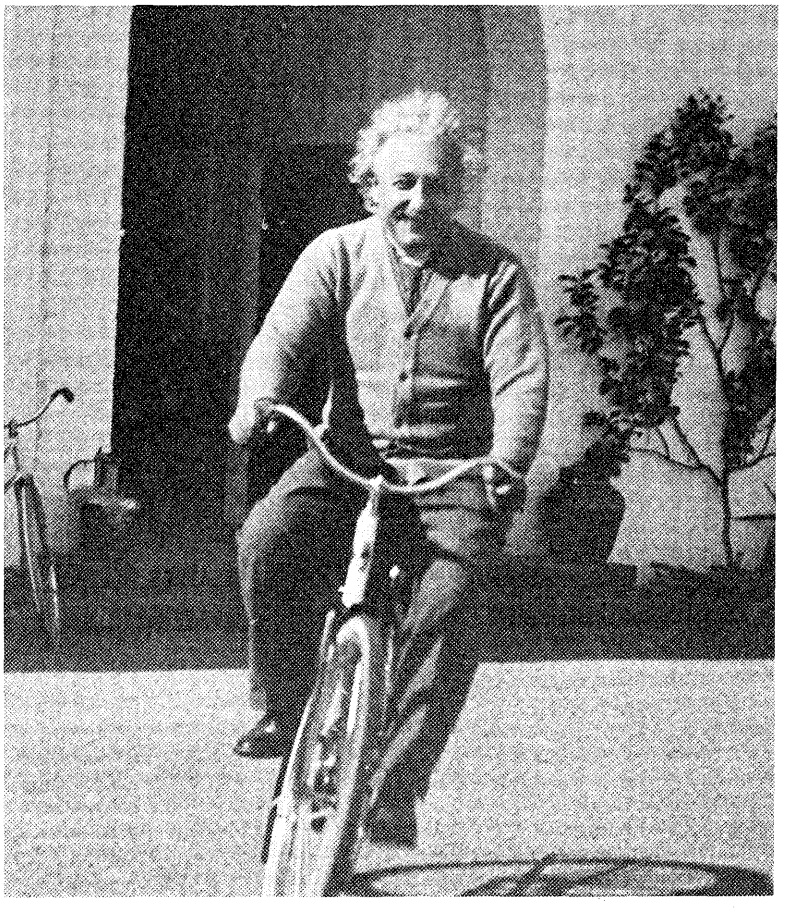
Linus Pauling, who came to Caltech in 1922 to do graduate work under Arthur Amos Noyes, used quantum theory to explain the nature of the chemical bond.



Biochemist Henry Borsook's early work on vitamins led him to develop the cheap, nutritious "multi-purpose food" that has fed millions around the world.

Caltech's world-famous Jet Propulsion Laboratory had its genesis in these first experiments on propellants, conducted in the Arroyo Seco (1936-37) by members of the first rocket team— John W. Parsons, Frank J. Malina, and Edward S. Forman (foreground)—graduate students working with Theodore von Kármán.

Caltech faculty members began giving Friday evening demonstration lectures for the public in the late 1920's. The most popular lecture through the years was this demonstration of liquid air effects by Earnest C. Watson, dean of the faculty (1945-1960) and professor of physics from 1930 until his retirement in 1962. The lectures continue today, on Monday evenings in Beckman Auditorium.



The young Caltech's attractions for visiting scholars included scientific vitality, a salubrious climate, a variety of recreational opportunities.

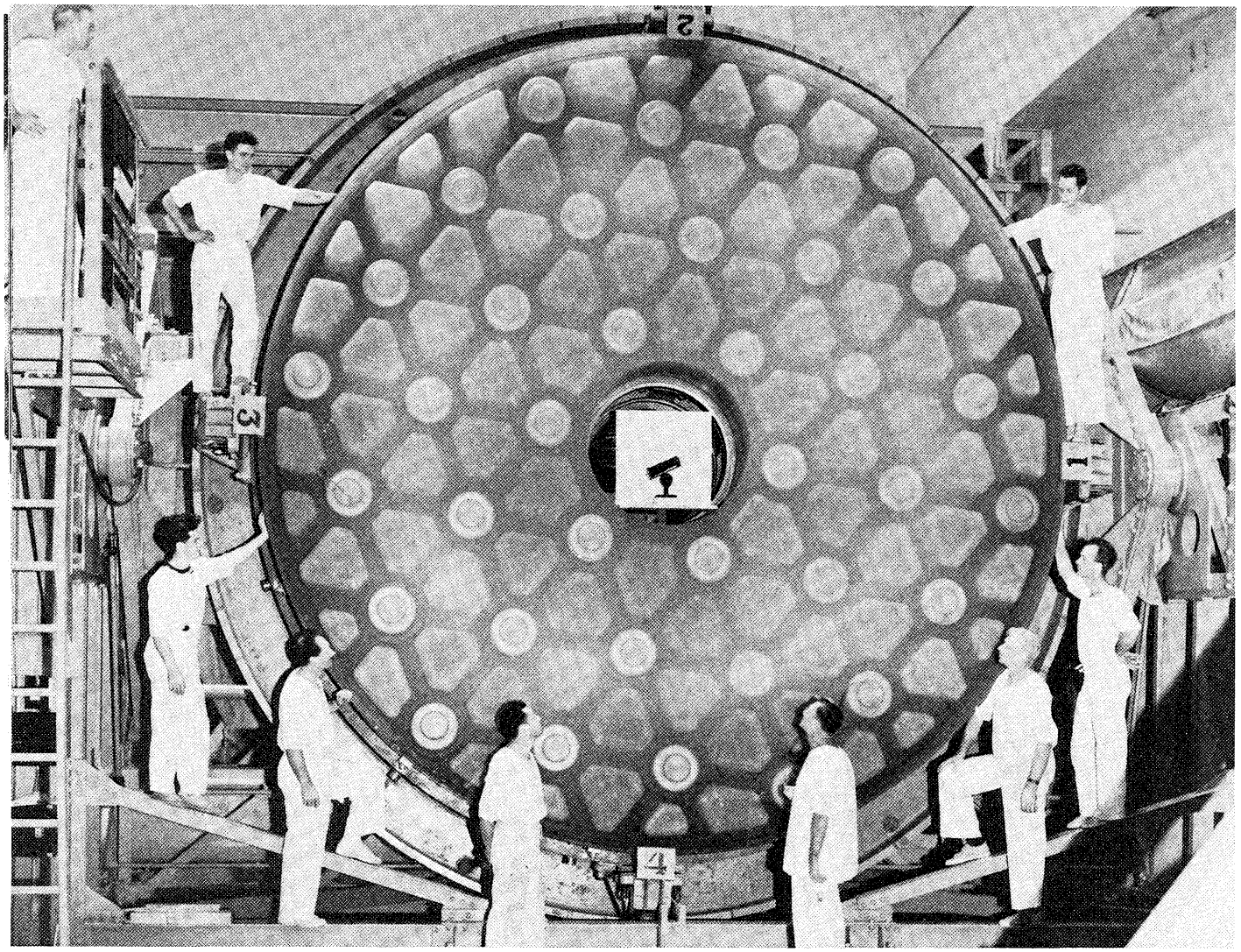
In 1928, George Ellery Hale, founder of both the Yerkes and Mount Wilson observatories, launched his last and greatest project—the 200-inch telescope.

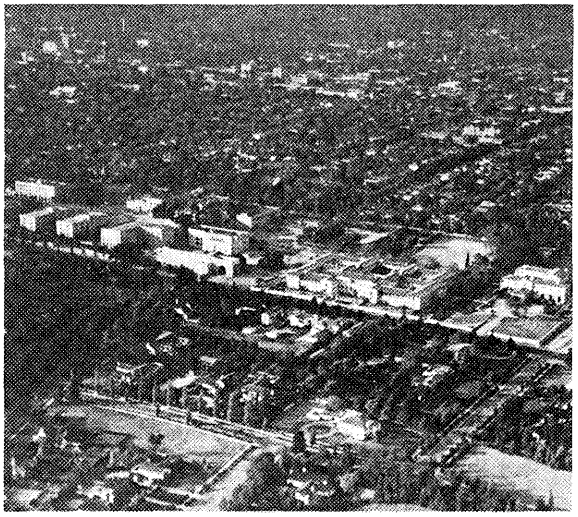
The 20-ton pyrex mirror of the telescope was brought to the Caltech campus in 1936 for the long and delicate process of grinding and polishing.

Installed in the big, windowless optical shop built for that purpose, the great disk, rotating on its mounting once every 80 seconds, was treated with 31 tons of abrasives ranging from carborundum to a fine grade of rouge.

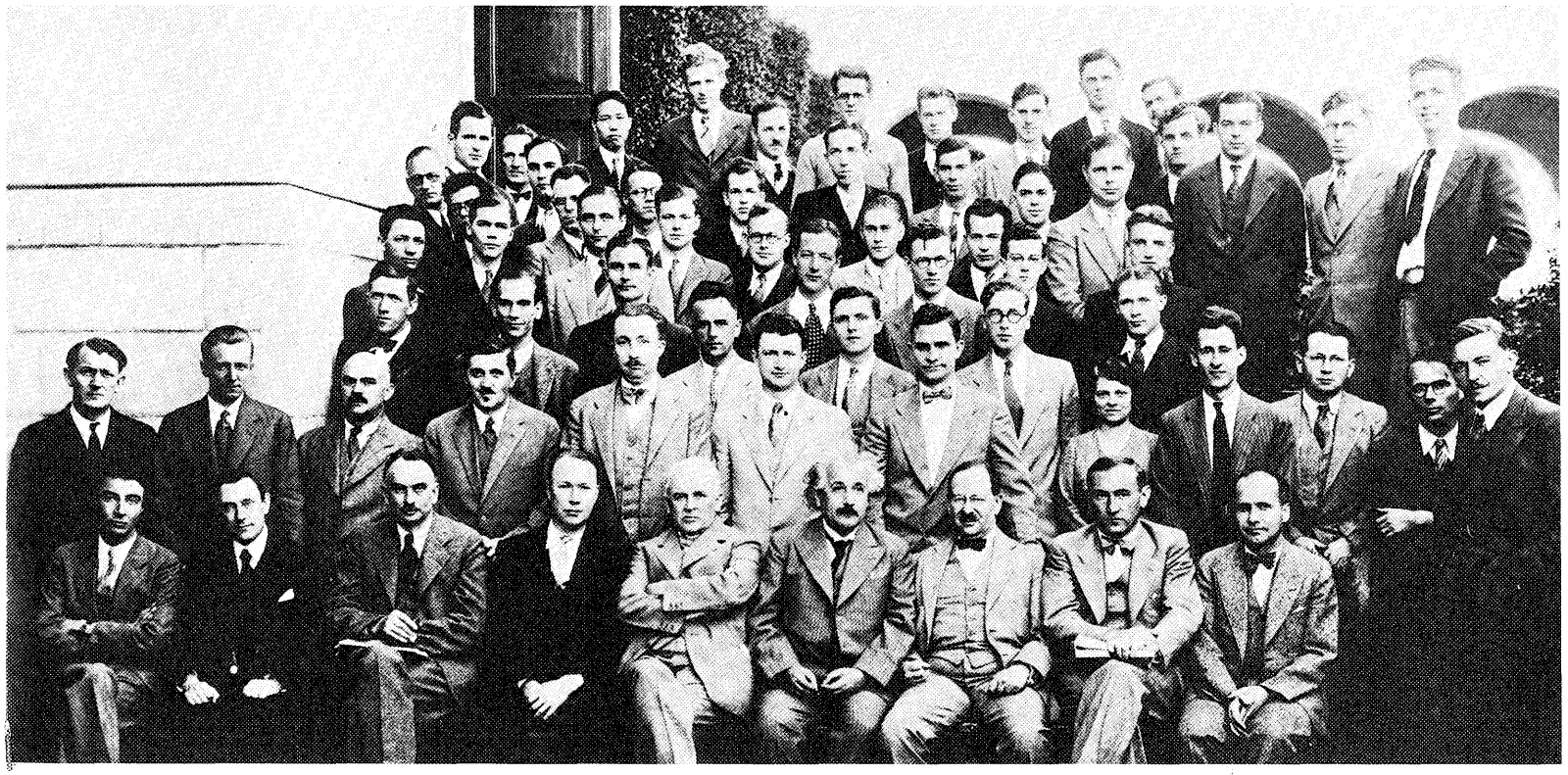
The polishing was interrupted for three years by the war, and it was not until 1947 that the now-concave mirror —$5^1/_4$ tons lighter and with its parabolic surface accurate to within two one-millionths of an inch—left the optical shop to be installed at Palomar.

Optical shop crew inspects the finished 200-inch mirror. In the center is a replica of Isaac Newton's first reflecting telescope.





By 1932 much of the Goodhue campus plan had been implemented. Added to the four original buildings were Guggenheim, Kerckhoff, Crellin, Kellogg, and High Voltage (now Sloan) laboratories; Dabney Hall of Humanities; the Athenaeum; and four student houses.



Physics staff in 1932 consisted of 27 faculty, 57 graduate students. Front row: Robert Oppenheimer, Harry Bateman, Richard Tolman, William Houston, Robert Millikan, Albert Einstein, Paul Epstein, Fritz Zwicky, Earnest Watson. Second row: Charles Lauritsen, William Stierstadt, Raymund Sanger, Gennady Potapenko, Jesse DuMond, Robley Evans, William Smythe, Miss LeGrand (secretary), Charlton Lewis, Everly Workman, Ira Bowen, Alexander Goetz. In the group at upper left are Victor Neher and Carl Anderson.

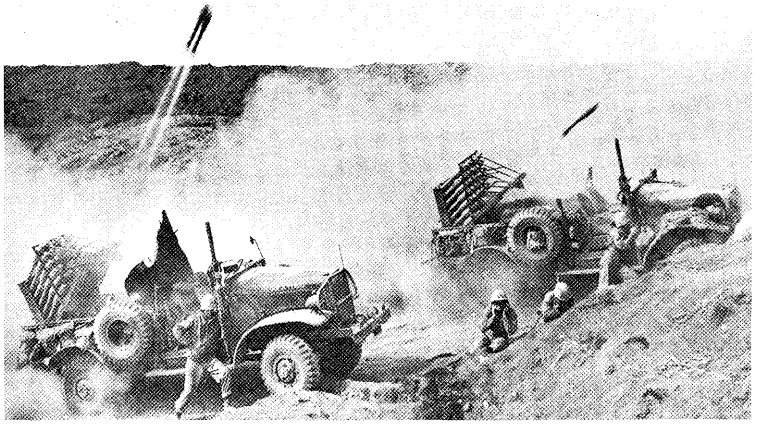
WORLD WAR II

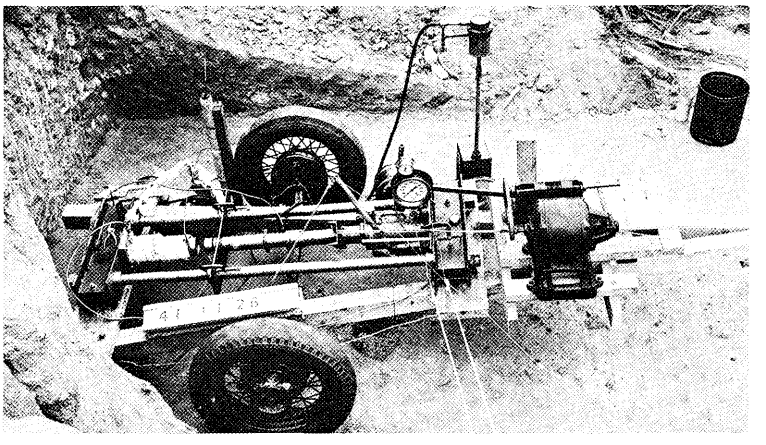
For five years, beginning with the summer of 1940, Caltech personnel and facilities were devoted almost exclusively to war work. A unit of Navy V-12 Engineering Specialists was housed and trained on the campus, and more than 24,000 men were instructed, under the Management War Training Program, in such fields as advanced meteorology, aeronautics, and ordnance.

But the Institute's major war contribution was in rocket research and development. Caltech supplied the U.S. Armed Forces, at a cost of nearly $80,000,000, with more than 90 percent of all rockets used during the war. Because the weapons were so urgently needed, the Institute turned out over a million rounds before industry could tool up to supply the demand.

Caltech barrage rockets in action—the Marine landing, Iwo Jima, Feb. 19, 1945.

Charles C. Lauritsen headed Caltech's enormous wartime program of rocket research and development. The rocket project staff grew to more than 3000.

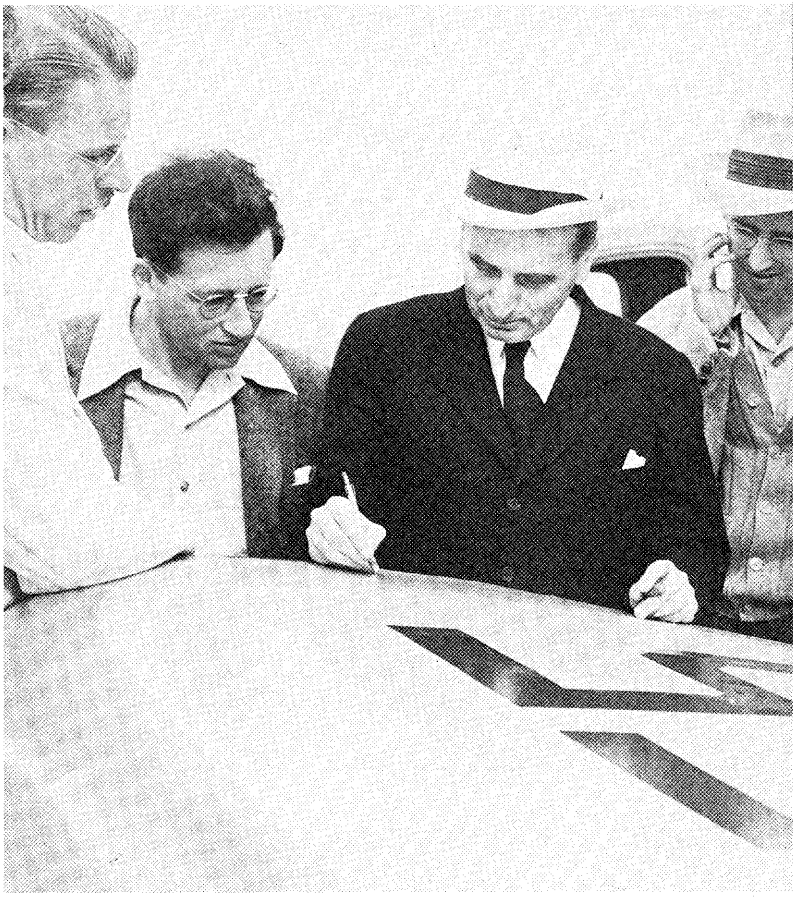




The first equipment for dry extrusion of rocket propellant, constructed by C. C. and Thomas Lauritsen, at the Eaton Canyon ammunition site, 1942.

Physicist H. P. Robertson played an important liaison role between science and the military, served on every major science advisory board during the war.

Chemical engineers Bruce Sage and Will Lacey directed rocket propellant research. Volunteers manned three 8-hour shifts to produce propellants.



Von Kármán (center) and Galcit rocket research group make final plans for the first test flight of their jet-assisted take-off (JATO) unit in 1941.

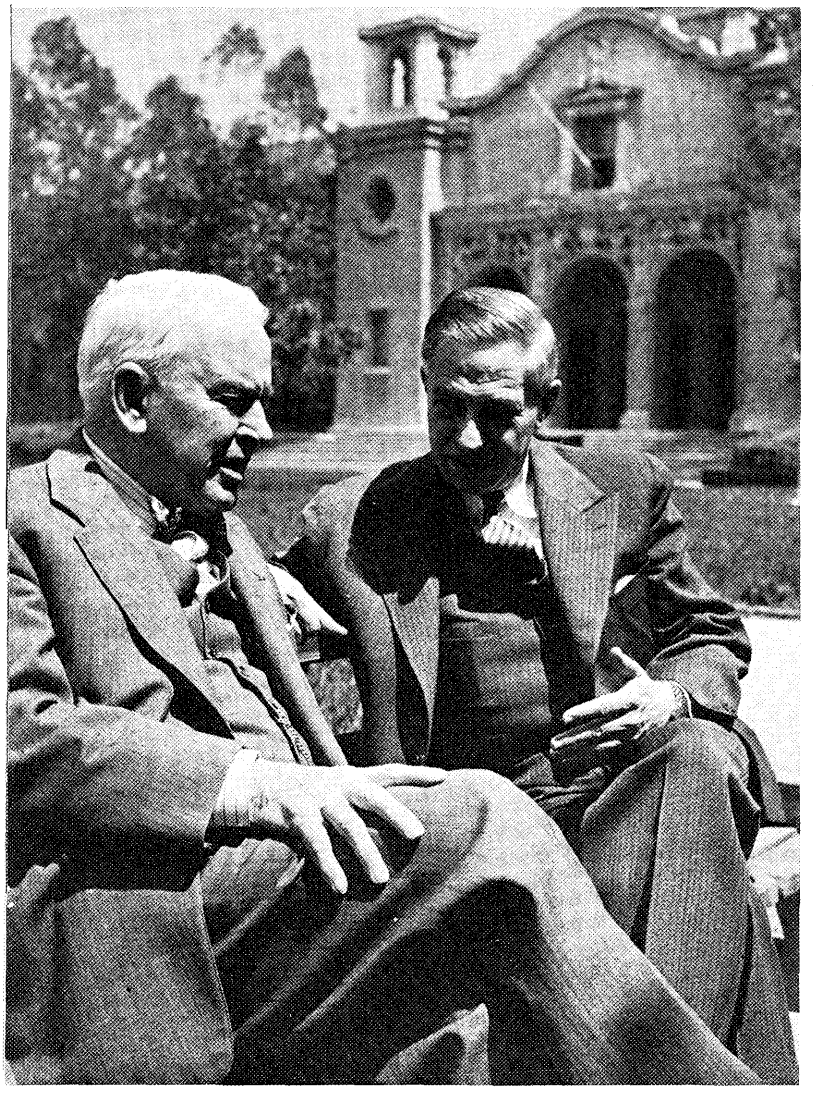
THE DuBRIDGE YEARS

With the retirement of Robert A. Millikan, Caltech in 1946 entered a new period of expansion under a new president—Lee A. DuBridge.

DuBridge, formerly chairman of the physics department and dean of the faculty at the University of Rochester, came to Caltech after five years as wartime director of the great MIT Radiation Laboratory. During his 20 years as president, Caltech's teaching faculty has doubled, the number of buildings has more than doubled, and the size of the campus has tripled.

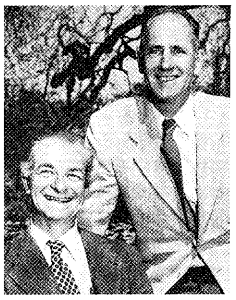
The Institute's growth has been selective, however. The number of undergraduates has increased by only about 80 students, to a total of 700. But in advanced study and research the number of graduate students has doubled, to 750; and the research staff has quadrupled, to over 500.

During a period of great demands on science and technology, and great pressures on education to mass-produce, DuBridge has guided the Institute in the tradition established by its founders—a tradition of scientific and engineering education at its best.

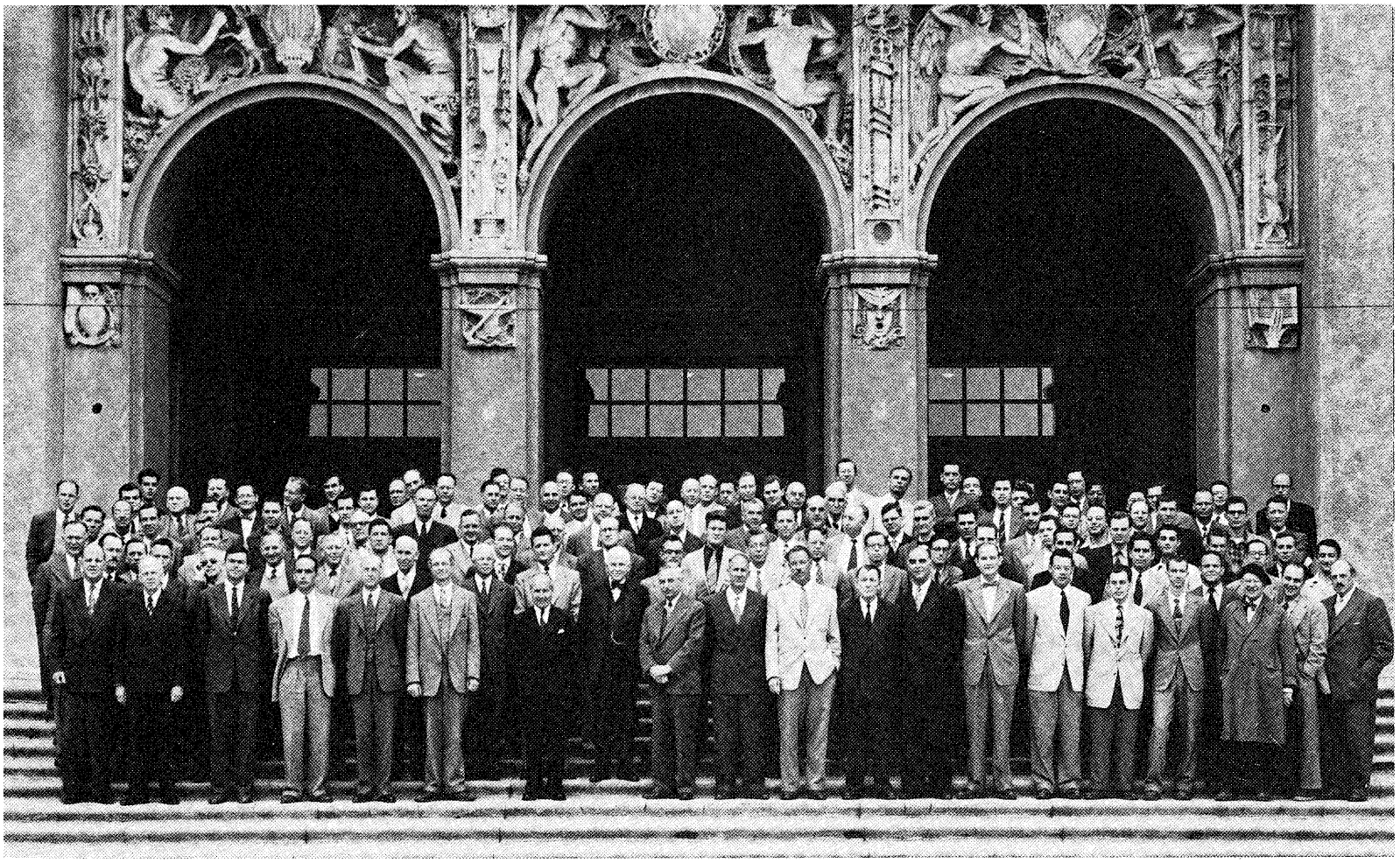


Robert A. Millikan, chairman of the Institute's executive council from 1921 to 1945; and Lee A. DuBridge, inaugurated president of the Institute on November 12, 1946.

The postwar years were a period of tremendous change for scientific education and research. The separate sciences were beginning to merge, as in the pioneer program established by Caltech's biology and chemistry divisions in the 1950's. New fields of study, such as molecular biology and geophysics, were emerging; and ancient sciences, such as astronomy, were vastly increased in scope by new tools of research. At Caltech today, 800 research projects are under way. The following pages illustrate only a few.



The boundaries between the sciences begin to disappear. In 1954 Linus Pauling, chairman of the chemistry division, and George Beadle, biology chairman, launch a major research program in chemical biology.



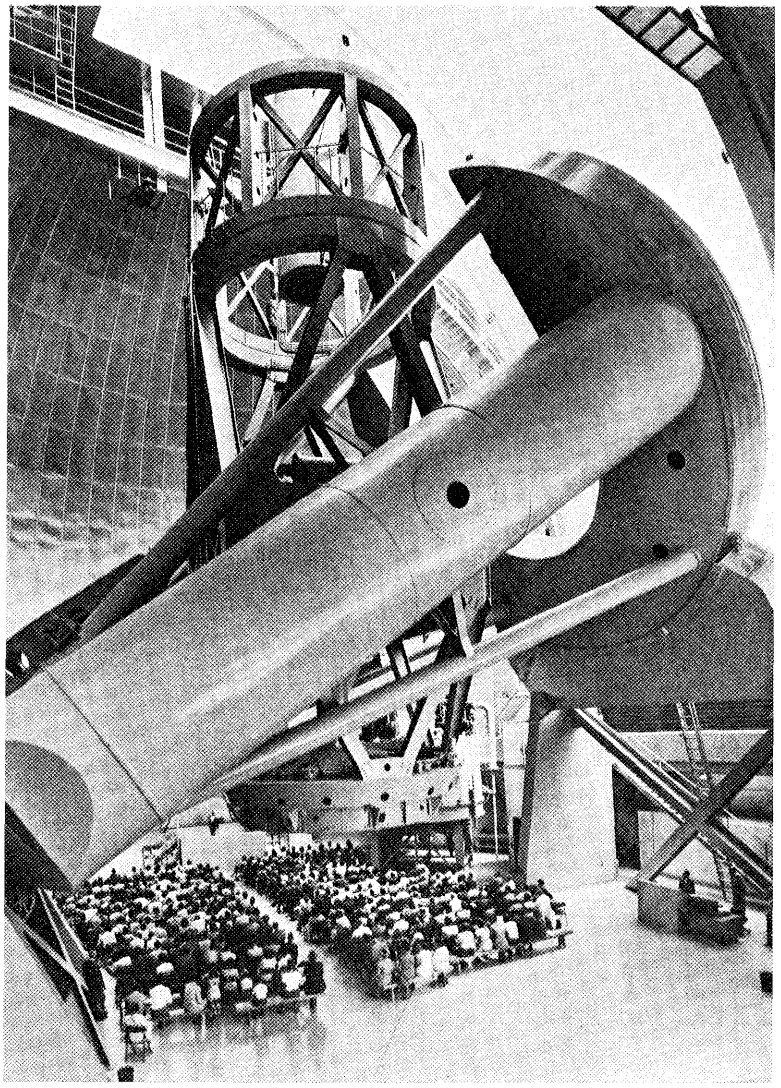
The Caltech faculty (or at least as many of them as could be rounded up) stands for its portrait on the steps of Throop Hall, April 1952.

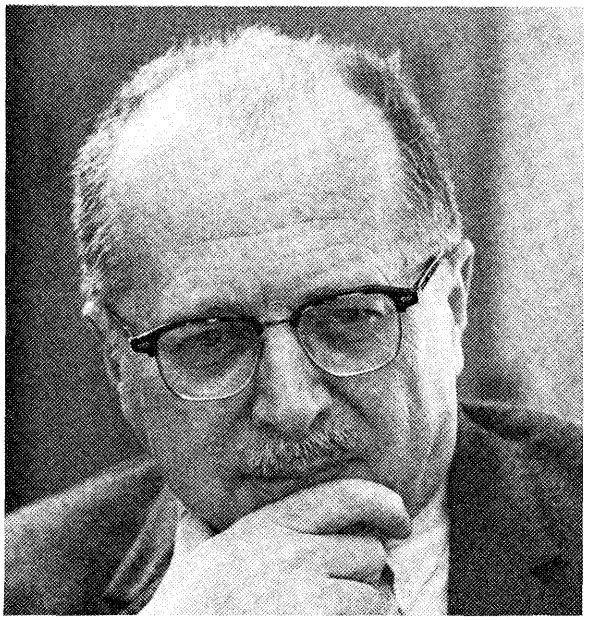
ASTRONOMY AND RADIO ASTRONOMY

The great Palomar Observatory, one of the most valuable research tools ever built, was completed in 1948. It's 200-inch telescope, able to probe from the atmosphere of the planets to star systems billions of light years away, has revolutionized concepts of the content, nature, size, and age of the universe.

With the completion of Palomar, the Institute began a program of teaching and research in astronomy and astrophysics. Under the guidance of Jesse L. Greenstein, the new department launched the study of the composition, temperature, masses, and evolution of stars and galaxies. This research, combined with work of the Kellogg Radiation Laboratory, has given new understanding of the nuclear history and chemical evolution of the universe.

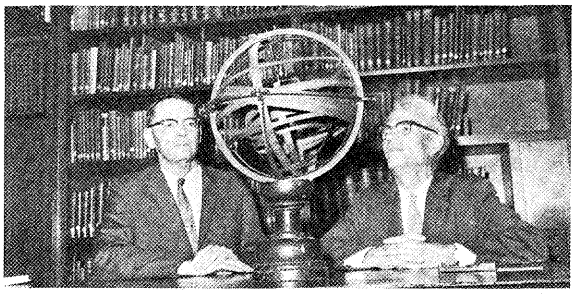
The Mount Wilson Observatory, a branch of the Carnegie Institution of Washington, but throughout its history closely allied with Caltech, is now operated jointly with Palomar.





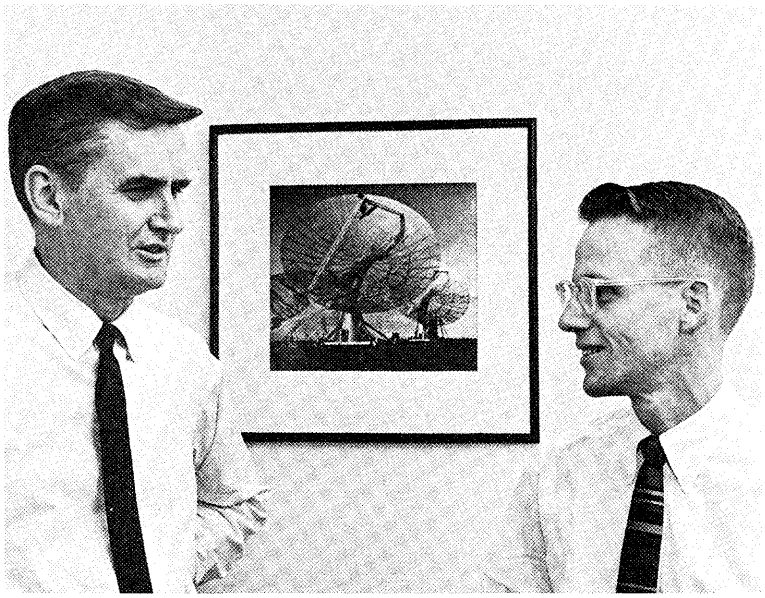
Jesse L. Greenstein came from Yerkes Observatory in 1948 to lead the Institute's new program of instruction and research in astronomy and astrophysics.

On the floor of the great Palomar Observatory dome, 300 distinguished guests from all over the world attend ceremonies, June 3, 1948, dedicating the 200-inch telescope to the man who started it all—George Ellery Hale.

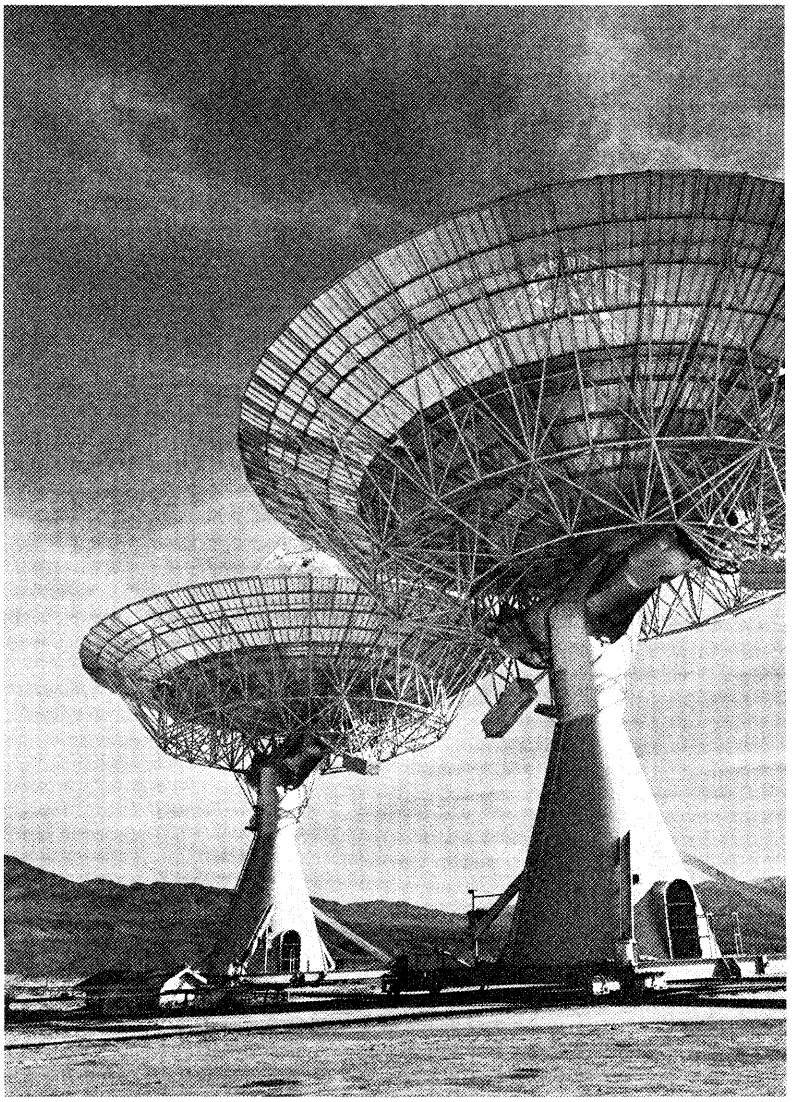


Horace W. Babcock (left) succeeded Ira S. Bowen as director of the Mt. Wilson and Palomar Observatories. Bowen, who directed final construction of the 200-inch telescope and its sophisticated auxiliary instruments, retired in 1964.

Radio astronomy, a powerful new ally in the study of space, is a rapidly growing field of study and research at Caltech. The Owens Valley Radio Observatory, with its two 90-foot antennae, has helped pinpoint and map sources of weak signals in space to near the edge of our universe. A new 130-foot radio telescope is scheduled for completion in 1967. In a ten-year development program, it is hoped that a total of eight large antennae will be built to make the Owens Valley installation the most powerful and versatile in the world.



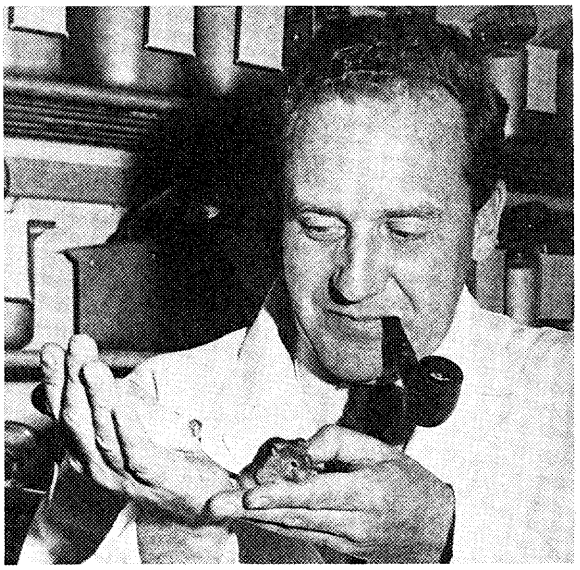
Radio astronomers Gordon J. Stanley, director of Owens Valley Observatory, and Alan T. Moffett collaborated with Palomar astronomers in discovery of radio galaxies and quasars—the most distant objects ever identified.



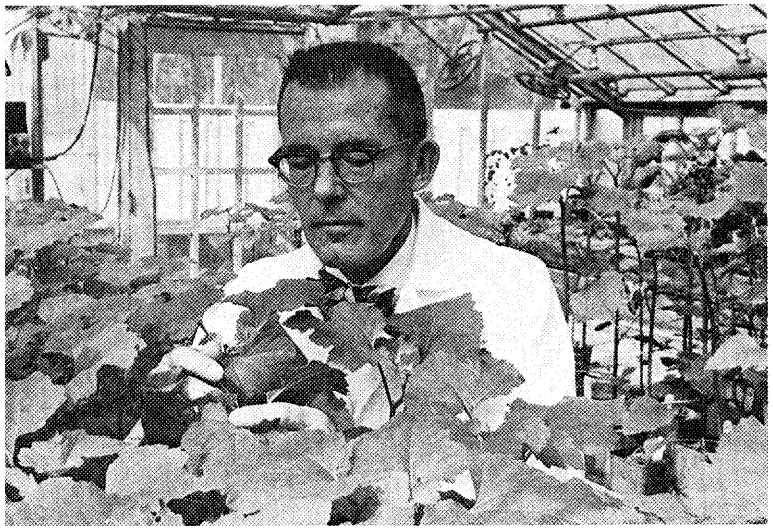
Twin 90-foot radio telescopes at Owens Valley Observatory are mounted on a quarter of a mile of railroad track to operate as a direction-finding unit.

BIOLOGY

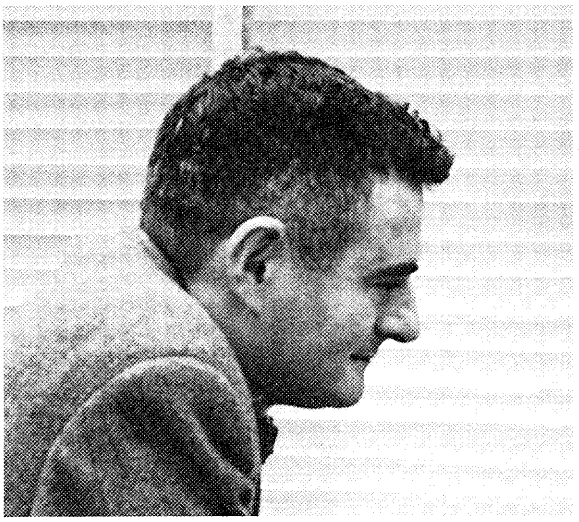
From its beginning the division of biology has concentrated on a few selected goals. Recent spectacular advances relate to the molecular bases of life—specifically to the identification and function of DNA and RNA. In the future, interest in simple organisms will expand to include more complex forms of life. At the same time, the division's continuing work in developmental and molecular biology will be extended to interact with new research on the brain and behavior.



Ray D. Owen, chairman of the division of biology since 1961, has contributed fundamental concepts to the field of immunogenetics and immunological tolerance in tissue transplantation.



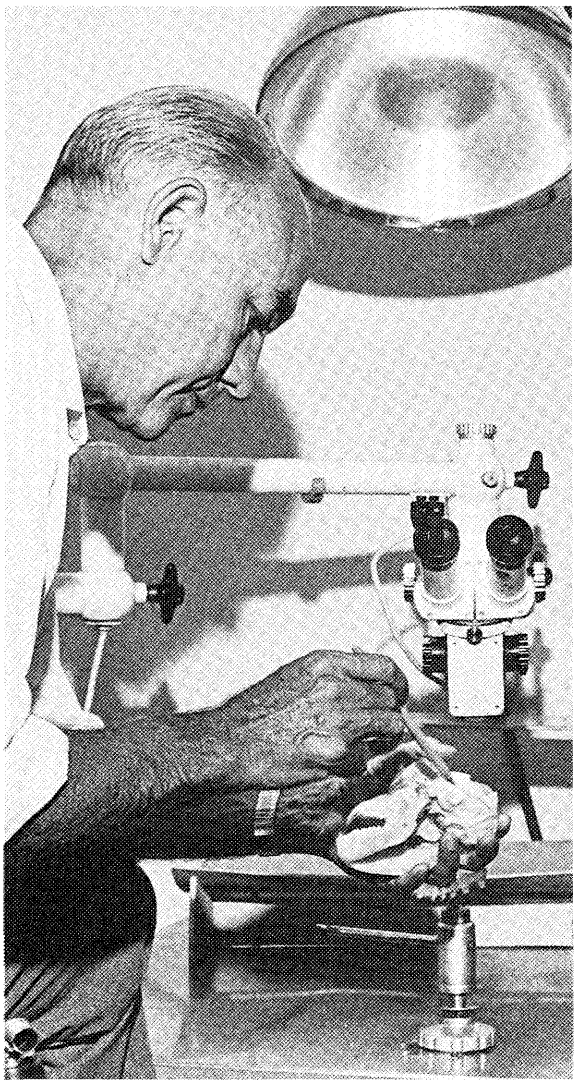
James Bonner (left) through his interest in basic plant biochemistry, has applied chemistry to studies of cell function, demonstrating the agents that control gene action as cells differentiate.

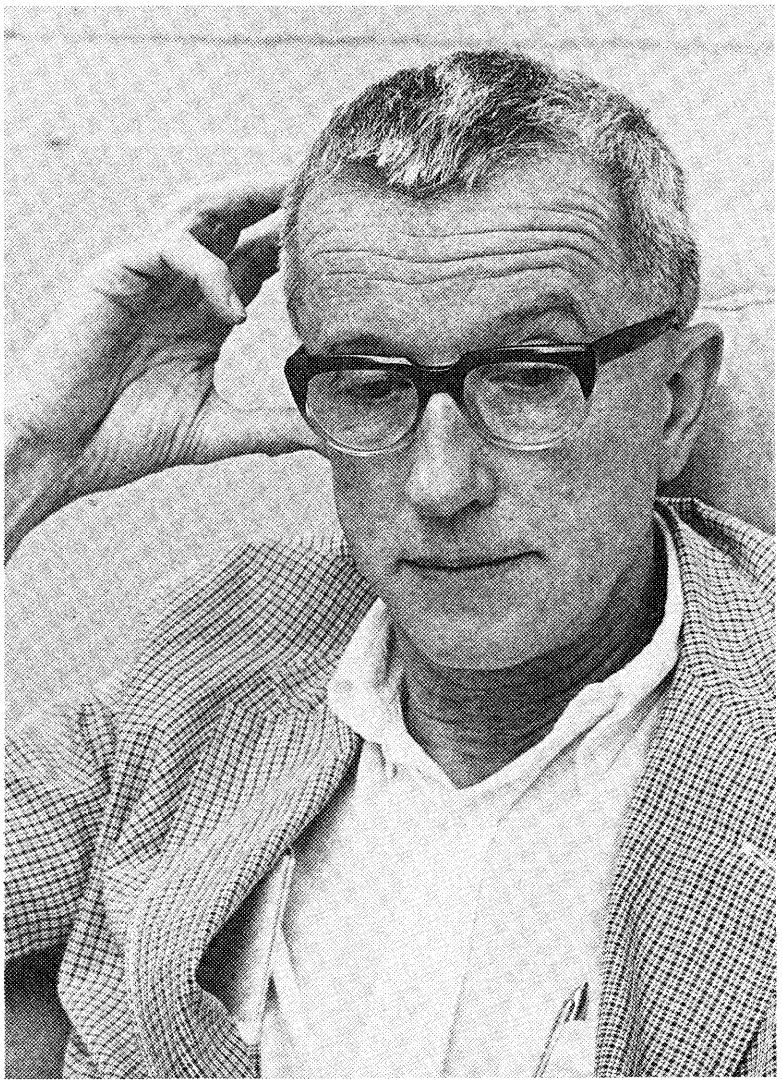


Robert L. Sinsheimer, professor of biophysics, discovered the existence of single-stranded DNA rings in viruses and found that these rings are converted into a double-stranded stage during the process of reproduction.

Roger W. Sperry, Hixon Professor of Psychobiology, developed the "split-brain" technique for studying the brain's circuitry, and proved that the nerve fiber circuits of the brain are established by intricate chemical codes specifying developmental patterns.

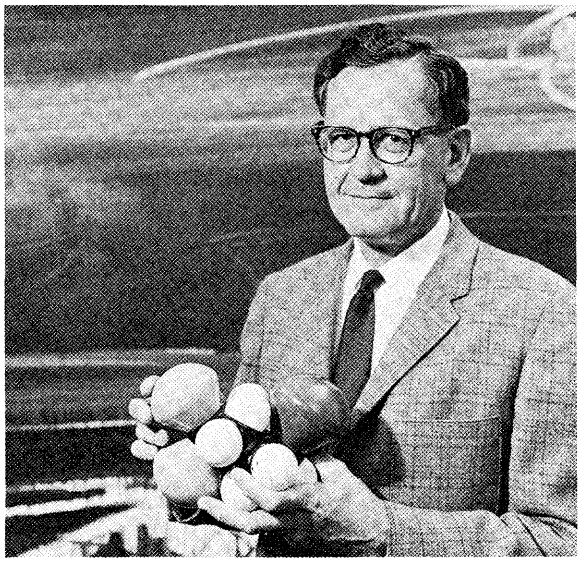
Max Delbrück, professor of biology, has played a decisive role in the understanding of the biophysical processes that characterize living systems and in the development of modern genetics through the precise use of viruses as research material.

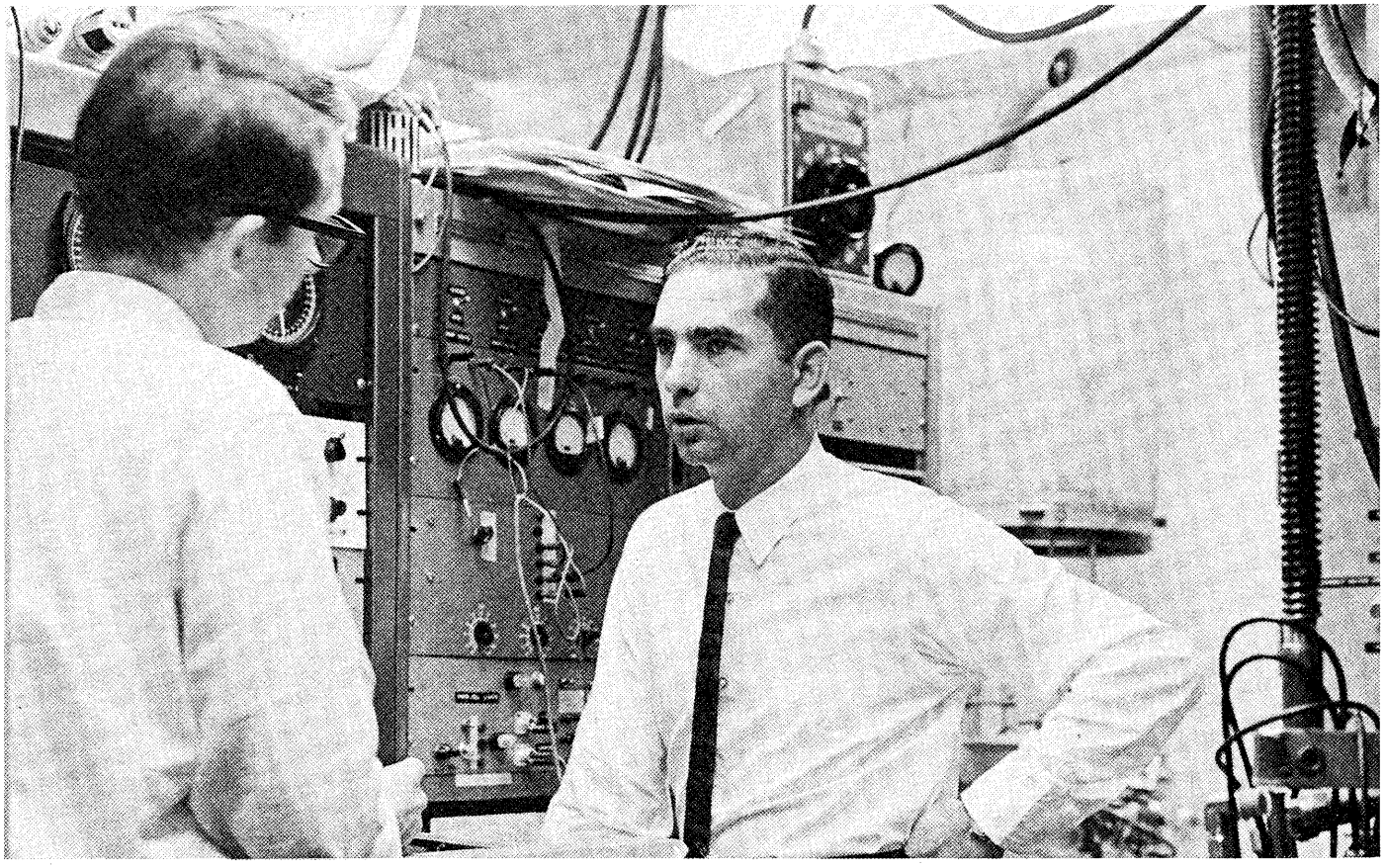




CHEMISTRY AND CHEMICAL ENGINEERING

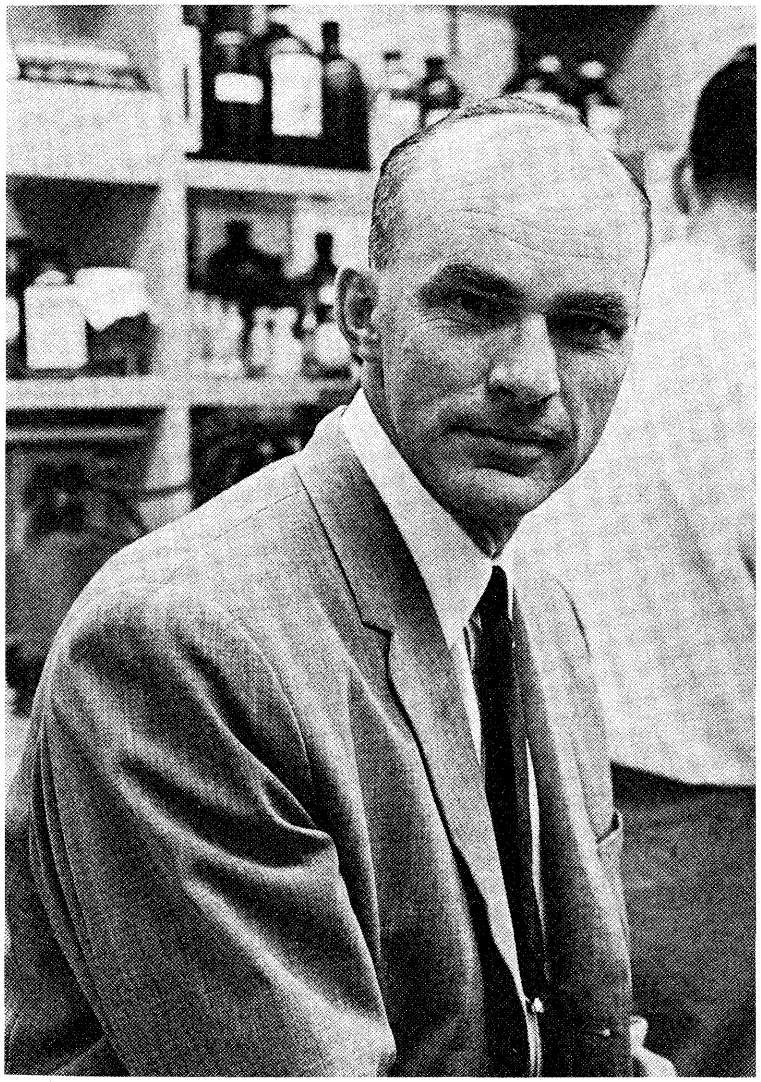
Under the chairmanship of John D. Roberts (right), the division embraces research in chemical physics, organic chemistry, inorganic chemistry, structural chemistry, biochemistry, and chemical engineering. A new chemical physics building now under construction on the campus will double the research space available for the division.



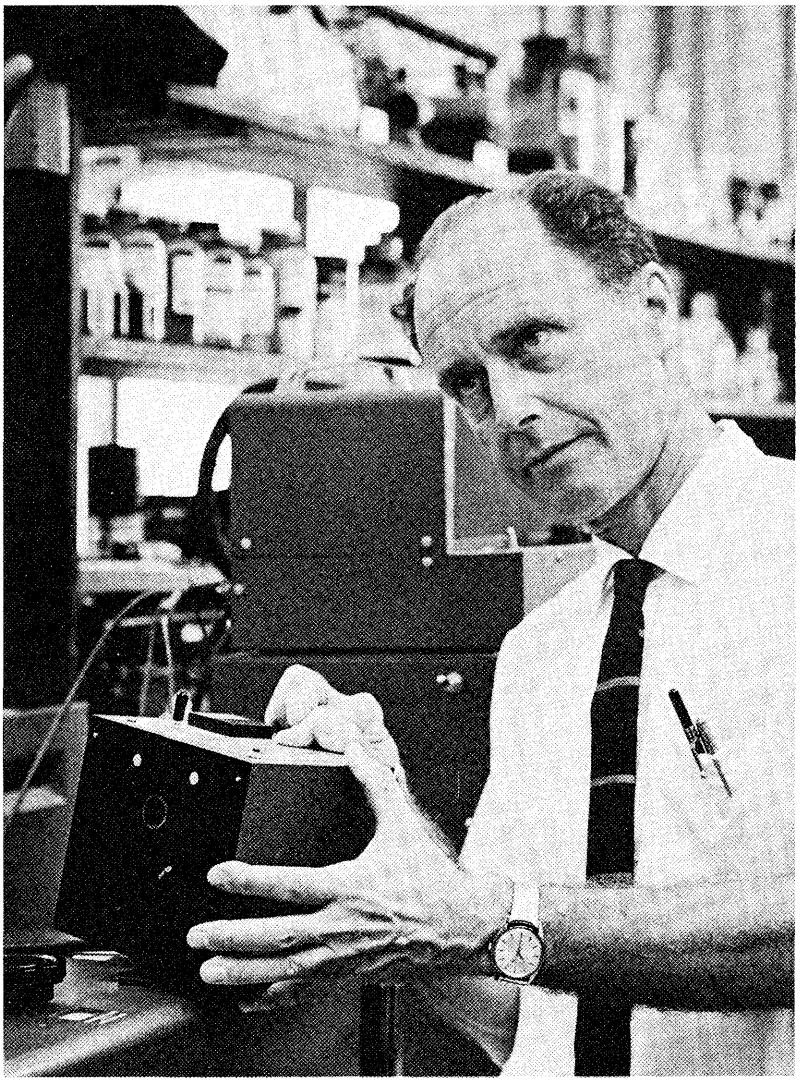


Aron Kuppermann, professor of chemical physics, and co-workers have made the first direct measurement of the minimum energy required for a chemical reaction.

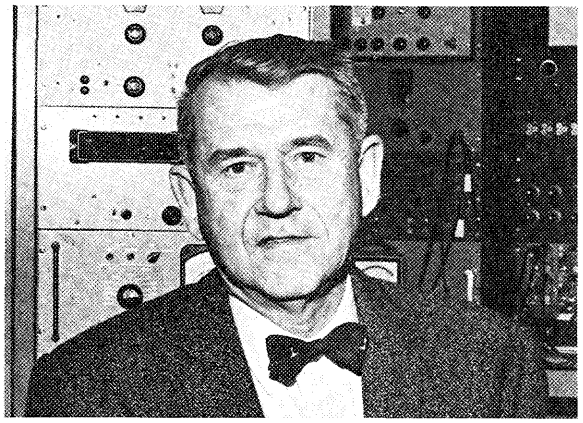
George S. Hammond, Arthur Amos Noyes Professor of Chemistry. His studies in photochemistry provide information on how to harvest, transfer, and store energy.



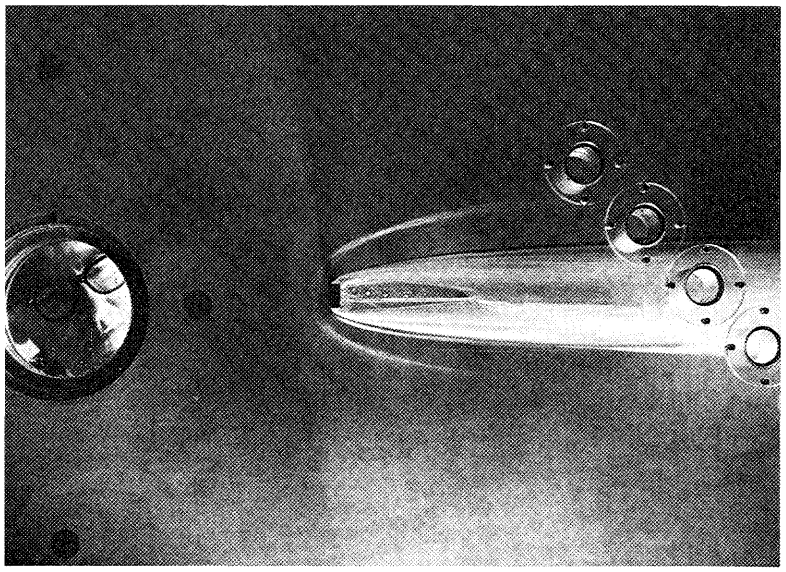
Norman Davidson, professor of chemistry, pioneered in developing techniques to study fast reaction rates, now works on the physical chemistry of nucleic acids.



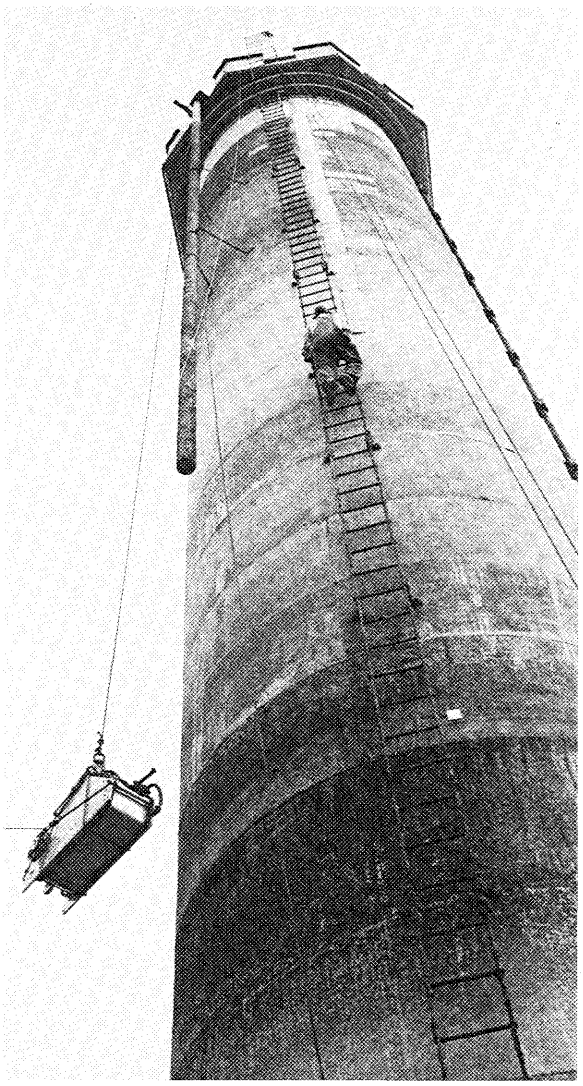
ENGINEERING and APPLIED SCIENCE



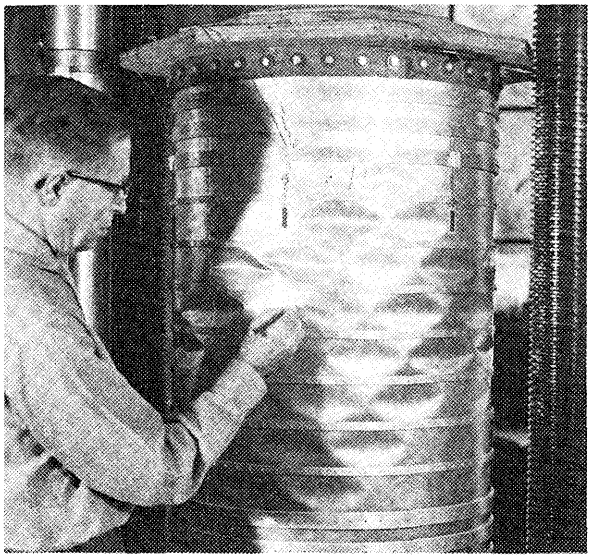
Engineering at Caltech has diversified greatly since Frederick C. Lindvall (right) became chairman of the division in 1945. Today, traditional engineering areas have been enriched with work in biological systems, seismology, environmental health, applied mathematics, information science, polymeric materials, solid state electronics, and plasma physics. This broad spectrum of interdisciplinary study results from the division's basic philosophy—to use modern science to solve current and anticipated problems in technology.

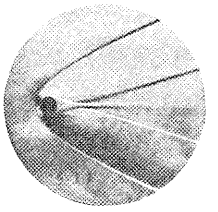


High-speed water tunnels, now widely used for a variety of hydrodynamic testing, originated at Caltech as a part of wartime torpedo research.



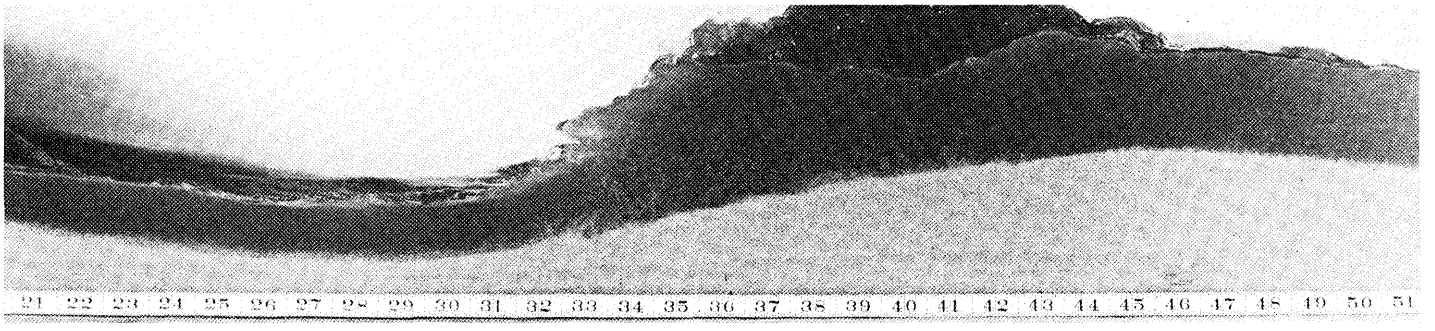
Engineers hoist a shaking machine atop Encino Dam intake tower for tests that will aid in designing earthquake-resistant structures.





Shock waves about a model in the hypersonic wind tunnel, pioneer tunnel for aeronautics research involving speeds ten times faster than sound.

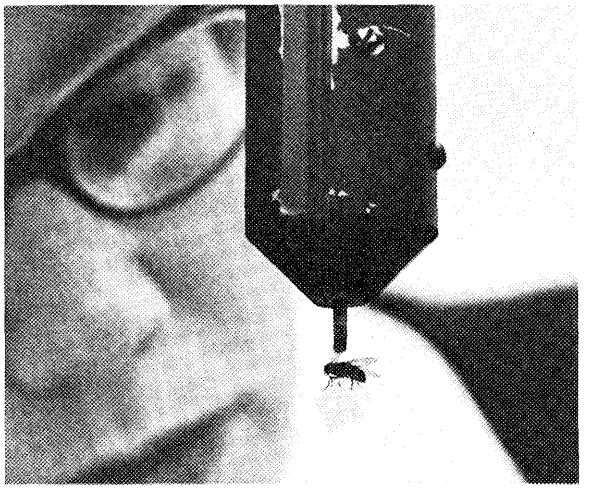
Ernest Sechler, executive officer for Galcit, studies structural reliability of lightweight aerospace components.



Laboratory investigation of wave action on a stream bottom. Such studies at Caltech have contributed greatly to water resource development.

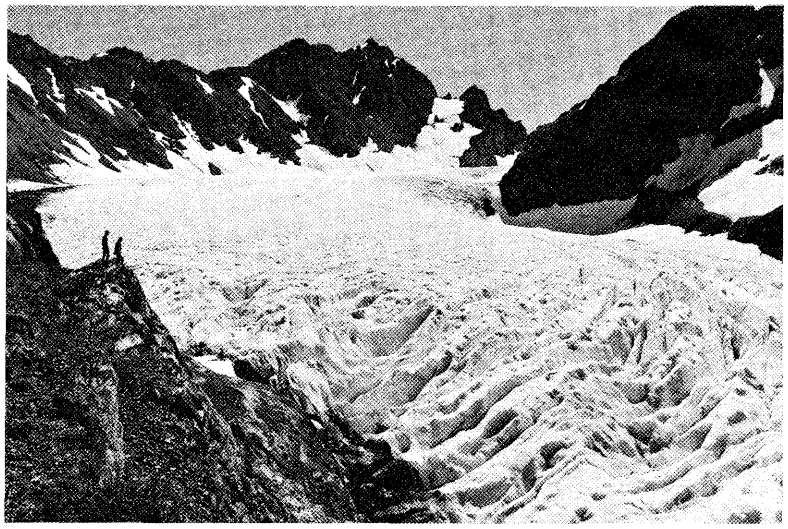
COMPUTING CENTER

The Computing Center, in use since 1963, has permitted completely new kinds of research (such as this analysis of the flight of a housefly following a visual target), and has encouraged complex studies not feasible before. In addition to serving the Institute's six divisions, the center is also being used to develop new concepts in information science that will make computers even more versatile in the future.

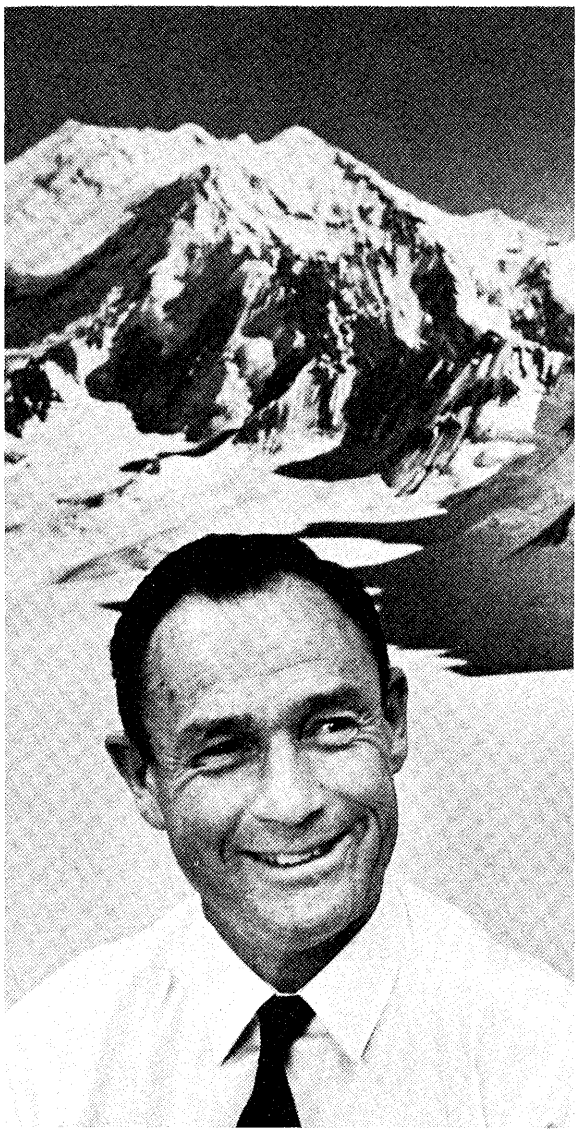


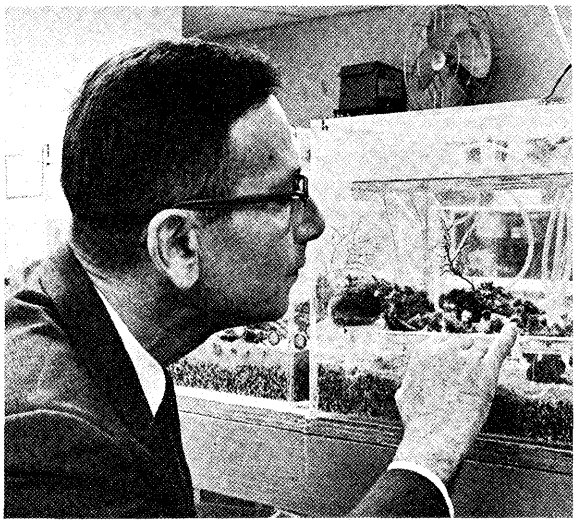
GEOLOGICAL SCIENCES

When Robert P. Sharp (right) became division chairman in 1952, geochemistry was just being introduced at Caltech. Today it is a major research area along with geology and geophysics. Another field now being developed is planetary science, an extension of the geologist's domain to detailed study of the planets and solar system. Although current work is diversified and sophisticated, the principles of classical geology continue to guide research and instruction.



Caltech geologists take a long-range look at Blue Glacier in Washington, where they have studied flow processes in ice each summer since 1957.





Heinz Lowenstam, professor of paleoecology, studies evolution of animals and their environments through geochemical analysis of fossil material.

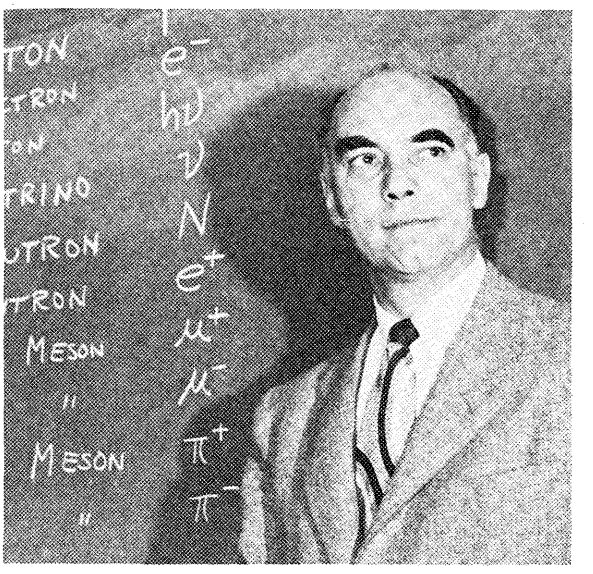
Comet Ikeya-Seki had its temperature taken in 1965 by planetary scientists, who combine geology, astronomy, and physics to study heavenly bodies.

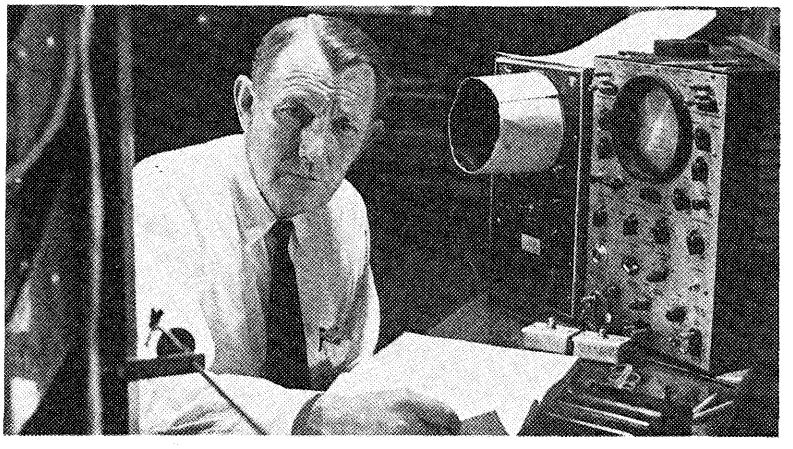
Leon Silver (center), professor of geology, leading a collecting expedition in the Grand Canyon, concentrates on the origins of the earth's very old rocks.

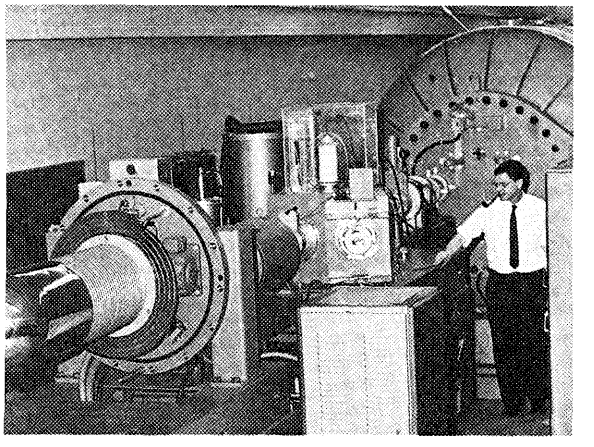
Clarence Allen (right), interim director of the Seismological Laboratory and an authority on the San Andreas fault, works on a major study of the fault with Professor Gerald Wasserburg.

PHYSICS

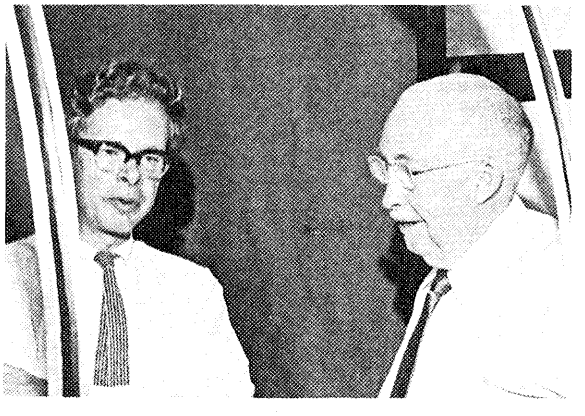
Physics at Caltech has traditionally been "pure" research. Under Carl D. Anderson (right), chairman of the division of physics, mathematics and astronomy since 1962, programs include theoretical and experimental investigations of elementary particles, studies of light nuclei, cosmic ray investigations, solar studies, infrared astronomy, nucleosynthesis and stellar evolution, nuclear and optical spectroscopy, low-temperature studies, and the nature of the interplanetary medium.



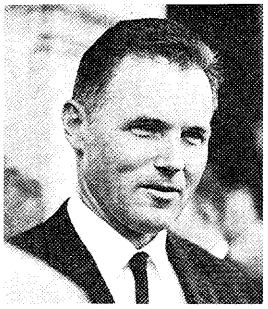


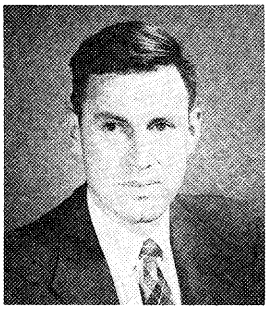


The leadership in experimental nuclear physics of Charles C. Lauritsen, now professor emeritus, created the Kellogg Radiation Laboratory in 1930 and resulted in the subsequent addition of a tandem Van de Graaff accelerator in 1961. This device (being used by Thomas Lauritsen above) can speed particles up to 12 MeV with high precision and accuracy.

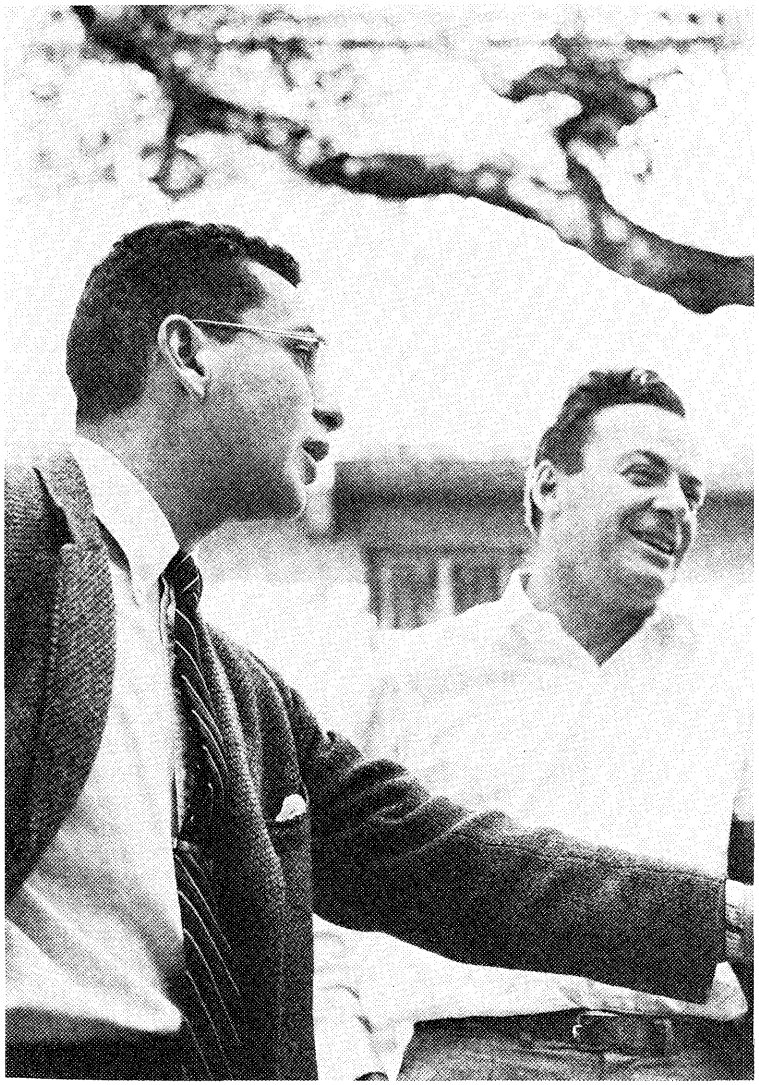


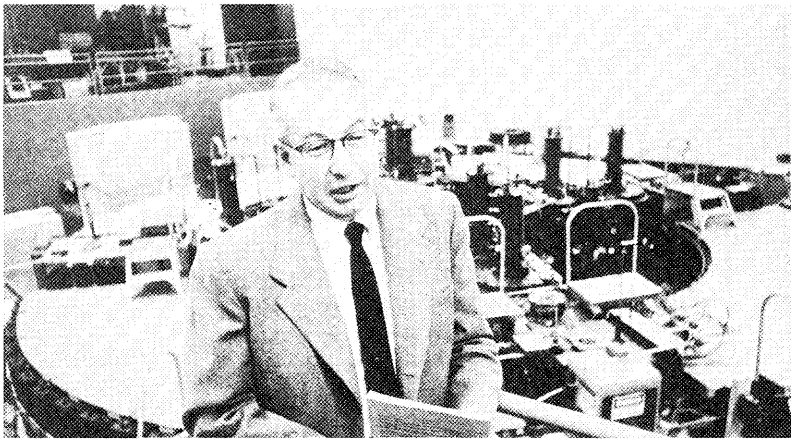
The third largest area of physics research at Caltech is led by Felix H. Boehm (left), whose work in nuclear spectroscopy and the Mössbauer effect has been closely related to that of professor emeritus Jesse W. M. DuMond (right) in x-ray spectroscopy and the search for reliable values of the fundamental constants.





Interdisciplinary research is exemplified in the work of physicists Robert B. Leighton, Robert F. Christy, and William A. Fowler, three of Caltech's 30 members of the National Academy of Sciences. Leighton built and operates a 60-inch telescope for infrared scanning of the sky; Christy has contributed substantially to the nonlinear theory of stellar pulsations; Fowler's research has attacked the problem of stellar energy and element synthesis in stars.





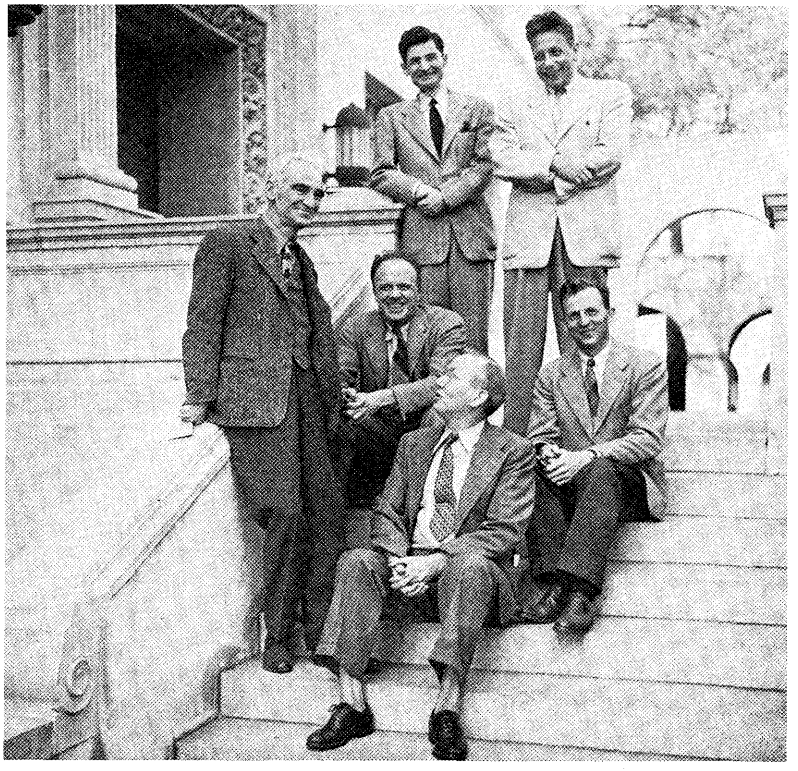
Provost Robert F. Bacher, division chairman from 1949 to 1962, was instrumental in the development of Caltech's 1.5 BeV synchrotron, used since 1951 to produce and examine some of nature's most fundamental particles.

Caltech's eminence in theoretical high-energy particle physics is symbolized by Murray Gell-Mann, co-author of the Eightfold Way theory, and Richard Feynman, 1965 Nobel Laureate for contributions in quantum electrodynamics.

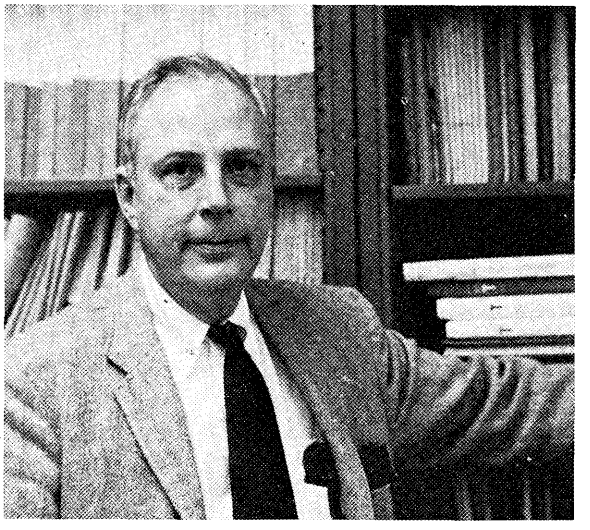
MATHEMATICS

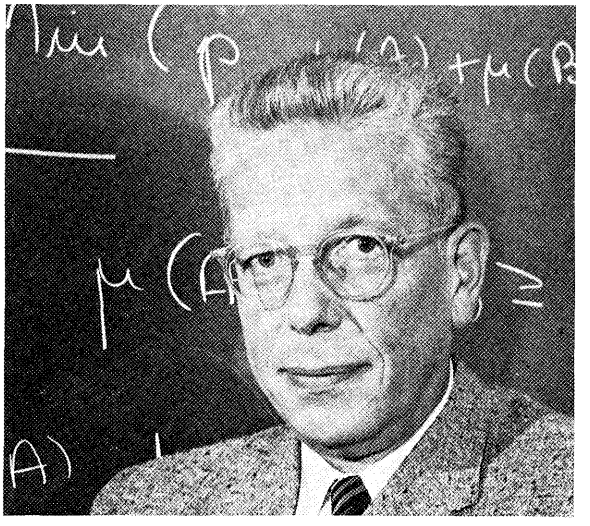
The Sloan Laboratory, completed in 1960, gave mathematics its first permanent home. Staff and program have now increased, and the number of graduate students has doubled. The fields of algebra, number theory, and analysis—the center of mathematical research for many years—have been strengthened, and functional and numerical analysis have been added. Also, a new option in applied mathematics has been created as an interdivisional program under Gerald B. Whitham, professor of aeronautics and mathematics.

E. T. Bell (left), who led the development of mathematics at Caltech, with 1948 staff members Michal, Bohnenblust (standing); Ward, Wear, Dilworth.



Professor of mathematics Marshall Hall, Jr., whose specialty is group theory and combinatorial theory, was appointed executive officer in 1966.





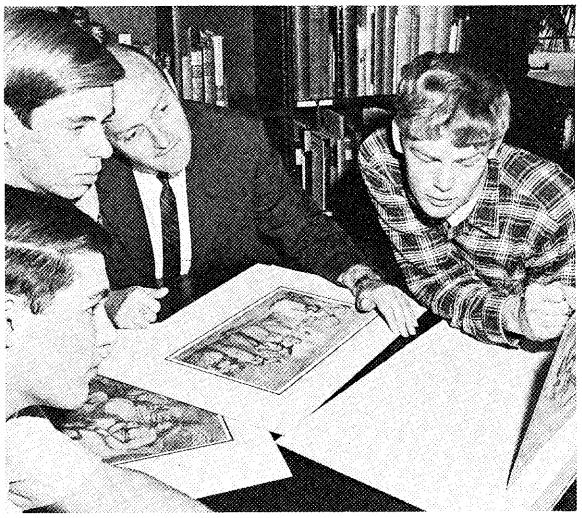
H. Frederic Bohnenblust, professor of mathematics and dean of graduate studies, served as executive officer for mathematics from 1948 to 1966. His field of interest is analysis.

HUMANITIES and SOCIAL SCIENCES

From the start, Caltech has provided a liberal education for undergraduates, who are required to take about one-fourth of their course work in the humanities. Now, with the study of human behavior and the relation of science to society becoming increasingly important, the division has increased its scope, changed its name, and is offering majors in English, history, and economics. The division plans to expand into new areas, such as science and national policy, and the study of human behavior under technological change. In the next few years the division of humanities and social sciences may well have the greatest percentage growth of any department at Caltech.

Hallett Smith, professor of English and Shakespearean scholar, has been humanities chairman since 1949.

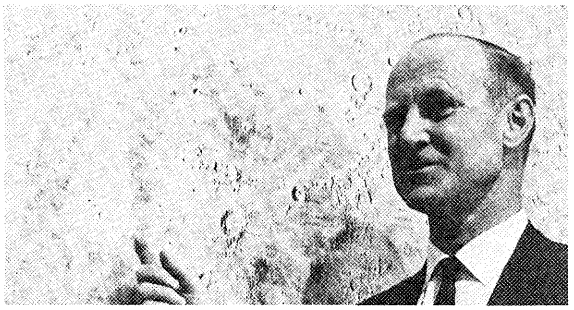
Newspapers and magazines from all parts of the world are available in the division's Public Affairs Room.



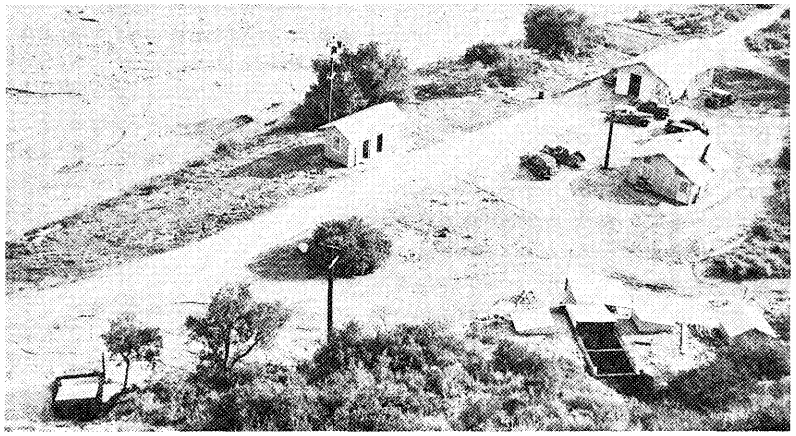
Dr. Robert Wark, curator of art at the Huntington Library and Art Gallery, teaches a Caltech art class.

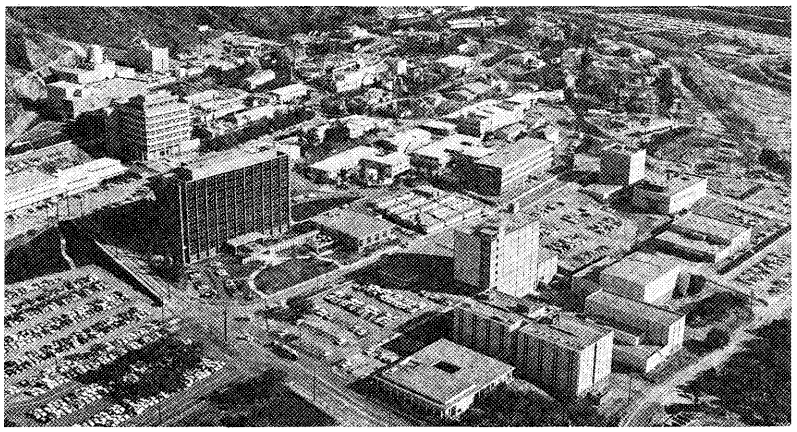
JET PROPULSION LABORATORY

From modest beginnings in 1936 as the Galcit Rocket Research Project under the direction of Theodore von Kármán, and wartime research in jet-assisted take-offs, Caltech's Jet Propulsion Laboratory has become the nerve center for American unmanned exploration of the solar system. William Pickering (right), a Caltech professor of electrical engineering who had studied cosmic rays with Robert Millikan, followed Louis G. Dunn as JPL Director



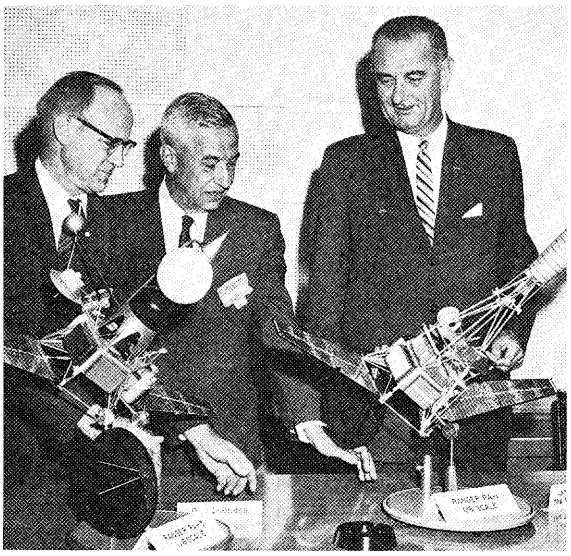
in 1954. Four years later JPL's Explorer I became this country's first successful satellite; JPL spacecraft have since flown past Mars and Venus and have landed on the moon, blazing a trail for man to follow.





Then—a few buildings on the western edge of Pasadena. Now—operated by Caltech for NASA, JPL has an annual budget of nearly $250 million.

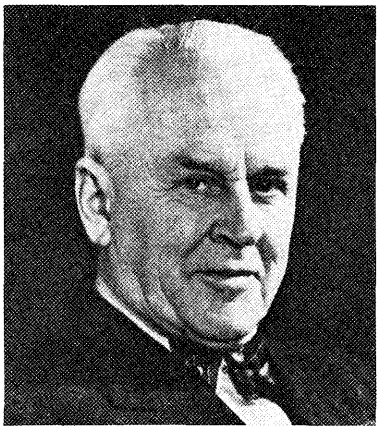
1941: JPL puts the U.S. into the rocket age as a jet-assisted take-off (JATO) unit pushes a plane into the air in half the normal time and runway.



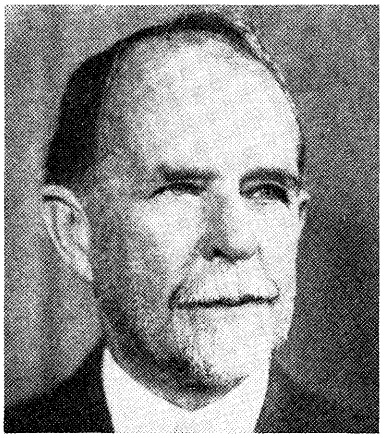
In the 1960's the nation came to rely greatly on JPL in the national space program. Here JPL's Pickering and Caltech's DuBridge brief Vice President Johnson on the Ranger spacecraft.

Surveyor I casts its shadow on the moon after sending back more than 10,000 pictures in 1966. It followed Mariner II, which made measurements of Venus in 1962; Rangers VII, VIII, and IX, which sent over 17,000 pictures of the moon in 1964-65; Mariner IV, which took pictures of Mars in 1965.

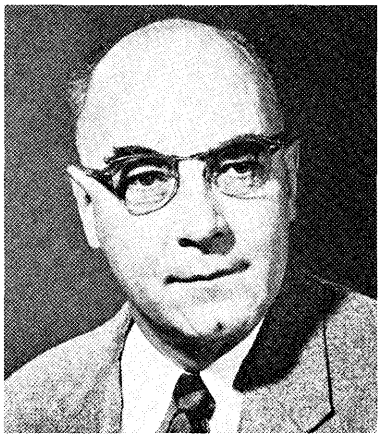
NOBEL LAUREATES



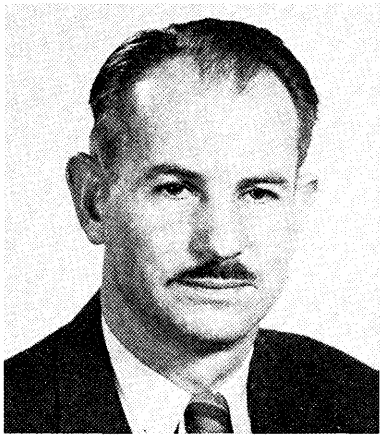
Robert A. Millikan, physics, 1923, measuring the charge of the electron and work on the photo-electric effect.



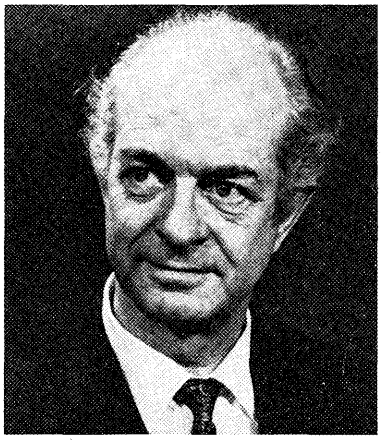
Thomas Hunt Morgan, medicine, 1933, the relation of chromosones to heredity.



Carl D. Anderson, physics, 1936, for his discovery of the positron.



Edwin M. McMillan, physics, 1951, for his discovery of transuranic elements.

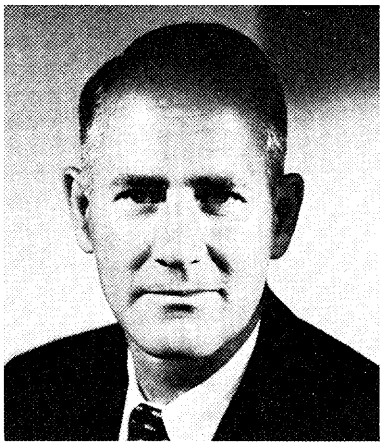


Linus Pauling, chemistry, 1954, for research into the nature of the chemical bond.

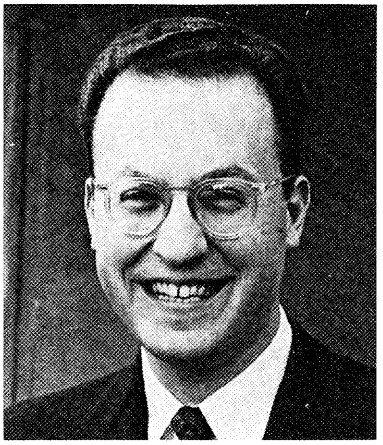
Since 1923, when Robert A. Millikan won the Nobel Prize in physics, Caltech has added ten names to its roster of Nobel Laureates. One of these men, Linus Pauling, received the award twice —for chemistry in 1954 and the Peace Prize in 1962.

Five of Caltech's Nobel award winners—Millikan, Thomas Hunt Morgan, George Beadle, Rudolf Mössbauer, and Richard Feynman—were members of the faculty; four—Edwin McMillan, William Shockley, Donald Glaser, and Charles Townes—were alumni; and two —Carl Anderson and Linus Pauling—were both graduates of the California Institute of Technology and members of its faculty.

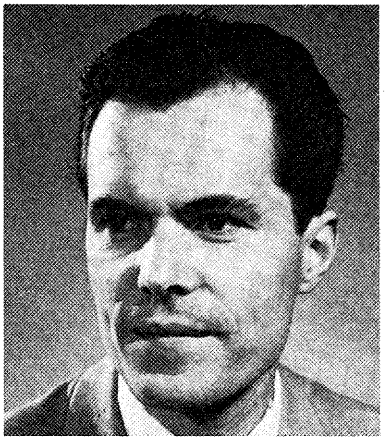
William Shockley, physics, 1956, work on semiconductors and the transistor effect.



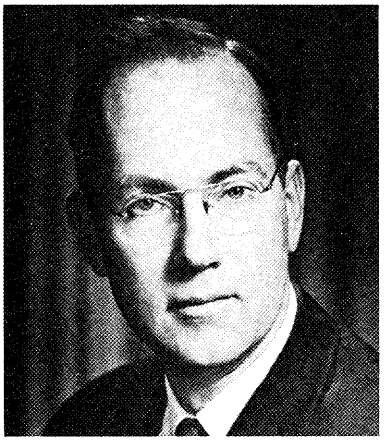
George W. Beadle, medicine, 1958, for his analysis of the chemical activity of genes.



Donald A. Glaser, physics, 1960, for his invention of the bubble chamber.



Rudolf Mössbauer, physics, 1961, discovery of recoil-free emission of gamma rays.

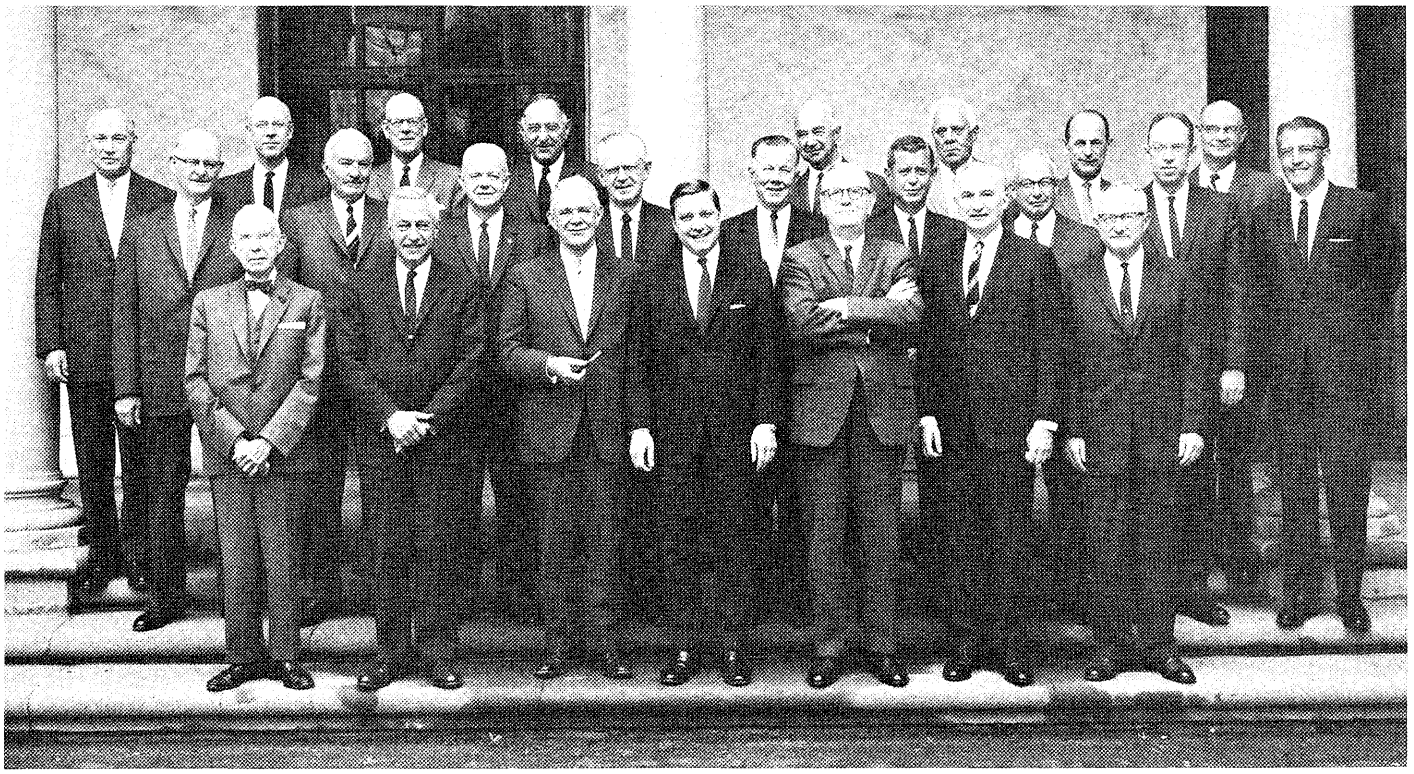


Charles H. Townes, physics, 1964, for development of the maser-laser principle.

Richard Feynman, physics, 1965, for fundamental work in quantum electrodynamics.

TRUSTEES

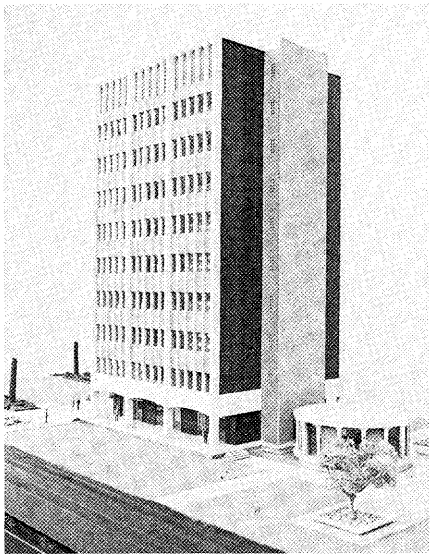
Members of the Board of Trustees, April 5, 1965. Back row: Arnold O. Beckman, chairman, Robert S. Ingersoll, John S. Griffith, Herbert L. Hahn, Lindley C. Morton, Edward R. Valentine, Richard R. Von Hagen, Lawrence A. Williams. Middle row: F. Marion Banks, Norman Chandler, Howard G. Vesper, Henry Dreyfuss, Leonard F. McCollum, J. G. Boswell II, Robert F. Bacher, Robert B. Gilmore, William E. Zisch. Front row: John E. Barber, L. A. DuBridge, Augustus B. Kinzel, Charles H. Percy, Albert B. Ruddock, Simon Ramo, James N. Ewart. Not present: Lloyd L. Austin, John G. Braun, William Clayton, Shannon Crandall, Jr., J. S. Fluor, Charles S. Jones, Thomas V. Jones, Earle M. Jorgensen, William M. Keck, Jr., Seeley G. Mudd, John O'Melveny, Elbridge H. Stuart, Thomas J. Watson, Jr., P. G. Winnett.



"Who, then, deserve the honor which is ours to bestow and the recognition for Caltech accomplishment thus far? Answer: first, the original trustees... who had the courage and the insight to start it off; second, all of their successors... who have put their names, their completely uncompensated time and labor, their trust, and in many cases their own funds, behind the development of Caltech."

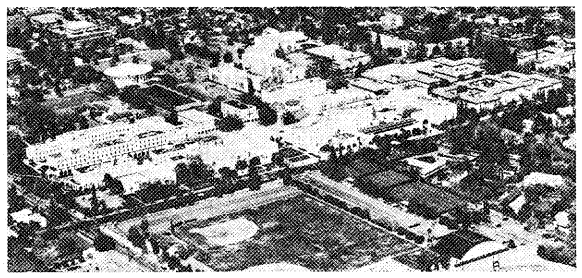
—R. A. Millikan

THE CAMPUS TODAY



Model of Millikan Library. The nine-story structure, gift of Seeley G. Mudd, will be completed in 1967.

Beckman Auditorium, the gift of Dr. and Mrs. Arnold Beckman, has become a campus landmark. Beckman, a Caltech alumnus, served on the chemistry faculty from 1928 to 1939, is now chairman of the board of trustees.



From Throop College's original 22-acre tract, the Caltech campus has grown to today's 72 acres and 50 buildings.

AND STUDENTS