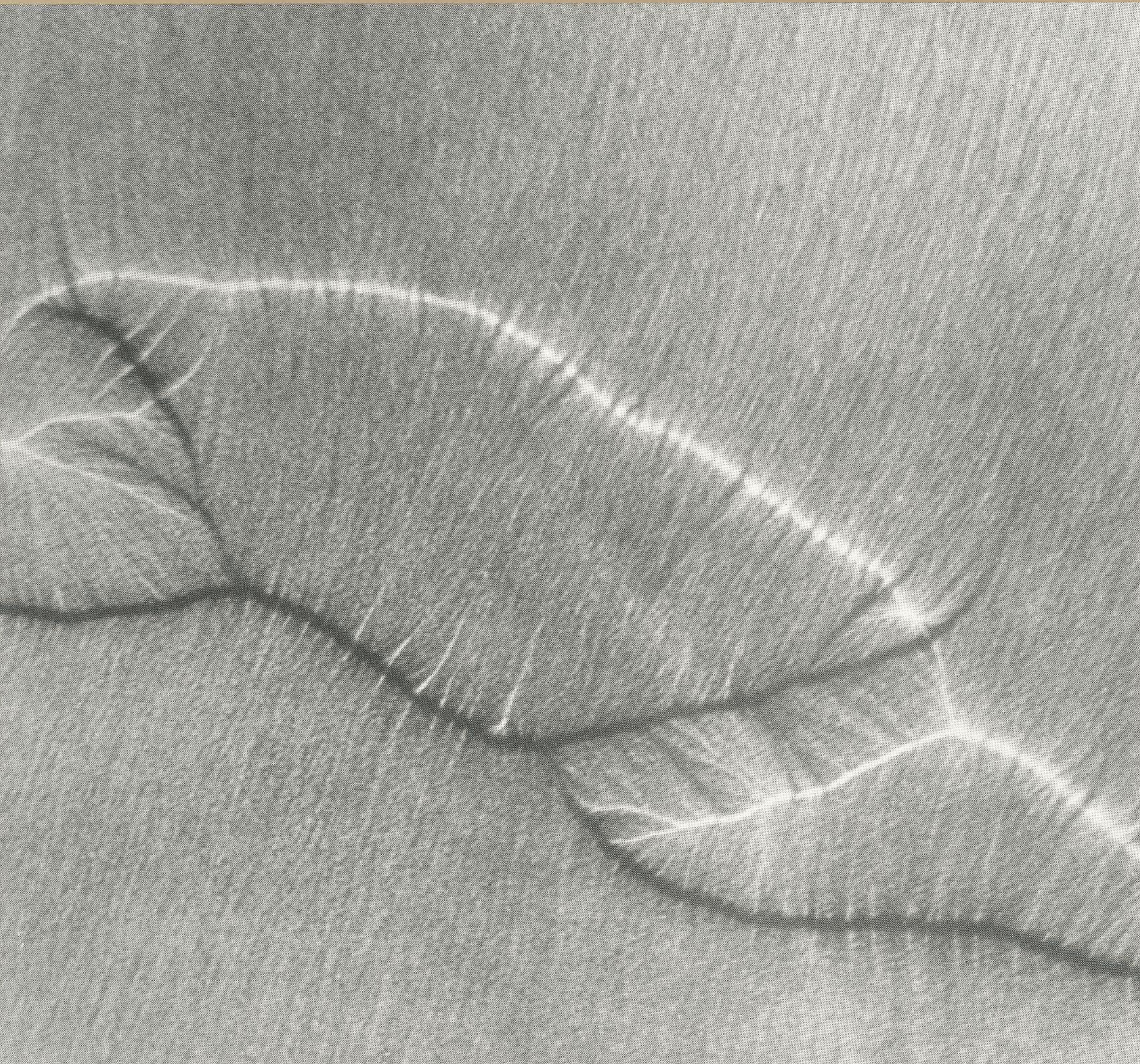
JANUARY 1969

E&S ENGINEERING AND SCIENCE

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY



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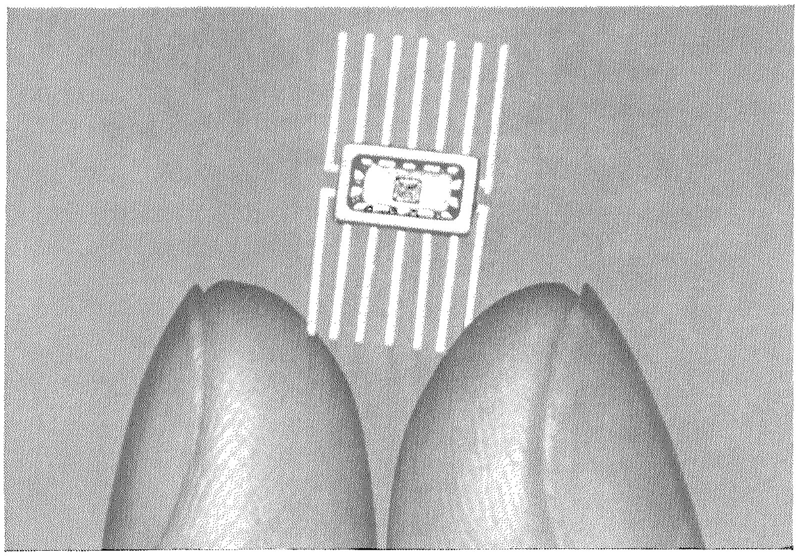

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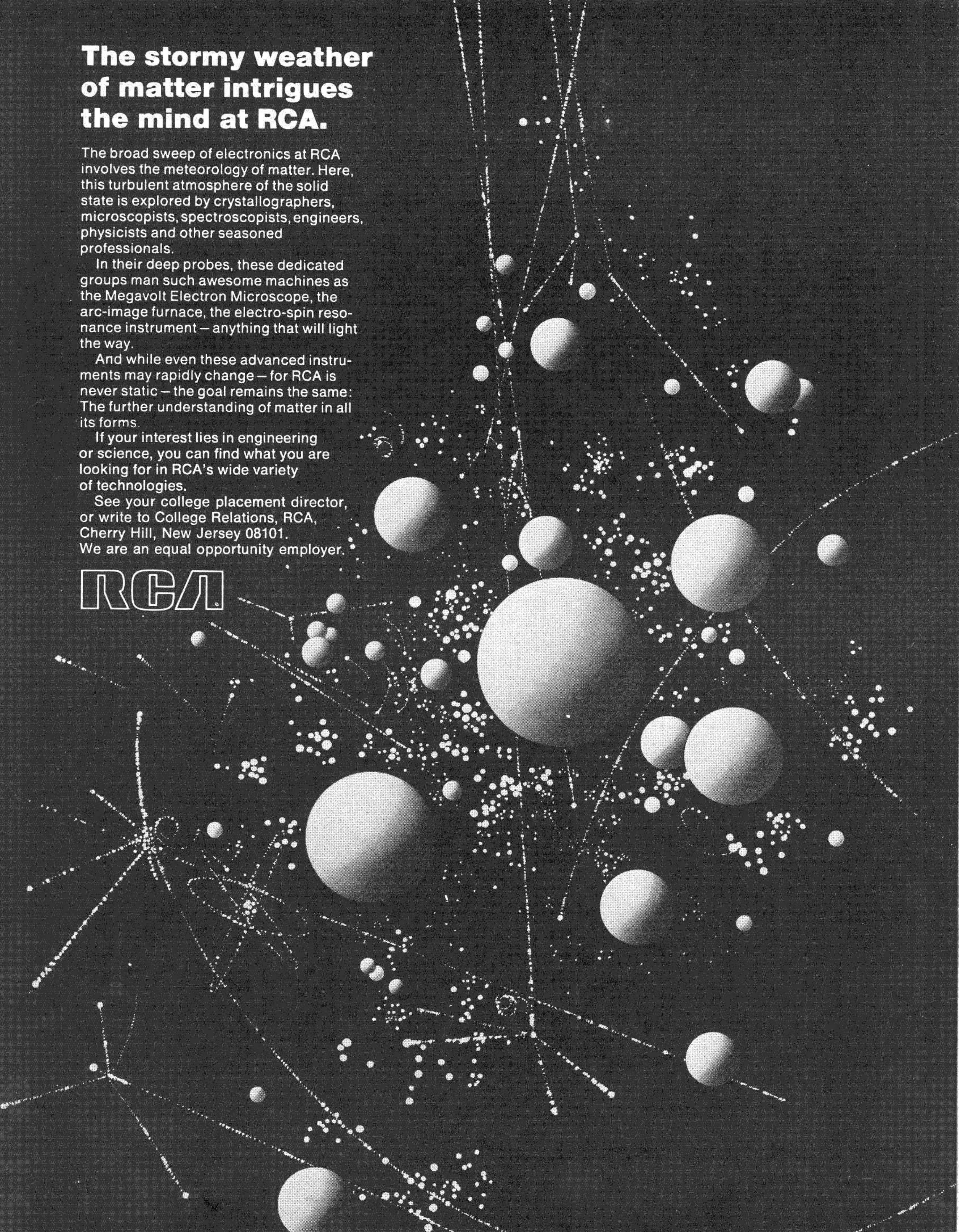

E&S

ENGINEERING AND SCIENCE

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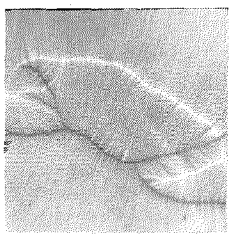

On The Cover

This photograph of a thin film of cobalt (750 angstroms thick) was made by means of the process of Lorentz microscopy, a new technique using the electron microscope that allows direct observation of the detailed magnetic structure of ferromagnetic materials. The magnetization configuration here is revealed by the ripple, which is always perpendicular to the mean direction of magnetization. In Caltech's electrical engineering laboratories graduate student Takao Suzuki and Charles Wilts, professor of electrical engineering, are producing other exciting visual representations of magnetic structure through the use of Lorentz microscopy (page 14).

Photo Credits

Cover, 14, 15—Takao Suzuki
8, 16, 19—James McClanahan
21—Robert L. Walker

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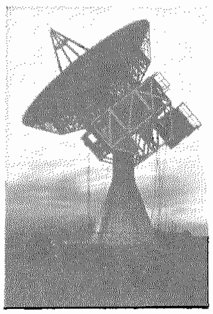

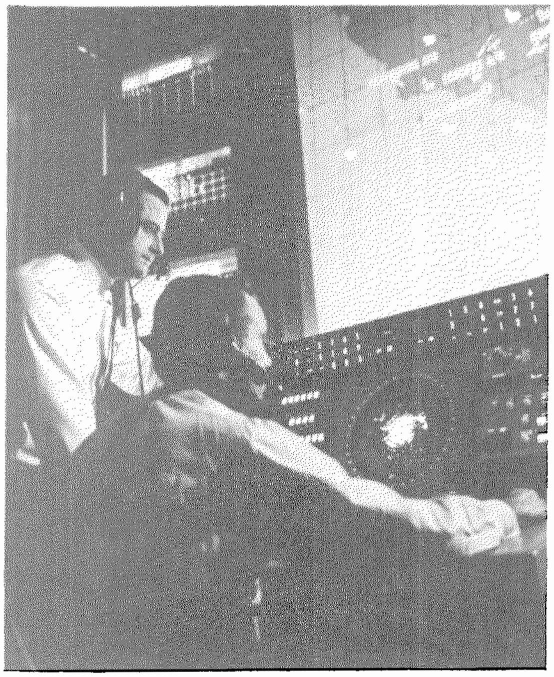

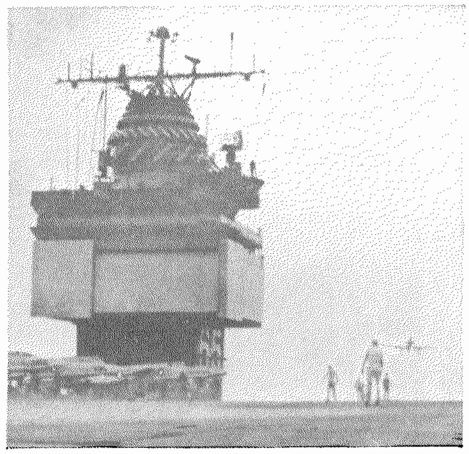

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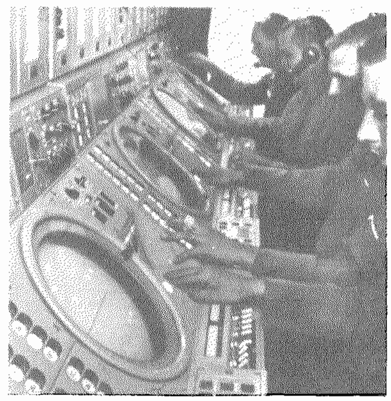

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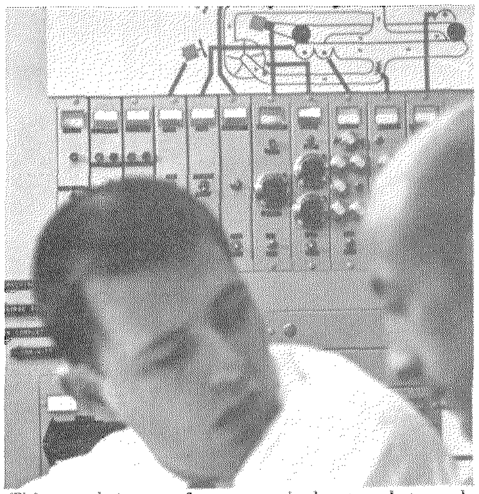

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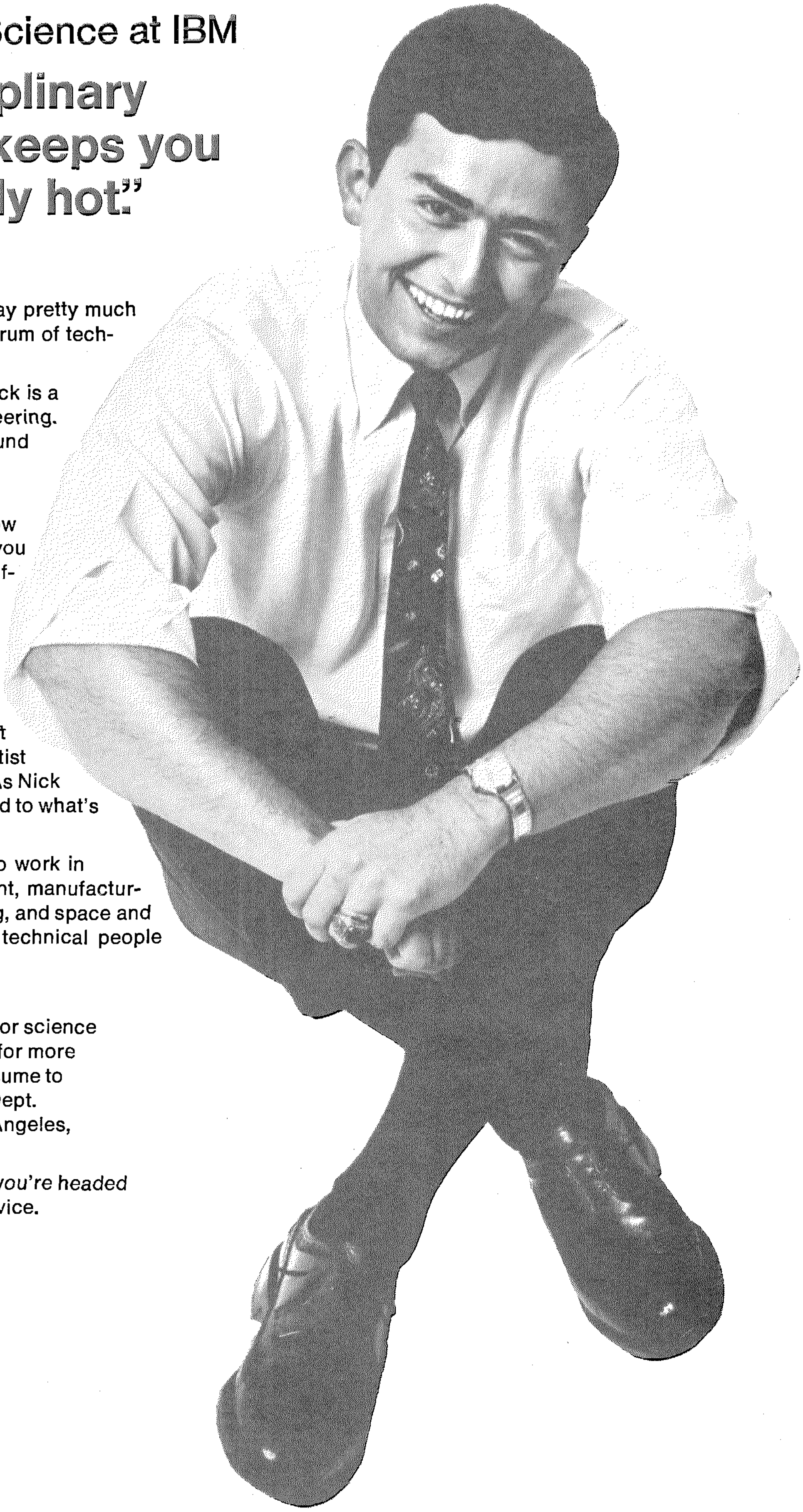

"Working in data processing today pretty much means you work in a broad spectrum of technologies," says Nick Donofrio.

An Associate Engineer at IBM, Nick is a 1967 graduate in Electrical Engineering. He's using his technical background to design circuits for computer memory systems.

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E&S
January 1969, Vol. XXXII, No. 4

Engineering for Earthquakes

By GEORGE W. HOUSNER

A Caltech engineer looks at the prospects for building-in protection against earthquake damage in seismic regions.

From an individual point of view the most alarming aspect of earthquakes is the possibility that they might kill or injure people, as in fact they often have done. In September of 1967 an earthquake in Iran killed more than 10,000 persons. In 1962 an earthquake there killed nearly 12,000. In 1960 Morocco had an earthquake that killed 10,000 people in the city of Agadir, whose population was only 30,000. In 1927, in China, over 200,000 were killed by an earthquake; in 1908, Messina, Italy, was struck by an earthquake in which more than 80,000 people died; in 1755, Lisbon, Portugal, had more than 60,000 casualties; in 1730, an earthquake in northern Japan killed more than 130,000. One scholar of the subject has estimated that during the past 4,000 years approximately 74 million people have been killed by earthquakes.

The danger to life and limb resulting from earthquakes is due primarily to poorly constructed buildings which have, as it were, built-in hazards. In some earthquakes, it is true, numerous casualties have resulted from tsunamis, the earthquake-produced ocean waves that sweep up on shore and wash away towns and people; and in other earthquakes people have been killed by the destructive movement of soils. Fires resulting from earthquakes have also killed many, but, in general, the major part of the death toll is due to poor buildings. These hazardous structures can be readily identified, but in some places the economic development of the country does not permit an improvement in the quality of construction, and in other countries the hazardous buildings are simply tolerated.

Buildings erected in southern California since 1933, when the earthquake provisions of the building code were adopted, are, in general, relatively safe. The typical southern California wood frame house with plaster walls, light in weight and relatively stiff and strong, is also quite safe during earthquakes. Indeed, houses that are being built now have certain earthquake-protective measures incorporated. The building department insists upon seismic braces and other precautions, such as reinforcing the chimney, to prevent injury and loss of life and to minimize damage.

However, it has been estimated that something

George W. Housner, Caltech professor of civil engineering and applied mechanics.

on the order of 40,000 buildings in the metropolitan area of southern California are pre-earthquake-code, unreinforced masonry buildings.

Some of my colleagues and I are currently involved in preparing a report for the National Academy of Engineering on the significance of the earthquake problem to the public and on the measures that should be taken to provide protection. In this report the overall point of view is taken rather than the viewpoint of the individual. What should the federal government, for instance, do about earthquakes in this country? What an earthquake means to a nation or to a large, highly industrialized community is quite different from what it means to an individual.

At the time of the large 1857 earthquake in southern California, the state was undeveloped, and Los Angeles was just a village. The earthquake is reported to have damaged a significant number of houses, but it could not be called a disaster, and from the point of view of the government it was not a serious event. On the other hand, now, when there are eight million people living in the area, a similar earthquake has the potential for creating a disaster if precautions are not taken to protect against it.

It appears that earthquake-protective measures are not usually adopted until a country reaches a certain stage of industrialization. For example, there were very large earthquakes in California in 1857, 1868, 1872, and 1906, but none of these induced any action to require that buildings be designed to resist earthquakes. Only when the population and industrialization reached certain levels was action taken—following the medium-sized Long Beach earthquake of March 10, 1933.

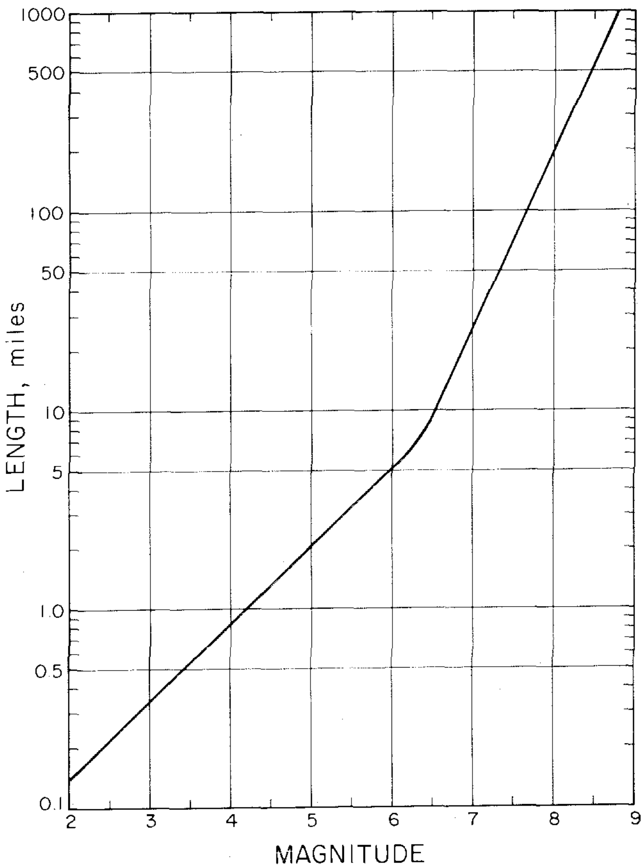
In most underdeveloped countries of the world, no earthquake precautions have been taken in the past even though the countries were densely populated. But when these countries began making large investments in dams, power plants, bridges, and factories, they began requiring earthquake-resistant design. Because an essential element of an industrialized economy is a skilled labor force, consideration must also be given to providing protection for the population. It is clear that what motivates society to spend money for protection against earthquakes is basically a desire to protect its industrial investment.

In the United States, as a whole, about 70 billion dollars a year are spent on construction. In the more seismic regions of the country about 10 billion dollars a year are spent. Considering that the average life of a structure is over 50 years, it is obvious that an enormous investment will accrue, and the desire to protect it is understandable. However, if everything were to be built so that it would survive a very strong earthquake without *any* damage, it might cost an additional 25 percent or more. In the more seismic regions of the country such an increase would mean $2.5 billion a year. From the overall point of view, it would be improper to spend that much money for this purpose.

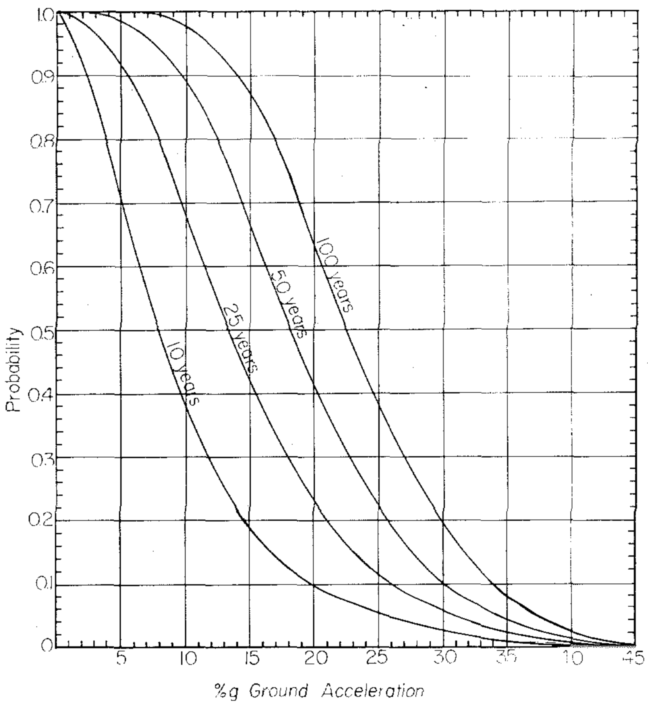
If nothing at all were spent to protect against earthquakes, we would indeed be courting disaster. Each time there was moderate shaking, costly damage would have to be repaired. Obviously prudence dictates spending something to reduce the damage. Suppose that, on the average, each dollar spent to provide earthquake resistance would reduce future damage costs by $4. This would certainly be worth doing. If more protection were desired, each additional dollar spent would result in a saving of perhaps $2. At some point, however, for every extra dollar spent, only a dollar would be saved, and beyond that the value purchased would be less than the expenditure. This would clearly be inappropriate. So a certain optimum amount should be spent on protection against earthquakes, and, as a corollary, there is a certain amount of non-hazardous damage that should be expected and tolerated.

When an earthquake occurs, a building vibrates back and forth, excited into vibration by the acceleration of the ground, and the amplitude of the deformations determines how much damage is done to the building. Strong ground shaking might cause the top of a 50-story building to sway back and forth as much as five feet.

The severity of shaking depends on the magnitude of the earthquake and its distance from the building. The magnitude of the earthquake can be associated with the length of slip on the causative fault (below). The 1906 San Francisco earthquake of magnitude 8.2 resulted from a slip on the San Andreas fault over a length of 250 miles, with a maximum relative fault displacement of about 20 feet, so that the area that experienced destructive shaking was at least 250 miles long. The 1964 Alaska earthquake of magnitude 8.4 had a slip of about 450



From charts like this, showing the idealized relationship between the magnitude of an earthquake and the length of slipped fault, engineers can estimate the area of severe shaking that will result from an earthquake of a given magnitude.



The probability of experiencing ground shaking (with maximum acceleration equal to or greater than a specified percent of gravity) can be predicted by plotting a chart based on occurrence of earthquakes in California, assuming them to occur at random in time and space. This gives average values that are only indicative of the general earthquake hazard in the state.

miles. On the other hand, the Long Beach earthquake of magnitude 6.2 had a slip of perhaps five or six miles in length. The intensity of the shaking on the surface of the ground varies relative to the distance from the slipped fault.

Given this information, an idealized chart can be plotted which shows the approximate areas affected by earthquakes of different magnitudes, with the intensity of shaking specified in terms of percent of the acceleration of gravity. A magnitude 7 earthquake, for example, will cover an area of about 2,500 square miles with ground shaking having a maximum acceleration of 20 percent of gravity or greater.

With this data, computations can be made (above) of the probability of experiencing ground motions of certain intensities, assuming the occurrence of earthquakes in California to be random in time and space. For example, in a 50-year period there is about a 40 percent probability of getting shaking of 20 percent of gravity or greater. The conclusion is clear; on economic grounds, when the probability per hundred years is less than 10 percent, it would be improper to design so that *no* damage would result in the event of such very strong but unlikely ground shaking. On the other hand, the probability of weaker shaking, say 10 percent of gravity, is large enough that buildings should be designed to come through with little damage.

Earthquake hazard is much like an iceberg in that a very large amount of the potential damage is not visible, and the invisible part can be even more serious and might constitute a greater disaster than the visible part. Suppose a big earthquake were to knock out our water supply. Most of the water for southern California comes over the Colorado River Aqueduct, which conceivably could be so damaged by an earthquake that it might take several months to put it back into shape. Of course, a portion of our water comes from wells, but in some earthquakes the movement of the ground has fractured the water pipes and stopped the distribution of water. Imagine the disaster that could result from prolonged interruption of our water supply.

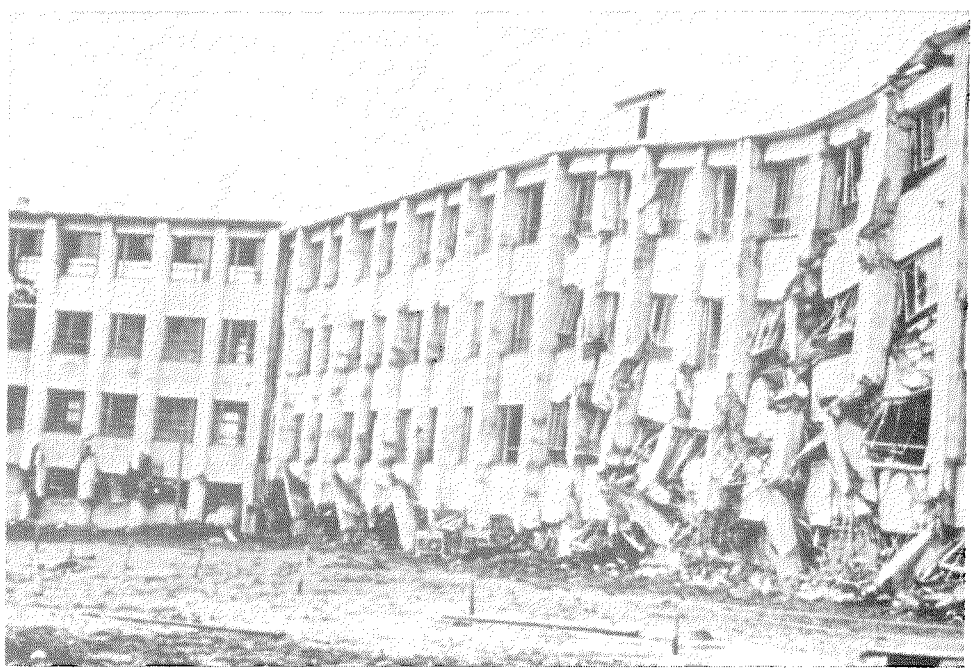
Suppose an earthquake were to destroy the electric power-generating stations. What would we do without electricity for several months? Last year an earthquake in the south central part of India damaged Koyna Dam, located about 150 miles south of Bombay. It was not extremely serious damage, but the dam provides water for a hydroelectric power plant which is the source of much of the electricity for the city of Bombay. The shaking damaged the power-generating station enough to stop the generation of power. Although Bombay felt only mild tremors, and no one was injured and no damage occurred, suddenly, because of loss of electricity, more than one million people were out of work. This is an economic disaster.

What would happen if an earthquake were to knock out all of the freeway overpasses, putting the freeways out of action for several months? We depend upon truck and rail transportation to bring in our food and the raw materials for manufacturing, and to take out the finished products. If those channels were cut off, the chaos that would result staggers the imagination.

The Alaska earthquake knocked out many bridges, and landslides took out the rail lines in many places. Rail and highway traffic were immobilized. The docks at Anchorage harbor collapsed, and the control tower at the airport collapsed. What would it be like in Los Angeles if this were to happen?

Imagine what would happen if an earthquake were to knock out our communications systems by damaging radio and TV transmitters and telephone relay stations. Or suppose the earthquake did extensive damage to manufacturing plants. What if all of the water, gas, transportation, electricity, communication, and manufacturing were out of operation for a month or so? This would be an inconceivable disaster, even if there was no injury or

The ground story of this university building in Japan collapsed in a 1968 earthquake. Although no one was killed, the cost of repairing such basic damage is prohibitive.



This eight-story building in Mexico City telescoped into a pyramid-shaped structure as a result of the 1957 earthquake.

loss of life caused by the earthquake.

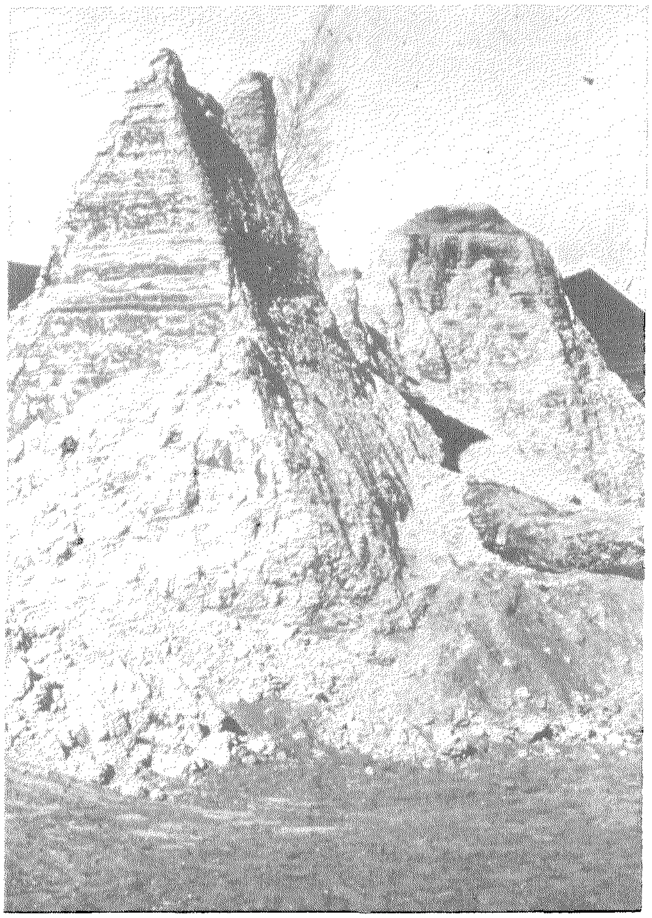
This imaginary disaster won't happen because people who are responsible are taking precautions to make sure that it doesn't. For example, electric power companies design their generators to withstand earthquake forces larger than specified in the building code just to be sure that the generators will not be put out of operation by an earthquake.

There are other projects in which the potentiality of an earthquake must be given very special consideration. One of these is the nuclear reactor power plant. It is estimated that during the next 25 years, some $30 billion will be spent on nuclear power plants. All of these will be very carefully designed against earthquakes, not only in California but everywhere in the country. To prevent any radioactive materials from getting into the atmosphere, these plants are designed to withstand, without damage, the strongest earthquake likely to occur. The cost is no object in making these facilities safe. In California they will be built on the ocean shore, so the possibility of tsunamis must be considered. Although we haven't had any major tsunamis in southern California, there is a remote possibility that we might. Because of this, the Southern California Edison plant at San Onofre is protected against tsunami action by a high wall.

A second example of projects that require special consideration is the high-rise building. In San Francisco there is now a 52-story building; in Los Angeles there are at least two 50-story buildings on the drawing boards, and consideration is being given to a 70-story building. A building of that size may well have from 5,000 to 10,000 people working in it, and its collapse might cause 5,000 deaths. Also, since such buildings are very costly, extensive damage to them would be a severe economic penalty for poor design.

Some of these high-rise buildings are being given very careful study. A digital computer is told the dimensions of the building, the distribution of mass, and the stiffness and strengths of the structural members. The computer is then told how the base of the building is shaken by an earthquake, and it then calculates how the building will vibrate during the earthquake and what forces will act on the structural members.

At Caltech we are providing earthquake data for the computer. Natural earthquakes of all sizes have not been recorded, and we are particularly lacking in records of big earthquakes. For example, a magnitude 8 earthquake has never been recorded in the region of strong shaking. To overcome this lack of data, we have developed a method whereby the digital computer generates simulated earthquake ground shaking which has the characteristics of a real earthquake. This can be generated for any desired size of shock. Simulated earthquakes are pro-



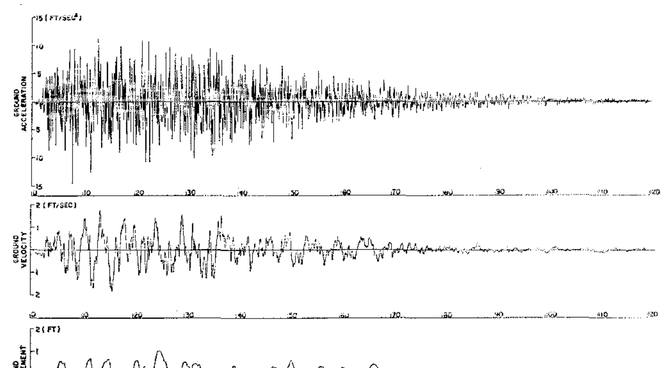
In the 1964 earthquake in Alaska, large areas of land slipped into the ocean. The apex of the pyramid shown here is the only remaining bit of lawn from a front yard that slid away in the Turnagain landslide.

duced for design engineers, who then study their effects on buildings.

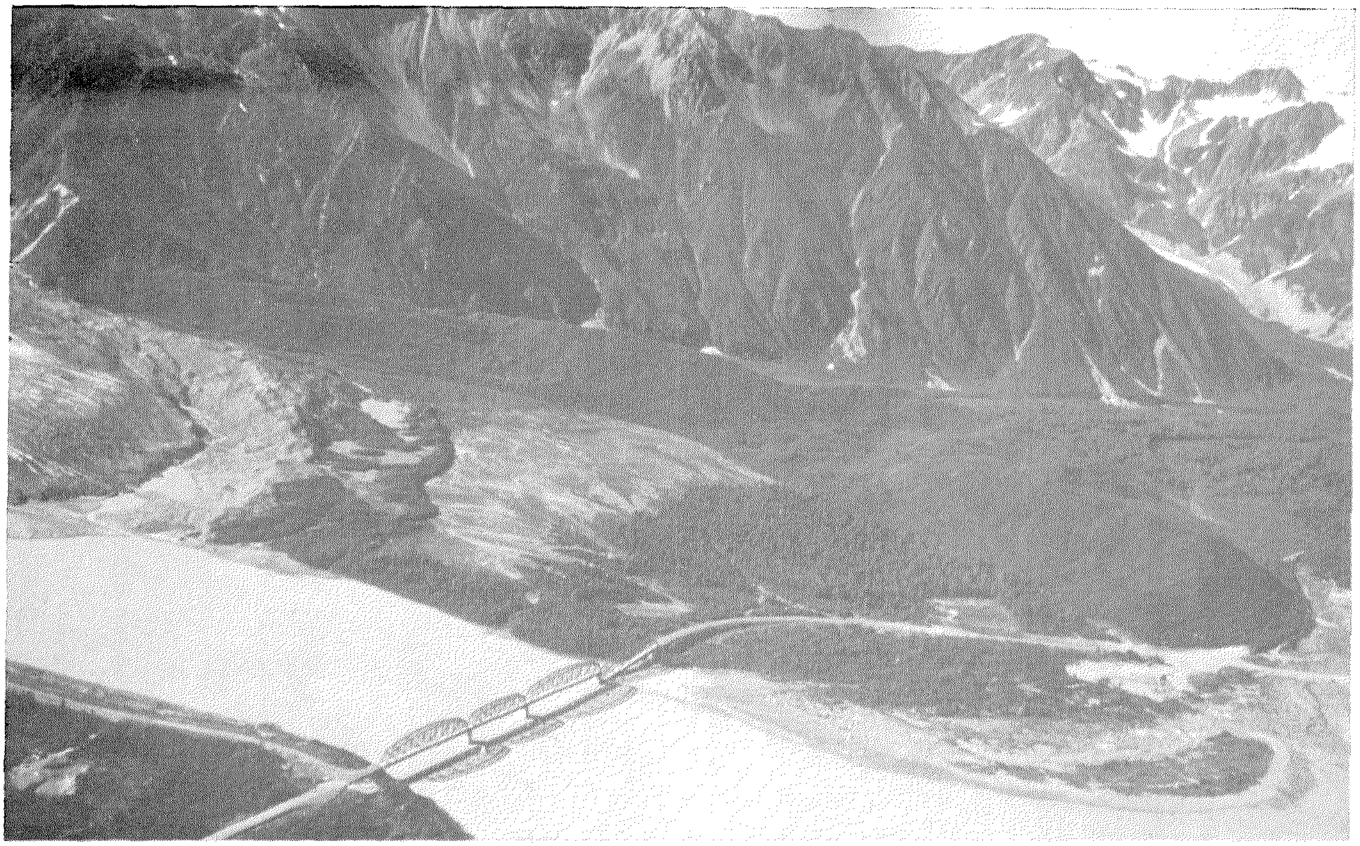
The earthquake safety of the very tall buildings now being constructed in California is a question of much interest to the public. Actually, the very tall buildings are, in general, safer than the shorter buildings because the building code requirements for them are relatively more stringent and because special engineering attention is given to them. There is also a natural law that ensures their relatively greater safety. Buildings must be designed to resist windstorms of an intensity specified by the building code. The maximum wind force is directly proportional to the height of the building, whereas the maximum earthquake force is approximately proportional to the square root of the height. Because of this, at a certain height the wind force becomes larger than the earthquake force. For most buildings this is in the 40- to 50-story range. It follows that the skyscrapers in New York, which are designed for wind forces, will be relatively safe in the event of an earthquake—more so than buildings of 20 stories or less.

Some industrial plants are so sensitive to ground shaking, however, that they are not built in California or in other regions where ground shaking is anticipated. An example is a special plate glass manufacturing process. In recent years a new method of making windowpanes has been developed, involving a large, elevated pool of molten glass which discharges a continuous sheet of glass at one end. We know that the water in swimming pools sloshed out during the 1952 Tehachapi earthquake. This is what would happen to the molten glass, a possibility that has discouraged glass manufacturers from building in seismic regions.

A final example of a special project sensitive to earthquakes is the California State Water Project, which will bring water from the Feather River to southern California, a distance of some 400 miles. It is essential that the water provided by this project continues to be available without interruption. It would be intolerable for a large community to be dependent on a water supply and then to have it shut down for half a year for repairs of earthquake damage. Clarence Allen, Caltech professor of geology and geophysics, and I are members of the Earthquake Advisory Board of the State of California Department of Water Resources, which suggested the earthquake ground motions that needed to be considered in designing the project. We also



Simulated earthquakes, produced by the computer, enable engineers to study the effects of an earthquake of a specific magnitude on the buildings they are designing. This chart shows a simulated earthquake of magnitude 8.0. There is no recorded data from natural sources for an earthquake of this magnitude.



During the 1964 Alaska earthquake traffic was immobilized when many railways, highways, and bridges (such as the one shown here) were knocked out. The lesson for engineers is that, in seismic regions, building design should take into account the largest earthquake which might occur in that area.

recommended that the project should be so designed that there would be no damage that could not be repaired within a short enough time that consumer services would not be interrupted. This means that the dams which form the water reservoirs must not fail; the pumping plants which can't be repaired quickly must not fail—but the aqueduct could be permitted to fail if it could be repaired in a reasonable period of time.

The aqueduct crosses the San Andreas fault three times, and where it crosses, its design was predicated on occurrence of a fault slip of 20 feet. This required that the aqueduct should not cross the fault in a tunnel, because in case there should be an offset, it might take too much time to dig a new tunnel. Therefore, the aqueduct crosses the fault on the surface of the ground and is specially designed so that, if the faulting occurs as anticipated, the 20 feet of displacement will be accommodated without interrupting the flow of water, and, if faulting occurs in an unanticipated way, the aqueduct will be repairable in a short period of time.

The earthquake problem affects us all, not only through the possible loss of life or limb, but in the effect it can have on our economy and our society. Even if no earthquakes come during our lifetimes, the problem still affects us because we are spending money to provide earthquake protection. It is important to remember that strong earthquakes come infrequently. Years may go by with no destructive earthquakes, but this doesn't mean that none are coming. There is a tendency on the part of the public to forget this. Periodically there are misguided attempts to have the legislature repeal the Field Act, which requires school buildings to be designed to resist earthquakes. But we do have an earthquake problem, and it is important that we keep it in mind. It is imperative that proper engineering be done on all of the construction that is going up, especially during a period of seismic quiescence. Otherwise we will be building ourselves a disaster.

Just as forethought has provided arid southern California with one of the most plentiful and reliable water supplies in the country, so can forethought make California one of the safest regions in the world for protection against earthquakes.

Lorentz Microscopy:

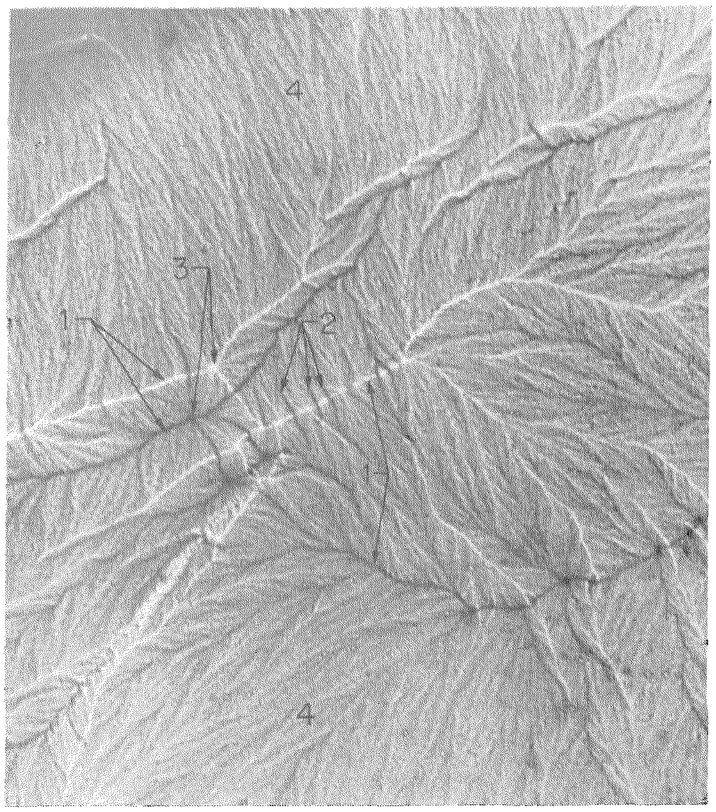
A new use of the electron microscope allows detailed observation of the magnetic structure of ferromagnetic materials

Lorentz microscopy is a new, somewhat different, use of the electron microscope. The technique is used for observing the ferromagnetic character of a material instead of its shape and size.

In normal microscopy work, the electron microscope is focused on the sample, producing an image according to the intensity of the electron beam as it passes through various thicknesses of the sample. This image, when magnified on a photographic plate, produces the electron micrograph.

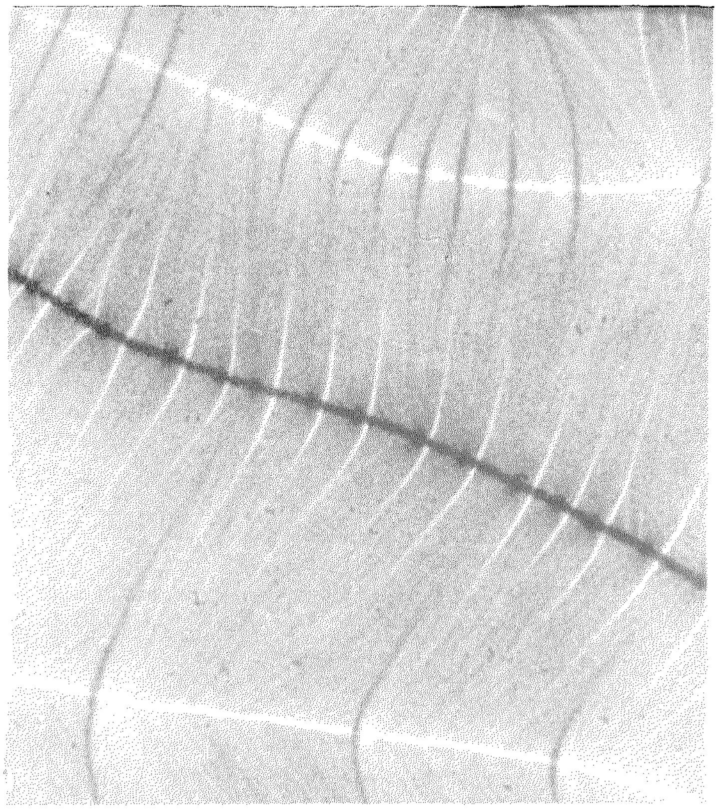
In Lorentz microscopy, however, the microscope is focused a small distance (about a quarter inch) from the sample. Differences in electron intensity are no longer observed, because they are out of focus. However, as the electrons pass through a ferromagnetic material, they are deflected slightly by the local magnetic field in the sample. Thus, if the field is different in different parts of the sample, a difference in electron intensity will be obtained at the focal plane caused by the very small Lorentz deflection of electrons (one thousandth of a degree).

The resulting image is magnified and photographed by the electron microscope, allowing detailed investigation of magnetic changes within the sample.



Observed structures—such as domain walls (1), where the magnetization changes by large angles in short distances—can be seen as either light or dark lines in this photograph. Various irregularities in wall shape can be seen, such as cross-ties (2) and Bloch lines (3), where the direction of rotation of magnetization within the wall changes. The general low-angle changes (about one degree) of magnetization direction throughout the sample can be observed as ripple (4) of the magnetization. This photograph of a pure cobalt film 300 angstroms thick was taken with a 100-kilovolt electron microscope at an out-of-focus distance of 1.1 mm.

A New Dimension



Domain walls appear in Lorentz microscopy because an electron is deflected according to the direction of the magnetic field in the sample—as given by the "right-hand rule." Sometimes electrons on one side of the wall are deflected toward the domain on the other side of the wall, giving a convergent or bright wall, while at other times the electrons will deflect toward their own domain, giving a divergent dark wall. Additional structures such as cross-ties and Bloch lines can also be seen here. The upper walls are 180° walls; the lower wall, with fewer cross-ties, is essentially a 90° wall. This is a picture of an 80 percent nickel, 20 percent iron, film 805 angstroms thick, taken with a 100-kilovolt electron microscope with an out-of-focus distance of 5mm.

Observation of this convergent domain wall, under very high magnification, shows the electrons behaving as predicted, from a quantum mechanical point of view. They are exhibiting diffraction fringes similar to those expected from an electron beam passing a knife edge. Although this is a very basic prediction of quantum mechanics, it is seldom observed in nature. This photograph, a 79 percent nickel, 21 percent iron, film 146 angstroms thick, was taken with a 50-kilovolt electron microscope at an out-of-focus distance of 3cm, using an extremely fine point source for electrons.

NEW SCOPE IN BLOOD FLOW STUDIES

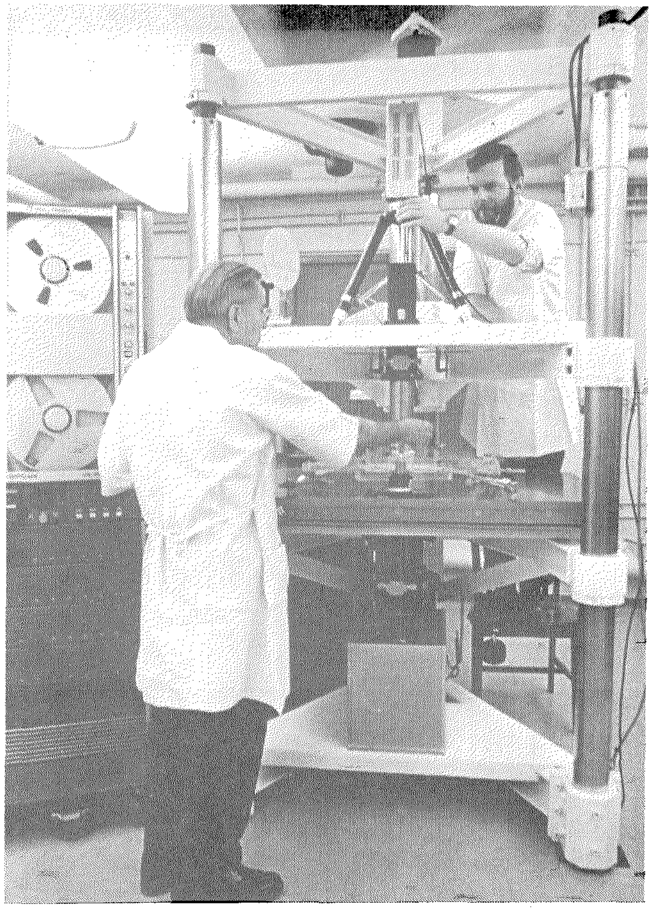
Caltech has, for nine years, had a research group studying the flow of blood in living and artificial systems. The work has been done under the direction of Harold Wayland, professor of engineering science, in collaboration with Wallace Frasher, M.D., of USC's medical school, who is also a senior research fellow in engineering at Caltech. The two men have now designed an experimental operating table that greatly expands the scope of their investigations.

The new instrument, which is called a Precision Animal Table and Intravital Microscope, is basically a 2½- x 4-foot table with attached microscopes, television equipment, high-powered lights, a life-support system, and measuring instruments. It took a year to design, six months to build in Caltech's engineering shops, and cost $20,000. Although it has been installed in the Thomas Engineering Laboratory for only a few weeks, other research institutes have already expressed interest in borrowing the design.

The new equipment has several features that are a considerable improvement over the ordinary microscope table previously used by the research group to examine blood flow in the tissue of experimental animals.

First, it has a high degree of stability that allows the observers to make precision measurements of flow rates in vessels as small as 5- to 10-micron capillaries.

Second, it permits the researchers to switch the area of their observation from one part of a subject to another because the ancillary equipment can be moved along with the animal without disturbing the normal functioning of the blood flow or of the optical equipment. The complete life-support equipment and measuring instruments, which must be rigidly attached to the animal, can be moved as a unit.



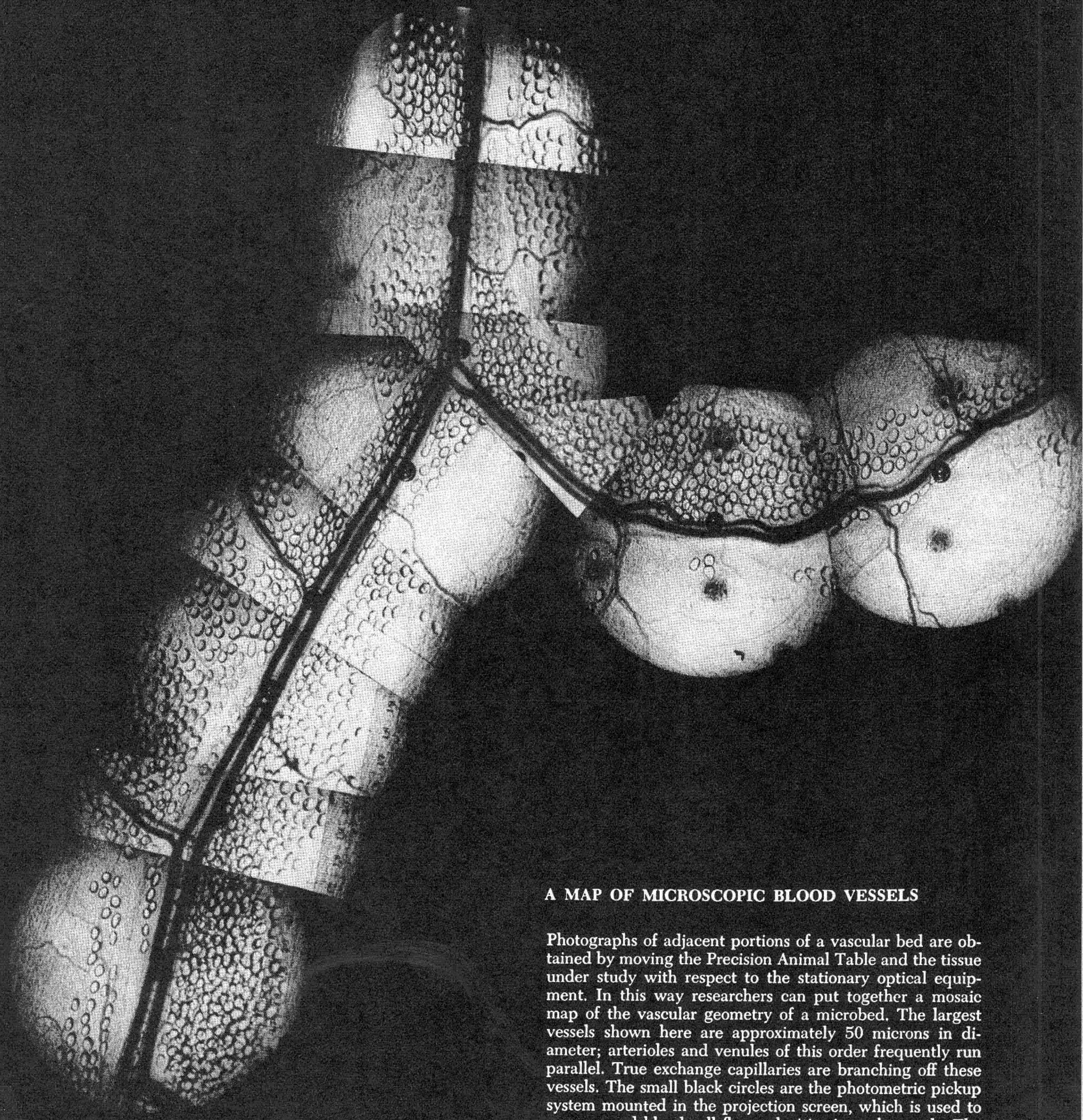
Harold Wayland focuses the microscope and Peter Gaehtgens adjusts the TV camera on the Precision Animal Table.

And third, the new table can accommodate the handling of both small and relatively large animals —up to the size of a mini-pig (250 lbs.).

The most significant advantage of the new equipment, however, is that it allows the research team to examine a much larger area of tissue than they could before. With the old-style table they could look at only one vessel at a time. Now they can explore a microbed (network) several millimeters square of associated blood vessels as large as 100 microns. In this way they can study the overall flow patterns of neighboring vessels and determine their relationship to one another.

The current research project is being carried on by Peter Gaehtgens, M.D., research fellow in engineering science at Caltech, who is exploring the distribution of blood flow in intestinal microbeds. The new equipment permits him to do careful quantitative study (how much, how fast, and how distributed) of blood flow.

The design and production of the table was a joint venture of the Institute and the L.A. County Heart Association-USC cardiovascular research laboratory, and was largely financed by the Alfred P. Sloan Foundation. The research is supported by a National Institutes of Health grant.



A MAP OF MICROSCOPIC BLOOD VESSELS

Photographs of adjacent portions of a vascular bed are obtained by moving the Precision Animal Table and the tissue under study with respect to the stationary optical equipment. In this way researchers can put together a mosaic map of the vascular geometry of a microbed. The largest vessels shown here are approximately 50 microns in diameter; arterioles and venules of this order frequently run parallel. True exchange capillaries are branching off these vessels. The small black circles are the photometric pickup system mounted in the projection screen, which is used to measure red blood cell flow velocities in such vessels. The bubble-like circles are fat cells.

George S. Hammond: Dynamic Chemist

The chairman of Caltech's chemistry division never went to school until the seventh grade, never took a science course in high school, and took chemistry in college only because physics wasn't available his freshman year. Then he made the decision to major in chemistry mostly because he needed the $37-a-year job as lab assistant that went along with it.

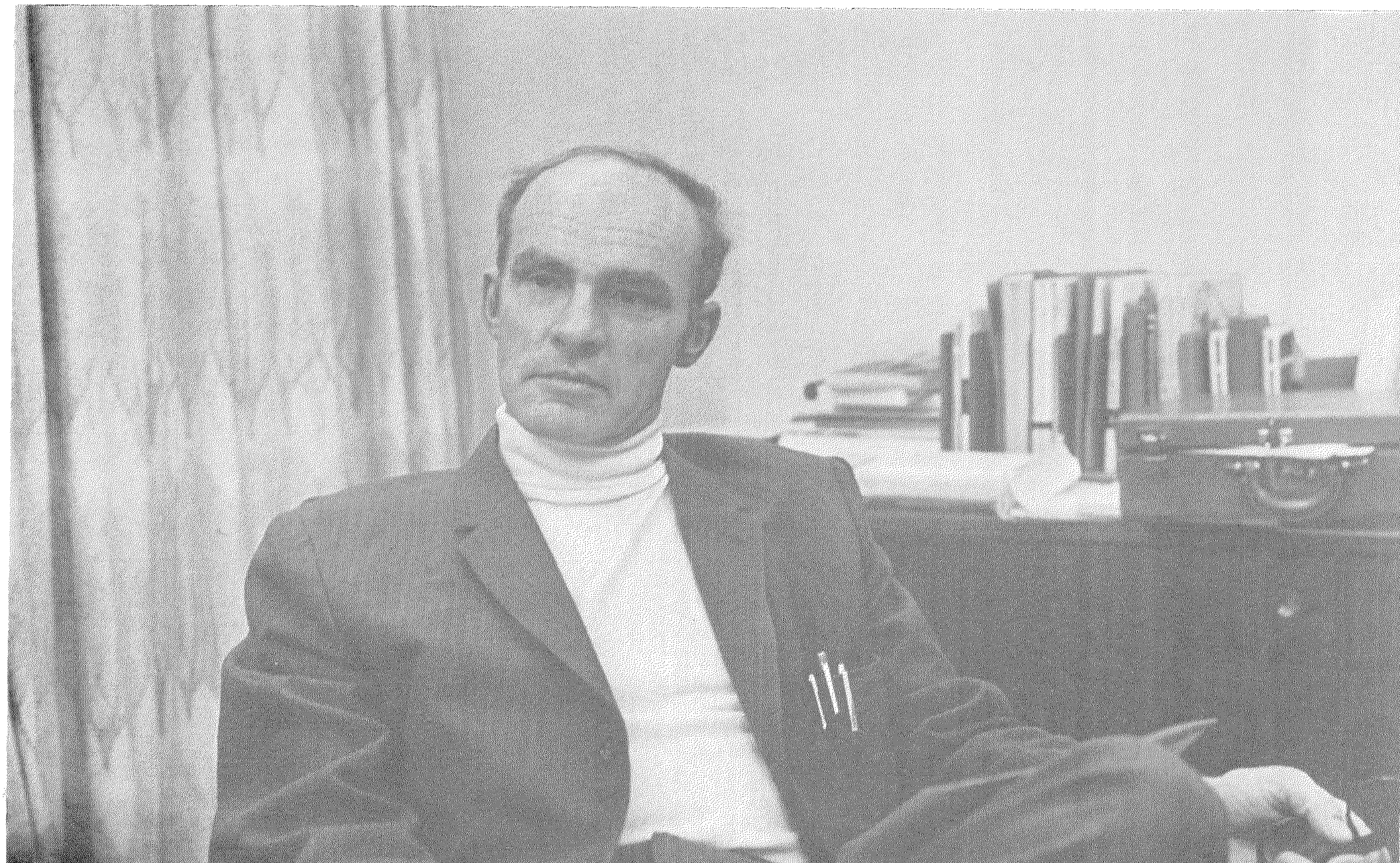
If his choice of a profession appears to have been made haphazardly, it is a misleading measure of the man. Nothing in the makeup or the career of George Simms Hammond is accidental. Today the chairman of the division of chemistry and chemical engineering at Caltech has gained international recognition for his ideas about making radical changes in the teaching of chemistry. And the qualities that have made him a brilliant researcher and educator are the same ones that years ago took him away from the New England farm life he wanted to escape—Down-East determination, independence, enthusiasm, and honesty.

George Hammond was the oldest of seven children living in relative isolation on his parents' dairy farm in Auburn, Maine. He was taught at home by his grandmother for his first six school years—just as his father was before him. By the time he got to high school George knew that he wanted to get out of farming and had already decided that a science major in college would be the way.

His father's death, when George was 13, shifted the responsibility of running the farm onto him and his chances for going to college looked slim. It was finally possible only because Bates College was seven miles away. ("Another 20 miles and I'd have been out of luck.") As it was, he worked for a year after high school to earn tuition money, and then commuted to Bates for four years, keeping up the farm along with his studies.

After graduation he went to work for a chemical firm in Philadelphia and stayed just long enough to decide that business was not for him. In the summer of 1943 he filled out applications to 12 graduate schools, and, with one exception (the University of Illinois didn't answer), they all offered him teaching assistantships.

"I was convinced there must be something charismatic about me—on paper," he recalls. "But the truth was that the government had just dumped hordes of Army and Navy trainees into the colleges, and there was a crying need for anyone who could function as a T.A. They probably would have snapped up my grandmother."



At Harvard, a decision to work under the well-known chemist Paul Bartlett put Hammond's scientific life into focus. Bartlett's nondirective brand of leadership was one that fit perfectly with George Hammond's independence. He still remembers with pleasure a period when Bartlett didn't talk research with him for 18 months.

Hammond now uses the same approach on his own students. "I'm interested in what my research students are doing, and I want to participate in it intellectually, but I'm not going to tell them what to do and have them miss all the fun."

"Of course," he adds, "this system only works because the people in the group are extremely talented and enthusiastic."

Hammond has held to this philosophy for many years, in both teaching and research. After a year of postdoctoral work at UCLA, he taught at Iowa State College in Ames for eight years. In 1957 he and his wife, Marian, and their five children spent a year on a Guggenheim and NSF fellowship at Oxford, Basel, and at Caltech. The next year he returned to Ames for one year before joining Caltech permanently as professor of organic chemistry. In 1963 he became Arthur Amos Noyes Professor of Chemistry, and, in 1968, division chairman.

When the explosion in chemical dynamics comes, as George Hammond predicts it will, you can be sure he will meet the change with some ideas of his own.

"It bothers me, now that I've become division chairman," he says, "that my opportunities for interaction with my research group are cut down. The personal and intellectual interaction with students is one of the best things I have."

But the job of chairman does not deter him from pursuit of other interests, such as his current crusade—curriculum revision.

Basically, he is convinced that the traditional subdivisions of chemistry are inappropriate for modern research and that their overwhelming influence in the standard undergraduate curriculum is stultifying. He thinks that a more realistic categorization of chemistry would be into structural chemistry, chemical synthesis, and chemical dynamics—his own field—which he predicts will soon surpass structural chemistry in importance.

About two years ago, Hammond decided it was time to put his ideas into practice, and he began to design a new course in freshman chemistry. He recruited his colleague Harry Gray as a "believing collaborator," and together they made their own chemical mix and served it to a group of 16 Caltech freshmen as an experimental chemistry course. About 40 percent of the course was devoted to an introduction to chemical dynamics. "Chemical reactions," Hammond says, "have just about disappeared from freshman courses. We put them back in, with enough system to intrigue most of the students."

This year Hammond and Gray are giving a sophomore course—their own brand of structural chemistry that Hammond describes as "a mishmash of organic, inorganic, and physical chemistry." But out of it they hope to bring a new coherence based on experimental and theoretical structural chemistry.

Hammond sometimes finds that there is more interest in his ideas in faraway places than at Caltech. This summer, at the invitation of the government of India, he will take part in a planning conference in Bangalore to revamp the teaching of chemistry in the universities of that country—a conference based largely on his ideas.

Maybe the Hammond approach will revolutionize the teaching of chemistry. Or maybe it won't do anything of the kind. Hammond himself is philosophic about the possibility of failure.

"Why should we always be so uneasy about failing?" he asks. "The real pioneers of human thought and action are forever trying new things and settling for partial success. If we'd talk to each other more about our oddball interests, we might learn something—and have fun trying. Maybe we'll look ridiculous part of the time. So what's new about that? If nothing else, we might learn to live with the feeling of foolishness."

When the explosion in chemical dynamics comes, as George Hammond predicts it will, you can be sure he will meet the change with some ideas of his own.

"After all," he admits with a grin, "in a straightforward way, what I want to do is change the world."

Jean-Jacques Weigle

1901-1968

A tribute by Max Delbrück and Robert Edgar

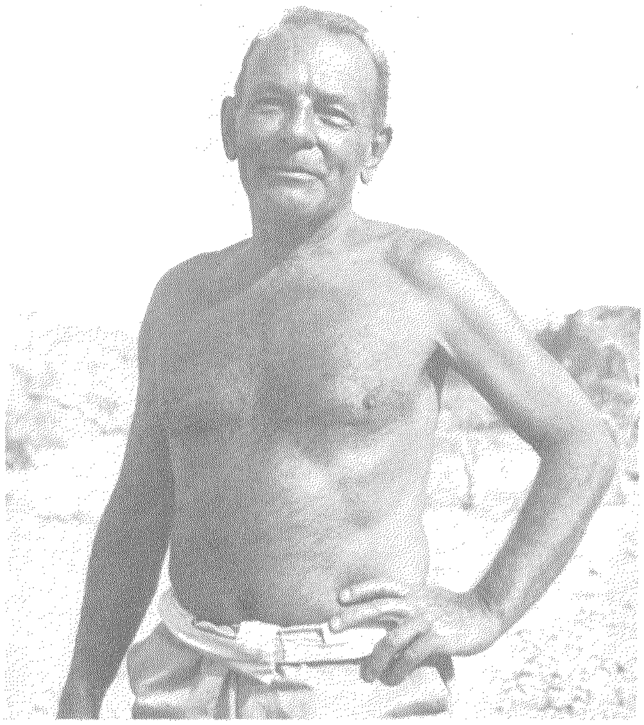
Jean Weigle, Caltech research associate in biology since 1949, died of a heart attack on December 28, 1968, at the age of 67.

Jean Weigle's scientific career consisted of two very distinct and distinguished halves—the first as a physicist and the second as a biologist. As a physicist he obtained his PhD at the University of Geneva, Switzerland, in 1923 at the age of 22. After a few years at Westinghouse and of teaching at the University of Pittsburgh, he returned to the University of Geneva as a professor and head of the physics department, where he remained for 17 years—from 1931 to 1948.

His physics was concerned with the solid state: refined applications of x-ray diffraction to the study of crystal structure; the effects of temperature on this diffraction; the diffraction of light by ultrasonics. The importance of this work was recognized by an honorary degree in science from the Case Institute of Applied Science in Cleveland in 1947 and by the award of the Prix des Trois Physiciens in 1962, given by the Académie des Sciences in Paris.

In 1946 Weigle had his first heart attack. In part because of this and in part because of a natural inclination to be free of obligations, he resigned his university positions in Geneva and became a research associate in biology at Caltech. He quickly learned the basic lore of working with bacteria viruses and focused his interest on a particular one called lambda, a virus that displays a tantalizing intimacy with its host bacterium. Weigle's early work concerned the interaction between viruses and host, and includes the discovery of a means by which the host specifically modifies the virus. In later years this phenomenon of specific host modification was proved to be a manifestation of a much more general mechanism, a cellular defense mechanism that operates at the level of the gene.

More significant was Weigle's role in uncovering the manner by which the lambda virus carries genes from one host to another. He was instrumental in revealing that special virus particles carry some bacterial genes in place of viral genes. This discovery helped reveal the manner in which this virus is able to insert its DNA into the structural continuity of the host DNA. The intimate relationship of the lambda virus to the host cell has served as a model to account for the action of viruses that cause cancer.

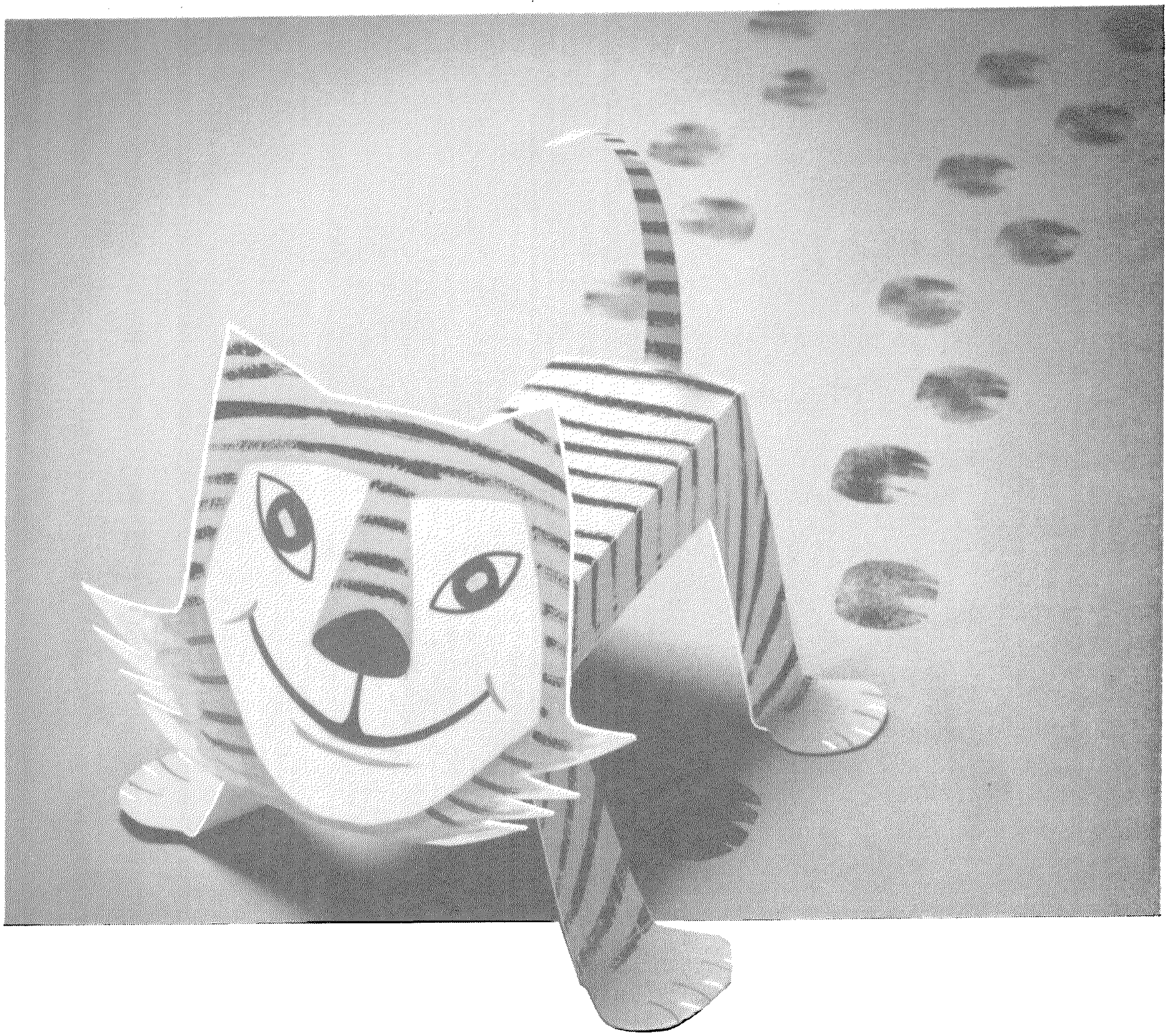


Jean Weigle on a desert camping trip—a favorite retreat.

The work for which Weigle is most noted is his demonstration, with Matt Meselson at Caltech and Grete Kellenberger in Geneva, that genetic recombination involves actual breakage and reunion of DNA molecules. This work has become a molecular biology classic—described in all texts, reprinted in all appropriate collections. Weigle displayed supreme craftsmanship in his experimental work. He cared about every step in his experiments. Most of his work was done in close and real collaboration, often with graduate students, whose development he aided in decisive ways.

A number of Weigle's friends are establishing the Jean Weigle Memorial Fund for the purpose of bringing to the biology division at Caltech scientists of outstanding talent. Through this they hope to preserve the nearly extinct species of the scientist who is indifferent to the organizational aspects of science and is wholly devoted to the beauty of the scientific endeavor as a way of life.

A memorial service for Dr. Weigle was held in Dabney Hall at Caltech on January 10, 1969. A transcript of the remarks made by some of his colleagues will be prepared for distribution to his numerous friends.



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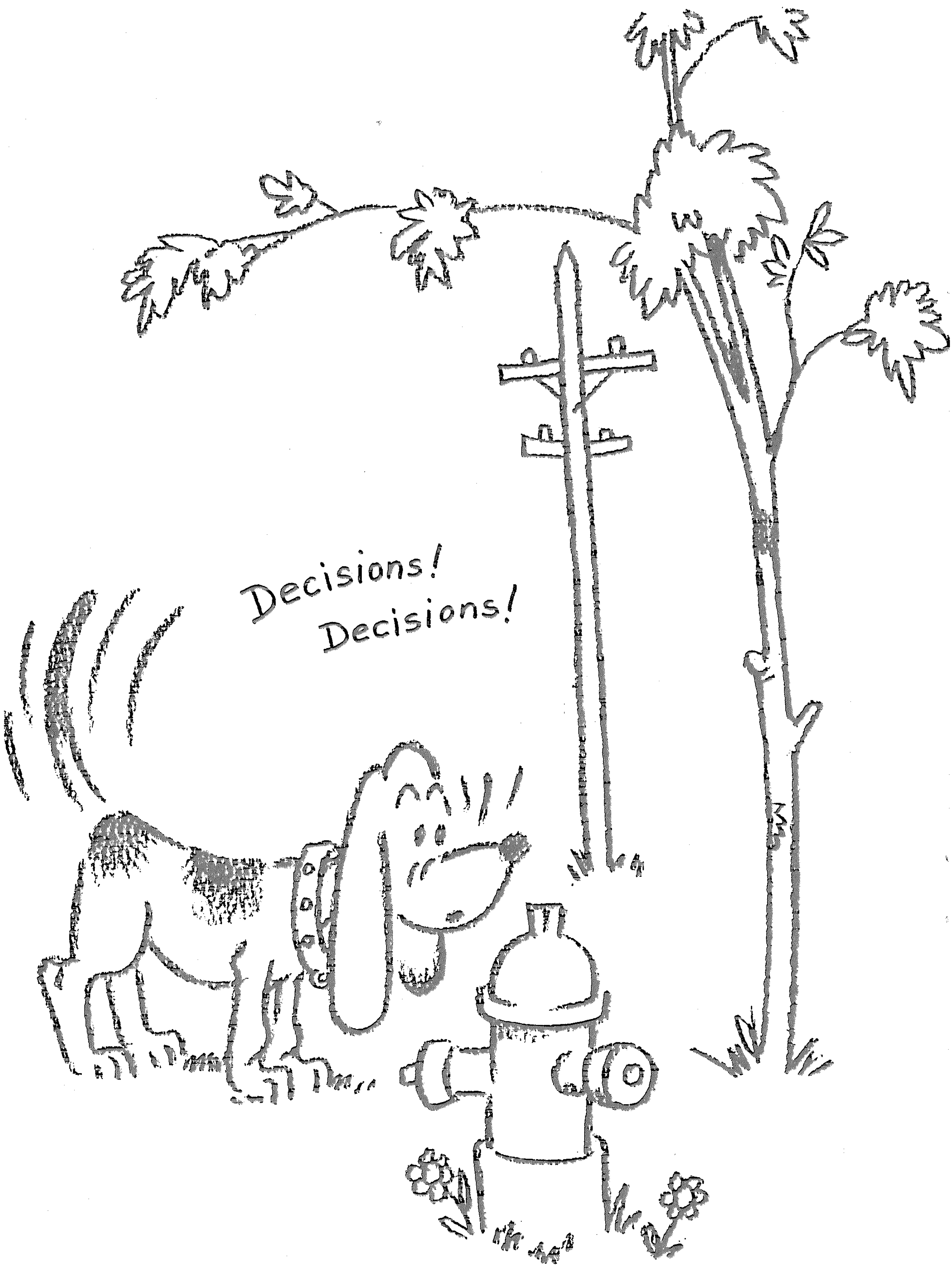
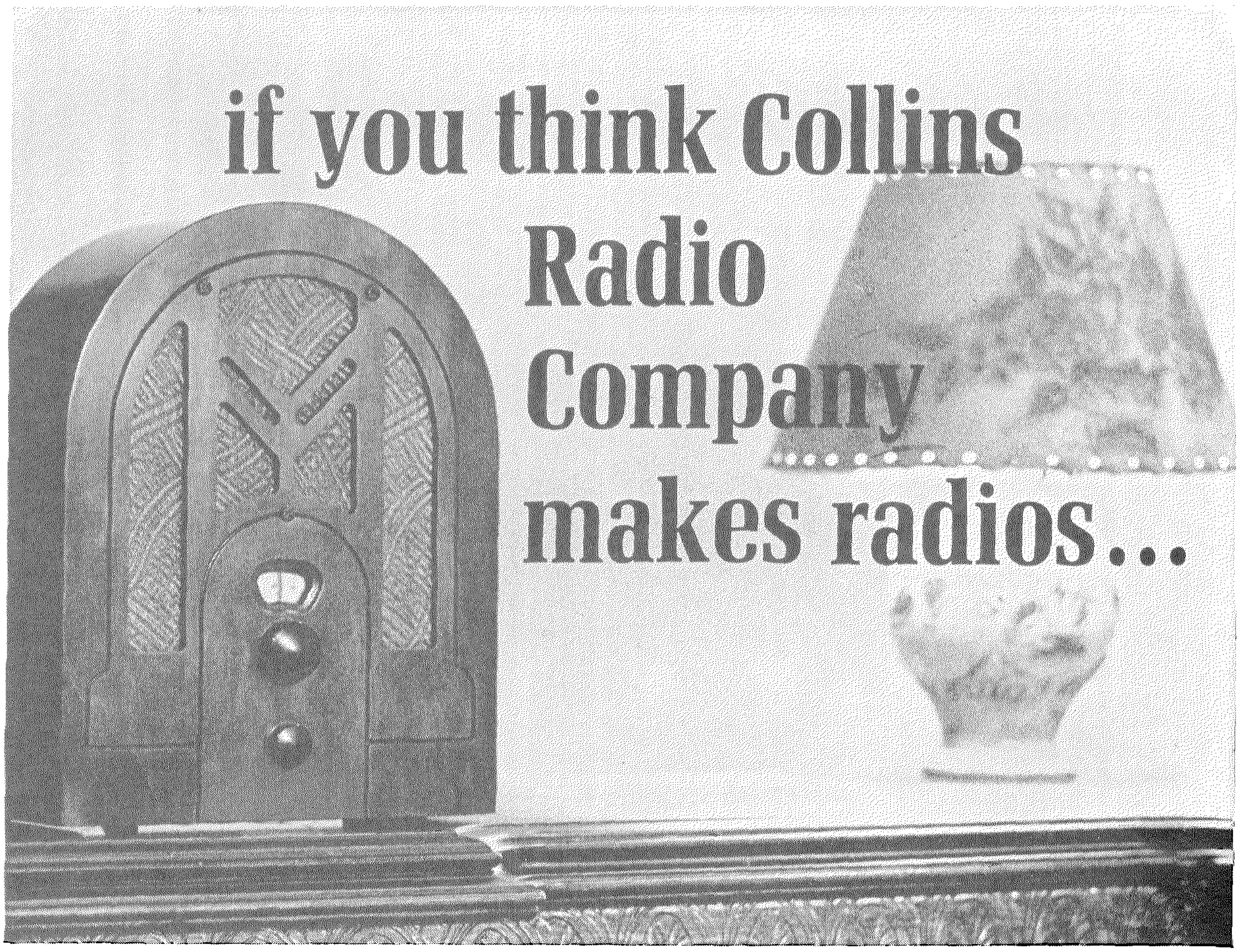

Decisions!
Decisions!



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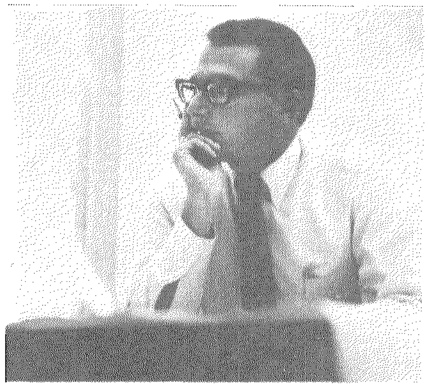

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14 Kipnis Mime Theatre.
15 L.S.B. Leakey—"Latest Evidence on Man's Evolution in Africa."
28 Isaac Stern, violinist.

March

7 *Phaedre,* performed in French by Productions d' Aujourd'hui.
14 First Chamber Dance Quartet.

April

13 The Pasadena Symphony, Richard Lert conducting.
25 Ali Akbar Khan, sarodist, sitarist, drummer.

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