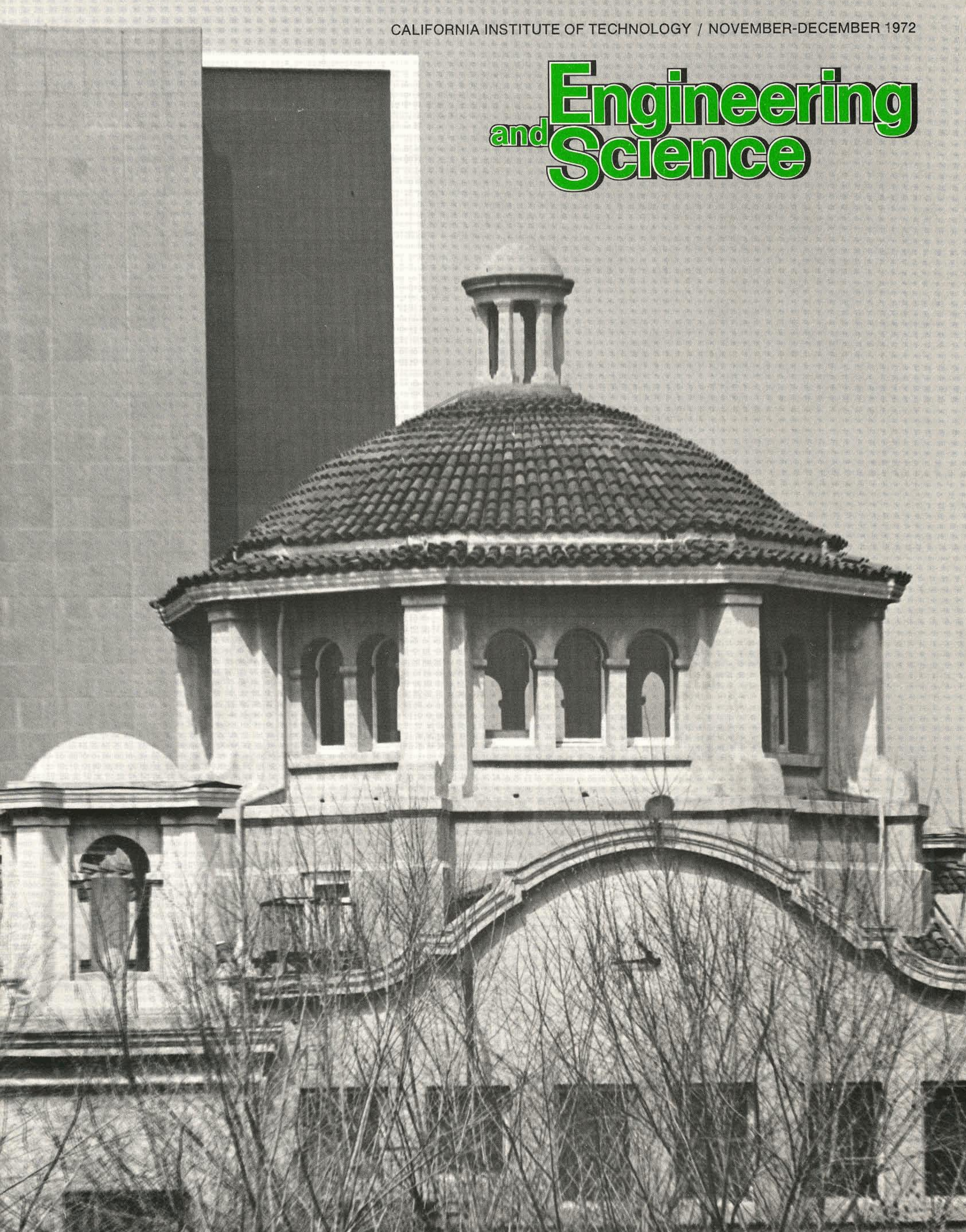
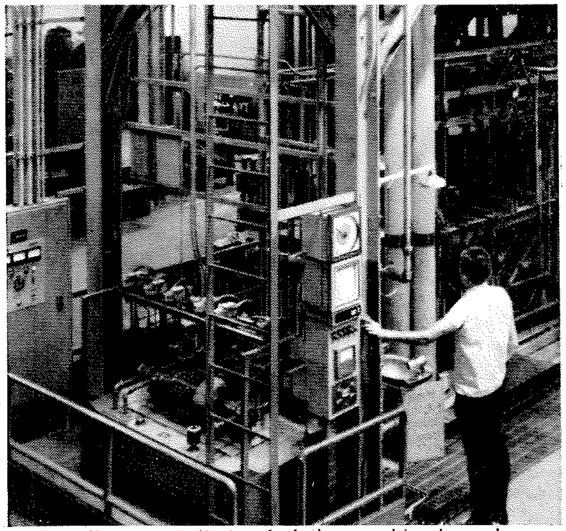
CALIFORNIA INSTITUTE OF TECHNOLOGY / NOVEMBER-DECEMBER 1972

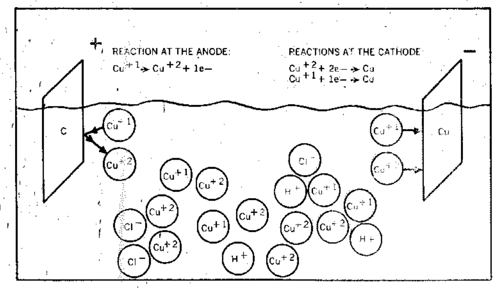
Engineering and Science



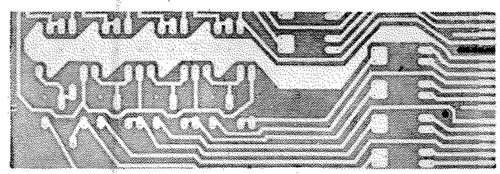
WESTERN ELECTRIC REPORTS



Automatic regeneration and plating machine has a heavy, rubber-lined tank with 22 stationary graphite anodes and 57 rod-like copper cathodes moving at the rate of 90 transfers an hour.



The action at the cathode. Electrochemical reversal of the etching reaction effecting etchant regeneration and copper recovery.



Typical printed wiring board consists of copper (only 0.0028 inch thick) laminated to a phenolic-resin panel. With the new process, unwanted metal is etched away with cupric chloride.

Creating an entirely new way to etch printed circuits.

One of the most common methods of printed circuit manufacturing is by batch-etching with ferric chloride. However, while batch-etching produces circuits of high quality, it also has some processing disadvantages.

For instance, it takes more and more etching time as the etchant is used. Then, to replace the spent etchant means considerable downtime. And the etching of 100,000 circuit boards produces 2000 pounds of copper in a non-recoverable form.

Engineers at our Columbus, Ohio plant set out to discover a better way to etch that would eliminate all of these inherent problems.

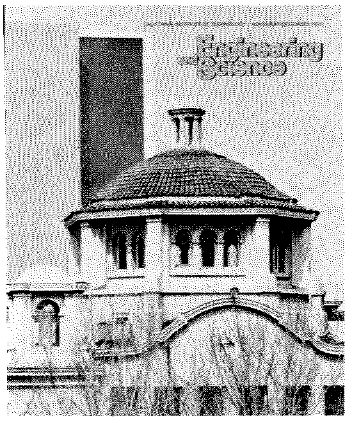
Their new process is the first closed-loop, spray-etching system that electrolytically reverses the chemical reaction of etching. It continuously recycles cupric chloride and has reduced the cost of etching wiring boards by over 90%.

Virtually all the problems of the old method have been overcome. No more machine downtime is required to change etchant. No more costly ferric chloride is needed. Etchant strength does not diminish. The etching rate is now constant and faster than the average ferric chloride rate. There's no more waste of etched copper. It is now recovered, about 20 pounds per hour, and resold.

Conclusion: The first completely closed-loop cupric chloride etching system in the printed circuit industry is a major innovation that has improved efficiency and quality, eliminated downtime and decreased costs by more than 90%. Furthermore, it has helped conserve a valuable natural resource.

Western Electric

We make things that bring people closer.



In this issue

Hail and Farewell

On the cover—a last look at Throop Hall's gracious curves outlined against the towering austerity of Millikan Library. Since 1910 the Throop cupola has been a graphic symbol for the California Institute of Technology, but age—and a good strong earthquake last year—made change imperative.

In mid-November the wrecking crew moved in, and debris from the interior was soon piled high along a barricaded Throop alley. By the end of January the building will be completely demolished, and landscaping of the site can begin.

Of course, a few bits and pieces were salvaged. Some removable items—stair railings, beams, doors, cabinets, and clocks, for example—were sold to collectors and bargain hunters to continue Throop's usefulness in tangible, if minor, ways. But for the most part, the building will soon be only a memory. "The Bell Tolls for Throop" (page 12) is our retrospective look and final tribute.

From Arms and Mudd to the Moon

It's a long, long way from Caltech's campus to the moon, but Harrison Schmitt, '57, made it, after seven years of effort. The first scientist-astronaut, Schmitt is a philosopher about space exploration, comparing the early astronauts to pioneers like Lewis and Clark, Zebulon Pike, and John C. Fremont in the winning of the American West. He views his own role as more like that of the farmers and ranchers who followed the pioneers into the wilderness to start using it for practical purposes. "Our Man on the Moon" (page 4) is based on an *E&S* exclusive interview with him, and it tells something about how he got where he is today.

From Here to Infinity

In "The Future of Astronomy" (page 18), Jesse Greenstein discusses recent discoveries in astronomy—where they have brought us in revising our view of the universe and where, with adequate funding, they may take us. Greenstein, a member of the Caltech faculty since 1948, is expert in the discovery of peculiar stars and the study of the spectra of low-luminosity white dwarf stars. Collaborating with Caltech physicists he developed the now accepted theory connecting the differences in the composition of stars with the nuclear processes within their interiors.

STAFF: *Editor and Business Manager*—Edward Hutchings Jr.
Managing Editor—Jacquelyn Hershey
Associate Editors—Bernard Cole, Janet Lansburgh
Art Director—Kathleen Marcum
Photographer—Don Ivers

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Our Man on the Moon

On December 11, Harrison H. Schmitt will climb down the ladder of Apollo 17's lunar module—*Challenger*—step out onto the surface of the moon, and take a long look around him. He will be the first scientist in the history of space exploration to take that look.

Not that this difference will be particularly evident from Schmitt's performance on the spot; he will be doing all the tasks assigned him as a pilot-astronaut. But scientists all over the world will be waiting to hear his reports after he returns because, with his training and experience in geology, he will instinctively and continually make evaluations of what he is seeing—in a way that has been impossible for any other man who has yet been on the moon.

If he had chosen to stick to the conventional professional paths after he finished his doctorate, Schmitt might have become a distinguished geologist almost anywhere on earth. Instead, in 1965 he signed on as one of NASA's first scientist-astronauts. And through the tough and sometimes turbulent years since then, he has steadfastly stuck to his belief in the importance of that role.

It takes a special kind of man to abandon an ordered, successful career to work seven years and travel 235,000 miles through space just for the chance to spend a few hours on a "planet" more desolate and more rugged than any place on earth. It takes a special combination of motivation, hope, and sheer hardheadedness to accept the responsibility of being the first scientist and geologist to go to the moon—particularly when his trip is the last moon-landing mission the United States will make for many years to come.

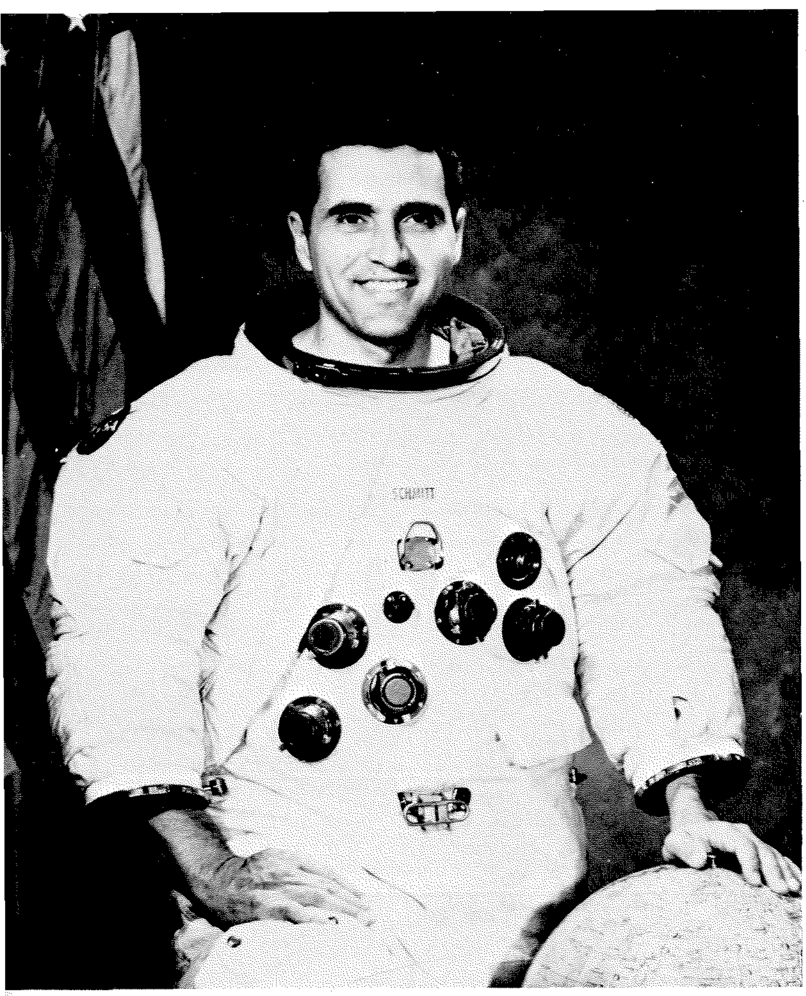
It is evident in even the most casual meeting that Harrison Schmitt is indeed a special kind of man. He seems taller than his 5 feet, 9 inches, and younger than his 37 years. He has short-cropped black hair, direct brown eyes, and his compact body moves with the fluid grace of an athlete. It is hard to visualize him in the cramped confines of a spacecraft, for even when he moves around a room, he seems uncomfortable within four walls.

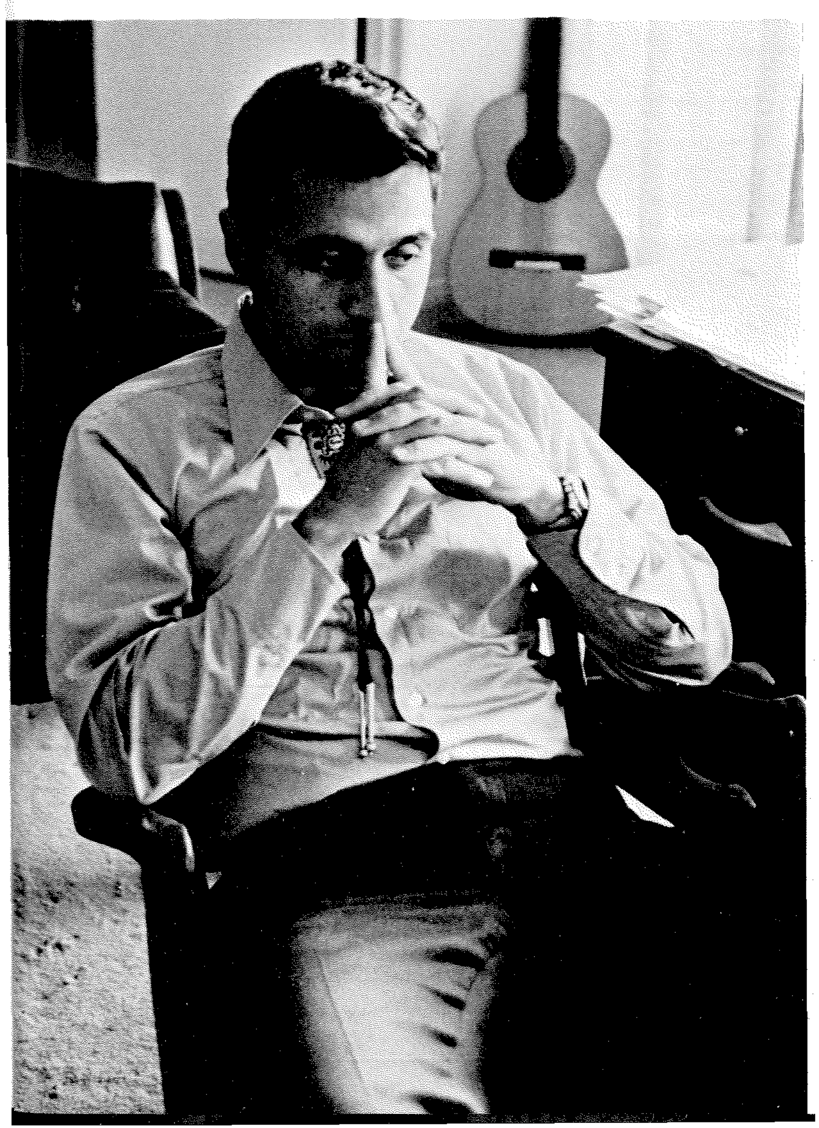
His conversational manner is easy. But occasionally he shows a reticence, a privateness, which—if he were a football player or the man facing you in a fight—would make it difficult to predict his next move. But he is openly emotional on subjects he feels strongly about. And when he talks about Apollo 17 and the reasons he became involved in the manned space program, he pounds his fist on whatever is available to make his points, and his voice gets low and husky.

"When I got involved in the space program, I was constantly asked: 'Why is it worth doing?' And my answer came from my feeling that if there is any clear message from history, it's that civilizations *need* frontiers and challenges, and that's what space offers us. The idea of exploring beyond the earth and to the outer reaches of space is new enough that everybody has trouble, myself included, in grasping it for what it is. When you start searching for ways to explain something you don't quite understand, you fall back on what is familiar and a part of your experience. And for me, America's western frontier is familiar. The parallels are close enough that we have to expect space exploration will influence us in the same way the frontier influenced us.

"The effect of the western frontier on us as a people has been basically and fundamentally good. It attracted special kinds of people, and in turn produced people with the kinds of special abilities and attitudes that helped us to face and overcome the many crises we went through. It has been good for mankind that a nation developed the characteristics we did. And what the western frontier did for us, the space frontier can do for the entire world.

"Space exploration gives us an infinite frontier within which we can further nurture values like respect for the rights of the individual, innovativeness, creativity, flexibility, and a balance between looking inward and moving outward. I think that alone justifies man's move into space. I think it particularly justifies this country's maintaining itself as the first and leading 'spacefaring' nation in history right now, because we are the only power





On Jack Schmitt may rest the hope of the scientific world for a fuller understanding of the moon.

on earth that can protect these values. That may be a very nationalistic point of view, but for me there's no other logical interpretation—at least not with my background and upbringing."

Schmitt's family was at the frontier as America headed west. Both his great-grandfathers were part of the American movement westward—to Tennessee on his mother's side and Minnesota on his father's. His father, Harrison A. Schmitt, was born into a lawyer's family only one generation removed from the frontier. Although the necessity to be a carpenter, a smith, or a hunter was rapidly disappearing when he was a young man around the turn of the century, the elder Schmitt nevertheless acquired these skills along with a jack-of-all-trades knack for improvisation.

Inheriting all his forefathers' frontier instincts, he gave them a modern twist. He was one of the first of a generation of university-trained geologists who took the art of mining geology and turned it into a science, using the new techniques of geochemistry and geophysics. From his first work in the Parral distict of Chihuahua, Mexico, in the 1920's to his last field trip in 1966 to the Mono Crater area of California, just a week before his death at the age of 70, he had discovered and developed some of the major mining districts in the Southwest—Christmas, Esperanza, Mineral Park, and Battle Mountain. His son—called Jack from the time he was a small boy to simplify life in a household with two Harrisons—was born on July 3, 1935, in Santa Rita, New Mexico, a small town in the southwest corner of the state not far from the

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Harrison Schmitt (Caltech BS '57, Harvard PhD '64) has probably spent more time working in his spacesuit in the last 18 months than he has relaxing in the comfort of his Houston, Texas, apartment. As part of the training for the Apollo 17 mission, Schmitt and his fellow astronauts—mission commander Eugene Cernan and command module pilot Ronald Evans—spent several hours daily working out in their pressure suits.

Rio Grande and next to one of the largest copper mines in the world.

When Jack was eight years old, the family settled down on an 80-acre homestead just outside the mining and ranching town of Silver City. Schmitt still retreats there occasionally "Basically, I'm not city-bred," he says. "Even though I've lived in cities most of my life, there are times when I need to get away from the closeness of it all."

Schmitt's father was the center of his life, and by association young Jack picked up many of the skills his father had learned as a youth. "There were all sorts of things to build and repair—additions to the house, garages, furniture, boats; anything that had to be done around home and many things that didn't. There were electrical work and plumbing, and even blacksmithing. We had quite a workshop and did just about everything imaginable with our hands."

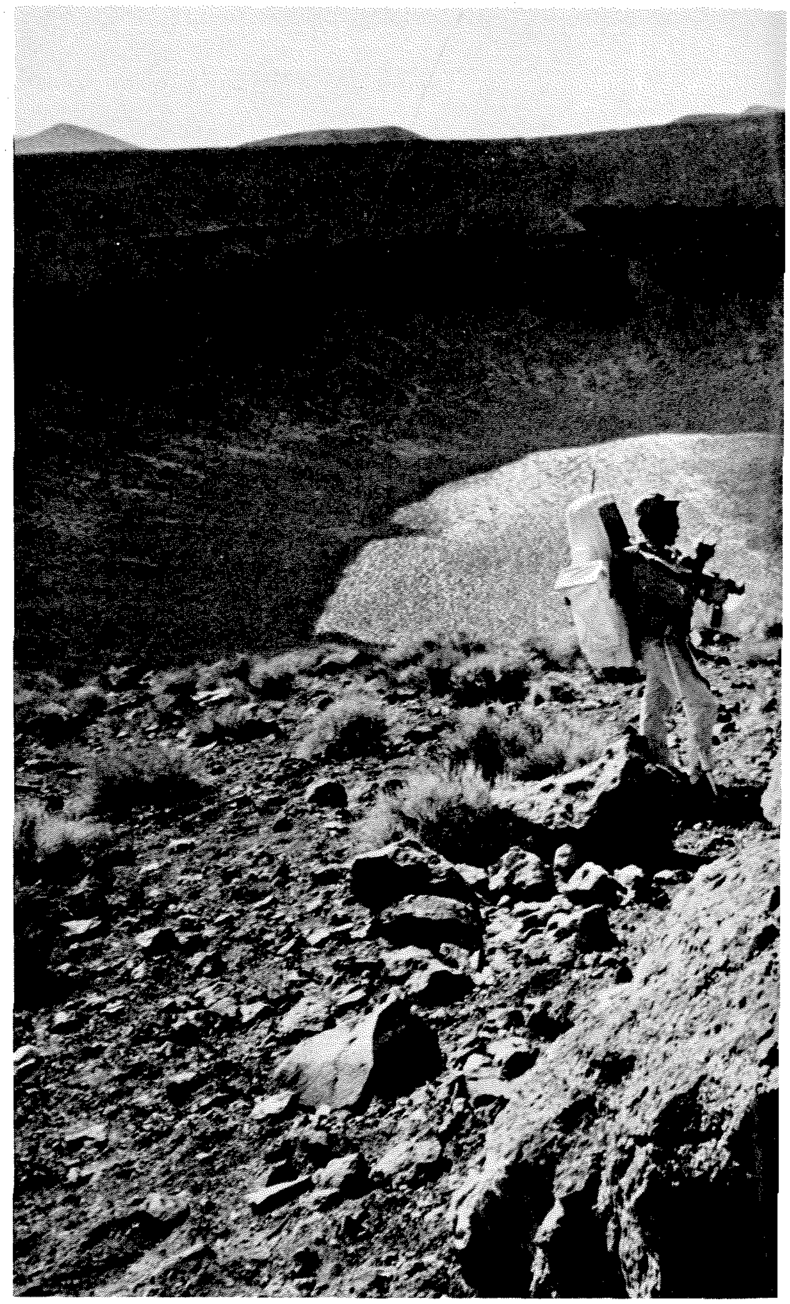
Against the backdrop of the rugged Pinos Altos mountain range of southwest New Mexico, Jack picked up a love of hunting, fishing, hiking and—not surprisingly—geology. "That part of New Mexico is beautiful," he says, "mountainous, semi-arid, but with small forested spots and streams here and there, and it is materially productive. It still takes my breath away every time I see it. I guess it was natural for me to learn something about what was around me."

As far back as he can remember, Jack traveled with his father through the Southwest—the mining camps, prospectors' digs, surveys of potential ore deposits, occasionally into the mines. "It was like one long camping trip, with all sorts of extras thrown in: learning about the rocks and features around us, listening to stories about the country, people, and places, and just being in the open. It's something you come quickly to love and never want to give up."

Leon Silver, who was one of Jack's professors at Caltech nine years later, remembers meeting him as an 11-year-old "aide" to his father.

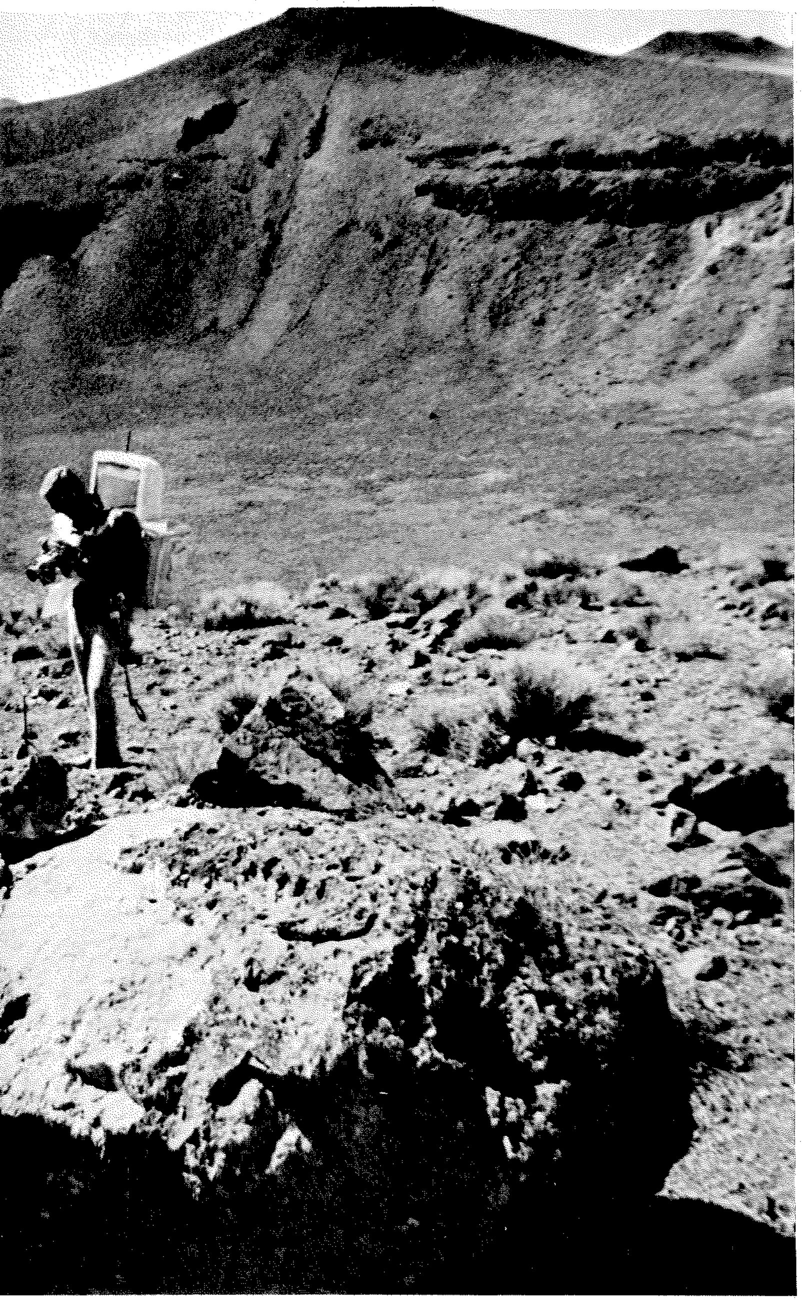
"I was a young graduate in geology from the University of New Mexico at the time," says Silver, "working that summer for a Caltech geology alumnus, Vincent Kelley, and I went with him to the Schmitt home. I sat there in the front room listening to those two distinguished geologists and tried to absorb as much as I could. And there, sitting quietly in a corner of the room, was this young boy doing the same thing."

By the time he was in high school, Jack was helping his father with surveying and other technical tasks. "My interest in geology wasn't something he cultivated deliberately," says Jack. "That was probably the furthest thing from his mind. I'm sure he was pleased that I was interested, but it wasn't any different than a farmer's son helping with the crops. Besides, it looked like he was enjoying what he was doing."



Familiarity breeds success as far as exploring the moon is concerned. At the half-mile-wide volcanic "Lunar Crater" in the Pancake Mountains near Tonopah, Nevada, astronauts Schmitt and Cernan practice some of the things they will be doing on the moon. This area, a mixture of mountain highlands and valley lowlands, resembles the Apollo 17 landing site—Littrow Crater in the Taurus Mountains.

That Caltech can claim Jack is due to the combination of his father's gentle influence and his own disdain for



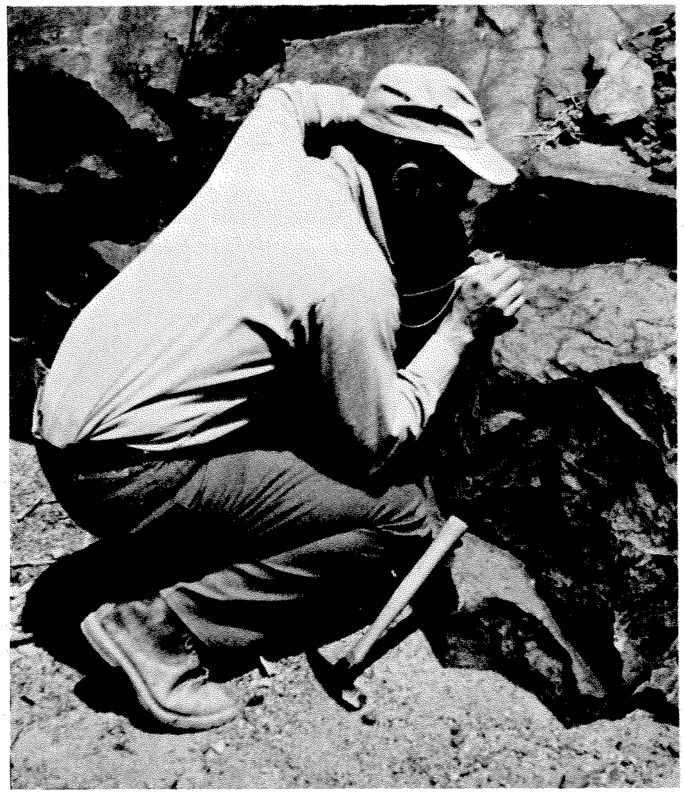
Caltech was the only school Jack Schmitt applied to. If he hadn't been accepted, he would probably have joined the Marines.

filling out forms. In his busy senior year at Silver City High School, Jack was president of the student council and a member of the school's football team, the Colts—which didn't win a single game that season. He also organized and played on a tennis team. Early in the fall his father suggested that it might be a good time to start applying to colleges. "I'd been thinking in a vague sort of way about Princeton, but hadn't done anything about it," Jack says. "My father suggested that I also apply to Caltech. He had heard it was a 'pretty good technical school.' That was the first time I had ever heard of it."

When the application forms arrived later that fall, Jack was busier than ever. Semester finals were coming up. He was studying for the national College Board examinations. He also had to study for the lead role in the senior play, Mark Twain's *A Connecticut Yankee in King Arthur's Court*. With all this on his schedule, Jack took one look at the "volumes" of forms Princeton had sent and immediately threw them out. He filled out the Caltech application quickly and sent it off without another thought. "It was foolish, I realize in retrospect, because I didn't learn until much later how difficult it was to get into Caltech," Schmitt says. "It was the only school I applied to. If I hadn't made it, I guess I'd have gone into the Marines like most of my high school buddies."

As a Caltech freshman in 1953, Schmitt was at first attracted to physics, which was a tremendously exciting field for scientists at that time. But he soon began turning his attention back to geology. His work in the field with his father gave him quite an edge over the other students in terms of practical knowledge. "Jack fitted into the geology department right away," says Silver. "But he seemed to have more in common with the graduate students and faculty than with his undergraduate classmates. He had a knowledge and sophistication in geology, even as a freshman, that was equal to, and sometimes far above, most of the graduate students in the department." As early as Jack's sophomore year his faculty adviser, Ian Campbell, suggested that Schmitt apply for a Fulbright scholarship to study abroad after his graduation. "First, he had to explain to me what a Fulbright was," says Schmitt. "When he did, I just looked at him and asked: 'Good heavens, ME?' "

By his senior year Schmitt had settled into a comfortable B average and had put the Fulbright out of his mind as unattainable. But two of his professors, Campbell and Richard Jahns, now dean of the School of Earth Sciences at Stanford, urged him to apply for the Fulbright as well as a National Science Foundation grant. To his surprise, he won both. He picked the Fulbright, and took off for a year at the University of Oslo, Norway—"an excellent school for studying the kind of geology that interested me." That interest focused during his last months at Caltech on the study of ecologites, rocks formed under high pressure and temperature from other basalt-like rocks. "The controversy was, and still is, over their origin," he says. It turned



A hand lens is a useful tool for taking a really close look at a rock on earth, but it would be excess baggage for a helmeted astronaut on the moon. Even so, Jack Schmitt took along a rock hammer and—even more important—his trained geologist's eye.

out that Norway was a classic locale for these kinds of rocks and the best place to collect information about them.

Schmitt feels that the year in Norway gave him something that no formal education could—perspective. "My education at Caltech is irreplaceable in terms of the basic store of knowledge and patterns of problem-solving I acquired," he says. "But as to knowing how to apply my knowledge wisely, I don't think I could have gotten that at any school. It isn't something that can be taught. I needed that year to put things in perspective, to question the worth of everything I'd learned, to separate the good from the bad."

After he returned to the United States, Schmitt spent the next two years (1958-1960) at Harvard working on his doctorate, first under a Kennecott Fellowship and then a Harvard Fellowship. In the spring of 1960 he returned to Norway on a Harvard Traveling Fellowship to collect additional thesis material on ecologites. Then came a stint as a teaching fellow at Harvard and geological work for the U.S. Geological Survey in New Mexico and Montana. In the spring of 1962, as a Parker Traveling Fellow, Schmitt stopped by the USGS offices in Menlo Park, California, to visit a Caltech and Harvard classmate, Daniel Milton (MS '56). Milton was working with another alumnus, Gene Shoemaker, who is now professor of geology at Caltech. "They were mapping the moon," says Schmitt, "and people sort of thought this was a joke. I looked at the maps, and it seemed pretty intriguing to me, though I didn't think too much about it."

In fact, Schmitt forgot about moon-mapping until after he got his PhD at Harvard in 1964. "Then when I started trying to figure out what there was to do with this fantastic education I had, the only thing that seemed very exciting was what Shoemaker was doing. It matched my growing philosophical interest in the space program. By this time Shoemaker had established the USGS astrogeology branch in Flagstaff, Arizona, so I wrote and asked him for a job."

Fortunately, Shoemaker had received approval for several new studies and was looking for geologists to man them. Schmitt became a project leader of a program that "only Shoemaker could dream up," developing field geology techniques for the first men on the moon—at a time when it was not at all certain that men would ever get there. The audacity of the idea delighted Schmitt. It was like Christopher Columbus ordering his lieutenants to draw up the itinerary of the first landing party in the New World before he even had any ships.

In the spring of 1965, the National Aeronautics and Space Administration sent out a press release asking scientists to volunteer as astronauts and in the fall Schmitt applied for the program. "I talked to a lot of people first," Schmitt says. "It may have seemed as if I couldn't make up my mind, but really the decision was inevitable from the minute I decided to take an active part in the space program a year earlier. I think I determine whether I do things or not by trying to project myself into the future and then asking myself: "Will I regret *not* doing this?' If the answer is yes, I go ahead."

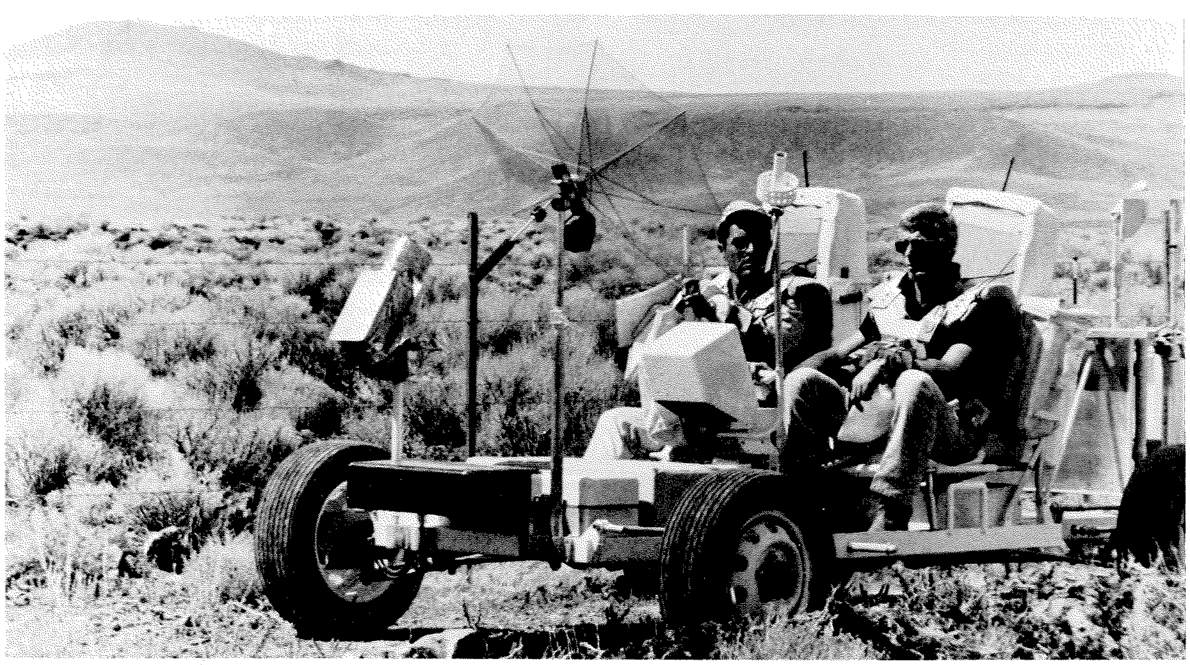
Schmitt was chosen as one of the first six scientist-astronauts, and he was the only geologist. This should have settled what he would be doing for quite a few years to come, but as soon as he completed Air Force pilot training in 1966, it was apparent that he had to make another crucial decision about his future. "As soon as I was assigned to NASA's Manned Spacecraft Center in Houston, it became clear to me that no one was sure that we were going to know how to land on the moon, and even if we did, my chances of actually flying there were very small. I had to decide whether I could make a contribution that would be worth staying for, or whether I should just forget the whole thing."

If he committed himself to continue, he was risking five or ten years on the slimmest of chances that he would actually get to the moon. "But it looked to me as if, even so, there were important things to do in the space program," he says. "So I stayed and took on not only my official assignment—helping develop the Apollo Lunar Scientific Experiment Package (ALSEP)—but also a number of other tasks on a more informal basis."

One of these informal projects was continuing as a co-investigator with Shoemaker in setting up a lunar field geology program under the USGS, and he also became active in the evolution of a joint NASA and USGS program to train the astronauts in geology. Just how active he became is hard to imagine, if you don't know Jack Schmitt—and completely logical if you do. What he believes in he pushes for, using whatever part of the firepower in his impressive personal arsenal the situation requires—intelligence, teamwork, bluntness and/or diplomacy, courage, hard work, and thorough-going competence, for example. And one thing he most certainly believes in is the absolute necessity of scientific training for astronauts.

"It was largely through his interest and intercession—directly and indirectly—that some very good non-scientist astronauts were persuaded that science was important," says Silver, "and a real field geology training program came into being."

"The program began on a trial-and-error basis," says Schmitt, "but we soon decided that its success would depend on three factors—the quality and professionalism



A far cry from a covered wagon, a lunar rover nevertheless serves about the same purpose—enabling men to travel further and in greater safety across unknown territory. Using a terrestrial version, Schmitt and Cernan explore the wilds of south central Nevada.

of the instructors, the teaching approach, and the material to be taught." His first step was to recruit many of the professors who taught him geology at Caltech and Harvard.

"Our early attempts were not as successful as we would have liked, probably because we were running things like an elementary geology course, and we simply didn't have the time to turn the astronauts into geologists. So we had to figure out a way to turn them into reliable geological observers, people who could report accurately back to the geologists on earth what they were seeing on the moon."

Schmitt and Silver together worked out an approach they thought would be effective. "We decided we had to be very selective in the kinds of problems we exposed the astronauts to, so they weren't saturated," Schmitt says. "We evolved the mission-oriented exercise, setting up specific problems in areas on earth that we suspected were geologically similar to the moon."

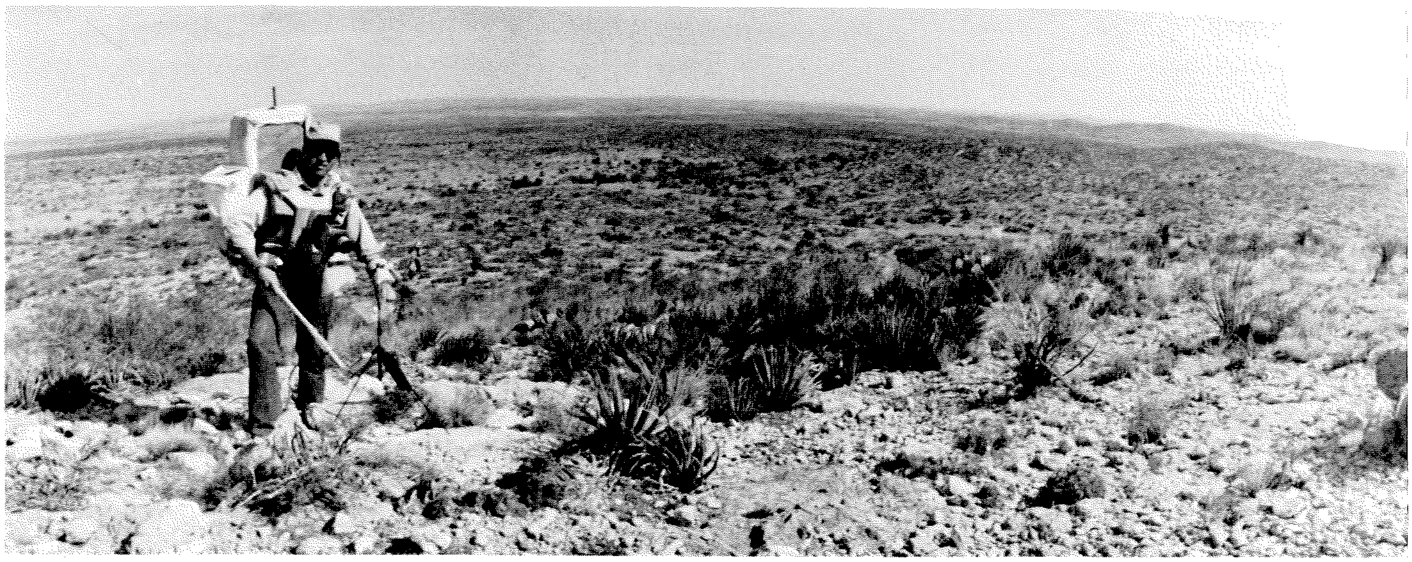
In 1969 Schmitt and Silver got the chance to put their theories to a systematic test when they took the Apollo 13 crew on a Caltech-funded expedition into the desert area near the Salton Sea in California. "That was the breakthrough," says Silver. "The enthusiasm of that crew, even though they never landed on the moon, persuaded NASA to permit, and eventually to encourage, similar intensive training in geology for the rest of the Apollo lunar crews."

As co-investigator for the Lunar Field Geology Experiment, Silver continued geological training with the crews of Apollo 14 and 15 (*E&S*, November 1971). Jack Schmitt was a member of the backup crew for Apollo 15, and Silver says: "He was the real geology teacher, because he was there all of the time, and he used every opportunity to make geological points. He was far more the prime instructor of those astronauts than I ever was."

After his work with the Apollo 15 crew was completed, Silver's commitments at Caltech made it necessary for him to step down from the prime responsibility for the astronauts' training. Another Caltech alumnus stepped in—William Muehlberger, who was chairman of the department of geological sciences at the University of Texas and is now the principal investigator for the Lunar Surface Geology Experiment for the Apollo 16 and 17 missions. Muehlberger and his co-investigators have made the Apollo 17 crew the best trained yet, at least in terms of time spent on the project—18 months of monthly field trips, plus many science lectures at the Manned Spacecraft Center in Houston. A lot of the effort of this training program has been focused on equalizing as nearly as possible the team skills of Schmitt and Eugene Cernan, the mission commander and Schmitt's companion on the lunar surface.

"Even though Jack started with the advantage of scientific training and vocabulary," says Muehlberger, "Gene Cernan has done a remarkable job of closing the gap. The two of them have developed an exceptional working relationship, and to an amazing extent they supplement each other's special abilities. It's in the post-mission interpretive sessions that we hope Jack's long scientific experience will pay dividends."

Silver, Shoemaker, and Muehlberger agree that Schmitt's unique role in the Apollo field geology effort for the past seven years has given him a kind of perception that will be vitally important to the success of this last moon-landing mission. It has given him a detailed knowledge that will make the rough terrain around the lunar landing site in the shadow of the Taurus Mountains as familiar to him as the New Mexico mountains of his childhood. "Because of this familiarity and because of his training as a geologist, we will be able for the first time to see, through his eyes, what is *different* about the moon, rather than the ways in which it is similar to the earth," says Shoemaker. "As good as they were, the other astronauts could only look for what we told them to, and for what they recognized from their training. With that information it has taken years to piece together coherent pictures of just the immediate areas around each



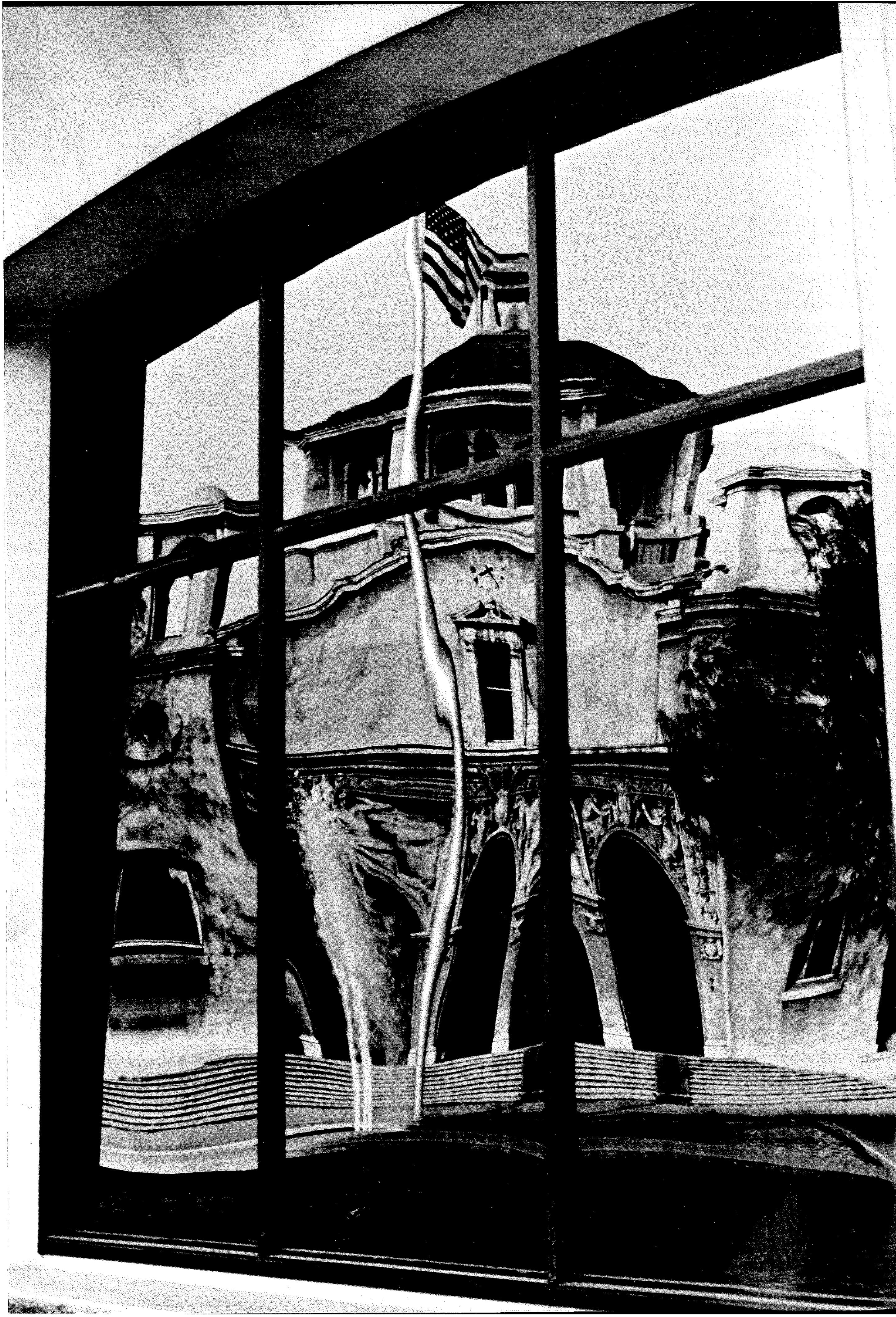
Loaded down by just about everything but his spacesuit, Schmitt tests equipment he will use on the moon in the bare expanse of West Texas. While his lunar field studies will help answer questions about the early crust of the moon, large meteor impacts, and young volcanic rock, much of Schmitt's time there will be spent in setting up remote experiments for earthbound scientists. These include investigations of heat flow, surface electrical properties, moon seismology, the response of the moon to the earth's tidal pull, gravity waves, the make-up of the lunar atmosphere, and the magnetic field at the moon's surface.

landing site. But we hope that Jack, on the spot with his unique knowledge and long experience, can do the same thing in minutes or seconds."

When Challenger lifts off the lunar surface on December 14, the Apollo series of moon landings will come to an end. Important as they have been, as far as Jack Schmitt is concerned they represent only the preface to man's future in space. "I have ultimate faith that this is just the beginning," he says. "We've taken a psychological and mechanical first step in evolving from an earthbound environment to the completely new one of space. It may be years, while we slowly realize the significance of what we've done, before we take our second step, but it is a step we will surely take."

Each astronaut has contributed in his own way, and in his turn, to the achievement. The other astronauts who have been to the moon have been as well trained scientifically as it was possible to train non-scientists in a relatively short time. But a field geologist like Jack Schmitt will be able to do the kind of on-the-spot observing, analyzing, and integrating that can make sense of the whole configuration and history of an area. On him may rest the hope of the scientific world for a fuller understanding of the moon—and ultimately, perhaps, for further exploration and understanding of the farther reaches of space.

—Bernard C. Cole,
Jacquelyn Hershey



The Bell Tolls for Throop

Swan or ugly duckling, for 62 years Throop Hall was a campus center and symbol.

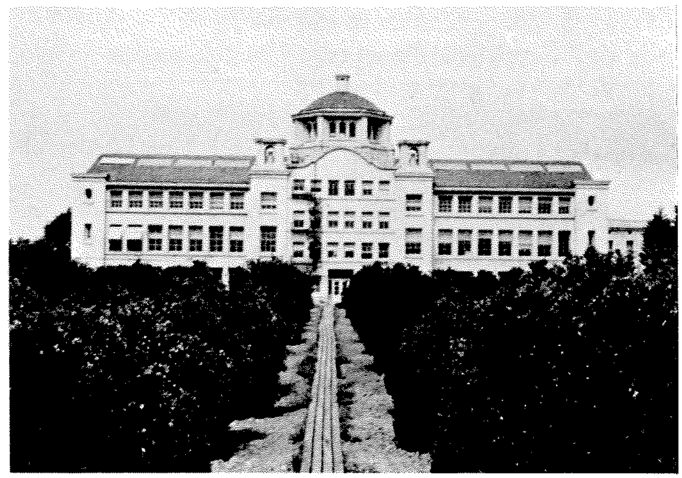
As a center of science and objectivity, Caltech seems an unlikely spot for sentiment. But as 62-year-old Throop Hall undergoes daily dismemberment, it's hard not to feel a few pangs. Aged, decrepit, and impractical as it had become, Throop was still a kind of campus center, a symbol, a reminder of the good old days.

Originally a source of pride to the Pasadena community, and generally described as "a magnificent building," Throop gradually became a catchall for offices for which there was no other place.

If the swan was never really denounced as an ugly duckling, nevertheless Throop began to look more and more out of place alongside the new buildings that sprang up around it. The ultimate disparity was reached in 1967 when rough-visaged, squat old Throop faced the tall, sleek Millikan Library across Millikan's sparkling reflecting pool.

On the morning of February 9, 1971, the San Fernando earthquake jolted Throop's past history and current debility into painful prominence. The walls were newly patterned with cracks that outlined long-sealed-up doors and remodeled walls, and the crumbled plaster revealed the building's dubious structural integrity. On the advice of structural engineers, the trustees reluctantly declared the building unsafe and marked it for demolition.

Throop Hall started as a dream in the mind of George Ellery Hale, the astronomer who was the philosophical architect of the modern Caltech. Back in 1908, when Throop Polytechnic Institute acquired 20 acres for a new campus on the southeast edge of Pasadena, Hale began to see his vision of a college of technology "second to none" move toward realization. As soon as the trustees chose the architects Myron Hunt and Elmer Grey to design the first building, Hale gave them sketches of his ideas for it. His ideas for the school as a whole must have been compelling, for in June of that same year he was able to persuade James A. B. Scherer, president of Newberry College in South Carolina, to become president of Throop.



In 1910 the east side of Throop Polytechnic's first building had ready-made landscaping—a large and verdant orange grove bisected by a boardwalk.

In October 1908, Hunt and Grey completed their plans for the building that would house the new school, and Hunt presented them publicly in an illustrated lantern-slide talk. The event drew a large crowd of culture-conscious Pasadenans, who became so enthusiastic about this addition to the town's prestige that they raised $160,000 for its construction. The courtly trustees gratefully christened the building Pasadena Hall, though that designation lasted only ten years.

When Scherer moved to Pasadena in November, he started poring over—and changing—the architects' plans. Eventually he made so many revisions that the trustees had to effect a compromise between him and the anguished architects. The compromise must have been to Scherer's advantage, because Hunt made no secret of his feeling that Pasadena Hall would be an architectural disaster. He described it as "Newberry plus the addition of that ridiculous, hard-to-reach, tower room!" The tower room became known around Pasadena as Hunt's Heartache.

But Hunt and Grey had their way when it came to the facade. Bolstered by Norman Bridge, president of the board of trustees, they declared that this first building on the new campus was symbolic of the glorious future of the fledgling school and that its entrance, therefore, should be imposing. They recommended that Alexander Stirling Calder, a Pasadena resident and a widely known sculptor, should design something to fit such a concept. Calder thought of sculptured arches gracing the building's entrance porch, but most of the trustees felt this was a bit grandiose. However, Bridge persuaded them to change their minds—partly, perhaps, because he offered to pay Calder's commission himself.

Although the building was not dedicated until June 8, 1910, the arches were unveiled in February. News of Calder's work had received so much attention that people came from all over the Southland to witness the presentation of the masterpiece. David Starr Jordan, president of Stanford University, gave the dedication address, remarking that future generations would be "amazed to find an achievement of this magnitude in this city on the outermost Western coast, far removed from all art centers."

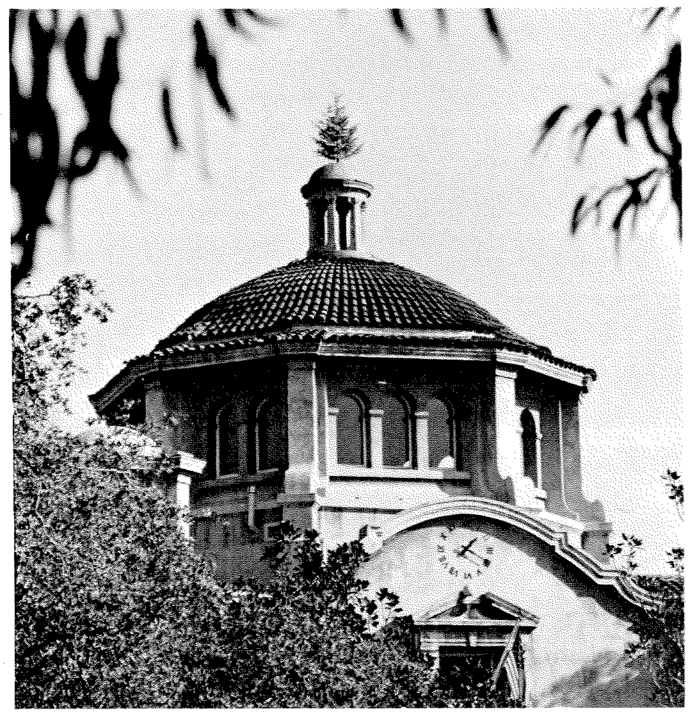
Henry Van Dyke, a favorite poet of the era, was also on hand, with verses especially written about "the flowery Southland fair, with sweet and crystal air."

The dedication of the building itself was attended by 3,000 people, who heard the builder, William Crowell, proudly announce that it contained 14,000 tons of materials. And architect Hunt declared—somewhat over-optimistically it turns out—that Pasadena Hall was "built for the centuries to come . . . it is fireproof and it is earthquake proof." The *Los Angeles Daily News* reported that "the building is wonderful. There are 62 large class and lecture rooms, with offices adjoining them."

With a faculty of 12, a student body of 31, and a curriculum focused largely on electrical, mechanical, and civil engineering, Throop Polytechnic Institute began instruction on its new campus in September 1910. Pasadena Hall, its only building (until the construction of Gates Laboratory in 1918), contained a staggering $40,000 worth of scientific and engineering equipment.

And formal instruction was not the only activity that went on in Pasadena Hall. For approximately 15 years, it was also the setting for a great deal of Pasadena's very active cultural life. Through Calder's archways came visiting lecturers and performers in the fields of art, literature, and music. In 1911 both Theodore Roosevelt and William Howard Taft gave speeches from its front steps. The influential Pasadena Music and Art Association held its musicales and exhibits inside.

Jesse DuMond, professor of physics emeritus, who came to the Institute as a freshman in September 1911, recalls that his first impression of Pasadena Hall was of "laboratories and classrooms filling the building completely, from basement to cupola."

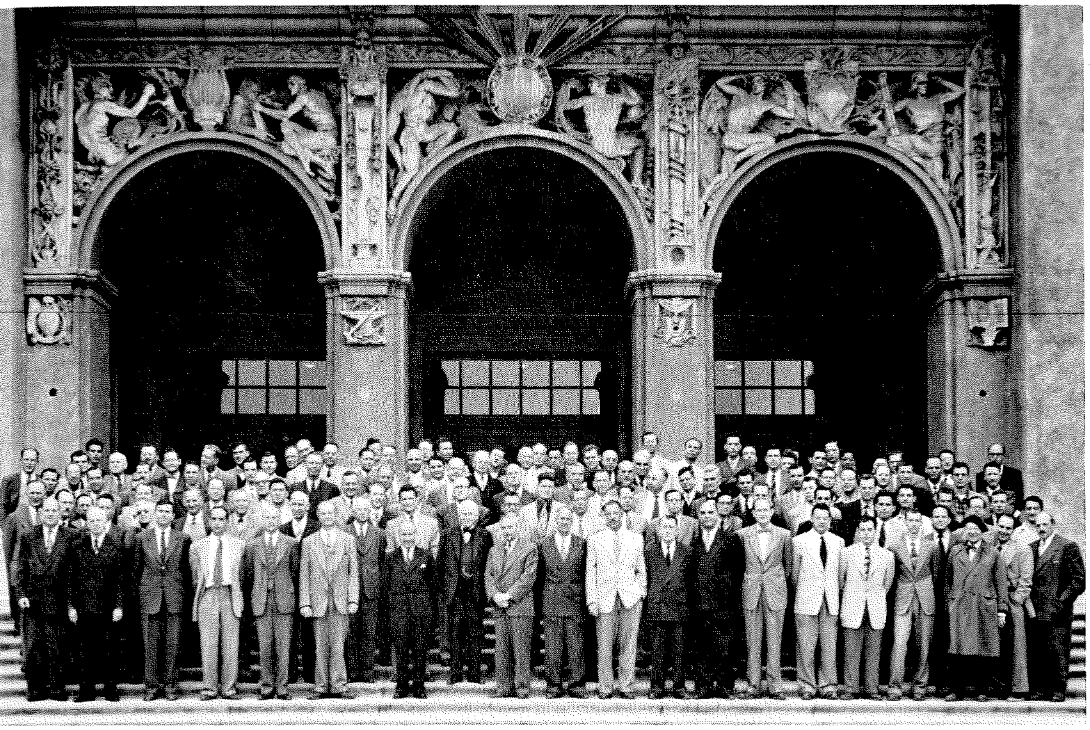


Throop's cupola may have been something less than an architectural triumph, but it made a superb base for a Christmas tree.

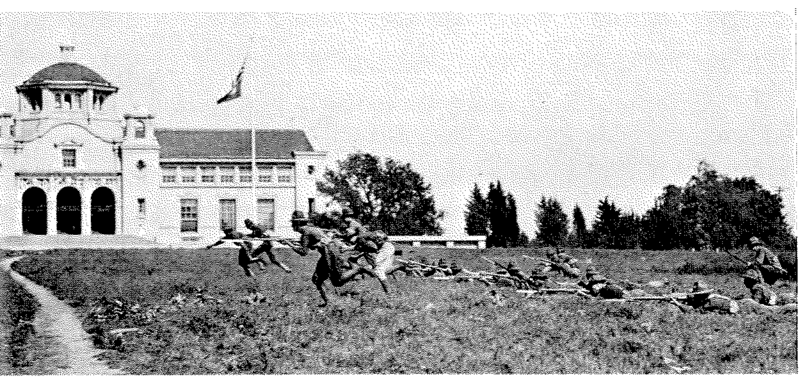
The ground floor held the hydraulics and electrical engineering laboratories. Students wore coats and ties to class in those days, and it is a tribute to their agility, perhaps, that there is no record of anybody's tie ever getting caught in the wheels, pulleys, and straps that were so large a part of the equipment of the labs. And while shower stalls were rare at that time, the students were still ingenious enough to find a way to immerse their classmates. They doused them in the vats in the hydraulics laboratory.

The administrative offices were on the main floor; the second floor had the classrooms, offices, and laboratories for civil and mechanical engineering (neatly divided, with civil engineering at the south end and mechanical at the north); and the third floor was entirely devoted to drafting.

The pulse of the Institute was in a large room to the south of the main entrance on the first floor—an area most recently occupied by the offices of the secretary to the board of trustees and the vice president for business

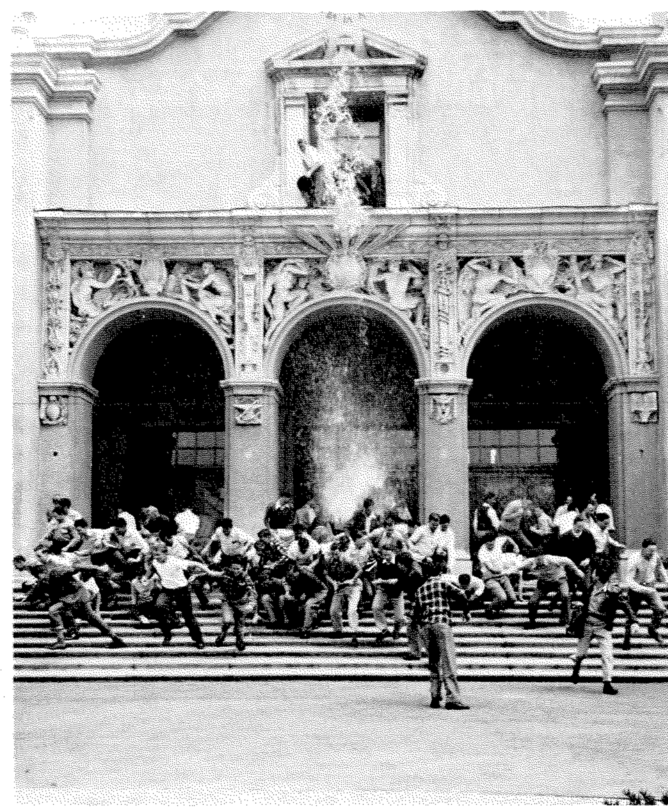


Just 20 years ago, the entire faculty could—and would—pose under Calder's arches.

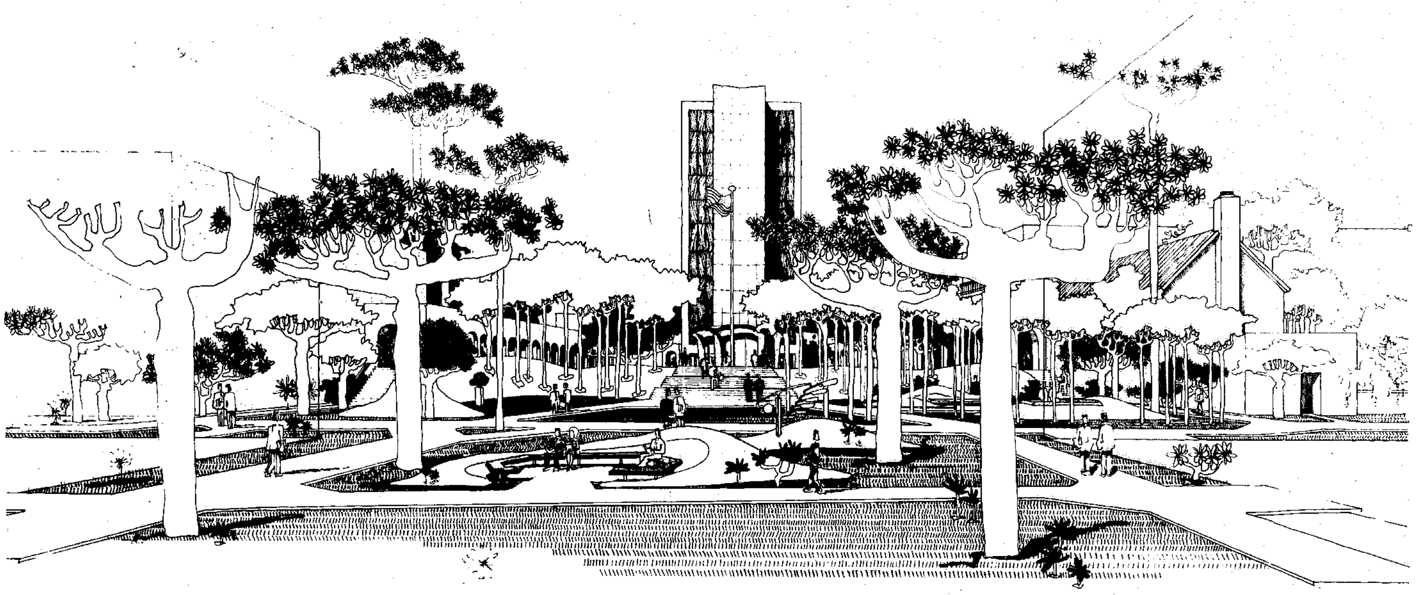


During World War I the Student Army Training Corps drilled regularly on the no man's land in front of Throop.

Thanks to the steeplejacks of the Fleming House Mickey Mouse Club, the Throop clock got a new face in 1965.



Throop's architectural features provided an ideal setting for water fights.



The site of Throop Hall will become a much needed, parklike, open space—with a vista of tree-shaded walks and lawns from the Athenaeum to Millikan Library.

and finance. This was female territory. There, Inga Howard, secretary to President Scherer, also occasionally typed students' papers and pasted ribbons on the diplomas. Grace Sage, the bookkeeper, made all her entries by hand; and a Miss Spinning guarded the library in one corner. Elizabeth Allen was secretary to the Institute's financial watchdog, Ned Barrett. She also answered the phone and saw to the bookstore across the vestibule. Miss Allen precipitated one of the school's earliest romances when she met and married Ernest Swift, then a teaching fellow in chemistry and now professor of chemistry emeritus.

One area of the main floor was not dedicated to administration—the classroom at the northeast corner of the building, presided over by Professor Clinton Judy. This was the humanities department. Evidently Professor Judy didn't need any more space, because his influence transcended the four walls. Frank Capra, '18, credits Judy with leading him into the world of the humanities—and through this to much of the humanist philosophy that later made his films world famous.

Capra edited the student newspaper in a small office in the basement of the building, just inside the back door—a room most recently occupied by the security office. He remembers the graduation ceremonies on Throop's front steps, the ROTC drills on the vast dirt area to the west of the steps, and the grove of orange trees in the "back yard" to the east. "In the spring the smell of the blossoms was truly unforgettable."

In 1910 Throop Polytechnic Institute dropped its Normal, Commercial, Grammar, and Academy schools so it could concentrate on becoming a "first-rate technical school" at the college level. In 1913 the trustees changed the name of the school to Throop College of Technology. By that time the enrollment had almost doubled, and by 1915 it had doubled again. Such growth inevitably produced changes in the use of Pasadena Hall. Assemblies and similar events had to be held out of doors. Inside, some controversy arose over the space occupied by a collection of stuffed birds owned by a faculty ornithologist named Dickey. The Dickey birds were banished in favor of more offices.

In 1920 Pasadena Hall officially became Throop Hall in honor of Amos Throop, who had founded Throop Polytechnic back in 1891. The enrollment had now risen to 350.

Over the next half century the rooms in Throop Hall changed shape with the frequency and ease of an amoeba. The first floor was partitioned into more and more offices in the early 1940's when Caltech was swamped with wartime activities. A major remodeling took place in the 1950's. In 1962 the bookstore was moved from the ground floor of Throop to the new Winnett Center. Then the south flight of the original double staircase was demolished to make room for the admissions office and an elevator. By 1965 the third floor had been renovated for occupancy by the purchasing department.

Only the southeast corner of the main floor remained, to the last, what it had been since the building opened in 1910—the office of the president. With the move last June of the administrative offices to the third floor of Millikan Library, a 62-year-old tradition ended.

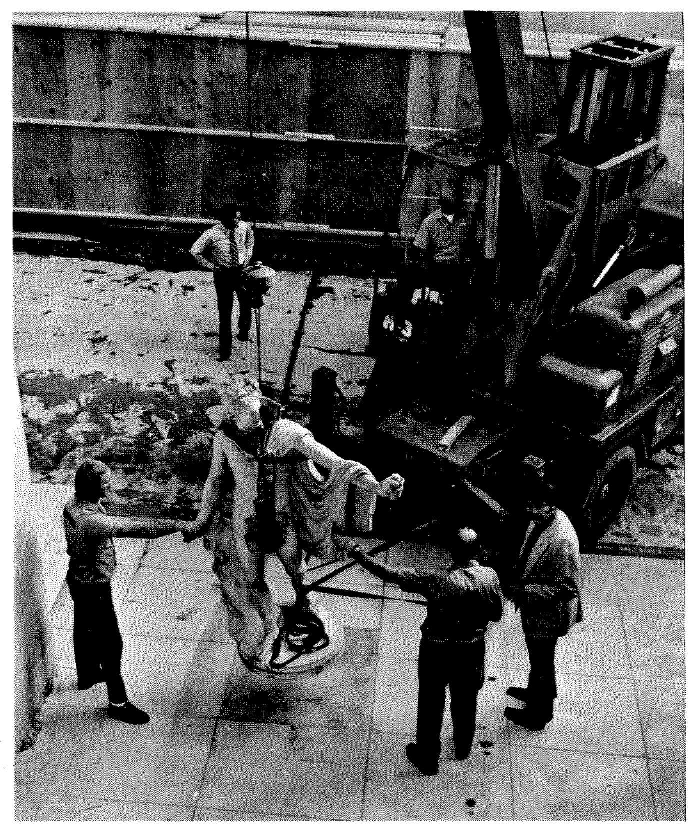
Razing Throop Hall is slated to take about three months, but before it could really begin, two important moves took place. First the statue of Apollo was taken—with care but not a great deal of dignity—to Dabney gardens. And, after a cliff-hanger about the fate of Calder's arches, they seem slated to wind up at the Pasadena City Hall—proving that sentiment still operates. It will be an expensive move, but Pasadena wants to honor its culturally minded pioneers whose faith in their new school of technology was so boundless.

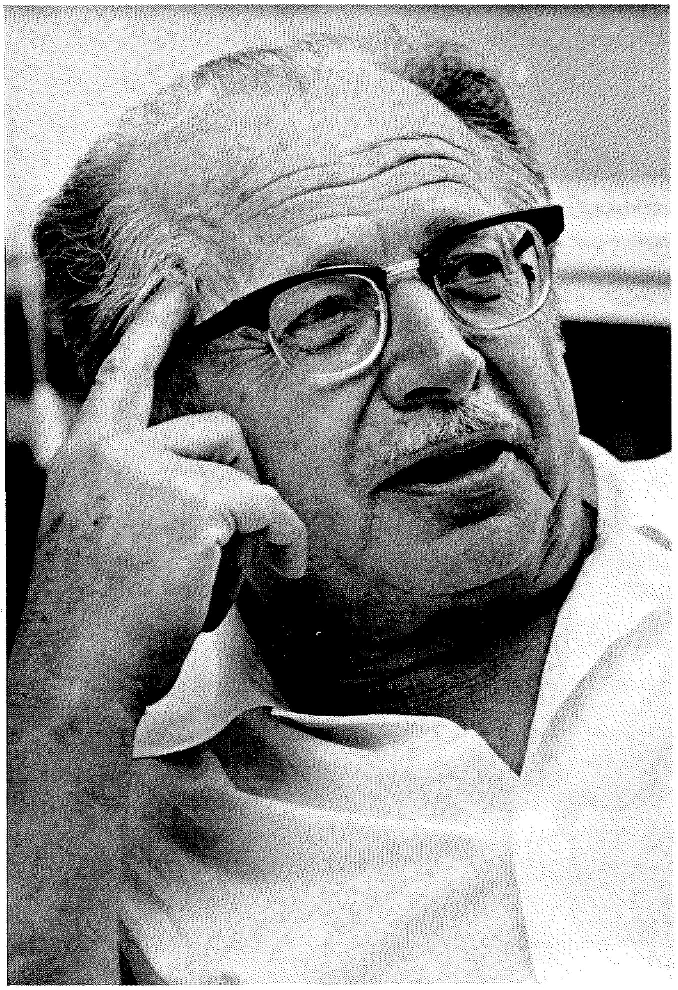
—Janet Lansburgh

Handle with Care

Caltech's peripatetic statue of Apollo spent more than 30 years in the main foyer of Throop, until remodeling in the 1940's banished him to the balcony between Throop and Kellogg for his second three decades on the campus. Last month, as his old home crumbled beside him, he was hustled off to begin a new life in Dabney gardens.

A seven-and-a-half-foot copy of the Apollo Belvedere in the Vatican Museum in Rome, the statue was commissioned by Louis Bradbury, a prominent Los Angeles resident, and secured for the new Throop College by architect Elmer Grey in 1911. Several generations of undergraduates can testify that, for a statue, Apollo is in practically perfect condition.





Jesse Greenstein, Lee A. DuBridge Professor of Astrophysics and staff member of the Hale Observatories and Owens Valley Radio Observatory, was chairman of the Astronomy Survey Committee which spent two years formulating a ten-year plan for the future of astronomy.

The Future of Astronomy

by Jesse Greenstein

After their startling discoveries of the last ten years, astronomers have come to realize that the actual universe is much stranger than science fiction.

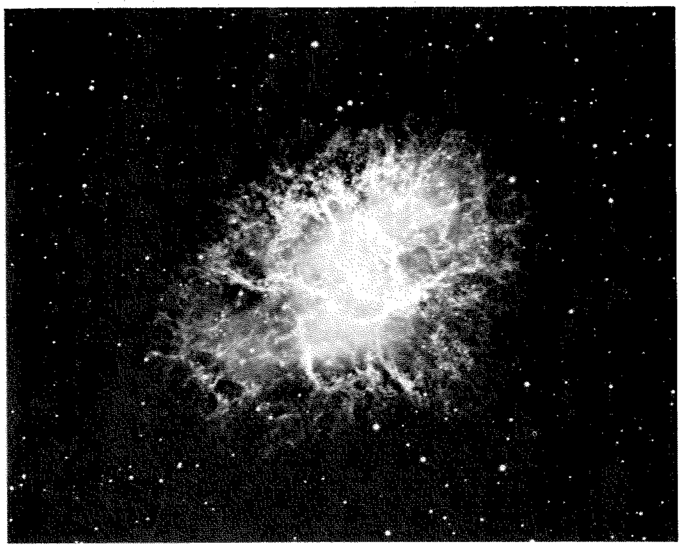
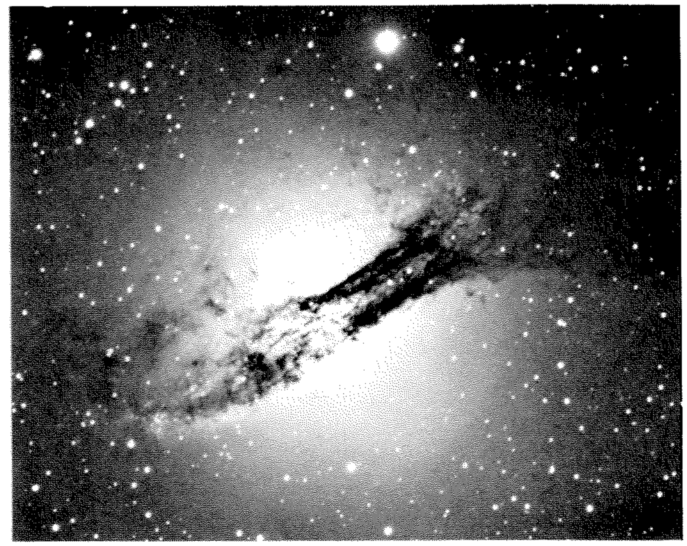
As in the age of Galileo, we are suddenly confronted with a new view of the universe. Instead of the sedate cosmos in which we thought we lived, we are in the midst of general cosmic violence—exploding galaxies and quasars, high-energy particles, magnetic fields—violence that suggests energy-releasing events like relativistic collapse, and other effects of the general theory of relativity.

But the discoveries that have given us this new view of the universe have provided few answers—and raised many questions:

- ☐ Where do matter and energy come from?
- ☐ Are there forces and energies at work that we have not yet discovered?
- ☐ How long will the sun shine and the earth survive?
- ☐ How many other "earths" are there, and are any of them habitable or inhabited?
- ☐ What further strange new types of objects does the universe hold?
- ☐ What was it like at the beginning of time, 10 or 15 billion years ago?
- ☐ Does time stretch backward forever, or was there a beginning?

To define the possible ways to answer these questions, an Astronomy Survey Committee was set up in 1969 by the Committee on Science and Public Policy of the National Academy of Sciences. It was directed to formulate for the government, and for scientists, a ten-year plan for the future of astronomy.

After two years of work the 23 members of the committee—and more than 100 members of an advisory panel—completed a two-volume survey. The first volume, *Astronomy and Astrophysics for the Seventies*, published this spring, outlines the main areas in astronomy that should be pursued more actively:

Cosmology
Quasars and Exploding Galaxies
Studies of the Sun
Stellar Evolution
The Evolution of Molecules, Planets, and Life
Exobiology

Not everyone will want to read the detailed discussion of each of these subjects—or have access to the report. But the background information and recommendations it contains are of great importance to the future development of astronomy and astrophysics in the United States—and at Caltech. With this in mind, I offer these highlights.

COSMOLOGY

It is now generally believed that about 10 or 15 billion years ago a cosmic "big bang" flung all matter outward at tremendous speed. After the first few minutes, in which only radiation existed, the cosmic fireball cooled down enough to permit nuclear reactions to fuse part of the original hydrogen to helium—in about the same amount that is observed in all galaxies today.

After about 100,000 years the gas, which was largely hydrogen and helium, cooled to about 3,000 degrees above absolute zero. All that is left today of the residual energy from this primordial fireball is a pervasive cosmic background radiation, present even in the emptiest reaches of space. The intensity of this radiation, which is observed by radio telescopes in the long wavelengths, is roughly equal to a temperature of about 2.7 degrees above absolute zero.

As the gas continued to cool, it gathered together to form groups of galaxies—and in a small group our own Milky Way was formed. Some of these galaxies had violent internal explosions. By looking at the very edge of the observable universe with radio telescopes—in effect, looking back in time—we can now detect those events as quasars and radio galaxies.

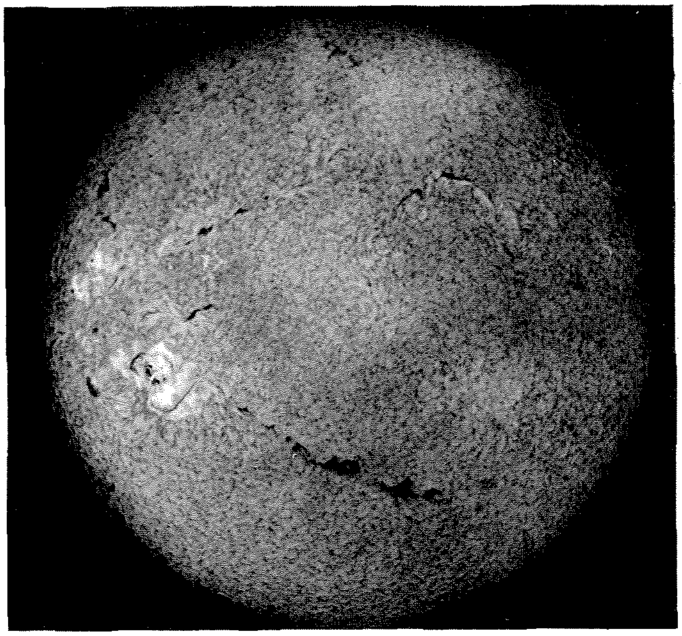
As each galaxy settled down, generations of stars were born—including the sun. Countless planets came into being. Life eventually emerged on earth—and perhaps also on other planets that had water and an atmosphere.

To some critics, the available data on the prevalence of violence suggest much more radical cosmologies than this one—which may indeed have many flaws. Even its main concepts might be erroneous, in fact, if some type of new physics is required to understand this entire universe. In any case, it will be a major task for astronomy in the next decade to test this broad picture of the evolution of the universe at every point.

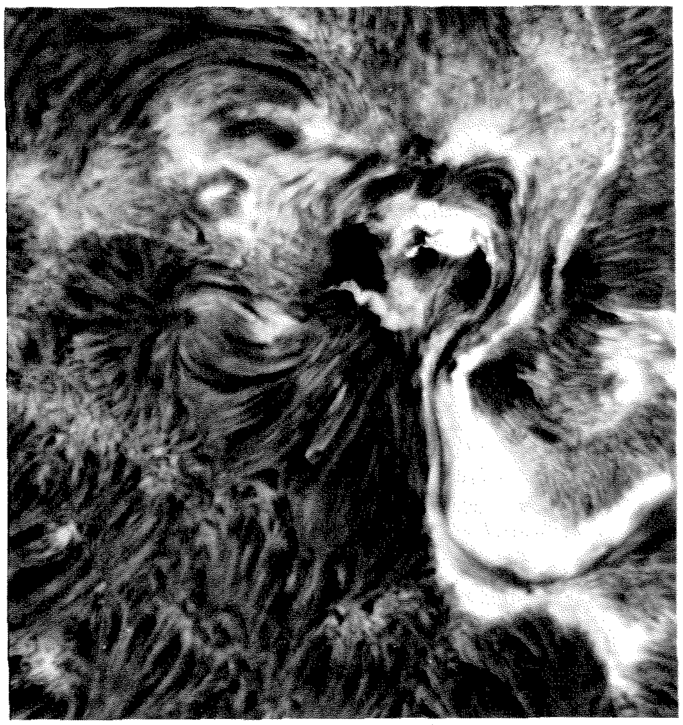
QUASARS AND EXPLODING GALAXIES

The picture of an expanding, explosive universe, developed by astronomers in the 1960's and early 1970's, is largely the result of the advent of radio astronomy, the discovery of quasars, and the closer optical examination of many strange galaxies. Quasars, the brightest and probably most distant of all known objects in the universe, emit energy in amounts far out of proportion to their apparent size. They also appear to eject matter at very high velocities—bubbles traveling up to 62,000 miles a second (one-third the speed of light). Many galaxies have energetic explosions that are equally unbelievable. Something like 2 to 5 percent of all the galaxies in the observable universe show evidence of explosions, violent events, and excessive infrared radiation in their nuclei. Though such super explosions seem to be confined to quasars, the nuclei of quasar-like Seyfert galaxies, disturbed radio galaxies, and even "normal" galaxies like our own Milky Way, show evidence for the ejection of matter from their nuclei on a smaller scale and at lower speed.

When galaxies go through the stage in which violent events occur, lasting about 100 million years, they may eject enough matter to equal the mass of a small or possibly even a normal galaxy. Is new matter being created in the nuclei of exploding systems? That would be "new physics" indeed.



During a ten-day period starting last August 2, a series of gigantic eruptions took place on the sun. Photographs taken at the Big Bear Solar Observatory revealed a great flare cloud about 100,000 miles long, which spewed electrons and protons across the solar system and caused some of the worst magnetic storms on earth in recent years. The origin and nature of solar flares is one of the subjects slated for intensive study over the next decade.



What mechanism is responsible for the ejection of such a seemingly inexhaustible supply of matter? What role does the nucleus of a galaxy play in its evolution? Is it some strange massive object whose physics is only dimly understood? Could it be that all the matter of a galaxy is ejected from its nucleus, and that, as a galaxy ages, the explosive capability of the nucleus dies?

Further studies of quasars, the nuclei of expanding and normal galaxies, and of supernovae, will not only tax the ingenuity of the theoreticians dealing with new and unexpected states of matter; they will also require significantly greater observational effort with the largest telescopes, using the most sophisticated electro-optical technology.

THE SUN

Because the sun is the closest star to us, we can study it in greater detail than any other star. In the last decade, the opening up of the extreme ultraviolet and X-ray regions of the solar spectrum by rocket and satellite observations has provided important new advances in solar research.

The solar corona is where mechanical energy—generated just below the surface of the outer layer of the sun—is deposited, in the form of steady heating and in violent events such as solar flares. The dominant emissions of the solar corona appear in the invisible regions of the spectrum, and abundance determinations of the elements in the solar spectrum—verified by analysis of the solar radiation—have given us a tool for a similar analysis of elements in stellar spectra. Such information about a star allows us (provided we know the stellar mass and radius) to determine the energy production in the star's nuclear furnace and to predict the star's future.

Observations of the solar chromosphere, solar flares, and magnetic fields have stimulated the search for these phenomena in the stars. Analogs have been found, since in some stars the same effects are present on a much greater scale. A light and radio stellar flare detected on a nearby star was a million times more intense than any on the sun.

Measurements from satellites, particularly the Orbiting Solar Observatory (OSO) series, permit study of rapid events and slow variations of radiation over periods up to a year, adding immeasurably to our knowledge of solar and stellar structure. Improvements in the angular resolution of the OSO spacecraft, four of which have been orbited in space around the earth since 1967, would make possible further progress in understanding solar flares and similar activity on other stars.

Improved observations from space go hand in hand with improvement and extension of observations from the ground. To get information of comparable scope and resolution to that obtained in space, we must continuously update existing ground-based and aircraft facilities and construct small specialized telescopes for the visible and infrared spectral regions.

More attention should also be given to detecting the elusive solar neutrino radiation. Using what must be the most remarkable telescope in existence (a 30,000-gallon tank of cleaning fluid placed deep in a mine in the hills of South Dakota), physicists have been counting neutrinos, the subatomic particles produced in nuclear reactions in the sun's core. They find that the sun produces only one-sixth as many neutrinos as are predicted by present theories of solar structure. The results of this experiment show either that the central temperature of the sun is lower than we have thought, or that we must question the weak-interaction (Feynman—Gell-Mann) theory of particle physics.

STELLAR EVOLUTION

The basic physical laws and processes that govern the structure and evolution of stars are now quite well known. Stars condense from the gas and dust of the interstellar medium, spend a few million years deriving their initial energy from gravitational collapse, and thereafter show little change during life-spans that range from about 1 million to 100 billion years. However, once the central supplies of hydrogen are eventually exhausted in their cores (where temperatures are highest and the reactions most rapid), a new phase of evolution begins. Hydrogen fusion is now restricted to a shell around the core; the core itself—now helium—contracts, the outer surface of the star expands and cools, and the star becomes a red giant or a supergiant. The greater the mass of the star, the greater the tendency for further heavy-element fusion processes to take place in its core. Thus, helium "burns" to carbon; then to oxygen, neon, magnesium, and so on, up the periodic table toward iron—the process of nucleosynthesis. Eventually, when all supplies of accessible fuel are exhausted, the star contracts to a very dense state, becoming either a white dwarf or—after a catastrophe—a neutron star. A massive star falls into a relativistic "black hole."

Although astronomers are increasingly confident of the basic validity of this picture of stellar evolution, present understanding of these fundamental topics is incomplete at best. It will take decades to reach a secure understanding of the formation of the elements and stellar evolution—with all their implications for the rest of astronomy and cosmology.

MOLECULES, PLANETS, AND LIFE

The formation of the earth and the solar system was once believed to be an extraordinary event. Now most astronomers think solar systems are commonplace, arising in a natural way during the formation of the stars themselves. How life begins on the planets is still obscure and is a subject best left to the biologist. How life becomes intelligent is perhaps the ultimate question. One of the more fascinating recent discoveries is that some molecules necessary for the development of life may have been present in the original dust cloud from which the solar system formed.

What were the initial conditions in the interstellar medium out of which the solar system formed? We know that both gas and dust were present. Photographic studies of the sky long ago revealed luminous clouds, which spectroscopic analysis has shown to be mainly hot hydrogen gas. Radio observations have mapped cool hydrogen clouds in spiral arms stretching around our galaxy, and they have detected such gas in other galaxies. Other molecules, such as combinations of carbon and hydrogen, and carbon and nitrogen, were discovered with the large spectrographs on conventional telescopes, and some have been found in other galaxies.

The most dramatic molecular discoveries, however, were made in the radio spectrum—the existence in interstellar space of the hydroxyl radical, carbon monoxide and its isotopes, carbon sulfide, silicon oxide, water, and ammonia, among others. Are there also more complex structures? Only a few years ago we would have said no. But by now we have found an undreamed-of array of such complex forms in space—molecules like formaldehyde, methyl alcohol, cyanoacetylene, formic acid, and formamide.

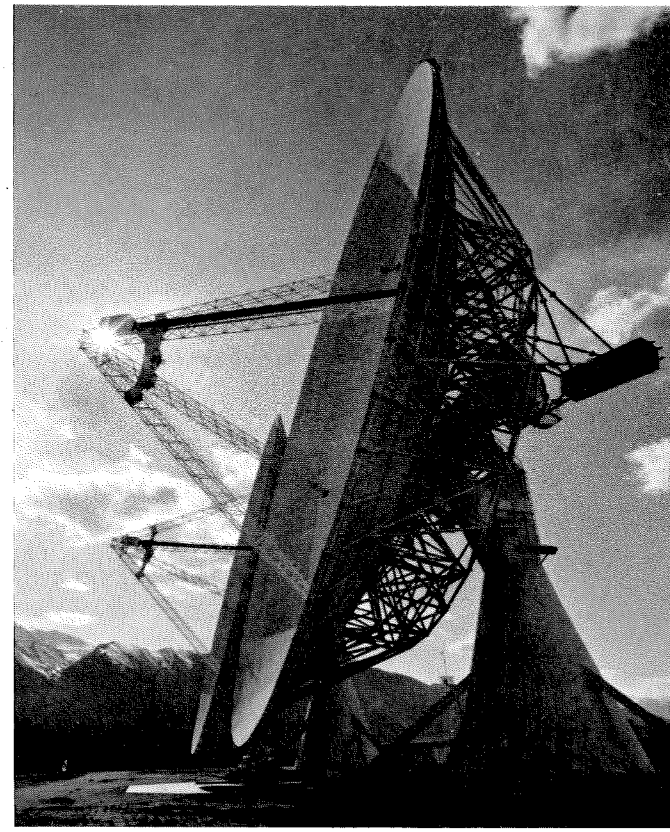
An important factor in constructing any theories of molecular formation will be the determination of the numbers of atoms—the building blocks of molecules—within the dust clouds. Since only a few of the important elements have their strongest absorption lines in the visible part of the spectrum, we must look to ultraviolet spectroscopy from space vehicles to provide this information.

EXOBIOLOGY

Our civilization may soon take one of the greatest steps in its evolution: It may discover the existence, nature, and activities of independent civilizations in space. As we point out in *Astronomy and Astrophysics for the Seventies*: "At this very instant, through this very page, radio waves are passing. Some may bear conversations that we could record if we pointed a radio telescope in the right direction and tuned to the right frequency."

In a hunt for extraterrestrial civilizations, however, it is clearly restrictive to construct a search aimed at detecting only signals generated to attract our attention. It would be preferable to detect signals that a civilization uses for its own purposes. Such signals would be more numerous—but unfortunately they would also be weaker, they would be at unpredictable frequencies, and they would require unscrambling. Even though no single signal indicative of civilized communication rises above the noise of natural radiation on a radio telescope, it is possible to analyze the spectrum for peculiar groupings of artificially produced "civilized" noise. Such methods call for observations of large numbers of frequencies and extensive analyses of the recordings with high-speed computers. We have the mathematical theory and technology to do both.

In today's rush of exciting "hard" astrophysical research, no major search for extraterrestrial civilizations has taken place. But more and more scientists feel that confirming the existence of such civilizations—and making contact with them—is now within our capabilities. It may happen in the lifetime of many of us. In the long run, this may be astronomy's most important and most profound contribution to mankind.



Number 1 on the list of programs recommended by the Astronomy Survey Committee is development of a radio telescope array far larger than any now operating, including that at Caltech's Owens Valley Radio Observatory.

RECOMMENDATIONS

If astronomy is to continue to progress, new facilities must be constructed, and new directions in research must be pursued. Federal expenditures in ground-based astronomy have averaged about $50 million, and in space astronomy about $200 million, annually. The entire program proposed by the Astronomy Survey Committee involves an additional $84.4 million a year over the next decade—about $51 million a year for new space projects and about $33.4 million a year for new ground-based programs. The committee has defined four programs of highest priority for federal support. In order of importance, they are:

1. A very large radio array, designed to attain resolution equivalent to that of a single radio telescope 26 miles in diameter. This should be accompanied by increased support for existing smaller radio programs and advanced, new, small facilities at universities and research laboratories.

2. An optical program that will vastly increase the efficiency of existing telescopes, by use of modern electronic auxiliaries, and at the same time create the new large telescopes necessary for research at the limits of the known universe.

3. A significant increase in support and development of the new field of infrared astronomy, including construction of a large ground-based infrared telescope, high-altitude balloon surveys, and design studies for a very large stratospheric telescope.

4. A program for X-ray and gamma-ray astronomy from a series of orbiting High Energy Astronomical Observatories, supported by construction of ground-based optical and infrared telescopes.

The committee has also identified several items of high scientific importance, which, although urgently needed, should not delay the funding of the other programs. These include:

- ☐ A very large millimeter-wavelength antenna for the study of new complex molecules in space, and of quasars in their early, explosive stages.
- ☐ Updating existing solar observatories on the ground.
- ☐ Continued support of the Orbiting Solar Observatories.
- ☐ An expanded program of optical space astronomy.
- ☐ A large orbiting space telescope.
- ☐ Doubled support for infrared and gamma-ray observations from high altitudes.
- ☐ Increased support for theoretical investigations.
- ☐ A large steerable telescope for observing wavelengths of one centimeter and above with more resolution.
- ☐ Increased support for astrometry to provide additional needed information on the positions and apparent motions of stars.

CALTECH'S ROLE

This outline of the major facilities required by the nation for the next ten years neglects, of course, the contributions of individual institutions. The universities of this country spend nearly $35 million annually on instruction and research in astronomy. Much of what the Astronomy Survey views as central to the future of astronomy (radio observations, X-ray astronomy, infrared astronomy, astronomical observations from orbit, the construction of new auxiliary electronic instruments to increase the light-gathering of modern optical telescopes—to name a few) is, in fact, going on at Caltech.

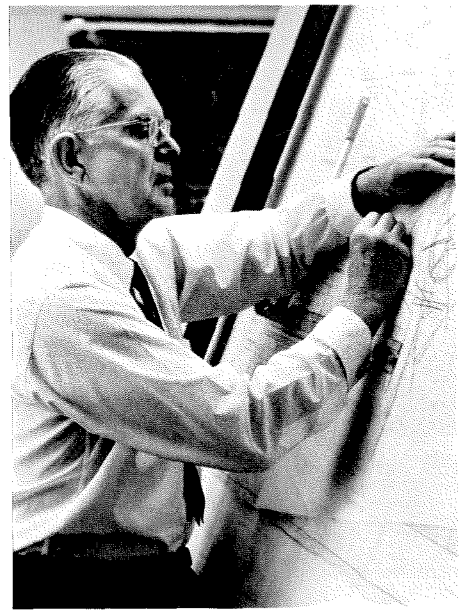
The effort in astronomy at Caltech is one of the broadest and most active in the world; it includes work over the entire range of wavelengths. Studies dealing with relativistic cosmology, observations of galaxies and quasars, radio astronomy, the origin of the chemical elements in stars, nuclear reaction rates that keep the stars shining, solar astronomy on the ground and in space—are all being actively pursued. The infrared program here is one of the most exciting in the world and has shown the enormous energies released both by explosions in in galaxies and by cool (nearly cold) stars, young and old.

It is depressing to see how unlikely is the growth in federal support we recommend. It is also not encouraging to see how little of the proposed increased support of new facilities and programs by federal funds would come to Caltech—or any other major university center—without a struggle.

I hope that Caltech will, by its past performance, justify its share in the future expansion in exciting new areas of astronomy. But we should not forget the benefits to scientific enterprise of institutions based on private funds, to some degree independent of federal funding. The existence of the Hale Observatories—the largest privately operated optical astronomy observatories in the world—attests the value of such institutions. There remains an interesting challenge to the private sector in helping *one* outstanding center of excellence survive, independent of the vagaries of federal funding. Auxiliary devices required by our large telescopes are not beyond the resources of individual donors; instrument costs range from extremely expensive to modest; new research in the infrared is relatively inexpensive; theoretical astrophysics costs no more than the salaries of the young men involved, and the use of a computer. The opportunities in the next ten years are clearly unparalleled, and I hope that Caltech will remain central to the production of those new developments in astronomy which so enormously enlarge the horizon of man.

HENRY AND DORIS DREYFUSS

Henry and Doris Dreyfuss died on October 5. Their son, John, paid this tribute to his parents at a memorial service held in Beckman Auditorium on October 22.



I am John Dreyfuss, and I welcome you warmly on behalf of my sisters, Gail and Ann, myself, our families, and—most of all—on behalf of my parents. They would have appreciated this day. As diverse and incredibly complementary individuals, and as partners, they enjoyed and they created beauty, love, and dignity. All those qualities are embodied in this gathering. My parents were partners in a life they loved through its last moments. But my mother was ill, and had little time left, so they elected to die as they had lived—together.

From the beginning, in 1929, they were partners in industrial design, creating a business they loved. In it they shared a great, quiet pride. Industrial design was an essential building block in their lives. Others included family, friends, possessions, and ideas. But the keystone supporting those blocks, and many more, was one of unsurpassed mutual respect and encompassing love. Before October 5th, some recognized the grand dimensions of that respect and that love. Now we all do.

For my sisters and me, and our families, the great gap created by the loss of our parents is partially filled by a legacy of wisdom and love and understanding. The essence of our feeling was captured by Bill Hewitt, a close friend and chairman of Deere and Company. Celebrating the 30th anniversary of his company's wonderfully close relationship with Mom and Dad, he displayed a 1936 tractor seat. It was an example of what that product looked like the year before my parents started working with Deere. On the seat was a message. It said, "We have come a long way from this, but there is no limit on how much further you can guide us."

For the Dreyfuss children, and grandchildren, and we hope for you, Bill Hewitt's words are as true today as they were when he said them six years ago. There is no limit on how much further we can be guided by the heritage of attitudes and convictions and ideas and designs my parents left. It is up to us. Mom and Dad meant something different to each person here. Some of you knew them longer than Gail and Ann and I have. You shared, as we did, the excitement, the challenge, the support and encouragement and the deep human caring that were part of being involved with them. As we consider what we share, please enjoy some of my parents' favorite music and a poem read by a valued family friend, which reflects the strong spirit of Doris and Henry Dreyfuss. May that spirit remain alive in each of us.

These lines were written by Hallett Smith, professor of English, former chairman of the division of humanities and social sciences, and a long time friend of Doris and Henry Dreyfuss.

Henry and Doris Dreyfuss were indeed inseparable. Their gifts were different: Henry was always the man of vision, seeing new ways to make things better, more useful, more beautiful, for *people*. Doris was the sharp detector of sham or fraud or pretentiousness.

Henry was a leader in such civic organizations as the Center for the Performing Arts, the Music Center, the Los Angeles County Museum of Art, Los Angeles Beautiful, and Pasadena Beautiful.

Doris was certainly in favor of these constructive efforts, but it was characteristic of her that she and a friend amused themselves by imagining a foundation called Pasadena Hideous, which was supposed to present suitable awards to the most ghastly atrocities constructed during the year.

Doris had her own civic interests. She spent untold hours working on the boards of Westridge School, the Pasadena Humane Society, and the Foothill Family Service.

With their varied talents, Doris and Henry catalyzed each other's strengths as only creative and vital people can.

They always realized, and those who knew them well also realized, that the Dreyfuss accomplishments—many and great as they were—belonged to both of them, though Doris hated to discuss it. They shared the same curiosity, the same ineradicable itch to know, that characterizes the scientist and scholar. The phone in a Caltech home would ring, and a familiar voice would say, "Doris and I have been racking our brains. Now, you tell us—who was the composer of *Eadie Was a Lady?*"

Henry became a trustee of Caltech in 1963 (and he was very proud of it), though he had been a faculty member of the engineering division for many years, and had annually lectured on industrial design to students in Business Economics. On the board, he persuaded his fellow trustees to employ the best architects to design new buildings on the campus. He introduced students, graduate and undergraduate, into the annual trustees' meetings at Palm Springs, and in these sessions he seated everyone in circles, so that nobody would be in a dominant position. He accepted very conscientiously the role of chairman of the Visiting Committee for the Humanities Division, getting to know the faculty, and endlessly asking students about their ideas and interests. When he observed what a wonderful time Albert Ruddock, the retired chairman of the board, was having at a party for a retiring dean, Henry gave a similar party for Albert, and it was a very lively affair.

When one asks about how Henry Dreyfuss will be remembered, it is easier to answer the question than it is for most great men. In St. Paul's Cathedral in London, there is an inscription to Sir Christopher Wren, its architect. The inscription says, in Latin, "If you seek his monument, look around you." That means to look in awe at those vast spaces and all that white marble. If you look for Henry Dreyfuss's monument, you will find it in a much more intimate and much more universal medium than a neoclassic cathedral. You will find it in the things we use in everyday life—the telephone, the sewing machine, the tractor, and a thousand others. His heritage is a *living* heritage; it is a part of our daily experience.

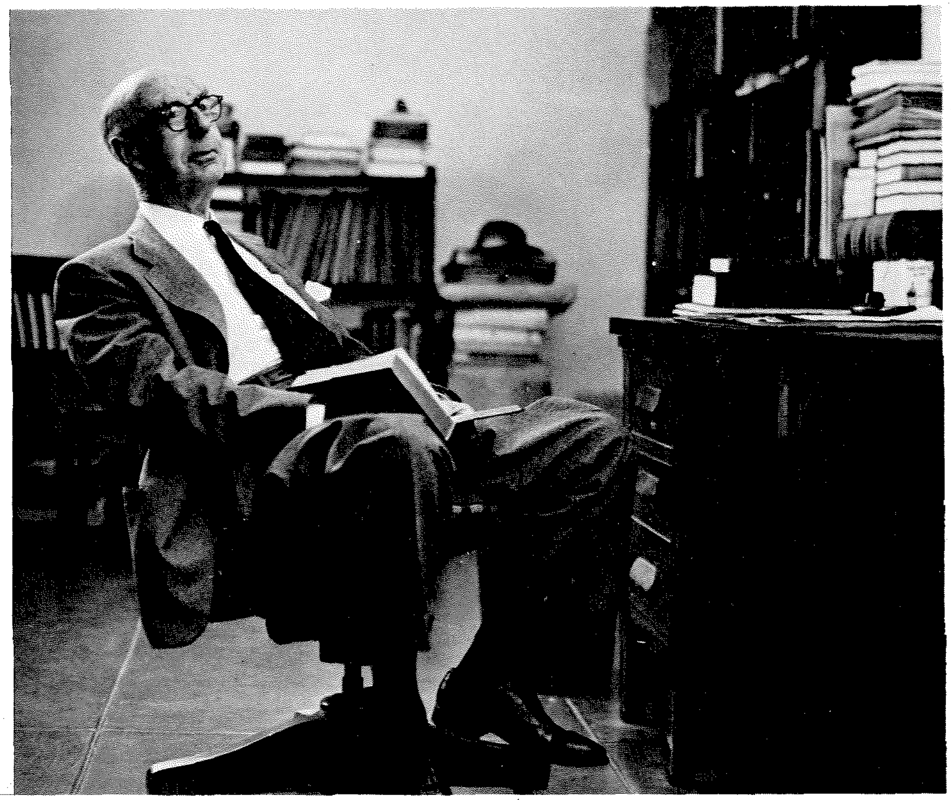
Henry's contribution to Caltech will not stop with his life. He confronted the monster that terrified most of us—the thought that we would be swallowed by our parking lots or deafened by our traffic. He knew that to lead the life of the mind, which is what Caltech is all about, it is necessary to have space, rest for the eyes and ears, some kind of order in the visible world. Close a street, plant grass and flowers and trees, tear down Throop Hall to provide an inspiring vista—he was often told it would be too expensive, or couldn't be done for one reason or another, but it usually turned out that he was right. And his vision of the environment for Caltech extended far beyond 1972. Future generations of students and faculty and staff will have reason to be grateful to this far-sighted planner whom they did not have the good fortune to know.

Henry and Doris worked best together. Their last, and perhaps their greatest, collaborative work was the *Henry Dreyfuss Symbol Sourcebook*, an international dictionary of symbols. They loved it—Henry with his belief that the eyes can catch visual symbols faster and more easily than the mind can catch words, and Doris with her keen insistence upon absolute clarity of meaning and simplicity of explanation. The whole world profits from their codifying a language which can be read by literates and illiterates, by people of many different cultures, and at the high speed required in a technological world.

In one of his earlier books, *Designing for People*, Henry wrote, "Wherever I go, I look for people who have achieved tranquility." He and Doris achieved it. Shakespeare knew about them:

Let me not to the marriage of true minds
Admit impediments; love is not love
Which alters when it alteration finds,
Or bends with the remover to remove.
Oh no, it is an ever-fixed mark
That looks on tempests and is never shaken.

George MacMinn
1884-1972



On October first, George R. MacMinn, professor of English emeritus, died in his home only a few blocks from the Institute. Professor MacMinn was one of the very few left of those who came to the Institute before it was Caltech; he arrived from Berkeley as associate professor of English in 1918 and retired in 1954. After 36 years of teaching at Caltech, he is probably remembered by more alumni than almost any other faculty member. In addition to the usual classes offered over the years by the English department, he taught courses in journalism, technical writing, American literature, and literature of the Bible. (One story has it that this preacher's son opened his classes in the Bible by making some offhand reference to God and then announcing: "And that, gentlemen, is the last time I shall utter that name in this course." It was Jehovah all the way.)

Coming to Caltech from managing the University of California Press at Berkeley, he organized the Caltech Press Club, and was for years the faculty adviser to the *California Tech.* Those who knew him well remember that he savored good journalism and the elegant phrase until the end of his life. He organized the first student dramatic club to put on modern plays. (Caltech had a tradition, which lasted into the early thirties, of producing Greek and Latin plays in translation.)

Born in New Jersey in 1884, George MacMinn received his AB from Brown University, and then as a young man went west, via Iowa State University and the University of California. And his intellectual interests went with him. In 1941 he published *The Theater of the Golden Age in California*, the pioneer study of the fabulous and bewildering theatrical life that hastened, like camp followers, to California after the gold rush. Much of his research for this book was done at the Huntington Library, where he is still warmly remembered after a third of a century. Out of his interests in teaching came two college texts, *Essays in Exposition* and *College Readings in the Modern Short Story*, the latter in collaboration with his good friend and colleague Harvey Eagleson. Before his death he had completed for publication a book-length manuscript, *Imagery in the Poetry of the Old Testament.* And among his papers there were enough lyric poems, both occasional and general, to more than make up a volume.

George MacMinn maintained a living interest in Caltech, especially in the humanities division, throughout his 18 years of retirement. This interest was fed in large part by his friends, and until his last year no news of the division, no publication—and not too much gossip—escaped his notice and, usually, his comment. But essentially his years of retirement he considered private years. He continued to live, as he always had, the life of a curable romantic; and he cured with a well-polished Stoic crust, which he used to protect himself and (especially after the death of his wife, Evelyn, in 1966) to save his friends from exposure to his own sometimes fretted nerves. His great loves continued to be music, especially Mozart and Vivaldi, and language. Elegance of diction earned his greatest respect, but a good pun always made him merry. He carried on long, delighted correspondences with persons whose minds he loved to taste, even when he had never seen them. Like a true romantic he loved, as he put it, "to squeeze the juice" out of an experience; and in his determinedly private retirement years even the simplest thing could be turned into an adventure—the blossoming of a jacaranda tree, the clear note of a lark, or shadows on the mountains.

—*Beach Langston*
Associate Professor of English

The Month at Caltech

Survey of Seniors

In May 1971 the Educational Testing Service conducted a survey of seniors at 94 institutions, including Caltech. The results have now been published, and though some of them reveal little that was not already known (for example, that 80% of Caltech's seniors plan to go to graduate school), some interesting trends did show up.

Many college students do not adhere to the orthodox religious backgrounds in which they were reared. This is even more true of Caltech students, and the trend increases from freshman to senior year. On the national average, the trend has been accelerating: College students in general have become like Caltech freshmen of a few years ago, and Caltech seniors have moved even further away from their family upbringing.

Caltech students often have been accused of knowing little beyond their courses, but the ETS study shows that this is not the case: 60% of Caltech seniors regularly read books that are not connected with their courses, compared with 45% of the national sample; and 57% of the Caltech seniors polled read scholarly or professional works on their own, as opposed to 48% of the comparison sample.

Caltech seniors were more active than their counterparts nationally: 43% of the Techers (as against 35% nationwide) were elected as officers of student organizations; 16% initiated or organized a student movement to change institutional procedures (as opposed to only 4% nationwide); and 15% were elected or appointed to a college office with power to influence policy, as opposed to 5% nationwide.

The Caltech seniors thought well of the school at which they had studied for four long years: 91% felt that they were "not treated as numbers."

When Fleming House picks up a trophy, they do it in a big way.

We've Got Their Number

Starting with a $50,000 grant from the Union Pacific Railroad Foundation, Caltech plans to modernize and computerize student record keeping. The consolidated, centralized system will improve the flow of information among the Registrar's, Deans', Graduate, and Admissions Offices. Automated processing should improve the scheduling of classes and final exams, maximize efficiency of classroom usage and instructional time, eliminate (or minimize) class schedule conflicts, and provide data for making academic plans and forecasting space and budget needs.

Cannon Law

Upon discovering that Southwestern Academy in San Marino had a spare cannon it was trying to dispose of, Caltech students in Fleming House decided to seize the opportunity to escalate interhouse warfare on the campus by several orders of magnitude. Two weeks of preparation and construction resulted in completely rebuilt wheels for the 85-year-old seige rifle, and general readiness for transport of the thing from the Southwestern Academy's front lawn, where the cannon had rested for 40 years.

One 3 a.m. Fleming struck *en masse.* With a veritable army of about 75, they dragged the big gun three miles from San Marino to the Olive Walk. In the weeks since, the residents of neighboring Page House have become noticeably more nervous as work progressed on restoration of the gun. At this writing it hasn't been fired, but no one is making any guarantees.

Record Breakers

The class of 1976, 231 strong, is the largest in Caltech's history, handily surpassing the 220 freshmen who arrived in 1970.

Why so many? Late acceptances did it. After the May response deadline, the Admissions Committee began to notify people on the waiting list because there were still some vacancies. The waiting-list students thereupon matriculated at a much higher rate than anyone had expected.

The ratio of men to women in the new freshman class is 205 to 26, about the same as for the last two years. (Women were first admitted in 1970.) Past experience predicts that, of the 231 members of the class of '76, about 145 will receive BS degrees at Caltech in the usual four years, and an additional 15 will take five years (or more) to do it. Of the remaining 71, most will receive bachelor's degrees from other schools.

Mariner 9 Retires

After 698 orbits of Mars which yielded photographs and other data of unprecedented volume and clarity, Mariner 9 finally ran out of gas. Specifically, its supply of nitrogen, used as attitude control fuel, was exhausted, and the satellite went into free spin.

After the spacecraft had returned 7,329 pictures, and stayed in orbit for almost a year (about eight months past the completion of its primary mission), JPL controllers finally had to send the command to shut the transmitters off.

Co-op Housing

In an effort to relieve the crush on the seven student houses, and to provide a supposed diversity of life styles, Caltech has gone into the co-op business. About 26 students now share the rent on three large houses just north of the campus on Holliston Avenue. They also share responsibilities for cooking, maintenance, and all of the other joys of householding.

If the experiment proves successful, several more Institute-owned houses may be converted into co-ops next year.

Black Hole?

"It is almost inescapable that (the X-ray source) Cygnus X-1 is a black hole," Dr. Richardo Giacconi of the American Science and Engineering Laboratory in Boston told a meeting of the American Astronomical Society at Caltech in October. Data from an X-ray telescope orbiting on the Uhuru satellite, have convinced some other astrophysicists that the source could be a star in the last stage of gravitational collapse.

Because of its intense gravitational field, a black hole emits no light, and in fact "swallows" any light coming near it. The only way now known to locate a black hole is if it forms a binary system with a visible star. By observing the visible star, the mass of the invisible partner can be inferred. A relatively small object, one with one to three times the mass of the sun, would most likely be a white dwarf or a neutron star. Something larger, however, could be a black hole.

After being scattered over the campus for the last year, the freshman chemistry labs are back in one place.

Noyes Annexed

When earthquake damage forced evacuation of the Gates chemistry labs almost two years ago, the freshman chemistry labs had to be scattered all over the campus. With the completion of the Noyes Annex in September, frosh chemistry finally has a new home.

The annex contains two large student labs, a seminar room, and instrument rooms and support facilities. Construction costs for the complex were held to $350,000 by tapping into existing utilities in Noyes.

After 52 years of service to freshman chemistry, Gates finally stands vacant. Present plans call for reinforcing the building to bring it up to safety standards, and remodeling the inner structure to serve as needed office space.

One Small Step

While hurrying across a park on the University of Chicago campus this fall—on his way to give a paper—Nobel Laureate Richard Feynman did not notice that the sidewalk he was about to cross was a few inches higher than the lawn. He tripped over the curb, and shattered his kneecap in the resultant fall.

Two passersby carried him to the hospital, where doctors removed what remained of his kneecap, and placed his leg in a cast. Confined to bed for a week, Dr. Feynman consoled callers by reminding them that basketball stars have learned to play without kneecaps, so a physicist should be able to do at least as well. In late November he was, by his own estimate, 98.9 percent recovered.

JPL Renamed

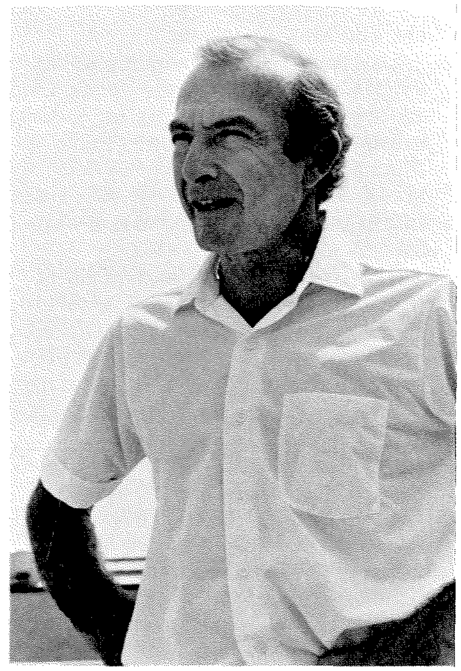
As a rider to a bill to create a national park to be named for former President Eisenhower, Congress recently passed a measure to rename Caltech's Jet Propulsion Laboratory the "H. Allen Smith Jet Propulsion Laboratory." The change honors the Congressman from California's 20th district, who is retiring this year after 16 years in the House of Representatives. The bill was signed into law by President Nixon and will take effect on January 4, 1973.

JPL is owned by NASA and operated for NASA by Caltech, so Congress has the right to rename JPL as it pleases—but the action nevertheless caught JPL and Caltech completely by surprise: Most people learned of the name change by reading it in the newspapers.

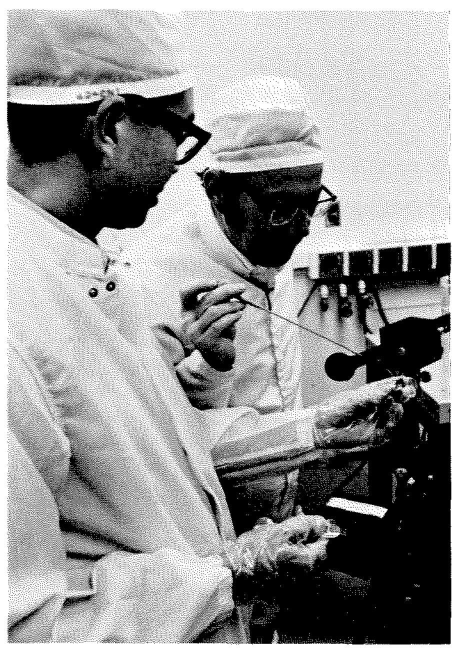
Student and faculty reaction was generally opposed to changing JPL's name, and a student group has been circulating a petition asking that the change be rescinded. "It's not that we are opposed to H. Allen Smith personally," said one of the student organizers, "but we don't think the name change is necessary. We like JPL. But if the name has to be changed, it should honor someone who has done a lot for the space program, and there are a lot of people—scientists and astronauts—who have done quite a bit more than H. Allen Smith."

Faculty Honors

Alan R. Sweezy, professor of economics, has been elected chairman of the Planned Parenthood Federation of America.



Sheldon K. Friedlander, professor of chemical and environmental health engineering, has been appointed consultant to the Los Angeles County Air Pollution Control District.



Gerald J. Wasserburg, professor of geology and geophysics, has received NASA's Distinguished Public Service Medal.

Letters

Timbuktu Revisited

Champaign, Illinois

DR. and MRS. CLAUSER:

Last spring as I was winding up my Peace Corps work in Sierra Leone, I read about your Sahara crossing and glorious entrance into Tombouctou* ("To Timbuktu—the Hard Way"—*E&S,* March-April). I had already made plans to visit there, so I decided to find your friends.

My trip was a bit easier than yours. On August 3, I flew Air Mail up to Tombouctou. A Mali Tourism Office bus met the plane and carried me and a few other passengers into town. I was pleased to discover that I was sitting right next to the hotel director, who had come out to meet the plane. In my halting French, I launched into an interview with him. Yes, he remembered you (how could anyone forget?), and he was pleased to see the copy of *E&S* that I had brought along. Unfortunately, the hotel chauffeur who had met you was out of town.

I spent the day exploring, and in the evening walked out onto the desert and sat for a while watching the stars. When I came back, I headed for my room, but a man intercepted me with a lot of French too fast for my comprehension. Then I figured it out; he was the gung-ho chauffeur who had led your welcoming party. The rumor of my arrival reached him as soon as he got back into Tombouctou, and he was eager to see the pictures and the mention of his help in the *E&S* article.

The next morning I had to fly out, but I left my *E&S* there with your friends, who send you their greetings.

My congratulations on your successful Sahara crossing! I talked to others who had done it, and it sounds like a mighty tough expedition. Good luck on all your future adventures.

LAWRENCE SHIRLEY, '69

**For anyone who questions the difference in Larry's spelling of the name of the city and ours, we'd like to point out that our atlas gives both of them—plus "Timbuctoo." As far as we're concerned, it's dealer's choice.*

In Memory of Milton Humason

Gumligen bei Bern
Switzerland

EDITOR:

On June 18 of this year, Milton L. Humason (1891-1972), formerly of the Mt. Wilson and Palomar Observatories, departed forever to the hunting grounds of the world's great astronomers. There we imagine him happily comparing notes about the baffling intricacies of our universe with Aristarchus, Galileo, the Herschels, Bessel, Fraunhofer, and George Ellery Hale, his former chief and promoter. Although disregarded by the mutual admiration societies and the windbags supposedly researching for the large national magazines, Humason has left his mark on astronomy for centuries to come, if the world survives that long.

Those of us who were lucky enough to be among his friends will always remember him for three most outstanding achievements.

First, as one of this century's great, if not its greatest, observer he enriched our knowledge enormously both through his discoveries and his penetrating observations of cosmic bodies and phenomena. These include comets, various features

Milton L. Humason

of the sun and the planets, the spectra of white dwarfs, remnants of novae and supernovae, the Humason-Zwicky stars, galaxies in general and their nuclei in particular, as well as clusters of galaxies to the remotest distances.

Humason never let himself be bluffed by those perennial high priests in astronomy who think they know it all. Although these moguls and their innumerable sycophants steadfastly claimed that the increasing redshifts observed by Humason in the spectra of ever fainter clusters of galaxies clearly meant that the universe is expanding, he never wrote about *the* velocities of recession of the respective galaxies but continued to call them *apparent* velocities of recession (and later, the symbolic velocities of recession).

When some colleagues denounced my search for faint blue stars near the north galactic pole as one of the "worst" jobs done in modern astronomy, Humason spent several years quietly observing their spectra and proved that each one of these stars (now called Humason-Zwicky stars) was unique and of a type not previously known. Likewise, when some of the so-called "greatest" insisted that intergalactic matter does not exist, or at least that it would never be observable, Humason most effectively collaborated with me to prove the contrary.

Upon his retirement from the Mt. Wilson Observatory, Humason joined me in my search for supernovae at the Palomar Mountain Observatory. During the five years of his work there, he discovered about 30 of these very rare objects, among them the first of a most important new type III.

Secondly, many who were originally outsiders to astronomy, and especially some of us lone wolves, could never have achieved what we did without Humason's continued support and help. He saw to it that the Babylonians had to allow us "undesirables" the use of the giant telescopes of our two observatories. He also spent much time instructing us, so that we would be able to make optimum use of the available instruments.

Finally, and perhaps most important, Humason was the ideal of a scientist who knows that society has made it possible for him to pursue in peace the quests that interest him most, and that for this privilege he must in turn serve and repay society. He thus became one of the all-too small group of scientists who consider it their highest duty to bridge the ever widening gap between science and the general public. For this many men in all walks of life will remember him as their friend.

He always had the goal of a sound society and a beautiful world in his mind rather than the realization of any of the degenerate ambitions which motivate the actions of so many misguided scientists.

FRITZ ZWICKY
Professor of Astronomy
Emeritus

Climb Our Mountain

Pasadena

EDITOR:

In January 1962, *E&S* published a letter from Richard Jali, '55, saying that a peak in the California Sierra had been named after Caltech. Jali, along with Jim Eder and Ted Matthes (also class of '55), had made an ascent of this peak on June 25, 1961, and they then proposed to the Board of Geographic Names of the Department of the Interior that the mountain be named Caltech Peak. The proposal was accepted, and the name appeared on topographic maps within a year or two afterward.

I passed through the area in 1965, thought it was nice that there was a Caltech Peak, and forgot about it until the summer of 1971 when I spent 10 days camped at an unnamed lake within sight of it. I took a picture of the mountain then, and hung an enlargement on the wall of my office when I got back to Pasadena.

There it attracted the attention of Jim Greenfield (at that time director of corporate relations in the Institute's development office). He had climbed the peak in 1970 in a party with Dick Mooney from the business services office. Greenfield urged me to make the climb when I returned to the area the next summer, so on August 20, 1972, my wife and I went to the top.

We started out at 7:40 a.m. from our camp some six miles distant and west of the ridge on which the peak is located. We weren't sure we could make the climb from that side, but it looked easy to get to a saddle on the ridge about a thousand feet below the summit. We thought we could scramble around from there to the eastern side and then walk up the comparatively easy eastern slope.

At 9:20 we were at Lake South America, directly west of the saddle, and we climbed the 900 feet to the saddle by 10:45. There we discovered that the ridge falls off very sharply to the east, but a chute leads upward on the western slope. We followed that up for another 100 feet, and it took us to an easy route on the eastern side. By 12 noon we were at the top—13,832 feet high.

A group of people who had climbed the peak on November 10, 1963, had left a register at the summit—a notebook placed in a tobacco can tucked under a rock cairn. We read the register carefully, and I tried to note all the Caltech people who had been there before us. One of the entries, dated August 16, 1964, consisted of four or five pages of history and glowing description of Caltech written by Thor Hansen, '64. It made me realize that I should probably have brought along a catalog—or at least a copy of *Facts About Caltech*—to leave at the top.

After that there was a five-year gap before Eric Jensen, '70, and Roger Jensen, ex '71, signed in on August 21, 1969. They were followed a couple of weeks later by Volker Vogt, '64. Vogt's party, camped at Milestone Basin, included Roger Hendrix, '65, and Alan Limpo, '64, but it does not appear that they climbed the peak.

Dale Dalrymple, '73, made the ascent on September 12, 1971, spent the night 30 feet below the summit, and headed along the ridge to Mt. Stanford the next day. My wife and I seem to be the only two Caltech people who climbed the peak in 1972.

We spent an hour at the top, looking around, taking a few pictures, and eating lunch, and started back to camp at 1:10. My notes say, "Arrived camp 4:05—a great day."

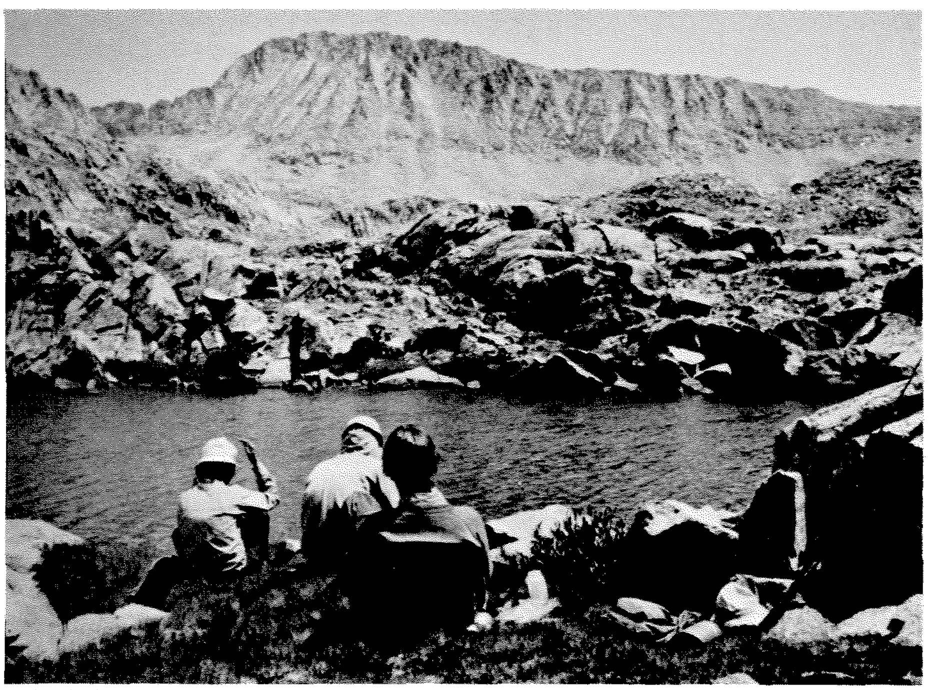
It *was* a great day; the views in all directions from Caltech Peak are sensational. To the south is the entire Kern River valley, and you can see the peaks in the area around Mt. Whitney on one side and the Kaweahs and the mountains to the north and south of them on the other side. To the east are Mt. Tyndall and Mt. Williamson (at 14,375 feet the second highest in the Sierra) and Diamond Mesa just across the John Muir Trail. Directly west the entire basin of the upper Kern River is laid out before your eyes. It was so beautiful we had a hard time tearing ourselves away.

As Dick Jali indicated in his 1962 letter, the climb is long (26 miles) and arduous if you do the entire trip from Independence, over Shepherd Pass, and then up the mountain and back again. However, it is an easy day's hike from any camp in the Upper Kern area or along the Muir Trail near Tyndall Creek.

The *Climber's Guide to the High Sierra* indicates that an eastern approach is Class 2—that is, it may require holding on with the hands occasionally, but in general it is possible to walk to the top. The western approach is Class 2 with a short 50-75 feet of Class 3 climbing where footholds and handholds are necessary. Whatever the class officially assigned to it, the climb is not really difficult or dangerous. It does require some agility in scrambling over rocks and keeping one's footing in steep, loose sand and rock.

The peak is not as high as Mt. Whitney, but the views are just as spectacular. One refreshing difference is in the number of people climbing the mountain on any summer day—two or three, possibly, rather than Whitney's several hundred. Climbing Caltech Peak is a grand experience, and I hope other students and faculty will want to make the effort—and enjoy the scenery and the special sense of "ownership" that we felt.

WILLIAM P. SCHAEFER
Registrar



Caltech Peak

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