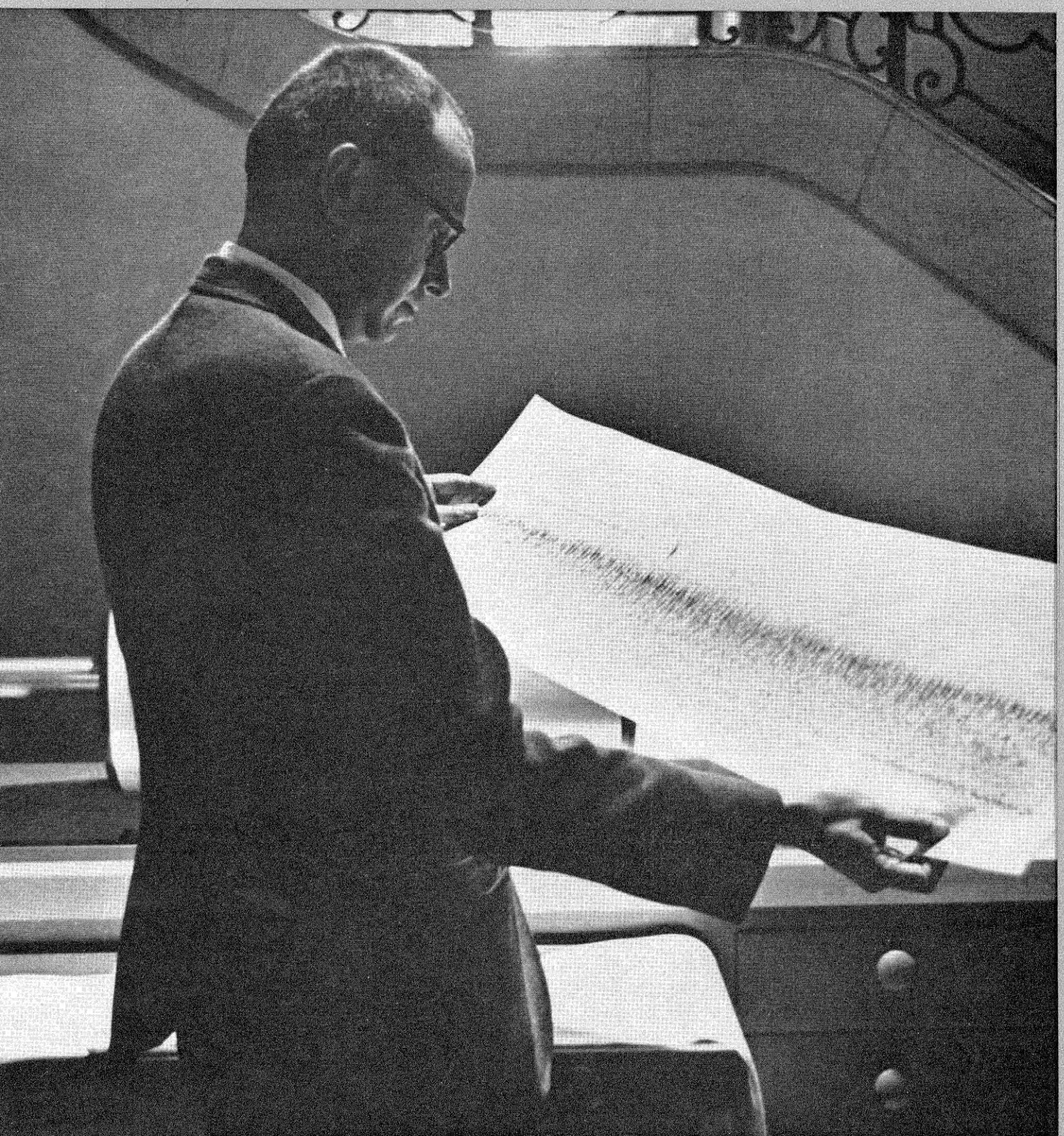
ENGINEERING | AND | SCIENCE

April 1964



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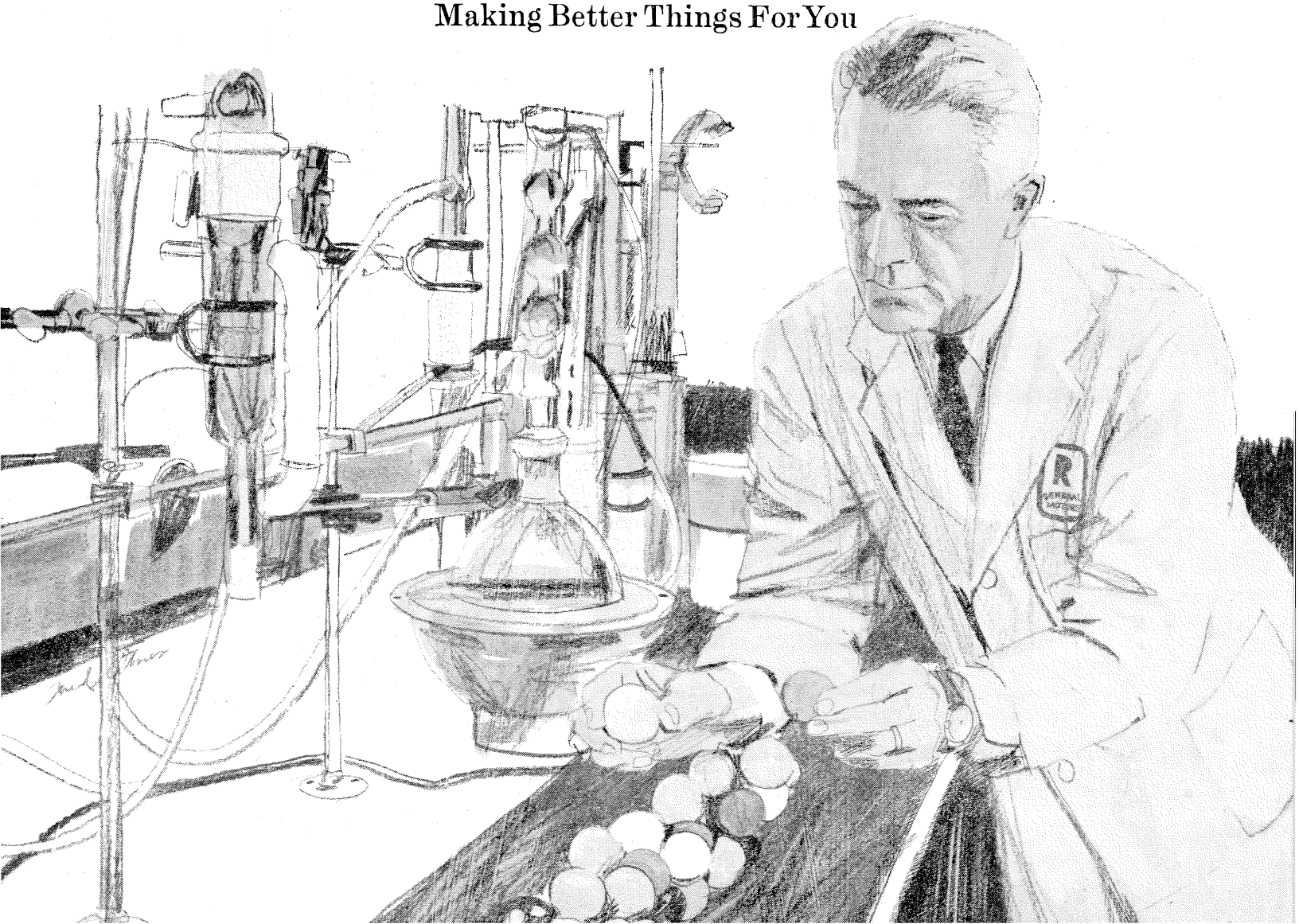

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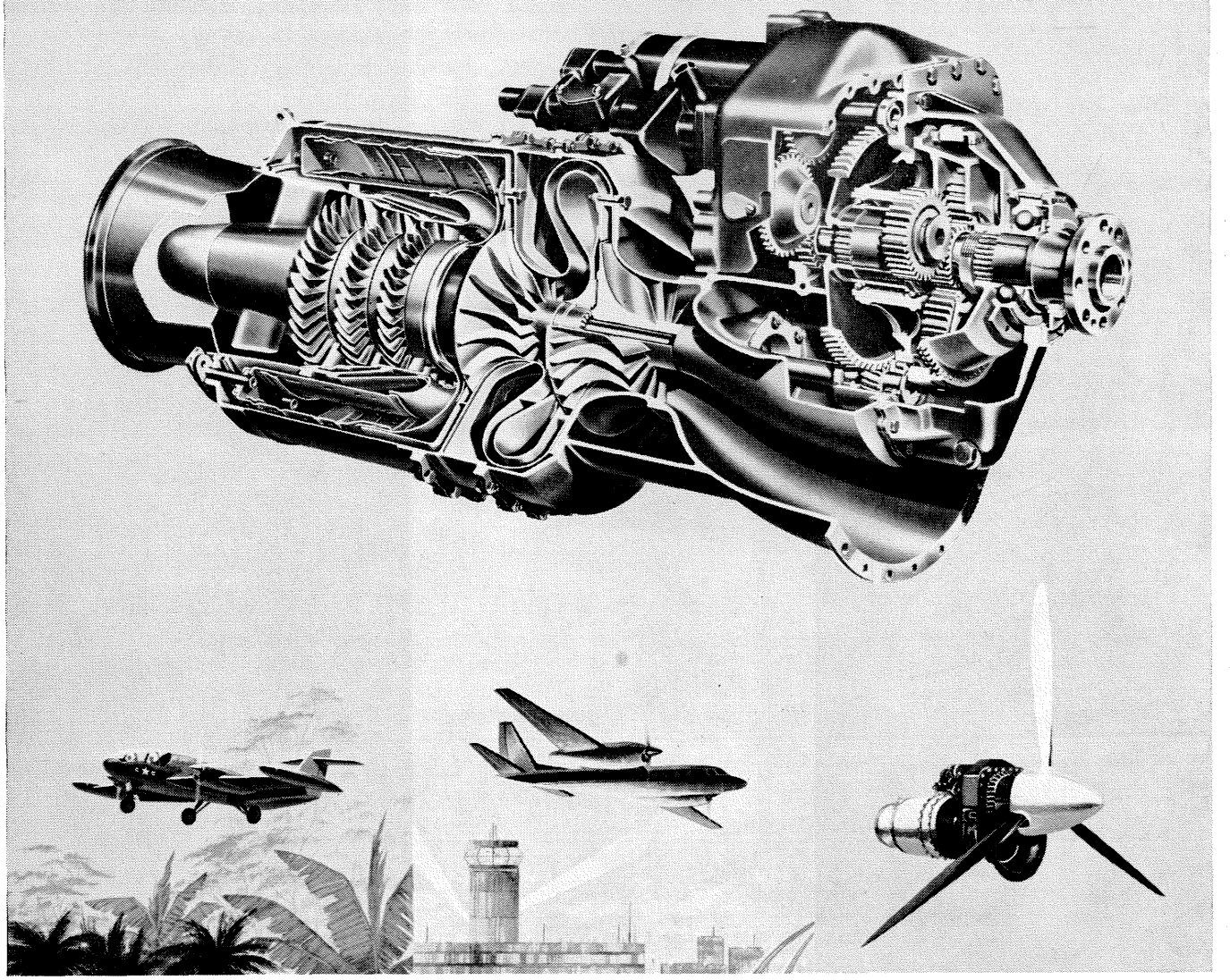

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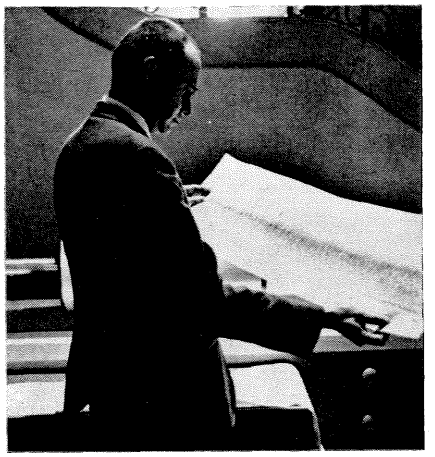

On Our Cover

Frank Press, professor of geophysics, and director of Caltech's Seismological Laboratory, examines one of the first seismograms of the great Alaskan earthquake on March 27.

After any large earthquake the Seismological Laboratory goes on an emergency basis. The staff comes in to work as soon as news of the earthquake reaches them — some going on telephone duty, while others develop and study seismograms.

One of the first on hand is usually C. F. Richter, professor of seismology and developer of the Richter earthquake magnitude scale. On March 27 he arrived at the Laboratory shortly after the initial shock of the Alaskan quake was recorded on the instrument he keeps in his living room.

On page 7 he describes the hectic activity of the days that followed.

Norman H. Brooks,

professor of civil engineering, in "Hidden Flow Patterns in Reservoirs" (page 12) tells how future engineers will be able to remove water selectively from reservoirs by merely tapping the desired layer. Thus, water can be chosen for its mineral content and temperature. Although pioneering studies of stratification date back more than 20 years, engineers have only recently found how to draw off single layers as desired.

Dr. Brooks has been a member of the Caltech faculty since 1954, when he received his PhD here.

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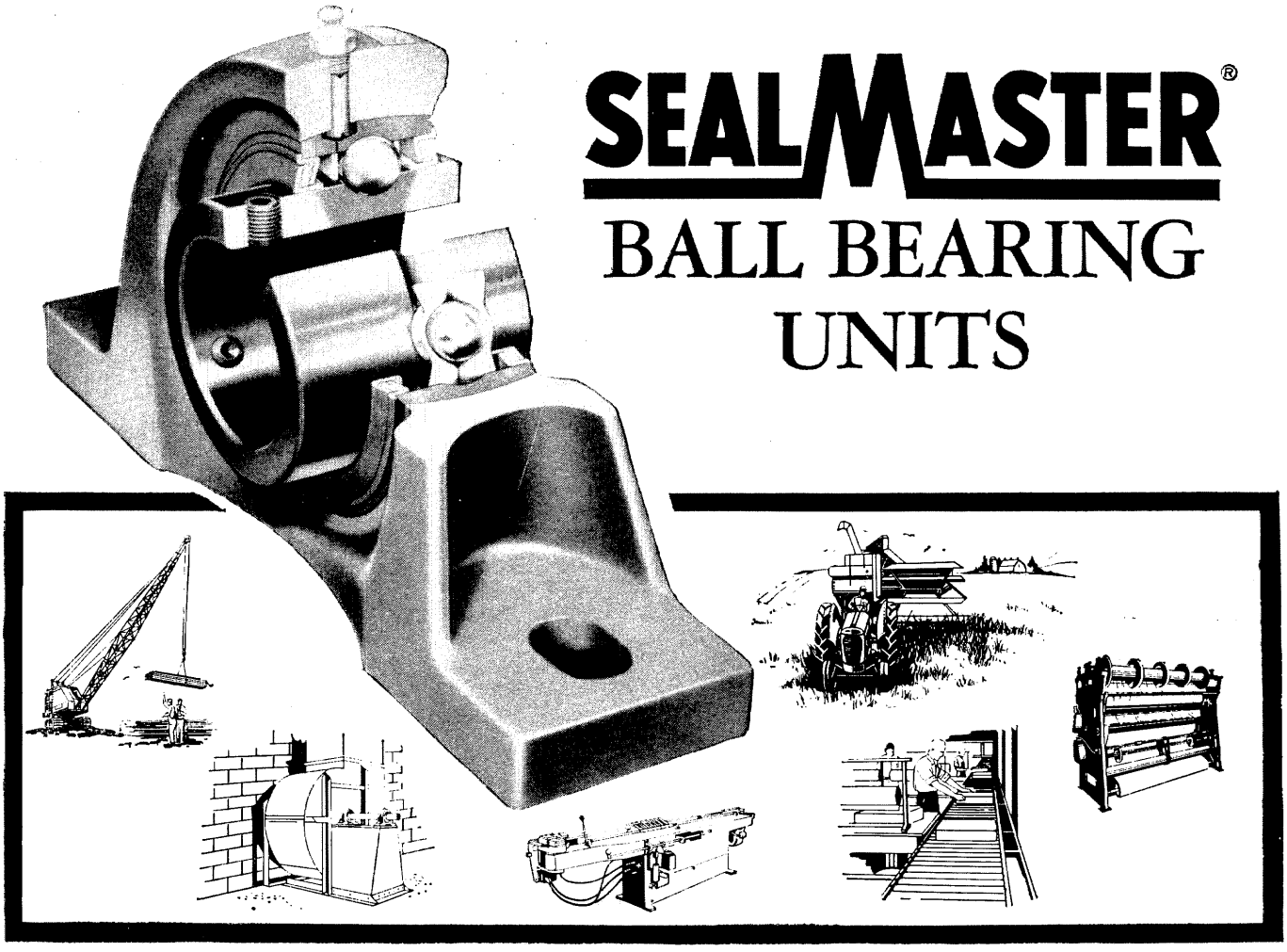

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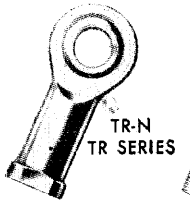

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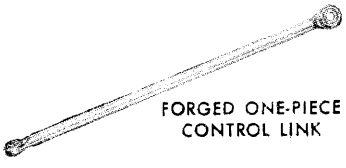

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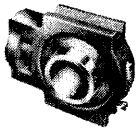

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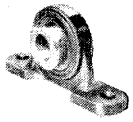

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ENGINEERING AND SCIENCE
April 1964, Volume XXVII, No. 7

Caltech's Seismological Laboratory goes to work on

THE ALASKAN EARTHQUAKE

by C. F. Richter

C. F. Richter, professor of seismology, checks the seismograph he has installed in his living room — always expecting the unexpected.

My wife at first was very dubious about having a seismograph installed in the living room. It seemed rather a brutally coarse intrusion among her neat furnishings. She soon found that all her friends found it interesting and exciting, a perfect conversation piece. Now she could hardly be separated from it.

The installation has been a timesaver during real emergencies and false alarms. I make a habit of checking it frequently, always expecting the unexpected.

On the evening of Friday, March 27, I interrupted a broadcast concert.

"There's a great earthquake recording."

"Yes?" (Very sleepily) "Where is it?"

That, I remarked, was indeed the question. I went on studying the seismogram, which was still making large swings as late waves arrived over long paths.

The record of a very large earthquake is often particularly hard to interpret because of the tangling of successive recording lines and the tendency of equipment to overload or drive the writing point off the paper. Before long I was fairly sure that the distance was moderate, of the order of two or three thousand miles. The magnitude, certainly, was high.

The concert ended. At this point I found that somehow the telephone unit had been off the hook. I put it in place, and almost at once got a ring.

It was Mr. Corcoran of the UPI, with early news of the Alaskan earthquake. I was able to confirm that it was a great and probably disastrous event, and to give a minimum magnitude of 8.

It seemed wise in so important a case to go to the Laboratory, where more recording instruments and more information were available. While driv-

ing the short distance (three miles) I was a little startled to hear myself already being quoted on the air (correctly).

Mr. Nordquist was already at the Laboratory; he had been called by the official sea warning service, and had already reported back to its Honolulu headquarters. The additional instruments gave little further information; those available at such hours for emergency use (writing in ink) have magnifications in the moderate range, and were overloaded, like my seismograph at home. Better information would have to wait until next day, when the regular seismograms, which are recorded photographically, would be unloaded from the drums and developed.

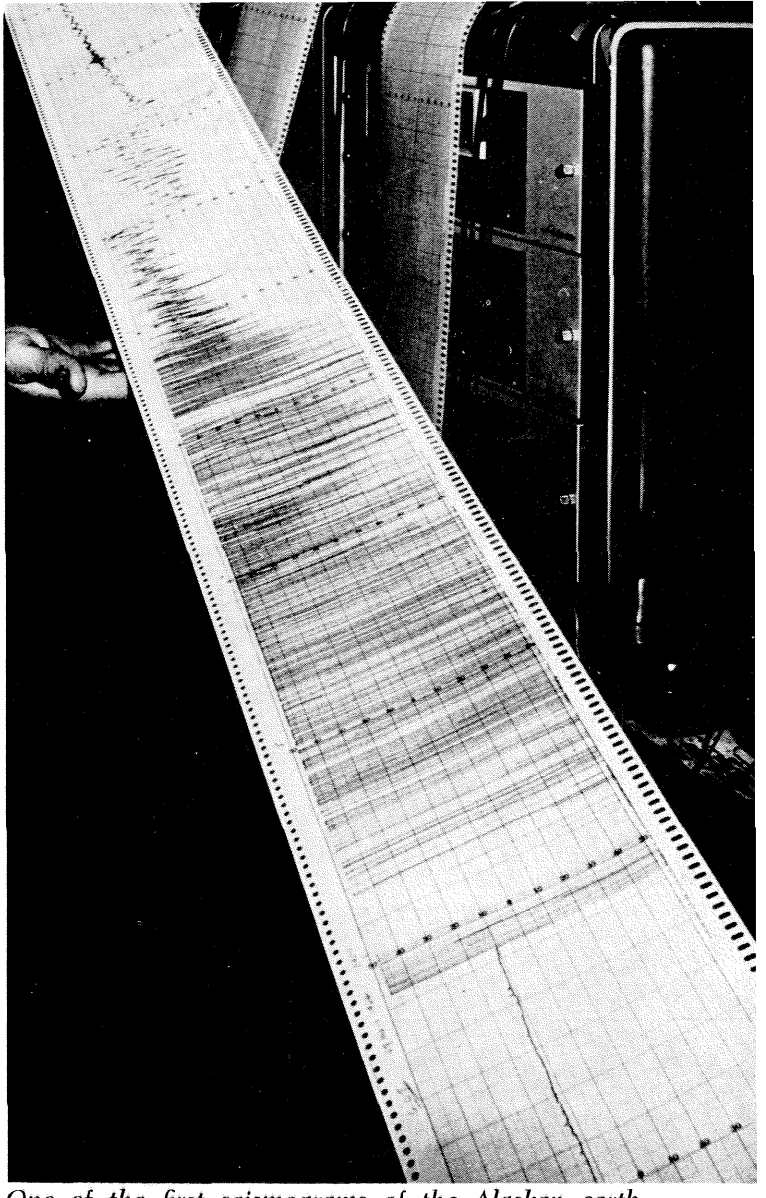
Most of this time the Laboratory telephones had been ringing; but since it was impossible to answer them without dropping the work on the records, and very little could be given out anyway, we simply let them ring.

Some of the small aftershocks which followed the main event gave useful details. Finally, I called in to the principal press services and newspapers, giving our time of recording and the same magnitude estimate of 8 or over. It chanced that my call was the first notice of the event to reach the Pasadena newspaper offices; the next regular edition being Saturday afternoon, they were on off-hours, and grateful for the alert.

I returned home, determined to get a sound night's rest; but at times during the night I received the radio news, noting the progress of the sea wave and the disaster at Crescent City.

Certain oddities and misunderstandings in the early news deserve notice. Among these are wrong guesses about the epicenter of the earthquake, or the fault on which it may have originated. Newsmen are very pressing for such statements immediately after the event; it is hard to explain to them that there simply isn't sufficient information for even a guess. Some seismologists allow themselves to be wheedled into guessing, whereupon the guesses are circulated as definite determinations.

This is probably the explanation of the frequent press mention of the Fairweather fault, a great feature of southeast Alaska which probably had nothing to do with this earthquake. Still more obvious was the report of "location" of the epicenter at Yakutat Bay, where a great earthquake did occur in 1899. There was also the report that a seismologist had placed the origin of this earthquake at a depth of 186 miles (300 kilometers, in case you're wondering). How, one wonders—considering all the evidence of origin near the surface? It is, indeed, a matter for reflection; probably a strong wave on the seismogram, representing an echo from the surface of the earth's core, was misidentified as an echo from the surface of the earth itself, which would mean that the riot started pretty far down.



One of the first seismograms of the Alaskan earthquake. The single line at the bottom of the seismogram shows the normal motion of the earth, which gives way to a sudden violent earthquake.

Then there were those "mysterious" waves along the Gulf Coast in Texas and Louisiana in the first hour, long before the great sea wave had reached the California coast. They were seiches — oscillations in the lagoons along the Gulf Coast, set up by resonance with the great seismic surface waves, traveling out from the source at speeds of two or three miles per second, with periods from fifteen or twenty seconds up to two minutes, correspondingly enormous wavelengths, and amplitudes of several centimeters (or inches) at various points, as reported to the press by a number of recording stations. At Pasadena we found an amplitude in

the 20-second periods of over a centimeter, making the full range (or double amplitude) about an inch; in the longer-period waves the amplitudes were still larger.

Seiches were probably started here and there all over North America. There were numerous accounts of oscillations in ponds and swimming pools. A correspondent sent me a clipping from the Louisville *Courier-Journal,* detailing the local mystification over the oscillation of two lakes in Kentucky. The seiche in Lake Washington at Seattle was observed by many persons, and recognized as due to the earthquake, since it coincided in time with other effects like the swaying of chandeliers, and occurred while first reports from Alaska were arriving. Well recorders must also have run wild almost everywhere, but only a few reports of the kind have as yet come to my attention.

On Saturday, with Dr. Stewart Smith holding off press representatives and other visitors, I went to work on the photographically recorded seismograms, with the results on amplitude already mentioned. These, plus comparison of the main shock with aftershocks, led to a magnitude at first conservatively stated as 8.2, but revised to 8.4 later.

At this time I was very glad to see Mr. Graham Berry of our News Bureau, since I had a very delicate problem. The aftershocks, to that point, hadn't been large enough. "Båth's law" requires that an 8.4 earthquake should have at least one 7.2 aftershock. (Even the latest large aftershock, April 16, seems not to have exceeded 6.7. Is a larger one still to come?)

Nothing would be easier than to raise a dangerous alarm. Headlines ANOTHER BIG ONE EXPECTED could disturb people and perhaps delay needed relief work. Yet some warning seemed called for. We decided to point out that the aftershocks to date had been smaller than usual for so large a main shock, adding that no later shock would be expected to approach the main one in magnitude (also a slightly risky statement, since unexpected large later shocks do happen).

Sunday at the Laboratory was mercifully quieter, and I could settle down in peace to getting the recorded times of the aftershocks. For the first three hours there was a hopeless tangle of small shocks

Stewart W. Smith, assistant professor of geophysics, examines a record of the Alaskan earthquake taken from an experimental, long-period seismograph that he is developing. This instrument differs from other seismometers in that it is especially designed for the very long-period vibrations of the earth, which can be likened to the ringing of a bell. It records directly on a magnetic tape that can be processed by a digital computer, where a type of spectrographic analysis is done that separates the various "tones" of the vibrating earth. This experimental instrument was put into operation only a few hours before the Alaskan earthquake.

In the measuring room of the Laboratory, Charles F. Richter studies a seismogram of a 24-hour period including the main Alaskan quake. Here, seismograms from the 16 outside stations maintained by Caltech, and those from many other countries, are measured for intensities and timing of quakes. This seismogram was recorded with the east-west instrument at Goldstone, California.

superposed on the large waves of the main earthquake; but in the following ten hours about 50 shocks of all sizes were measurable. (Still more, of course, were found later on the records of our more sensitive outpost stations.) We wished to get these data to the U. S. Coast and Geodetic Survey center at Washington as promptly as possible, since the location of epicenters of these small shocks casts much light on the main event.

Monday was as turbulent as might be expected. On this and the next day I spent more than half my time on the telephone. Most of this was legitimate exchange of information with the press and official sources; some of it was most unnecessary — free lance feature writers trying to intrude and snatch material; cranks; and news sources insisting on repetition of material already issued and in general circulation.

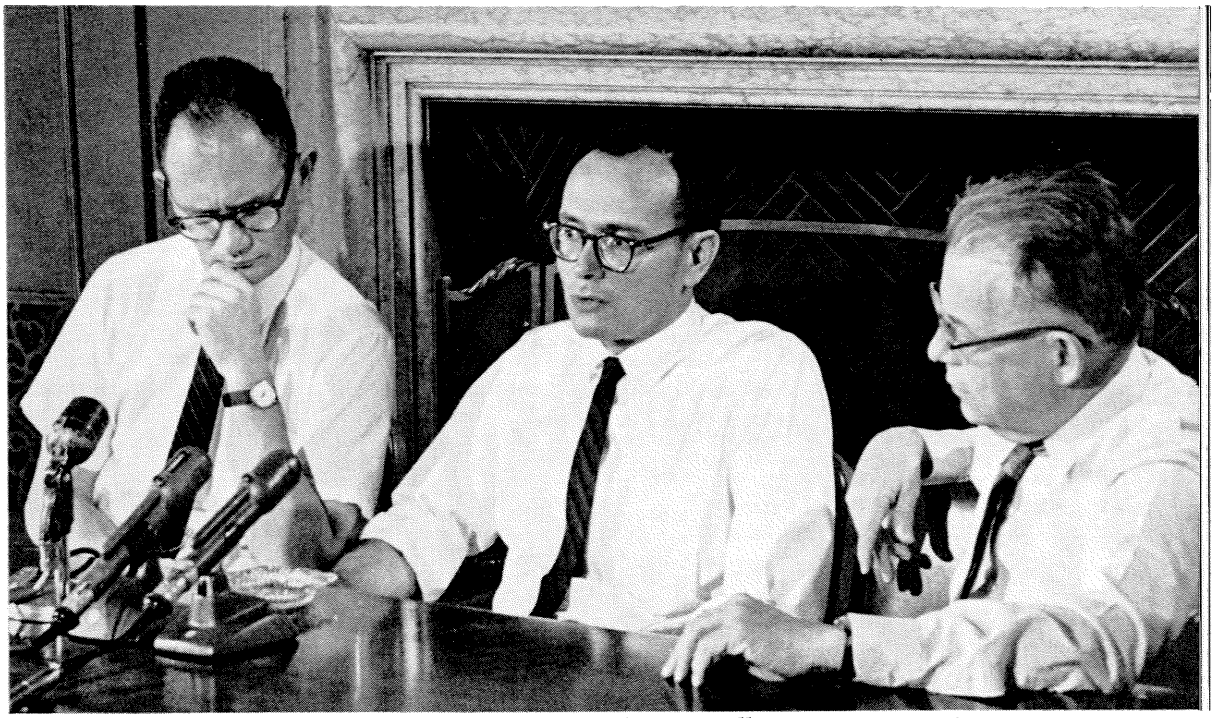
The office at Washington was most efficient and effective. Late in the day we began to get preliminary epicentral locations and other information. The main earthquake had centered near the coast between Anchorage and Valdez; epicenters of aftershocks were in a band extending offshore to the vicinity of Kodiak Island. This band presumably outlines the extent of faulting in the main event. An earthquake next day, off the British Columbia coast, was apparently independent.

News pictures in the daily press, showing effects at Anchorage, confirmed previous suspicion that the spectacular breaks in the ground do not represent faulting. They are the result of slumping, or rather of lateral lurching, in the loose ground of a terrace, under the shaking of the seismic waves from the earthquake source, which was about 60 miles distant.

Journalistic interest in the large oscillations of the whole earth "ringing like a bell" — to use the phrase which has been stuck on it — was a blessing to me, since it diverted attention to Dr. Press, Dr. Stewart Smith, and others concerned in that work.

An unmitigated curse were the calls which began, "We hear continuous rumors that this earthquake is going to touch one off on the San Andreas fault . . ." Perhaps this scare started spontaneously, but it seems to have been kept alive by news sources repeatedly badgering busy scientific men for denials. One of the best ways to lay ground for a panic is to keep broadcasting "There is no cause for alarm, there is no cause . . .", instead of merely reassuring individual Nervous Nellies and keeping the scare quiet.

It should be said that the general level of reporting on this occasion is a credit to the press. Information was factual, even when the facts were incompletely understood. Rumors were not extensively circulated. Lack of information from the most seriously affected area was emphasized, and caution in drawing conclusions was evident.



C. F. Richter (right), at a press conference with Clarence Allen, associate professor of geology and geophysics; and Frank Press, director of the Seismological Laboratory, who report on studies of the Alaskan earthquake made in a flying visit to the area in early April. In Alaska, the men installed special seismological stations to facilitate location of the aftershocks, so that eventually it will be possible to map the fault that was responsible for the main quake.

Much of the damage in the Alaskan earthquake seems to have been caused by sliding earth, rather than shaking — as in the Turnagain area of Anchorage shown here.

HIDDEN FLOW PATTERNS IN RESERVOIRS

by Norman H. Brooks

The fluids around us — water and air — are almost always stratified according to their density. For many ordinary engineering problems dealing with strong motions on a relatively small scale (such as flow of water in a pipe, or the flow of air around the wing of an airplane) we may easily neglect the density stratification; the ordinary mechanics of homogeneous fluids apply. But when we consider weak motions in large bodies of fluid, the slight variation in fluid weight with depth (due to gradients of temperature or salinity) may profoundly alter the fluid motion.

When the density increases with increasing depth in a reservoir, or in the ocean, the stratification is stable; each parcel of fluid has its own position of stable equilibrium, and work is required to displace it either up or down. By contrast, in a homogeneous tankful of fluid no work is required to push a parcel of fluid from bottom to top because an equal and opposite displacement is induced. All water in a homogeneous body has ***equal*** potential energy or piezometric head, whereas density-stratified water does not.

Density stratification is found in most large man-made reservoirs, such as Lake Mead behind Hoover Dam. Two basic flow problems of interest to civil engineers are: (1) What happens to the river water entering the reservoir? (2) What happens when water is withdrawn through outlets in the dam?

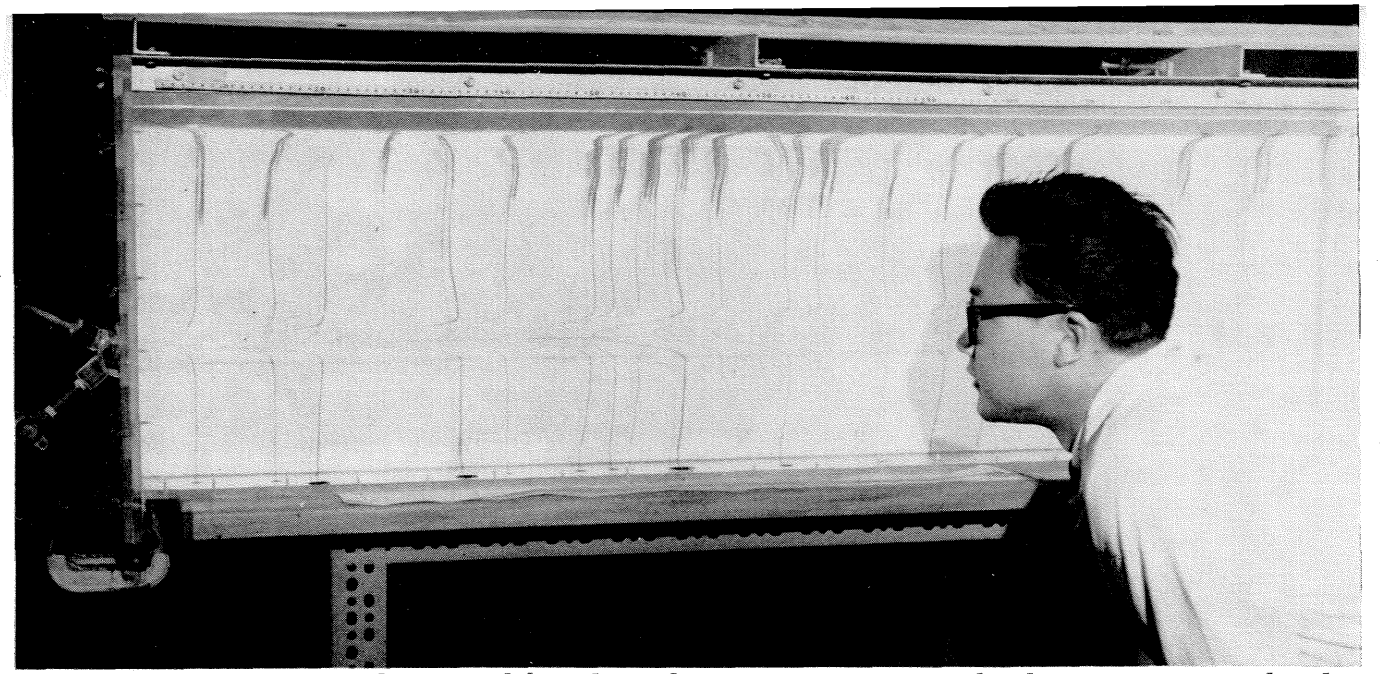
It has been found that river inflow is usually slightly denser than reservoir water because of its sediment load and colder temperature. Within a few years after the closure of Hoover Dam, a huge, submerged pool of muddy river water was found adjacent to the dam, proving that there was a definite current of this heavier river water along the bottom of the reservoir for 120 miles, from the river mouth to the dam.

A pioneering laboratory study of density currents at Caltech 25 years ago helped to clarify this phenomenon, and demonstrated many interesting features of these submerged underflows which are called density currents by the engineers, and turbidity currents by geologists. Because of the slight density difference between the underflow and the reservoir, the downward slope of the reservoir bottom provides the force to keep the current going, while vertical mixing between the layers is retarded by the stratification.

Density currents are to be found in many places. Surely you have felt the density current on your bare feet when you opened the refrigerator? And there are many examples in the atmosphere and the ocean. Geologists debate the question of whether turbidity currents are a major factor in the submarine movements of sediment or not.

The question of what happens when water is drawn from a reservoir is the subject of intensive research in the W. M. Keck Laboratory of Hydraulics and Water Resources at Caltech. In recent years it has been found at Grand Coulee Dam that the temperature of the Columbia River downstream of the dam could be partially controlled by selecting the level from which water was withdrawn from the lake — the coldest water coming from the deepest outlets.

Temperature control is important when the water is used for cooling, as it is at the atomic energy facilities in Hanford, Washington. Water



R. C. Y. Koh demonstrates selective withdrawal of a layer of water in a simulated reservoir. Dye makes flow pattern visible; distortion of vertical lines shows which layer of water is being drawn out of the outlet at left.

can be withdrawn selectively from a stratified reservoir almost like pulling individual sheets out of a pile of papers. Layers of water above and below the level of the outlet may hardly be disturbed; their vertical motion is inhibited by the density difference.

Selective withdrawal in the future may well become a very important tool in the management of water quality of rivers. Water with excessive dissolved salts may be released at times when it is needed only for power or navigation, but not for irrigation or municipal use. In the future, water inventories in water-scarce areas like the Pacific Southwest may well list the contents of a reservoir not only by the total volume but by subtotals according to quality.

In the Keck Laboratory, precise quantitative measurements of the flow in the withdrawal layer have been made by Dr. Robert C. Y. Koh, research fellow in engineering. In a lucite tank 15 inches deep and 8 feet long (above) he simulated a reservoir with a uniform density gradient. Thirteen layers of water of successively decreasing salt content were added very slowly in a day-long filling operation for each experiment. After another 12-hour wait, diffusion would blend the individual layers together to produce a uniform density gradient. For the experiment shown above, the density gradient was 0.03 percent per centimeter or 1.2 percent increase from top to bottom.

To make the flow pattern visible Koh dropped dye particles from the top which left vertical dye streaks as they fell. Horizontal displacement was indicated by the distortion of the dye lines, and velocities were determined by comparing photographic images taken at known time intervals.

For his doctoral thesis Koh was also successful in finding an analytical solution for the case of very low velocity, based on the viscous boundary layer equations and the diffusion equation for salt (or heat). The experiments agreed very closely with the theory for the experiments at the lowest velocities, but started to deviate, as expected, for the higher velocities.

So the question remains as to how well small scale laboratory results can be transferred to the prototype.

However, Dr. Timothy Kao, Caltech research fellow in engineering, solved the problem in his doctoral thesis at the University of Michigan in 1963, by using the Euler equations and neglecting viscous resistance and diffusion. In contrast to Koh's theory, his solution is restricted to relatively large velocities. The real reservoir case probably falls in between these two known theoretical solutions.

Work at the present time is aimed at developing some approximate theories in this in-between range, and making some experiments on a larger scale. In the meantime, various agencies are attempting to make better field measurements. The work at Caltech is supported by a three-year grant from the National Institutes of Health, U.S. Public Health Service.

These new findings will enable civil engineers, for the first time, to make approximate predictions of flow patterns for selective withdrawal, and to design into new dams appropriate outlets for management of the quality of water discharged through them.

The Month at Caltech

Honors and Awards

Don L. Anderson, assistant professor of geophysics, and Steven C. Frautschi, assistant professor of theoretical physics, have received unrestricted basic research grants from the Alfred P. Sloan Foundation.

Dr. Anderson, who received his MS in 1959 and his PhD in 1962 from Caltech, plans to use his grant to carry on investigations of the elastic and non-elastic properties of the earth mantle, and to make an interpretation of wave lengths and free oscillation caused by large earthquakes.

Dr. Frautschi, who has been at Caltech since 1962, will continue his research on the powerful forces which bind strongly interacting particles such as neutrons, protons, and mesons together.

John D. Roberts, professor of organic chemistry and chairman of the division of chemistry and chemical engineering, received an honorary doctor of science degree from Temple University in Philadelphia on March 21.

Pol Duwez, professor of materials science, and Ronald H. Willens, assistant professor of materials science, are co-recipients of the 1964 Champion H. Mathewson Gold Medal of the American Institute of Mining, Metallurgical and Petroleum Engineers, for a paper on their development of entirely new metal alloys by a unique rapid cooling process. Dr. Willens, a former graduate student of Dr. Duwez', received his BS in 1953, his MS in 1954, and his PhD in 1961 from Caltech.

Leader of America

Roy Wilkins, executive secretary of the National Association for the Advancement of Colored People, will be on the Caltech campus April 22 and 23 as the third and last YMCA Leader of America for 1963-64.

Mr. Wilkins, the grandson of a Mississippi slave, was born in St. Louis in 1901. While still in college, he served as secretary for the local chapter of the NAACP in St. Paul, Minn. In 1923 he received his AB from the University of Minnesota and immediately went to work on the Kansas City, Mo., *Call*, a leading Negro weekly. After eight years as a newspaperman, he joined the administrative staff of the national NAACP. From 1934 to 1949, he served as editor of its official magazine, *The Crisis*. He was unanimously elected executive secretary of the organization in 1955.

Arthur H. Young

Arthur H. Young, emeritus lecturer in industrial relations, died on March 4 in a Santa Barbara hospital. He was 81 years old. A pioneer in the field of management-labor relations, he was one of the founders of the Institute's Industrial Relations Center in 1939, and served on the Caltech faculty from 1939 to 1952.

Born in Joliet, Illinois, Young worked in steel mills as a young man, and was vice president of U.S. Steel from 1934 to 1937.

He was chief safety expert of the U.S. Employees Compensation Commission, managed industrial relations for the International Harvester Company, established and directed Industrial Relations, Inc., from 1924 to 1934, was consultant to the International Labour Organization in Geneva, and was a member of the New York State advisory committee on employment.

In the first world war he served as chief safety expert of arsenals and Navy yards, and in World War II he was a consultant to the Secretary of War and a civilian member of the Navy Manpower Survey Board. He was awarded the Navy's Meritorious Civilian Service Emblem in 1944.

When Mr. Young became lecturer emeritus in industrial relations in 1952, some of his friends and associates established the Arthur H. Young Fund in Industrial Relations. The income from this fund is used for the support and maintenance of the Arthur H. Young Visiting Lecturer in Industrial Relations.

Mr. Young is survived by his wife, three children, nine grandchildren, and five great grandchildren.

Guggenheim Fellowship Awards

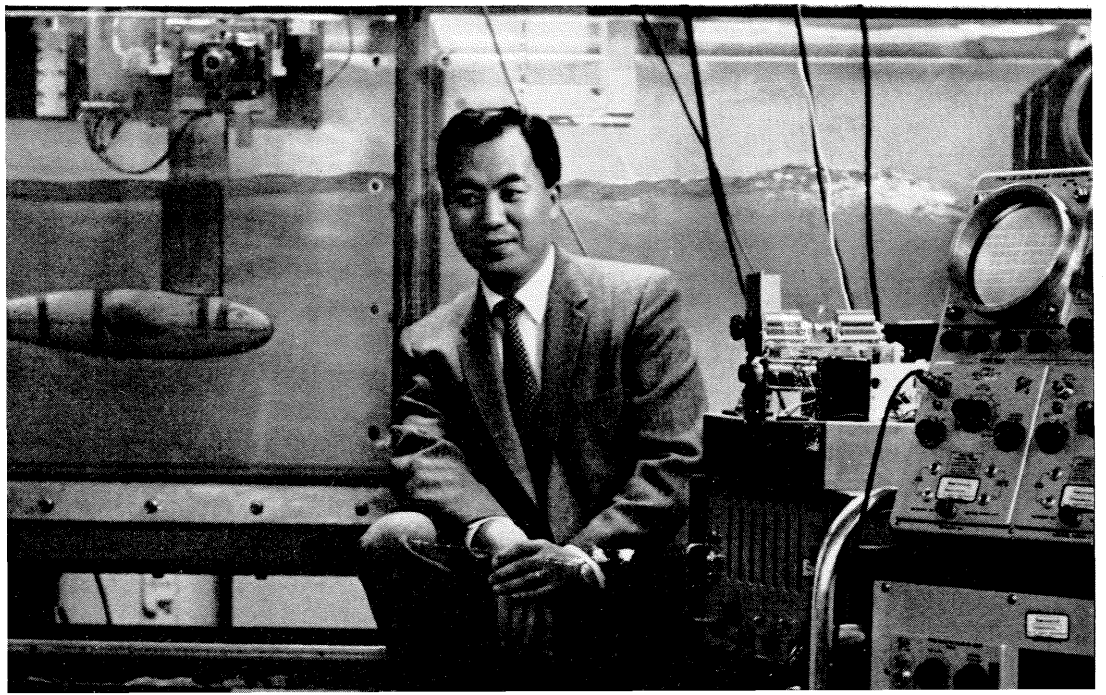
Two Caltech professors were awarded Guggenheim Fellowship Awards this month — Leon T. Silver, associate professor of geology; and Theodore Y. Wu, professor of applied mechanics.

Leon T. Silver, associate professor of geology.

Dr. Silver will continue his studies of the history and age of the earth by analyzing the uranium and lead isotopes of ancient crystalline rocks in Norwegian and Swedish fjords. He has already made extensive investigations of the Grenville Precambrian belt — a broad zone of rocks, extending from the San Gabriel Mountains in southern California to the Northeastern United States, which formed more than 1100 million years ago. These rocks represent some of the roots of a great mountain chain which ran for 4,000 miles across the American continent. Recent petrological and geochronological studies indicate rocks of similar character and approximately the same age in southern Norway and Sweden. After study and field work in Europe, Dr. Silver will continue his investigations of the isotopic content of the rocks by chemistry techniques in the Caltech laboratories.

Dr. Wu will carry out studies of hydrodynamics of free surface flows at the University of Hamburg in Germany, and at several other universities in Europe.

This particular field of hydrodynamics has been developing rapidly in recent years, spreading into such fields as geophysical and biophysical fluid mechanics. It is concerned with water waves, cavity flows, jets, wakes, and stratified flows in meteorology and oceanography. Dr. Wu will study the viscous effects on cavity and wake flows, and the interaction between gravity waves and boundary layers.



Theodore Y. Wu, professor of applied mechanics.

NEW LIGHT IN THE UNIVERSE

Astronomers identify an object in space that is farther away from us, and moving faster, than anything yet observed.

An astronomer and a radio astronomer at Caltech have just identified an object in space that is farther away from us, and moving faster, than anything ever observed before. This object is also far brighter than any light source yet seen. It emits some 100 times more light than an entire galaxy of 100 billion stars.

The object, catalogued as 3C-147, was located by Thomas Matthews, senior research fellow in radio astronomy, from observations made with the twin 90-foot dishes of the Caltech Radio Observatory. The recession rate was then measured by Maarten Schmidt, associate professor of astronomy and staff member of the Mount Wilson and Palomar Observatories, using the 200-inch Palomar telescope. He found that 3C-147 has an apparent velocity of 76,000 miles a second – almost half the speed of light. It is so far away that its exact distance cannot be given at present.

For the past 35 years, astronomers have measured the composition of an object by analyzing the spectrum of its light. In a spectrogram, light is split into its different wave lengths in the same way that a prism separates colors. Each chemical element emits its own characteristic pattern of lines. These lines form the spectrum and are the fingerprints that denote the presence of various elements in the object's atmosphere.

The wave lengths of the lines of each chemical element are known. However, if an object is moving away from us, the lines in its spectrum are shifted to longer wave lengths, toward the red. In 3C-147, the lines were found to be shifted to wave lengths 54½ percent longer than the wave lengths observed in the laboratory. This large red shift corresponds to an apparent velocity of 76,000 miles per second.

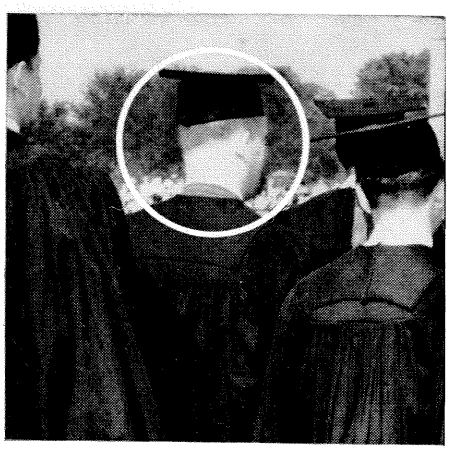
3C-147 is one of the recently discovered "quasi-stellar radio sources." These objects were first noticed in 1960 because they were emitting strong radio noise. At first they were believed to be ordinary stars in our own galaxy. On photographic plates they look like stars, producing very bright images with sharp edges, whereas galaxies tend to show up in photographs as smears of light with fuzzy edges. But the large red shifts found for these objects show that they are enormously bright objects, billions of light years away. They could be the nuclei of exploding galaxies, or they could even be objects in intergalactic space never seen before. Apparently they are undergoing titanic explosions, because they radiate enormous amounts of energy both as light and as radio waves.

Dr. Matthews estimates that perhaps a quarter of the thousands of radio sources in the universe are these star-like objects. To date, hardly more than a dozen have been found.

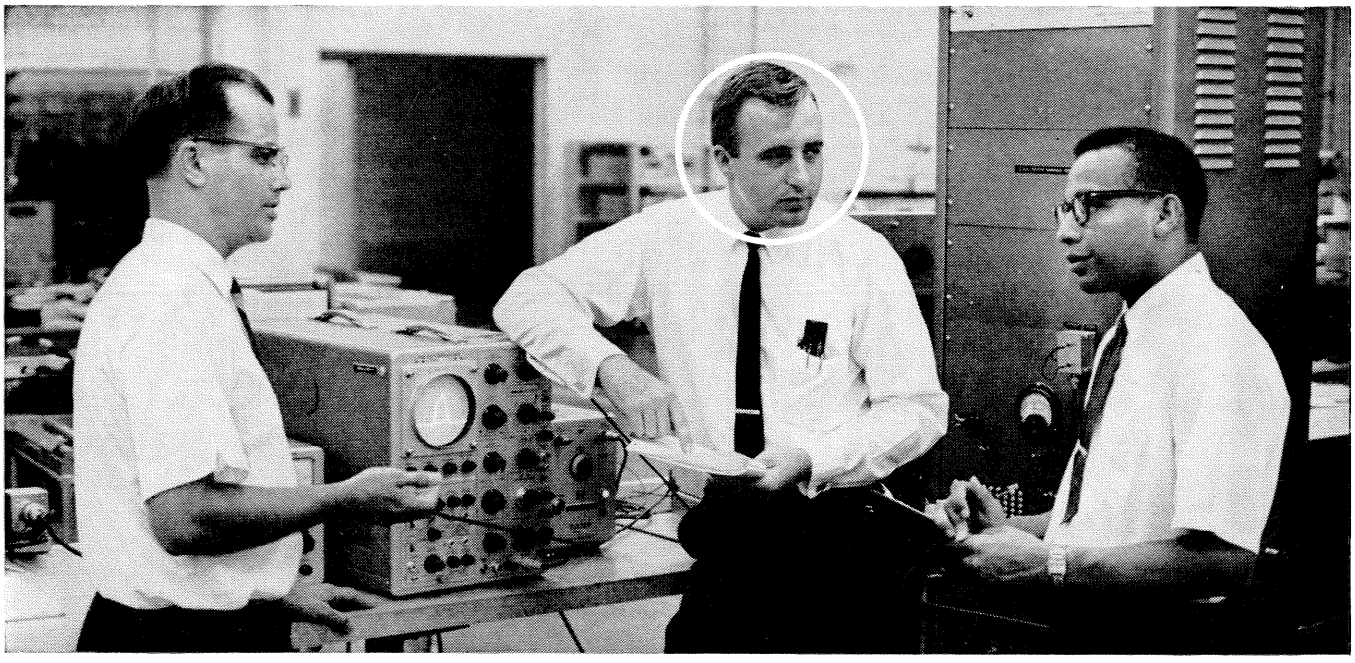
Before the discovery of these new objects, it was thought that the big 200-inch telescope at Palomar, which was designed for the study of the size of the universe, had reached as far into space as it was capable of doing. But these new objects are so very luminous that they enable the telescope to observe much farther out.

If the red shifts can now be determined for enough of these very distant objects, a true model of the universe may eventually be constructed.

Radio astronomer Thomas A. Matthews and astronomer Maarten Schmidt.



Tom Huck sought scientific excitement



He's finding it at Western Electric

Ohio University conferred a B.S.E.E. degree on C. T. Huck in 1956. Tom knew of Western Electric's history of manufacturing development. He realized, too, that our personnel development program was expanding to meet tomorrow's demands.

After graduation, Tom immediately began to work on the development of electronic switching systems. Then, in 1958, Tom went to the Bell Telephone Laboratories on a temporary assignment to help in the advancement of our national military capabilities. At their Whippany, New Jersey, labs, Tom worked with the Western Electric development team on computer circuitry for the Nike Zeus guidance system. Tom then moved on to a new assignment at WE's Columbus, Ohio, Works. There, Tom is working on the development of testing circuitry for the memory phase of electronic switching systems.

This constant challenge of the totally new, combined with advanced training and education opportunities, makes a Western Electric career enjoyable, stimulating and fruitful. Thousands of young men will realize this in the next few years. How about you?

If responsibility and the challenge of the future appeal to you, and you have the qualifications we seek, talk with us. Opportunities for fast-moving careers exist now for electrical, mechanical and industrial engineers, and also for physical science, liberal arts and business majors. For more detailed information, get your copy of the Western Electric Career Opportunities booklet from your Placement Officer. Or write Western Electric Company, Room 6405, 222 Broadway, New York 38, N. Y. And be sure to arrange for a personal interview when the Bell System recruiting team visits your campus.

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Twenty-Seventh Annual Alumni Seminar

Saturday, May 2nd, 1964

Dinner and Evening Programs

Huntington-Sheraton Hotel, Pasadena

THE LITTLE RED SCHOOLHOUSE STILL HAUNTS US — *Mrs. Georgiana Hardy*

Mrs. Hardy has been a member of the Los Angeles City Board of Education since 1955 and is currently serving a second term as president of the Board. Long active in health and welfare work, Mrs. Hardy was a member of the White House Committee on Youth (1935-39), vice president, National Girl Scouts (1938-42), on the personnel staff of the National Red Cross (1943-45), a member of the United States Attorney General's Conference on Juvenile Delinquency (1948), and chairman of the Los Angeles County Conference on Community Relations (1953-55). She is widely known as a book reviewer on the program "Cavalcade of Books," which won the Peabody Award for best educational television show in the United States in 1953. Her present activities include membership on numerous welfare and health agency boards, including the Los Angeles Welfare Planning Council, the Los Angeles United Nations Association, the Los Angeles County Heart Association, the California Association for Health & Welfare, United Way, Inc., and the research council of the Great Cities Program for School Improvement.

Special Exhibits

Tranquil and Torrential Flows in the New 130-ft. Tilting Flume—Dynamic Tests of Structures—Linear Accelerator.

Special Lecture

Beckman Auditorium, 11:45 A.M.

SCIENCE IN SPACE — *Lee A. DuBridge, President, California Institute of Technology*

Space science is as old as Aristotle and as new as the latest launching at Cape Kennedy. Though it was long the exclusive property of astronomers and physicists, it now is of interest to chemists, geologists, biologists, and engineers. Some of the past achievements and current problems relating to the science of space will be discussed, particularly those of interest on the Caltech campus and at JPL.

Seminar Lectures

THE STRAIN OF IT ALL
9:30 A. M. and 2:15 P. M.
Hugo Benioff, Professor of Seismology

Dr. Benioff is retiring as professor of seismology at the Institute this year, and will touch on the highlights of his career and feature recent research which has indicated that, although the elastic rebound mechanism correctly describes the generation of shallow earthquakes, a different type of source mechanism is involved in deep earthquakes. Our knowledge of the prime mover resulting in shallow earthquakes is still largely speculation.

ZANZIBAR, ZAMBIA, AND ZUIDWES AFRIKA
9:30 A. M. and 2:15 P. M.
Edwin S. Munger, Professor of Geography

Zanzibar's revolt signals more than the overthrow of centuries of Arab domination with the help of Castro and Co. Subsequent military unrest in Tanganyika, Kenya, Uganda and even in Gaboon suggests a new type of European involvement on the continent. Zambia is the independent name of Northern Rhodesia which has, thanks to partly American-owned copper mines, potentially the highest per capita income of any African state. Zuidwes Afrika, to give South West its old Dutch spelling, is the subject of critical decision by the World Court, possible token invasion from West Africa, and great pressure on the U. S. in the U. N.

THE MONKEY-KIDNEY TRIALS
9:30 A. M. and 3:15 P. M.
Ray D. Owen, Professor of Biology; Chairman, Division of Biology

Although great medical benefits could be obtained from successful organ transplantation, there are formidable biological barriers to success. Recently,

Is it news that a leading maker of spacecraft alloys had a hand in dolling up Mildred Kinne's potting shed?

It isn't really surprising that a single U.S. corporation provided the metal for the outer skin of Mercury space capsules. It's perfectly natural to be called in on that kind of a job when you lead the nation in developing a line of alloys that resist extreme heat, wear and corrosion.

You'd also expect that a leading producer of petrochemicals could develop a new base for latex paint—called "Ucar" latex—since paint makers are among its biggest customers. Now Mildred Kinne can paint right over a chalky surface without priming. It's dry in minutes. And her potting shed will look like new for many New England summers and winters.

But it might indeed be surprising if both these skills were possessed by the same company. Unless that company were Union Carbide.

UNION CARBIDE

Union Carbide also leads in the production of polyethylene, and makes plastics for packaging, housewares, and floor coverings. It liquefies gases, including oxygen and hydrogen that will power rockets to the moon. In carbon products, it has been called on for the largest graphite shapes ever made. It is the largest producer of dry-cell batteries, marketed to millions under the trade mark "Eveready." And it is involved in more atomic energy activities than any other private enterprise.

In fact, few other corporations are so deeply involved in so many different skills and activities that will affect the technical and production capabilities of our next century.

It's already making things a great deal easier for Mildred Kinne.

UNION CARBIDE CORPORATION, 270 PARK AVENUE, NEW YORK, N.Y. 10017. IN CANADA: UNION CARBIDE CANADA LIMITED, TORONTO
Divisions: Carbon Products, Chemicals, Consumer Products, International, Linde, Metals, Nuclear, Olefins, Ore, Plastics, Silicones, Stellite and Visking

much popular attention has been given the relatively prolonged function of chimpanzee and other primate kidneys transplanted into humans. Dr. Owen will discuss the present status of this field. He has been engaged for a number of years in studies of the immunology and genetics of transplantation.

QUASI-STELLAR RADIO SOURCES
9:30 A. M. and 3:15 P. M.
Maarten Schmidt, Associate Professor of Astronomy

Recently, a few radio sources have been found to be associated with objects that look like stars. These quasi-stellar objects have been found to be extremely distant galaxies. They are very compact and many times brighter than ordinary galaxies, but their source of energy is an enigma. The existence of these radio sources makes it possible to investigate the far reaches of the Universe.

AUTOMATION – AUTOMATIC UNEMPLOYMENT?
10:45 A. M. and 3:15 P. M.
Alan R. Sweezy, Professor of Economics

Widespread concern about the rapid rate at which workers are being displaced by automation is contrasted with the contention by others that there really is no problem: automation automatically stimulates the economy to whatever extent is necessary to reemploy the displaced workers. There is little basis for the latter easy optimism. Dr. Sweezy will discuss how the problems of automation can be answered and how we can have both adequate expansion and sound finance (in the sophisticated meaning of that term).

RECENT WORK ON THE MÖSSBAUER EFFECT
10:45 A. M. and 3:15 P. M.
Rudolf L. Mössbauer, Professor of Physics

The Mössbauer effect is a powerful new research tool in physics. The discovery of the phenomenon of recoilless nuclear resonance absorption of gamma radiation has provided the experimental physicist with the most sensitive method available so far for measuring extremely small differences in energy between different atoms or nuclei. The new method permits studies of numerous phenomena in the fields of solid state physics, chemistry, nuclear physics, and relativity. For this work Dr. Mössbauer was awarded the Nobel Prize in Physics.

MOLECULAR PARTNER CHANGING
10:45 A. M. and 4:15 P. M.
Aaron Kupperman, Professor of Chemical Physics

Chemical reactions occur in general as a result of collisions between molecules and other molecules or electrons or light quanta. The mechanics of such collisions and how they lead to chemical reactions will be described and illustrated with an animated cartoon. The use of crossed molecular beams and digital computers in these investigations will be described.

CALTECH'S PEDAGOGIC COMPUTER
10:45 A. M. and 4:15 P. M.
Gilbert D. McCann, Professor of Electrical Engineering; Director of Computing Center

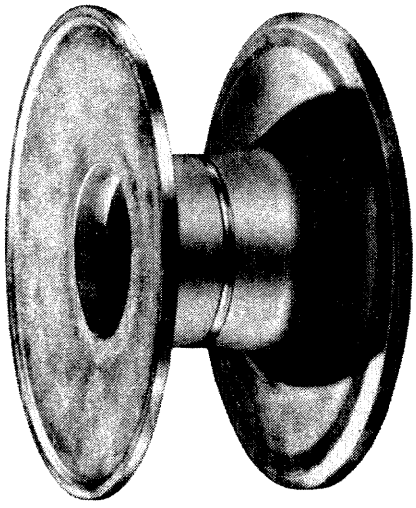
The Institute has recently placed in service a new computer system concept that provides better communication and interplay between experimental research and both students and faculty. This facility, with its remote stations and interplexed mode of operation, will be described, together with some of its more important applications. These include plans for its future use in undergraduate and graduate courses, its applications to nuclear physics, physical chemistry, seismology, and research on living nervous systems.

NEW SCHEMES TO TEACH ARITHMETIC
2:15 P. M. and 4:15 P. M.
Richard P. Feynman, Professor of Theoretical Physics

The teaching of arithmetic in elementary schools is being transformed by mathematicians and educators. Subjects from sets to plane geometry and probability are considered appropriate for all elementary school children. Professor Richard Feynman, a member of the State Curriculum Commission, which advises the State Board of Education on the selection of textbooks for California public schools, will discuss and criticize these new ideas.

SEA URCHINS, SEAWEED, AND SEWAGE
2:15 P. M. and 4:15 P. M.
Wheeler J. North, Associate Professor of Environment Health Engineering

The vast kelp beds of southern California are one of the richest areas of the sea. Fishes, shellfish, and the kelp itself are harvested from these submarine forests. In recent years our kelp beds have suffered serious deterioration and it is believed that marine waste disposal upsets a delicate balance, favoring sea urchins which graze the kelp to extinction. A program of sea urchin control is succeeding in restoring kelp to the sea floor off San Diego and represents man's first large-scale attempt to "farm" the open sea.



FORGINGS ELIMINATED REJECTS ON THIS EARTHMOVER HUB . . . *and cut cost 16%*

Originally, this earthmover wheel hub was not a forging. Now it is **forged** in steel. Here's why . . .

While reviewing costs of the original part, the earthmover manufacturer discovered that: (1) Cost of the hub was too high; (2) rejection rates during machining were high because of voids and inclusions; and (3) hidden flaws required costly salvage operation.

By converting to **forged** steel hubs, the manufacturer has saved 16%, has completely eliminated rejects and repairs of parts in process, has achieved 100% reliability of the part.

Forgings have greater inherent reliability and strength because they:

1. Are solid, void-free metal
2. Have higher resistance to fatigue
3. Are strongest in withstanding impact and sudden load
4. Have high modulus of elasticity
5. Have low mechanical hysteresis
6. Have unique stress-oriented fiber structure

Memo to future engineers:

"Make it lighter and make it stronger" is the demand today. No other metalworking process meets these two requirements so well as the forging process. Be sure you know all about forgings, their design and production. Write for Case History No. 104, with engineering data on the earthmover hub forging shown above.

DROP FORGING ASSOCIATION

55 Public Square • Cleveland 13, Ohio

When it's a vital part, design it to be

FORGED

Personals

1928

EDWARD E. TUTTLE is now president of the Essick Manufacturing Company, which has its head office in Los Angeles, and — with its subsidiaries — operates six plants in the United States, producing lines of construction and road building equipment, air cooling equipment, and commercial laundry equipment. Tuttle is also senior partner of the Los Angeles law firm of Tuttle & Taylor, and a trustee of Orthopaedic Hospital and Pomona College.

1931

JOHN R. McMILLAN is now president and a director of the Reserve Oil and Gas Company and serves as the firm's chief executive officer. He resigned as president of the Lacal Petroleum Company in Los Angeles to assume his new post. He had previously served as president of Fullerton Oil and Gas, executive vice president of Monterey Oil, president of the Monterey Division of Humble Oil, and president of the Monterey Gas Transmission Company of Houston. He was one of the organizers and first president of the Transwestern Pipeline Company.

1932

JOHN A. LEERMAKERS, PhD, is now director of the Kodak Research Laboratories in Rochester, N.Y. He had been associate director since 1961, and has been with Kodak since 1934. The Leermakers live in Brighton, N. Y., with their three sons.

WILLIAM SHOCKLEY, who is now Alexander M. Poniatoff Professor of Engineering Sciences at Stanford, recently received the Holley Medal, awarded biennially by the American Society of Mechanical Engineers, for "outstanding discovery, invention, and leadership in bringing the transistor into existence and into the service of humanity."

Bill is also serving as a consultant for the Clevite Corporation in Palo Alto, where he was director of the Shockley Laboratories before joining the Stanford faculty.

1935

ROBERT J. HALLANGER is now vice president of the Fibreboard Paper Products Corporation in San Francisco. He was formerly director of engineering.

1937

DANIEL G. SCHUMAN has been elected vice president for finance at Bausch & Lomb Inc. in Rochester, N.Y. He joined the company as comptroller in 1959.

1938

WILLIAM S. ALTHOUSE, JR., has been appointed vice president-finance by Baker Tools Inc., in Los Angeles. He has been with Baker since 1938 and has been a member of the board of directors since 1958. He was elected a vice president in 1962.

1940

GERALD P. FOSTER is now assistant professor of public administration at the University of Denver College of Business Administration. He was formerly a visiting assistant professor of public administration at USC.

HAROLD S. MICKLEY, MS '41, Ford Professor of Engineering at MIT, is now serving as director of the new Center for Advanced Engineering Study, established at MIT by a $4,000,000 grant from the Alfred P. Sloan Foundation. He is also chairman of the MIT Faculty for 1963-64 and ex-officio chairman of the Committee on Educational Policy.

1941

LELAND G. SWART, MS, is now heading the new Fixed Underwater Systems Department of the Bell Telephone Laboratories at Winston-Salem, N.C. He was formerly supervisor of a group engaged in the design and development of military underwater transmission systems for the U. S. Navy. He has been with Bell Labs since 1945.

1942

FREDERICK H. FELBERG, MS '45, is now assistant laboratory director for technical devisions at JPL. His management responsibility includes the Systems, Space Sciences, Telecommunications, Guidance and Control, Engineering Facilities, and Propulsion Division. Fred was formerly associate director of the Southern California Cooperative Wind Tunnel at Caltech, and joined JPL in June 1960, as deputy chief of the Engineering Mechanics Division. He became acting chief of the division in 1962. The Felbergs and their two children live in Altadena.

1943

CHARLES P. STRICKLAND, JR. has been named manager of the Industrial Refrigeration Division of the Scott Co. of California, mechanical contractors, in Los Angeles. He was formerly Pacific Regional Manager for the York Corporation, a subsidiary of Borg-Warner.

1944

GIFFORD E. McCASLAND, PhD, associate research professor in the Institute of Chemical Biology at the University of San Francisco, has been awarded $61,000 for studies on cancer. The three-year grant was given by the National Cancer Institute.

CLIFFORD I. CUMMINGS, former lunar program director at JPL, is now manager of Advanced Systems Development Operations for Electro-Optical Systems Inc., in Pasadena. He had been on the JPL staff for 17 years, most recently as special assistant to Director WILLIAM H. PICKERING, '32, MS '33, PhD '36.

1945

WARREN M. MARSHALL, III, BS '45 AE, BS '48 ME, is now exploitation engineer in the Delta Production Division of the Shell Oil Company in New Orleans.

CLARENCE J. WOODWARD is now president of The Rucker Company in Oakland, Calif. He has been with the company since 1953, most recently serving as vice president and general manager. The Woodards and their four children live in Orinda.

1949

HUGH C. CARTER, president of the Hugh Carter Engineering Company in Long Beach, has been elected president of the Consulting Engineers Association of California, a state-wide association of consulting engineers in private practice.

ROBERT D.DALTON, JR., MS, partner with his father, ROBERT H. DALTON, '25, MS '26, PhD '28, in the firm of Dalton & Dalton, Consulting Structural Engineers, has been elected president of the Structural Engineers Association of Northern California. The Daltons have worked together since 1953, are currently associate structural engineers for the new $5,000,000 Oakland Museum. The younger Dalton has a daughter, Vickie, 14, and a son, Keith, 11.

1950

RUDOLPH C. FREY, MS, is now instrument division engineer for The M. W. Kellogg Company, a subsidiary of Pullman Incorporated, in New York. He was formerly assistant instrument division engineer.

1951

FREDERICK T. RALL JR., MS, chief of the aerodynamics branch of the B-70 engineering office, a division of Wright Patterson Air Force Base, is now at MIT on an Alfred P. Sloan fellowship for a year's study in executive development.

ROYAL S. FOOTE, MS, is now vice president of the Science Management Corporation in Denver, Colo. He was formerly southwestern regional manager of Beech Aircraft's Government Marketing organization.

1952

FRANCIS R. KRAMER is now research supervisor at the Du Pont Company's Carothers Research Laboratory at the

experimental station near Wilmington, Del. He was formerly supervisor of research at Du Pont's nylon plant in Seaford, Del.

ALAN K. FORSYTHE, MS '59, writes that "I am now engaged in a sailing voyage, having worked for three years at JPL to amass my fortune. Three of us are sailing our own yacht to the South Pacific, having visited nearly every island in the Caribbean Sea in the past year.

"Our boat is a 33-foot Brittany Class Sloop, built in England, and named the *Easterling*. We are now arranging to transit the Canal, and then to visit the Galapagos, Marquesas, Tahiti, Fiji, and New Zealand, before turning homeward. No specific plans have been made beyond that point.

"I do expect to return to the space industry or some related work when I return, with perhaps another education interval between. But there will be time to consider that later . . ."

1957

WARREN FURUMOTO, assistant professor of biology at San Fernando State College, has been awarded a $20,500 grant from the National Science Foundation for a two-year study of sub-units of tobacco mosaic virus.

1958

THEODORE C. OAKBERG, is now instructor of physics at Antioch College in Yellow Springs, Ohio. He received his MS degree in physics from the University of Cincinnati, and is working for his PhD there.

1959

PETER ALBERSHEIM, PhD, will join the faculty of the University of Colorado next fall as associate professor of biochemistry. He is now on the staff of the Harvard University Biological Laboratories.

1960

EDWARD R. FLEMING, PhD, is now associate head of the structure and materials department in the spacecraft sciences division at the Aerospace Corporation in El Segundo. He has been a member of the company's technical staff since 1961.

1961

STUART B. BERGER, PhD, joined the Materials Research Laboratory of the RCA Laboratories at the David Sarnoff Research Center in Princeton, N.J., last fall. He had been on the staff of the Bell Telephone Laboratories in Murray Hill, N. J., since 1961.

1962

JULIAN V. NOBLE AND KIP S. THORNE received MS degrees in physics from Princeton University in January.

PLACEMENT ASSISTANCE TO CALTECH ALUMNI

There are two ways in which the Placement Service may be of assistance to you:

(1) To help you seek new employment or a change of employment.

(2) To inform you when outstanding opportunities arise.

This service is provided to Alumni by the Institute. A fee or charge is not involved.

If you wish to avail yourself of this service, fill in and mail the following form:

To: Caltech Alumni Placement Service
California Institute of Technology
Pasadena, California 91109

Please send me:

☐ An Application for Placement Assistance

☐ A form to report my field and operation so that I may be notified of any outstanding opportunities.

Name ..... Degree (s) .....

Address ..... Year (s) .....

.....

CALTECH CALENDAR

ALUMNI EVENTS

May 2
Alumni Seminar

June 10
Annual Alumni Meeting

FRIDAY EVENING DEMONSTRATION LECTURES

Lecture Hall, 201 Bridge, 7:30 p.m.

April 24
The Alternative Futures of Pasadena
—Robert Oliver

May 1
Chemical Kinetics: The Description of Chemical Reactions at a Molecular Level
—Aron Kuppermann

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Meetings: 15th Floor, Engineers' Club, 206 Sansome St., San Francisco
Informal luncheons every Thursday at 11:45 A.M.
Contact Mr. Farrar, EX 9-5277, on Thursday morning for reservations.

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3920 Dunster Way, Sacramento, Calif. 95825

Meetings: University Club, 1319 "K" St.
Luncheon first Friday of each month at noon.
Visiting alumni cordially invited—no reservation.

After McNair designs it, Kelly has to manufacture it

In the broad spectrum of engineers and scientists we constantly seek, we can use more manufacturing engineers like Edward Joseph Kelly (right, six years out of Tufts this June). Mark well the distinction between Kelly's responsibility and that of his opponent in the debate pictured. Out of it upon completion of their differing assignments will come a photographic information storage and retrieval device that will bear our "Recordak" trademark, well known in banking and other businesses.

Dave McNair has determined how the mechanical, optical, and electrical components and subassemblies have to work and fit together for the equipment to do its job. He has come up with a working model. Management likes it.

Enter Kelly. His task: to tell us exactly down to the last detail what we have to do to multiply McNair's working model by x, a number chosen by the marketing people. To make the production-run machines work not merely as well as McNair's hand-built one, but better. To decide which parts we should buy and which we should make. To specify the tooling for the parts we make. To specify also the tools for assembly and inspection. To design the fabrication processes. Better than just designing the processes, to see the need for a process which no previous manufacturing engineer had realized was needed and which happens to make the product an irresistible bargain for the ultimate user and a money-maker for us.

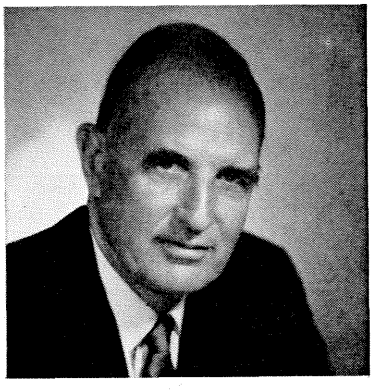
We need that kind of manufacturing engineer so that we can teach him how to run a big business.

EASTMAN KODAK COMPANY,
Business and Technical Personnel Department, Rochester, N.Y. 14650
An equal-opportunity employer offering a choice of three communities:
Rochester, N.Y., Kingsport, Tenn., and Longview, Tex.

Kodak

Define Your Career Objectives!

■ An interview with W. Scott Hill, Manager—Engineering Recruiting, General Electric Co.



W. Scott Hill

Q. Mr. Hill, when is the best time to begin making decisions on my career objectives?

A. When you selected a technical discipline, you made one of your important career decisions. This defined the general area in which you will probably begin your professional work, whether in a job or through further study at the graduate level.

Q. Can you suggest some factors that might influence my career choice?

A. By the time you have reached your senior year in college, you know certain things about yourself that are going to be important. If you have a strong technical orientation and like problem solving, there are many good engineering career choices in all functions of industry: design and development; manufacturing and technical marketing. If you enjoy exploring theoretical concepts, perhaps research—on one of the many levels to be found in industry—is a career choice to consider. And don't think any one area offers a great deal more opportunity for your talent than another. They all need top creative engineering skill and the ability to deal successfully with people.

Q. After I've evaluated my own abilities, how do I judge realistically what I can do with them?

A. I'm sure you're already getting all the information you can on career fields related to your discipline. Don't overlook your family, friends and acquaintances, especially recent graduates, as sources of information. Have you made full use of your faculty and placement office for advice? Information is available in the technical journals and society publications. Read them to see what firms are contributing to advancement in your field, and how. Review the files in your placement office for company literature. This can tell you a great deal about openings and programs, career areas and company organization.

Q. Can you suggest what criteria I can apply in relating this information to my own career prospects?

A. In appraising opportunities, apply criteria important to you. Is location important? What level of income would you like to attain? What is the scope of opportunity of the firm you'll select? Should you trade off starting salary against long-term potential? These are things you must decide for yourself.

Q. Can companies like General Electric assure me of a correct career choice?

A. It costs industry a great deal of money to hire a young engineer and start him on a career path. So, very selfishly, we'll be doing everything possible to be sure at the beginning that the choice is right for you. But a bad mistake can cost you even more in lost time and income. General Electric's concept of Personalized Career Planning is to recognize that your decisions will be largely determined by your individual abilities, inclinations, and ambitions. This Company's unusual diversity offers you great flexibility in deciding where you want to start, how you want to start and what you want to accomplish. You will be encouraged to develop to the fullest extent of your capability—to achieve your career objectives, or revise them as your abilities are more fully revealed to you. Make sure you set your goals realistically. But be sure you don't set your sights too low.

FOR MORE INFORMATION on G.E.'s concept of Personalized Career Planning, and for material that will help you define your opportunity at General Electric, write Mr. Hill at this address: General Electric Co., Section 699-10, Schenectady, N. Y. 12305.

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