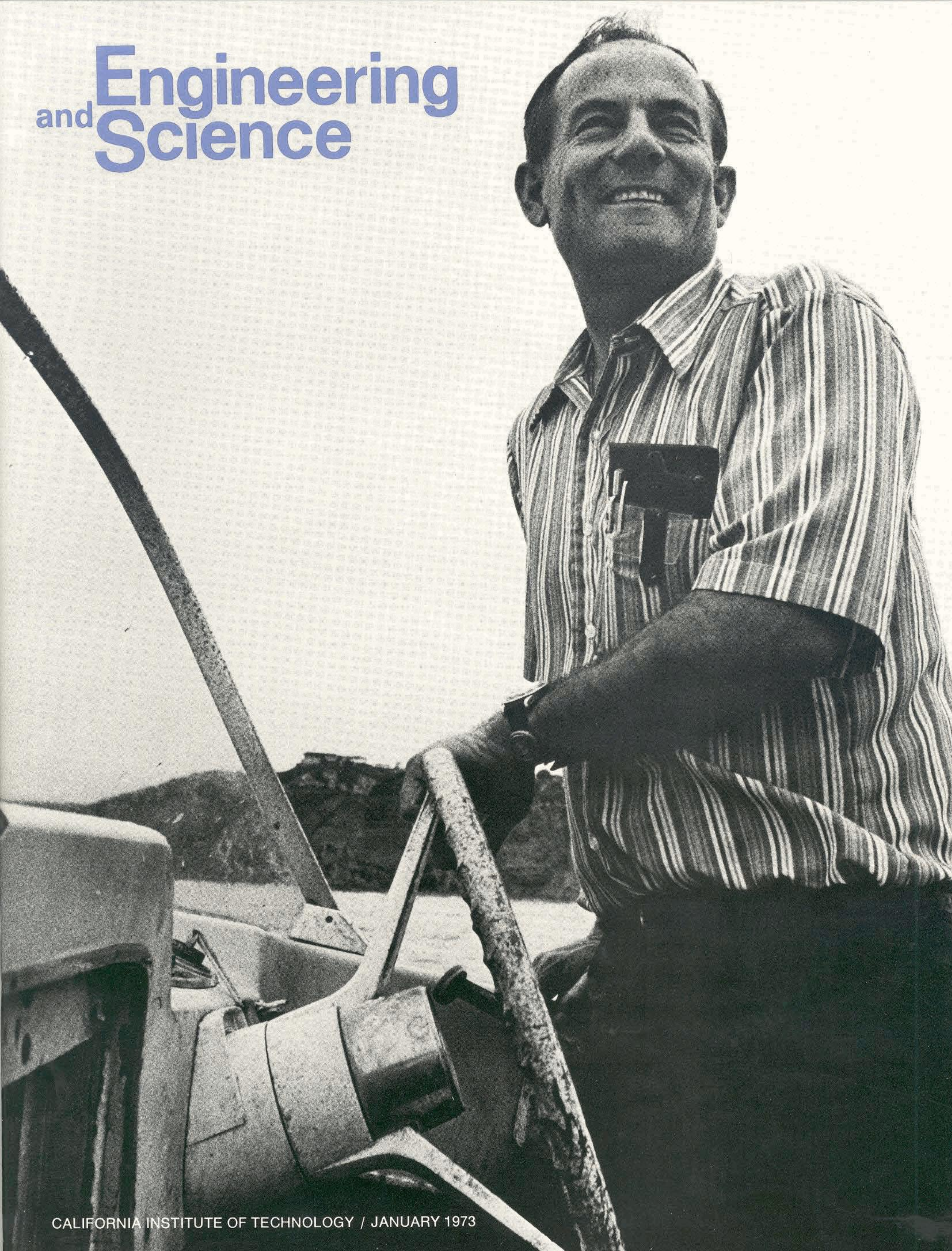
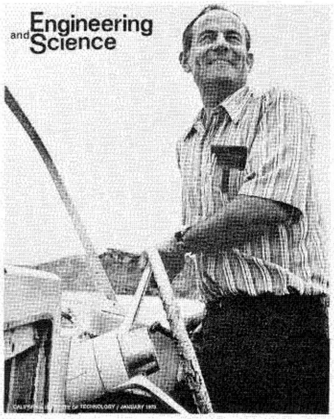
# Engineering and Science



CALIFORNIA INSTITUTE OF TECHNOLOGY / JANUARY 1973




**On the cover**

Wheeler North, professor of environmental science, is at the helm of the marine laboratory's boat—and also of a project to restore California's once-lush kelp forests. North graduated from Caltech in 1944 and has been a member of the faculty since 1963. "Help for Kelp" (page 14) summarizes some of his research problems and progress.

# In this issue

**Brown Bag**

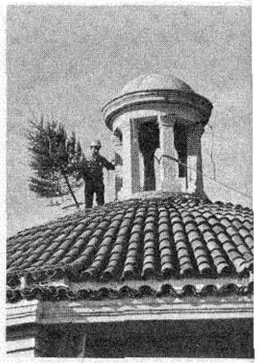
Just a year ago *E&S* published excerpts from an interview with Harold Brown by a representative group of faculty and students. That was such an informative session that we repeated it this year—with interviewers representing a much broader segment of the Institute community. Some of the highlights are on page 4.

**Last Man on the Moon**

The Apollo 17 launch from Cape Kennedy on December 6 had a special interest for Caltech. It was the last scheduled moon launch, after 10 years of manned space exploration. It was taking the first scientist-astronaut to the moon. And he was Caltech's Jack Schmitt (*E&S*—October 1972), who got his BS in geology here in 1957. Naturally, then, Graham Berry, director of Caltech's news bureau, flew to the cape to make sure Jack got off all right. Berry's vivid firsthand account of the launch is on page 8. It is accompanied, appropriately enough, by a set of striking photographs of the launch taken by Alan Stein, Caltech '71.

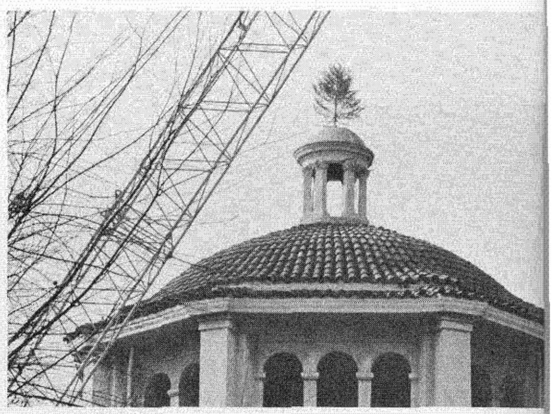
**Continued Story**

In our account last month of old Throop Hall, we included a picture of the Christmas tree that has traditionally spent the holiday season perched on the Throop dome. Amazingly, this year it appeared again and made a defiant last stand until the wrecking crane moved in on December 20. In the spirit of the season, though, the wrecking crew removed . . .



the tree before starting to destroy the building—then *topped* this gesture on . . .

Friday, December 22, by putting the tree back *up* again for the holiday weekend.



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and Engineering and Science

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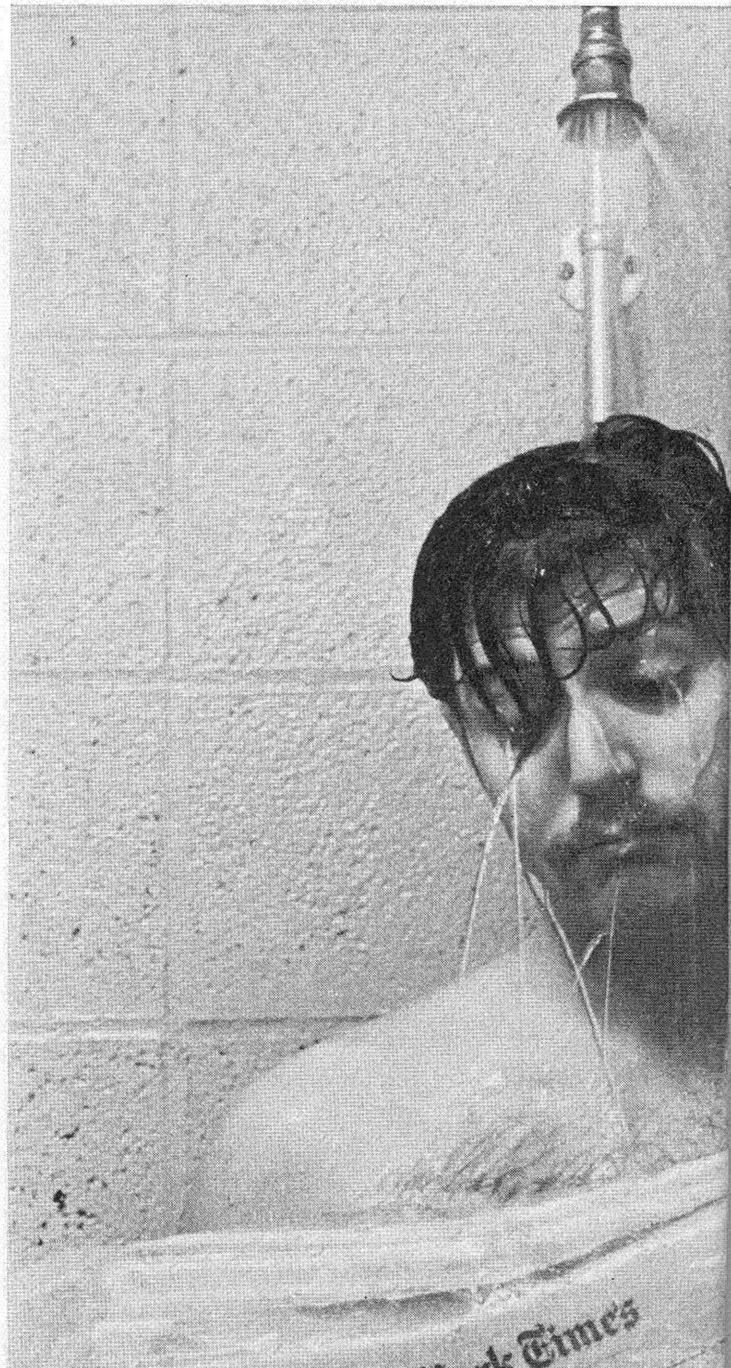
# We keep the news fit to read.



# AN INTERVIEW WITH HAROLD BROWN

**THE PARTICIPANTS**

**Anne Bacon**, assistant to director of development
**Peter Beckman**, '74, editor-in-chief, California Tech
**Jesse Beauchamp**, associate professor of chemistry
**Don Davidson**, '38, chairman, Alumni Fund
**Lee Hood**, assistant professor of biology
**Don Hudson**, professor of mechanical engineering and applied mechanics
**Andy Ingersoll**, associate professor of planetary science; staff associate, Hale Observatories
**Joe Morin**, '73, president, board of directors, ASCIT
**Jerry Pine**, professor of physics
**Gerry Ward**, chairman, Graduate Student Council

BACON: I remember in the early fifties it was being said around the nation that we didn't need any more scientists or engineers. Then suddenly the demand went up again and there was the great boom. Now, with the federal government withholding funds, are we going to find ourselves in the same boat we were in 20 years ago? Is pure research going to be hampered—and graduate fellowships?

BROWN: It is certainly true that the demand for graduate science and engineering seems to go in cycles. It is also true that federal support seems to go in cycles, and federal interests seem to change from one thing to another.

The up-cycle that started in 1957-58 with Sputnik was actually a continuation of an overall trend that began right after the war, of *very* strong federal support for basic research, which produced a certain way of supporting graduate students too. It was run that way for about 20 years—and it's *still* run roughly that way. But in the late sixties national interest—popular interest—began to change. People became more and more concerned with social ills whose solutions weren't possible in purely technical terms. In the second place, the university population, which had been going up very fast all through the fifties and sixties, had to level out—just as any exponential has to level out.

These two things came together, along with a federal fund shortage, to produce a very severe crunch on the universities. I think Caltech hasn't suffered nearly as much as many other places, but we've had our difficulties, too.

The federal government's reduction of support for science and technology has, of course, hurt our support of graduate students. There has been a confusion, I think, between the need for scientists and engineers in society as a whole and the question of how rapidly the universities can continue to grow. Our own students have been largely oriented toward academic research after they leave. And that's where there's been the most severe leveling out of job prospects

I think that as people become clearer on what the real societal problems are, and as they become clearer about how to solve them, there is going to be an increasing number of jobs for technically trained people, because all the questions of environmental pollution and regulation of environment, and new transportation systems, and so on, are going to demand new kinds of technology and new people to do them.

I don't think that Caltech can, any better than any other place, outguess the future to the degree of training people now for what they will be needed for very specifically 15 or 20 years from now. I do think that a Caltech education can be, and to a very real degree is, training people broadly enough in science so that they *can* move from one thing to another.

HOOD: It seems to me that one of the things Caltech has been very good at in the past is guessing where the action is going to be in the future. It's very evident now that we have limited resources with which to make guesses, so, in your estimation, where is the action going to be in the next ten years?

BROWN: When I start to answer the question of whether we should go into this or that area, it is on the basis of several things. First of all, in which areas is it going to be important for academic science to produce results? What is society going to be interested in? Where does the science and technology itself lead? It's not enough to have a problem. The state of the technology and science has to be such that you can contribute to the solving of the problem. That leads to the third matter—specifically, what talents does Caltech have, or can it accumulate, to help solve these problems?

It seems perfectly clear to me that biology and chemistry, and engineering also, can and will combine to make big advances in medical technology.

Another area is the application of engineering, and science, to problems of environment. I would include in that, for example, some of the things we are already doing —our environmental engineering sciences program, and also the Environmental Quality Laboratory. EQL is rather different from some of the things we've done. The problem is to make sure that there are enough components of technology in it so that the faculty feel comfortable with it. But I would associate that problem also with something that's quite different in organization—namely the Center for Natural Disasters—which is a center for research on the problems of natural disasters. That clearly has a much larger component of technology. Nevertheless, it also has to bring in the studies of systems and of public policy, the economics of these questions, and the political and social problems that go with them, because insurance is a big part of natural disasters, and land use is a big part of natural disasters, and all the rest. I would place the Disaster Center with the Environmental Quality Laboratory as an attempt by people at Caltech to try to bring together different kinds of technology, and to apply

them to problems that either implicitly or explicitly are matters of public policy.

The Population Program is not quite as well known at Caltech as the other two, but it exists here and might in the future combine very well with EQL to look at a still broader question of public policy.

Now all these things are largely applied. I think that there are also some places in basic research that are flowering or are ripe to be exploited. It is clear that astrophysics—both experimental and theoretical—is really coming up with new things faster than people can explain them, and we might be willing to gamble on setting up something in that area.

But I'm not foolish enough to think that this sort of question is something I can decide all by myself. Even if I had the power to do so, I don't think I'm smart enough. I have to listen to other people, and try to decide who to listen to, see what the consensus is—if there is a consensus —and then make my decision.

INGERSOLL: We've been talking about areas of research that Caltech might move into. What about teaching? It seems to me there's a demand for good science teaching at the graduate and undergraduate level, and that Caltech *has* good teachers who are perhaps not being used to their fullest capacity as teachers. One of the reasons is that students are so expensive. Do *you* feel that students are expensive? Do you feel that Caltech is going to take more or less advantage of its teaching capabilities?

BROWN: It depends on how you calculate the expense of a student. If you do it by dividing the resources we've got for teaching (which is essentially the number of faculty that a certain limited amount of dollars can pay

We should have as many students as we can without seeing the quality of the teaching go down. That's why I'm in favor of a slightly larger student body

for)—if you divide that by a certain number of students, then the answer comes out that students are expensive. To me, that suggests that we should have as many students as we can without seeing the quality of the teaching go down. And that's why in general I'm in favor of a slightly larger student body. Many faculty feel that beyond a certain number the nature of the interaction with students changes and the quality goes down. However, I would still favor adding students until you get to the point that the nature of the educational experience changes, and I think that 800 is *not* the limit for undergraduate students. I would be very surprised if it were 1,000—but I don't think it's as low as 800, and for that reason I think it would be a mistake to reduce it to 600 or 500 as some people have suggested.

I haven't really answered your question, except to suggest that one way Caltech can do more teaching is to have *some* more undergraduate students—and graduate students too.

INGERSOLL: I think some demand for teaching is for a different sort than we presently offer our undergraduates. It's perhaps more popular science for adults who want to learn a little physics, and maybe never use it. It would be for students—but not necessarily young students. This is a pet thing with me. Adults may want to come here and take classes. Is that a potential financial source for Caltech?

*Beckman*

BROWN: Yes, but indirectly. We do a certain amount of popular science—like the Watson lectures in the Beckman Auditorium. I think those are very popular. But I think there's something worth seeking, at least, in trying to bring that kind of thing to a much larger audience. Some faculty members, I think, would be interested in giving a series of lectures which describe modern astronomy—or six or ten lectures which describe geological or planetary science, or biology, chemistry, or whatever. We're toying with the idea of organizing a subsidiary, to which Caltech would lend its name; and interested faculty members, for a consulting fee, would give such lectures.

If the new videotapes and cassettes prove as inexpensive as some people think, you might have an enormous home audience for this thing, as well as a separate audience of junior college and college people, and it might serve a much broader educational function. The faculty might be more interested in doing this than in

*Ingersoll, Bacon, Ward*

some of the consulting they now do, in fact—and it might make some money for Caltech too. It's kind of an exciting idea—I don't know whether it will work. It depends on a lot of marketing and production questions that I don't know the answers to. It also depends on whether there are enough faculty who are both able and willing to do the lecturing and can do it well.

WARD: Some people I've talked to both within the Institute and from outside have expressed the feeling that perhaps private education will undergo a demise in the next 30 to 60 years because of financial difficulties.

BROWN: It may not take that long.

WARD: My question is, do you think this is likely, and what can be done about it?

BROWN: I think it's possible. Maybe I have to be an optimist, but I don't think it is likely for the leading private institutions, although there are some examples of rather good ones that have in a sense gone under. They have not disappeared from view, but they have become either supported or run by the state. Many public schools are very good and innovative, but I think they'd be much less so if they had no competition at all from the private schools. So I think the incentive is there and as long as enough people work hard at it, there's a chance of keeping the private schools—if not affluent, as they once may have been—at least in acceptably good health. I'm willing to work at it.

PINE: I wanted to ask you to put yourself in the position of maybe the chairman of an influential faculty committee —instead of administration. What would be your pet causes to improve the level at which we do our teaching?

BROWN: I think I would, under those circumstances, take a very careful look at shortening the curriculum. Students seem to come with so much better preparation than I recall arriving in college with, that I should think it would be possible to cut some things out. Whether it's humanities requirements for some students who now get in high school what I didn't get until I was in college, or whether it's abandoning some of the physical science requirements for students who aren't planning to be faculty members on the physics or chemistry faculty of a research university, I don't know.

I am not suggesting that every student make out his own curriculum or simply announce that he has been at Caltech long enough to consider himself educated; although I wouldn't rule out trying that with a few students, just to see how it worked. But there do seem to me to be an awful lot of required courses, and the more requirements there are beyond, say, one year's worth of courses—the less possibility there seems to be for educational innovation.

BECKMAN: I was wondering—about once a year the local rumor mill comes up with the story that the trustees are about to change the teaching functions by abolishing the undergraduate option, turning Caltech into a grad-only teaching institution.

BROWN: You know, I've never heard that from a single trustee. I've heard it from a lot of other people around here.

BECKMAN: Do you think this is a possibility?

BROWN: I think the trustees, if they got a strong recommendation to this effect from the faculty or from me, would have to look at it very carefully before they could be persuaded to abolish undergraduate education at the Institute.

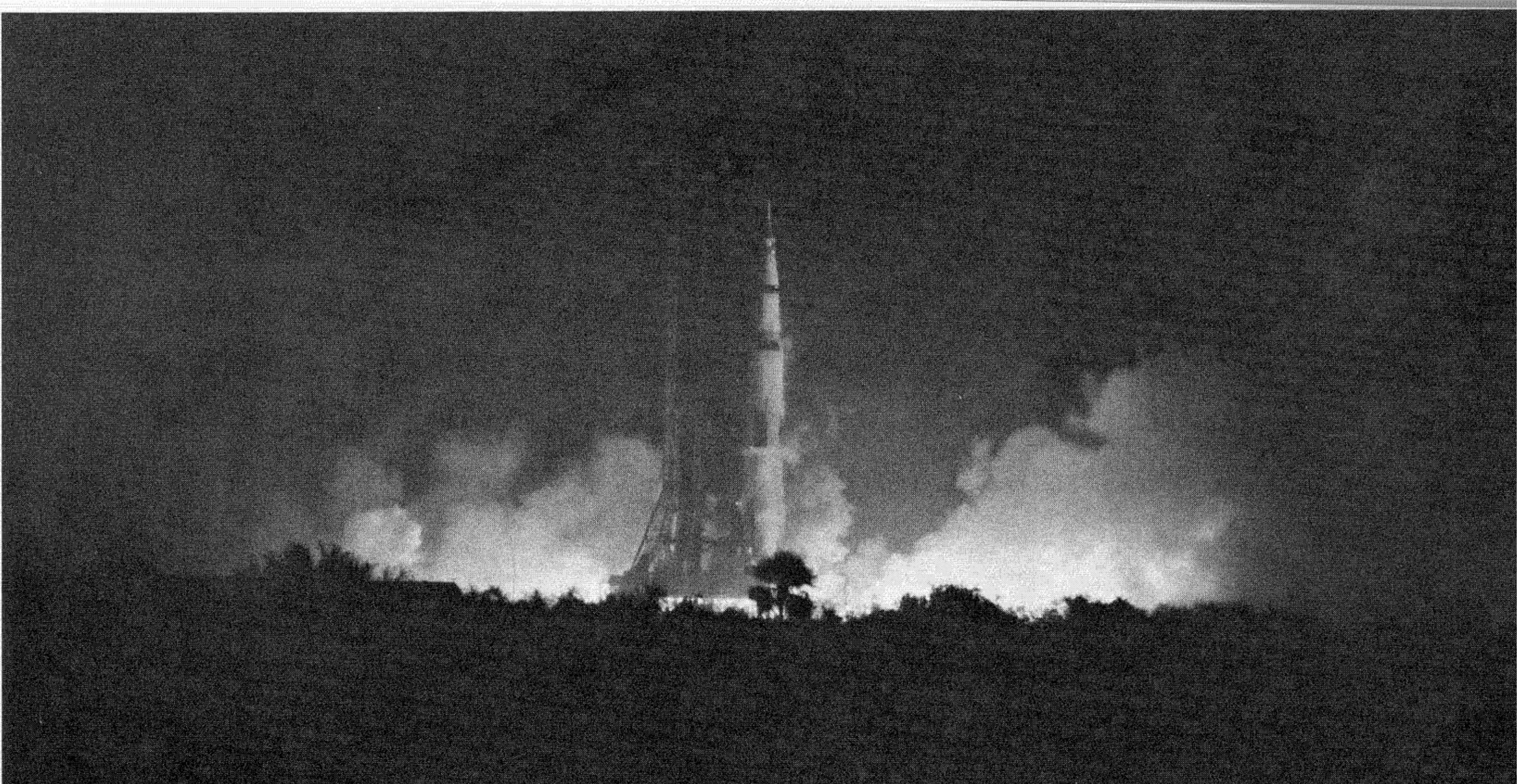
HUDSON: What do *you* think the undergraduate school does for the Institute?

BROWN: I think it gives us a little flavor. The undergraduates are not all quite sure about what they want to do. And so they put the rest of us to a little more of a test to justify what *we're* doing. Otherwise I think we would be even more introspective and self-satisfied than we are.

HOOD: I've got friends at MIT and Harvard who say there's considerable pressure these days to hire women faculty members. As far as I know, we have two, or something like that?

BROWN: Two professorial faculty members, out of 250. And the pressure is on us too.

*continued on page 30*



# APOLLO'S LAST FLIGHT

Poised for lift-off on December 6, Apollo 17 gleamed in the greenish white glare of spotlights. It stood upright like a 36-story white arrow on the launch pad next to its umbilical tower. The only visible movement was oxygen boiling from the tanks and condensing into a vapor trail that undulated lazily before evaporating in the black night beyond the glare.

Suddenly clouds of orange steam and smoke exploded from the pad. The orange became brilliant white and slowly the great bird lifted, the growing white tail illuminating like daylight the surrounding flatlands, lagoons, and estuaries.

There were spontaneous cheers at the news site three and a half miles from the launch pad. The lift-off was beautiful after an unprecedented two-hour and forty-minute delay.

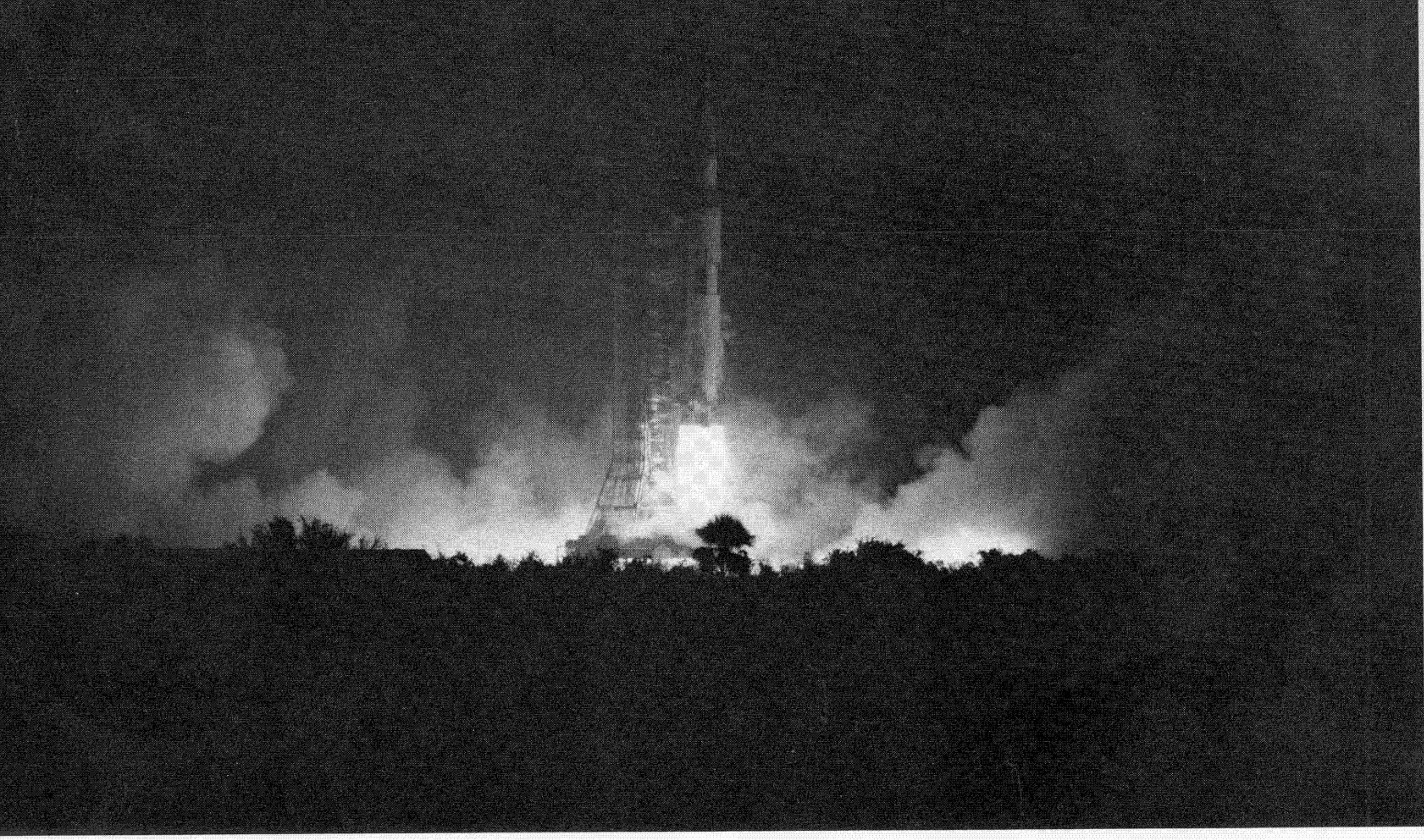
Some neophytes wondered why the lift-off was silent. The wonder was cut in mid-thought as the ground began shaking, accompanied by a low rumble. It was a Cape Kennedy earthquake. As the bird climbed higher, the rumble broke into a great roar that cracked into a thousand fragments like the snapping of countless bull-whips, as shock waves from the Saturn nozzles lashed at each other. It was stimulating and awesome to see, hear, and feel the power required to carry three men far from the earth.

Apollo 17 continued to stream upward ahead of its half-mile trail of white fire, and soon became visible to a half million people crowded along the causeways and estuaries around the Kennedy Space Center. They had come in autos, campers, trailers, motor homes, trucks, buses, planes, and boats from everywhere. The highways were lined with parked vehicles and all the big parking centers on the Cape were jammed with buses.

As Apollo 17 continued to climb, it could be seen over much of the southeastern United States, the Bahamas, and northern Cuba. It arched over slowly as it climbed, its unique broken roar barely audible. It was visible for six minutes before disappearing into the night.

More than 2,000 people at the Apollo news site began pouring out avalanches of words and pictures about the spectacular departure and the significance of this last of the great Apollo flights to the moon.

The exhilaration of the lift-off pushed thoughts and emotions swiftly through one's mind. It was clear that the event was emphatic evidence that America, torn with self-criticism and inner hostilities, is capable of great achievement. This certainly was one. In fact, to be able to send men to another cosmic body with the great expectation of getting them back safely is a momentous accomplishment in itself. Even those who see the Apollo program as a "moon-doggle" and say it is of no practical value must



admit that is a great engineering and technical endeavor.

It is, of course, that and more. Much more. The Apollo program marks a historic point in the earth's history comparable to that when animals evolved from the sea to the land. As President Nixon said of Apollo: "Few events have ever marked so clearly the passage of history from one epoch to another." Many agree that when the history of the 20th century is written it will be remembered above all else as the time when man broke the gravitational chains that bound him to the earth and began the exploration of space.

A frontier has been reached whose potential cannot yet be realized. It is known only that the objectives and findings will be different from those of the more familiar frontiers of the past that produced homesteads, gold, and other treasures. Despite claims that the benefits of the space program are its practical spin-offs in such things as the miniaturization in electronics and seismology—and they are benefits—the real treasures are yet to be found. They may include much more knowledge about the solar system, a more enlightened sense of human values, and perhaps even the discovery of life elsewhere in the universe.

We can hope that America, which has played such a key role in the pioneering push to get man into space, won't let the challenge drop. At this time its value cannot be

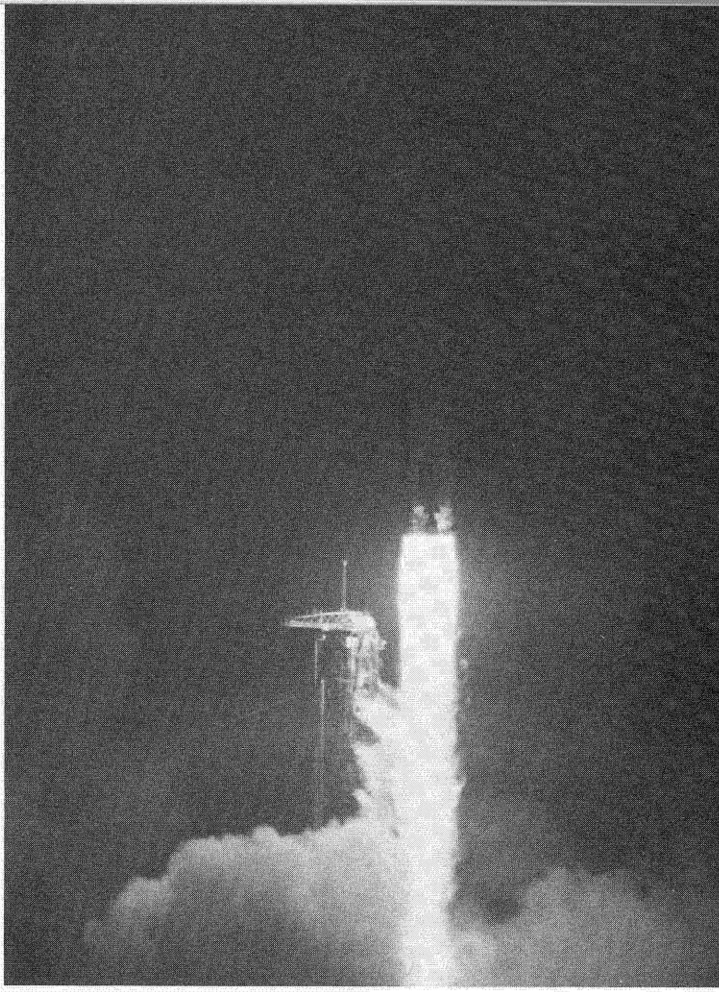
by Graham Berry

determined on how much revenue it will bring in. It is not for people whose feet are in the clouds and whose heads are in the cash register.

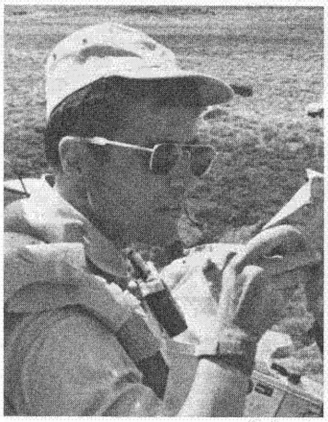
The magnificent torch of the space program will continue to be carried by institutions like Caltech, whose head has been the clouds for several generations. One of Caltech's founders, George Ellery Hale, lifted the Institute's eyes above the horizon long ago in pioneering the building of such great instruments as the 200-inch Hale telescope at Palomar and the 100-inch at Mt. Wilson.

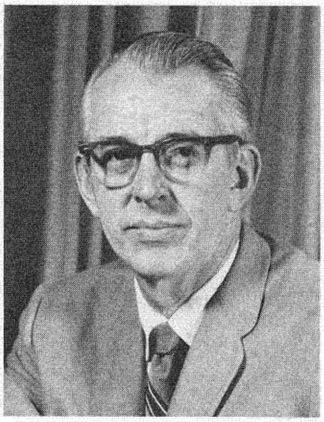
As they should, Caltech and Caltech people have played leading roles in America's space program since the start—only 13 years ago. Under Director William Pickering, Caltech's Jet Propulsion Laboratory led this country into the space age with the flight of Explorer I, launched from what was then Cape Canaveral, on January 31, 1958. Today at Cape Kennedy the Explorer I launch pad is marked with a plaque commemorating that milestone.

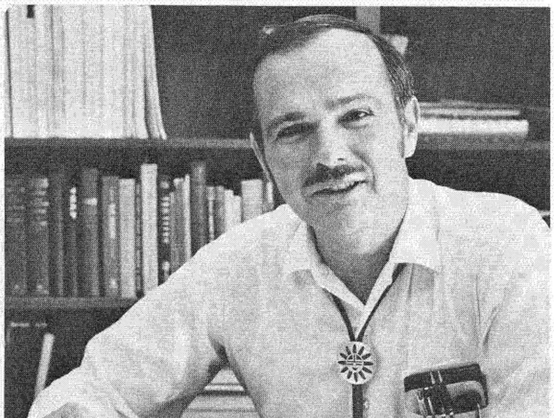
## Caltech men have played leading roles in the space program from the start




*Pickering*


*Schmitt*


*Fletcher*


*Shoemaker*

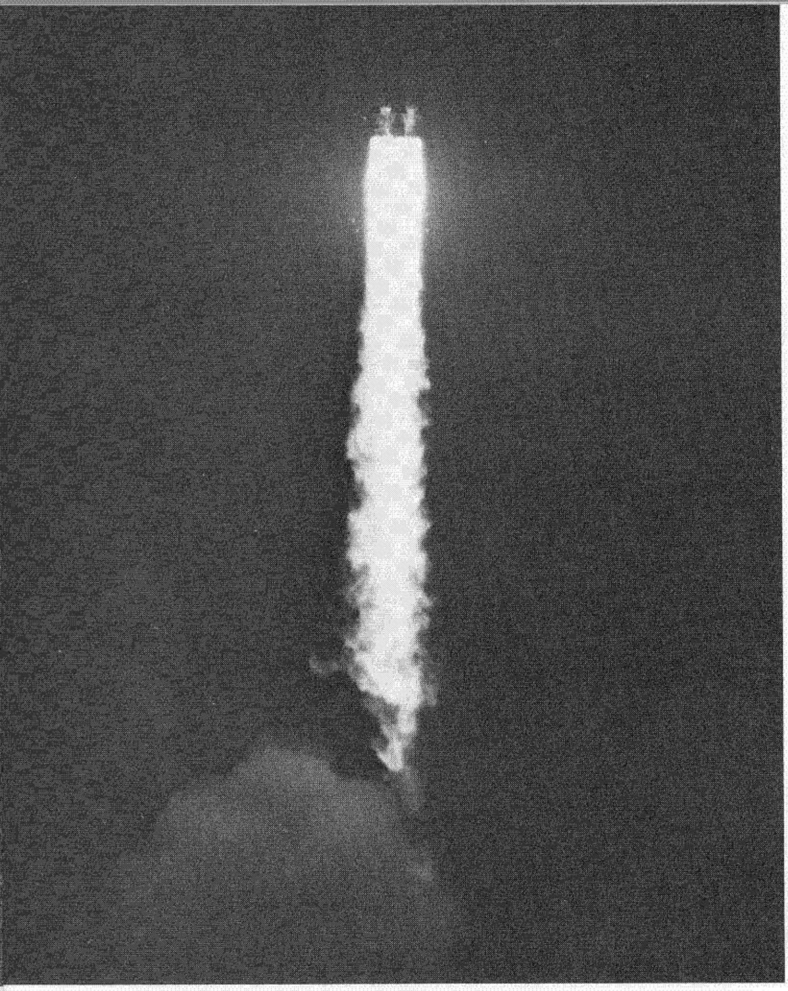
In addition to managing the successful Mariner flights to Mars and Venus, JPL directed the Ranger and Surveyor spacecraft programs. They paved the way for the Apollos by determining that the lunar soil would support the weight of a man so that he wouldn't sink into a sea of dust. The Rangers and Surveyors, along with Orbiter, helped locate suitable sites for Apollo landings.

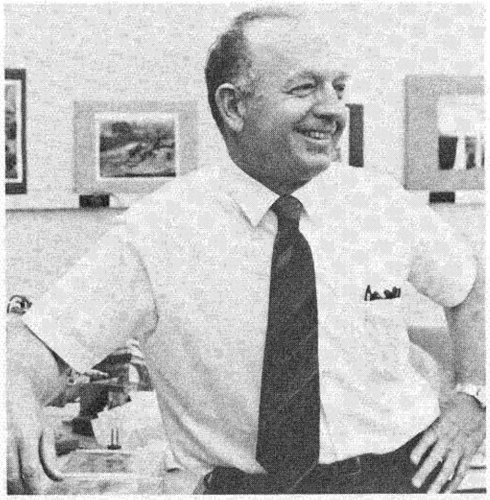
Many more Caltech people than can be listed here are intricately woven into America's space effort. NASA Administrator James C. Fletcher (PhD '48) is a Caltech alumnus, as are many other NASA executives, astronauts, scientists, and engineers. And Caltech faculty members have been active in the space program since its inception.

One Caltech alumnus, Harrison H. Schmitt (BS '57), was the first scientist on the moon, as a member of the Apollo 17 crew along with Eugene A. Cernan and Ronald E. Evans. ("Our Man on the Moon"—*E&S*, November-December 1972.)

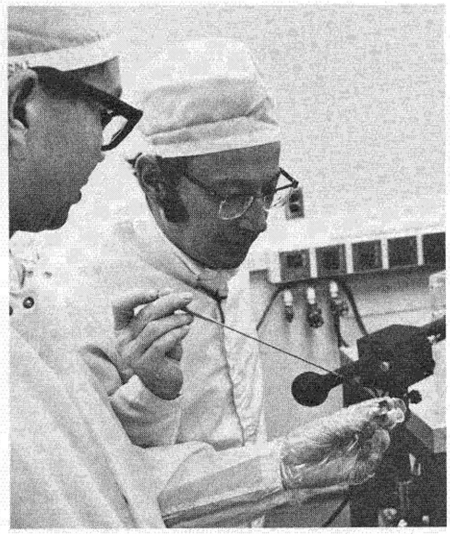
Another Caltech alumnus, Frank Borman (MS '57) was a member of the Apollo 8 crew that in 1968 made the first flight from the earth to another body in space. Apollo 8 orbited the moon ten times, as planned, and included earth and lunar photography and live telecasts.

Caltech even has a frustrated astronaut. He is Eugene Shoemaker (BS '47, MS '48), professor of geology, who

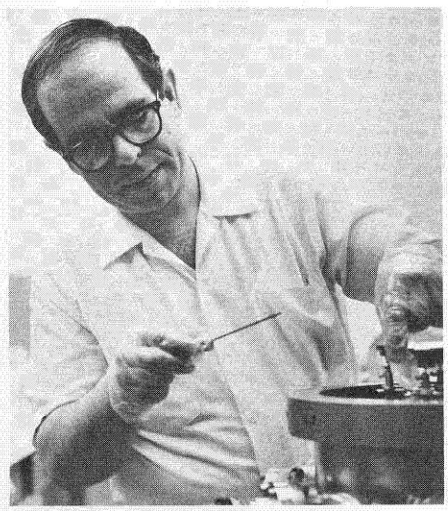




Silver



Wasserburg



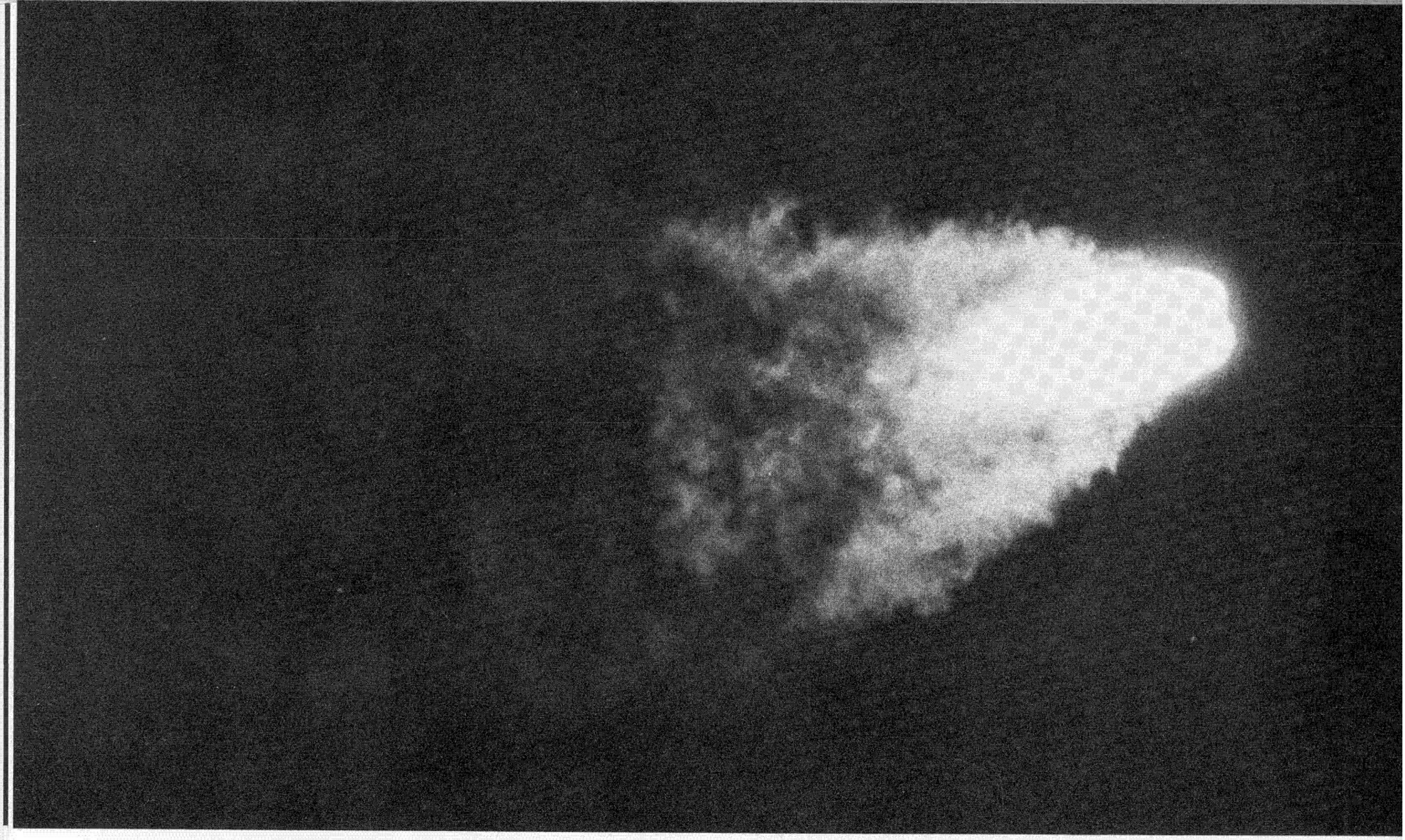
Papanastassiou

admits he was born too soon to go to the moon. Shoemaker conducted a long, uphill, and not always smooth struggle to bring science into the Apollo program, and he directed the field geology operations for several of the missions.

The man who pioneered in teaching geology to the astronauts is Caltech's Leon Silver (PhD '55), professor of geology. He quietly and effectively performed this task for three years, beginning in 1969, when one of his former students, astronaut Jack Schmitt, suggested the idea. ("Geology on the Moon"—*E&S*, November 1971.)

Energetic, red-haired Silver found the astronauts to be apt students because as jet pilots they were already good observers. He trained them in lunar-like landscapes—the Atomic Energy Commission's Nevada test site; the desert east of Indio, California; and New Mexico's Rio Grande Gorge. At Caltech Silver also heads a group that is age-dating lunar rocks and dust, and he has determined that, in some instances, lunar material shows an older age than it really is because of the presence of lead in the form of gas on the lunar surface.

The largest group of scientists working on lunar material is under the direction of Gerald Wasserburg, professor of geology and geophysics, in his surgically clean Lunatic Asylum. This group has established the date of the moon's formation at 4.6 billion years ago and



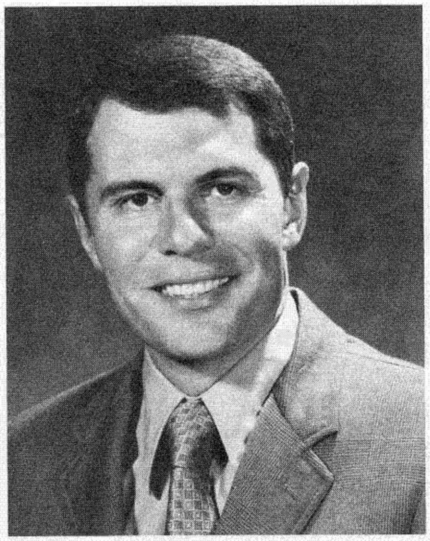
**The Apollo flights are ended —but the exploration of the moon will go on for years to come**

*Burnett*

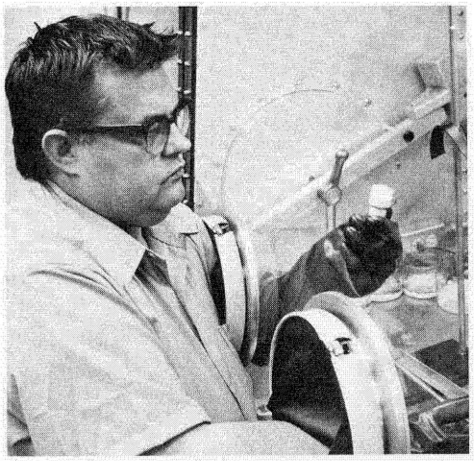
has found evidence of remelting on the lunar surface between three and four billion years ago.

Wasserburg recently was awarded NASA's Distinguished Public Service Medal for his leadership in helping plan the Apollo missions and for his planning of the handling and distribution of lunar samples. The geophysicist, who has worked with the Apollo program for five years, has served on a number of NASA committees and is currently a member of the physical sciences committee and the advisory committee to NASA headquarters.

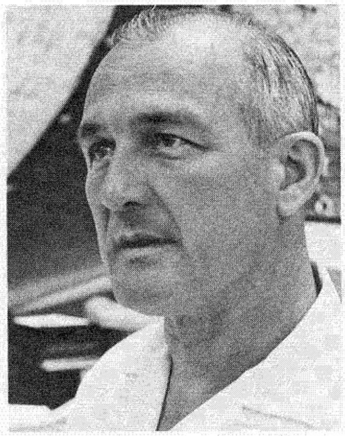
Wasserburg has developed a mass spectroscope that is more sensitive than any other for the chemical analysis of lunar material. He and his group use three age-dating techniques, based on the known decay rates of radioactive minerals into their decay products or "ashes." Dmitri Papanastassiou (BS '65, PhD '70) works with rubidium-strontium; Fouad Tera with uranium-thorium-lead; and Frank Podosek and John C. Huneke with potassium-argon. Podosek and Huneke also look for rare gases in lunar soils. According to theory, some rare gases such as argon, krypton, and xenon come out of the moon at low concentrations and are pushed back into the soils and rocks. Arden Albee, professor of geology, specializes in petrographic and mineral studies of lunar material.



Parker



Taylor



Muehlberger

Another Wasserburg associate, Donald Burnett, associate professor of nuclear geochemistry, had an experiment on Apollo 17. It was a sensitive neutron probe designed to help determine the rates at which material on the moon's surface has been deposited and eroded by meteorites over millions of years. The probe also will make it possible to date meteorite impacts on the moon. The instrument was developed by Burnett; Dorothy Woolum, Caltech research fellow in geology and physics; and research engineer Curtis Bauman.

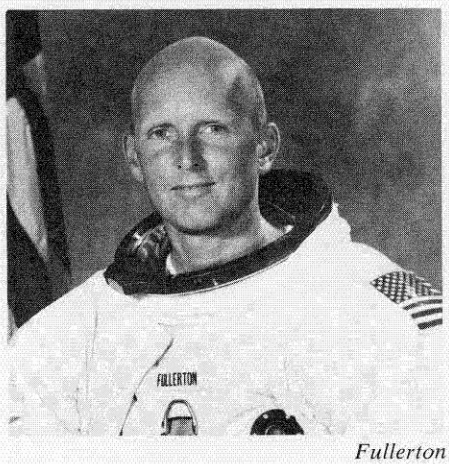
Two other Caltech professors, Sam Epstein and Hugh Taylor, are analyzing the isotopic geochemistry of lunar samples.

The list of Caltech alumni involved in Apollo is a long one. It includes Robert L. Kovach (PhD '62), now at Stanford, who was principal investigator of an Apollo 17 experiment, a seismic study to determine the geological characteristics of the moon down to a depth of nearly two miles. William R. Muehlberger (BS and MS '49, PhD '54), on leave from the University of Texas, was principal investigator of field geology for Apollos 16 and 17. Robert Parker (PhD '62) and Charles G. Fullerton (BS '57, MS '58) were capsule communicators for Apollo 17.

Although the Apollo flights are ended, they leave a rich legacy to scientists. Carefully stored in vaults at NASA's Manned Spacecraft Center in Houston is more than 90 percent of the lunar material brought back by the astronauts. Including the 250 pounds just collected by Gene Cernan and Jack Schmitt, more than 800 pounds are in the trust of Michael Duke (BS '57, MS '61, PhD '63), who is curator of lunar samples at Houston.

Thus, as the lunar samples continue to be distributed to laboratories at Caltech and elsewhere, the exploration of the moon will go on for years to come.

Epstein




Fullerton


M G. KERCKHOFF MARINE LABORATORY - CALIFORNIA INSTITUTE

# HELP FOR KELP

## Wheeler North is a marine biologist with a mission

One thing you can say for certain about California's kelp forests: They have a friend in Wheeler North. A marine biologist, a dedicated diver, and a Caltech professor of environmental science, North enjoys kelp as a magnificent plant and appreciates its vital role in the ecology of the ocean and the economy of the state. For almost 20 years he has been working to make sure that it thrives.

The waters along the Pacific coast once had dense marine forests that extended for a mile or so offshore all the way from San Diego to Alaska. But infestations of hungry sea urchins and an unprecedented rise in ocean temperatures in the late 1950's almost wiped them out. Identifying the culprits was North's first step toward preserving the remaining forests. The second was to start eliminating the urchins. As a third move, he has been experimenting with ways of planting new kelp in denuded areas where it once flourished.

Mature kelp plants release billions of spores each season, so North began by removing adult plants from still verdant forests and implanting them in areas where kelp once grew. But the low survival rate of the spores in nature makes transplanting full-grown plants pretty inefficient, so North worked out a method of culturing billions of kelp embryos in his laboratory for large-scale dispersals in the sea.

He has now developed two methods for getting plantings started in the ocean: tying small plants to styrofoam buoys which are anchored with a heavy chain to the sea floor; and scraping billions of embryos from a substrate at the planting site.

Even with these techniques now fairly well established, North is a long way from just doing underwater gardening. For instance, he is experimenting to determine the best season for planting, the best substrate for growing embryos, and the maximum depth at which the divers can work. Each new area he goes into has its surprises, and he has to adjust to them. And what he learns extends the hypotheses for further work.

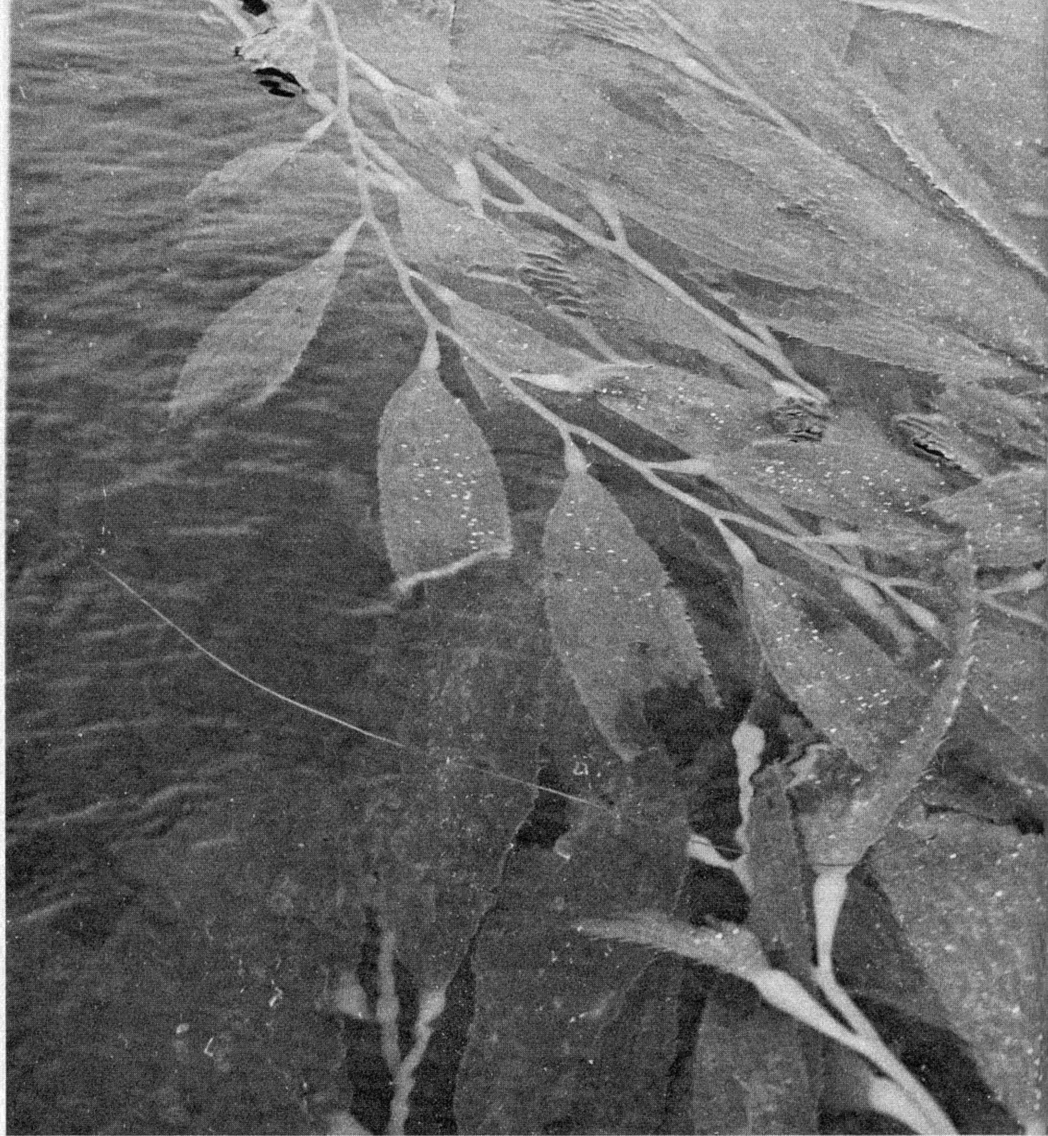
Currently, North is trying to reestablish two former kelp beds—one at Imperial Beach at the Mexican border and one at Palos Verdes in Los Angeles County. The project at Imperial Beach is doing well; at Palos Verdes the going is rough. He wants to know why.

In the 100-mile-long stretch of coastline between Imperial Beach and Palos Verdes, North and his colleagues have by now reestablished about 50 percent of the extinct kelp beds. One of the most verdant and productive is at Point Loma, where kelp is again plentiful enough that it can be commercially harvested. What is even more important to North, the underwater world is ecologically in balance, and exciting and beautiful to explore—which he does periodically to make sure everything is in order in the kelp forest.

*Home base for North's kelp studies is Catech's William G. Kerckhoff Marine Laboratory in Corona del Mar. In culture chambers there he grows enough embryonic kelp plants to make a jungle of the whole ocean. In nature, though, only three or four out of 1,000 billion embryos survive long enough to become visible plants, and still fewer ever grow up. But North manages to better the odds considerably. The embryos grown in the lab have a 100 percent rate of survival, and when they are released in selected areas in the ocean, their chances are 1 in 100,000.*

Kelp forests are an important part of the natural environment of southern California and a highly valuable asset economically. They provide both homes and food for many varieties of fish and crustaceans, which in turn provide both food and sport for man. Kelp also yields a chemical called algin which, by binding oily and watery fluids together, is useful as an emulsifier in foods like salad dressings. As a suspender, algin keeps pigment particles mixed with a carrying liquid in products like paints, pharmaceuticals, and cosmetics; and ice creams are smoother and packaged cake icings stiffer because of its ability to control viscosity.

The giant kelp, *Macrocystis pyrifera,* grows only along the Pacific coast from Baja California to Alaska in the northern hemisphere. One of the fastest growing of all plants—up to two feet a day—it eventually becomes one of the longest—up to 200 feet.




It may look like Caltech's answer to Vassar's daisy chain, but it's actually an important part of a serious kelp transplanting project. Small kelp plants are tied to styrofoam buoys attached to a heavy chain, which is transported by boat to an area slated for planting. Laid on the ocean bottom, the chain acts as an anchor until the kelp can take hold. It takes a lab crew several months to prepare a mile of chain, and a whole summer to process and plant 5,000 buoys. This system for reforestation of the sea is used in areas where there are large populations of kelp-grazing fish and a plant needs as much head start as possible.

## Thanks to North, California's kelp is in good condition

Hitting urchins with a hammer, North works to clear a safe area for kelp to take hold and grow—leaving no more than one urchin per square yard. Last summer hundreds of volunteer divers had such one-to-one encounters with hundreds of thousands of sea urchins, and thus gave trillions of embryonic kelp plants a bigger chance to survive. (In the process they also provided a lot of hungry fish with free meals.)

Another method North has developed to kill the urchins is to dump quicklime into the sea above them. The quicklime particles settle on some urchins, burning and killing them. And the presence of the chemical suspended in the water causes untouched urchins to release their holds on the bottom, leaving them prey to the ocean currents.

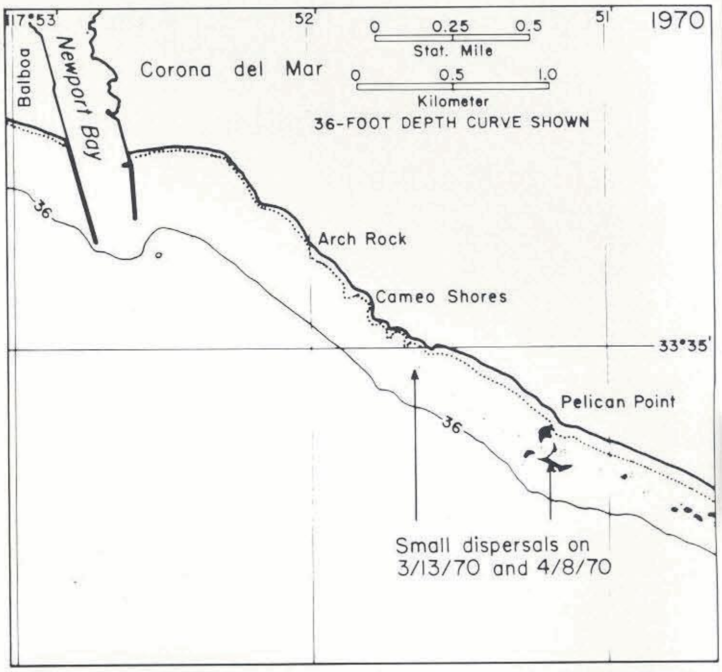
Nature's own agent for keeping the underwater kelp-urchin ecological balance is the sea otter, which finds the urchins a gourmet delight. But sea otters have been hunted almost to extinction, and though they are now protected throughout California, only in areas like Monterey Bay are the herds large enough to keep the sea urchin population under control.

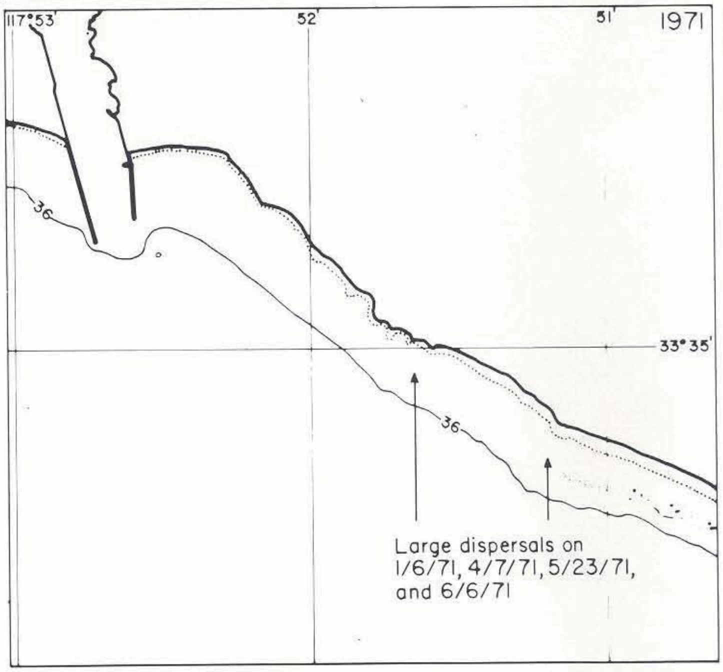
A horde of spiny, beautiful—and voracious—sea urchins attack a tagged kelp plant. The urchins (moving across the sea floor at about 30 feet per month) chew through the "holdfast" at the base of the kelp. Eating only an ounce or two and moving on, they cut loose up to 300 pounds of plant, which drifts away and dies. And the area over which the urchins have grazed becomes an underwater desert.

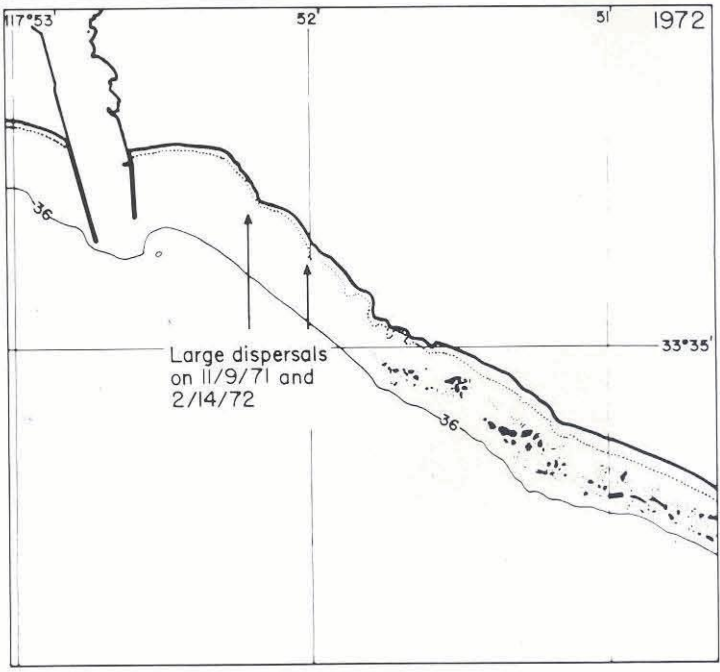
# North is making scientific farming of the ocean a reality

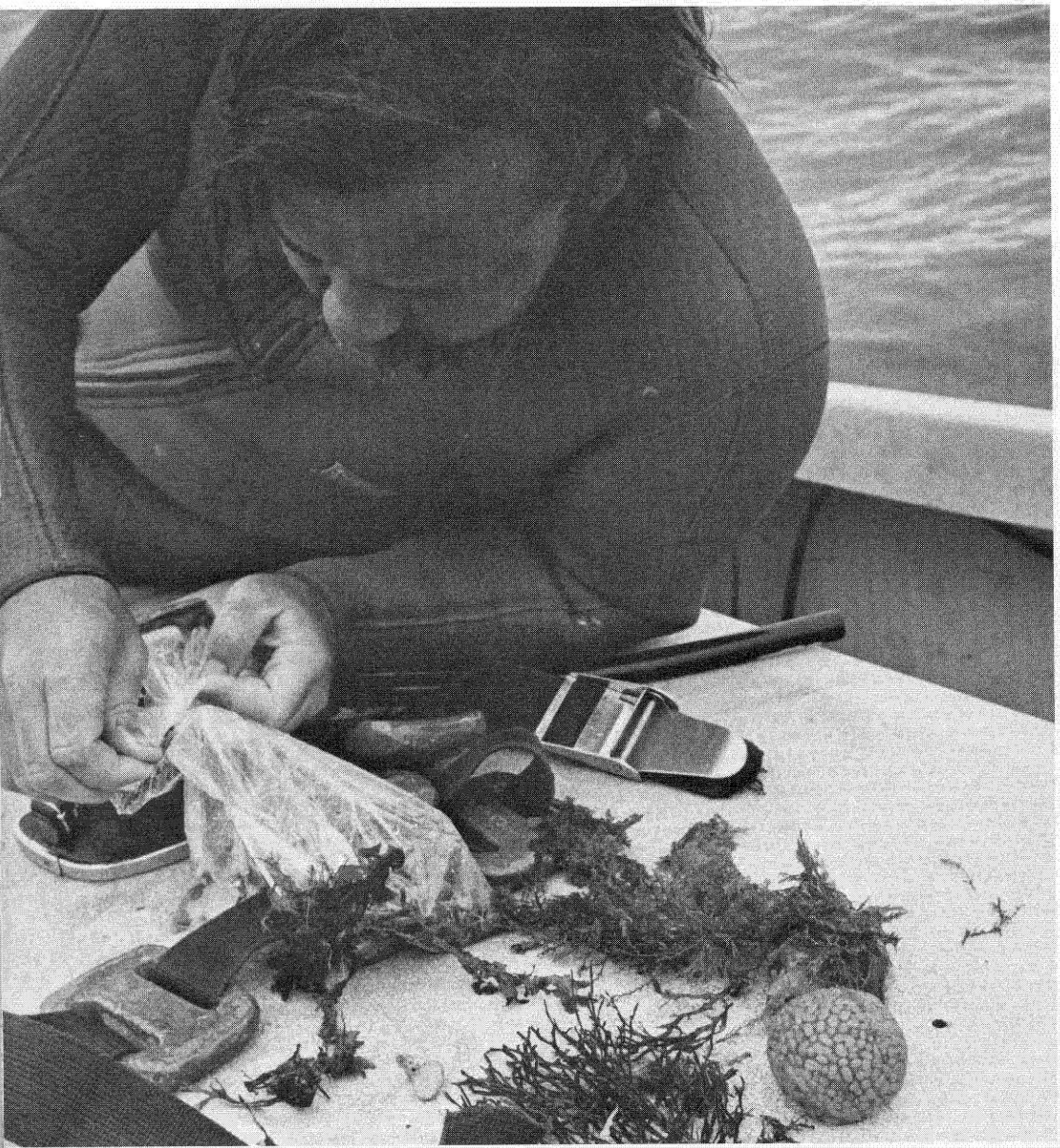
One way to keep track of the outcome of kelp planting experiments is to map both the dispersal areas and the location and density of the resulting beds. In 1970, North and his group made two small dispersals of kelp embryos off Cameo Shores and Pelican Point in Orange County, leading to some minor reappearance of kelp where there had been none since 1958. Kelp needs water that gets no warmer than 65 degrees Fahrenheit to thrive, and unusually warm surface water temperature in the summer of 1971 reduced survival rates among these young plants—though the spores at first took hold and grew as expected in the comfortably cool water on the bottom of the sea. For the last year a combination of large-scale dispersals and favorable water temperatures has created a vigorous forest of kelp, visible on the surface as a canopy of leaves. And embryos released off Arch Rock and Cameo Shores in the early spring of 1972 have resulted in enormous numbers of small plants on the ocean floor.

On his way to the bottom of the sea, North takes along a billion potential kelp plants growing on a folded fiberglass cloth, which acts as a substrate for a kelp culture. Cloths like these are laid on the bottom of still-water tanks in the lab, where they catch and hold spores from specially treated bottom leaves of kelp plants (sporophylls). In a few weeks the spores develop into embryos with sticky surfaces and are ready for transplanting. Then a diver takes the cloths to a favorable underwater location and scrapes them off with a plexiglas rod.



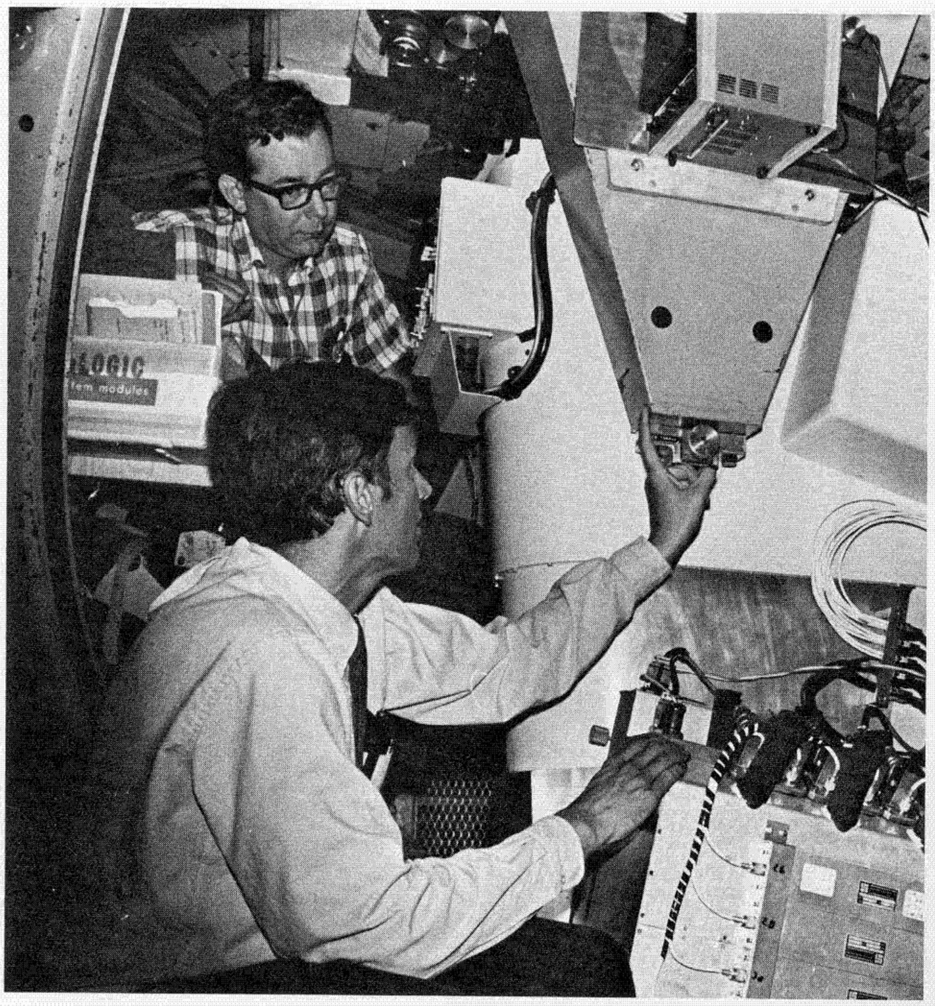





Part of a marine biologist's underwater activity is making species lists of plants growing in any area he is investigating. Graduate student Joe Devinny lays out what he has just collected—and instructor North brings up a few more items that might possibly have been overlooked.

# Electronic Revolution at Palomar




*The 32-channel spectrometer on the 200-inch Hale telescope at Palomar is one of several new systems for increasing the observational efficiency of the instrument. Edwin Dennison, director of the Astro-Electronics Laboratory, and J. Beverley Oke, professor of astronomy and associate director of the Hale Observatories, make a few adjustments in preparation for the night's observations.*

Gone forever are the daring, adventurous—and chilly—nights of observing on Palomar Mountain. No longer will the astronomer don an electrically heated flying suit, climb into the observing cage of the 200-inch Hale telescope 75 feet above the observatory floor, and crouch there all night.

With the aid of an impressive array of modern electronic devices—television, computers, image intensifiers, photomultipliers, and data processors—the astronomer now has complete control of the 500-ton instrument from the warmth of the Palomar Observatory's data room. With his night assistant he can look at a television screen, locate the stellar object he wants to observe, and wait for the automatic instruments to start feeding data to him.

These improvements make life much more comfortable for the astronomer, but the main benefits are in his ability to find cosmic objects more quickly and obtain information in a shorter time. And, with observation time on the 200-inch booked ahead for more than a year, this is a tremendous asset.

Most of this sophisticated new equipment has been designed, installed, and maintained over the last nine years by a group headed by Edwin Dennison, director of the Astro-Electronics Laboratory of the Hale Observatories. The efforts of the group have been concentrated in two areas—extending the observational limits of the telescopes, and improving their operating efficiency.

"The latter would appear to be of lesser importance," says Dennison. "But it is in fact more significant, since the principal gain achieved by telescopes larger than 20 inches in aperture is a gain in operational efficiency; that is, the amount of astronomical information that can be collected per hour. A technique that doubles the number of observations per hour can be viewed as giving the same result as a telescope with twice the collecting area."

This concept is very helpful when the dollar value of a new electronic instrument is being analyzed. A 60-inch telescope costs about $2 million and a 200-inch about $20 million. That means it is worth $2 million to double the effectiveness of the 60-inch or to increase it by 10 percent for the 200-inch. The $150,000 computer system installed on the 200-inch telescope a year ago has more than paid for itself by substantially increasing the operating efficiency.

The system provides a comprehensive, coordinated method of acquiring astronomical data and recording it on magnetic tape, punch cards, and print-outs, while at the same time controlling the telescope automatically. Information about the telescope and the observing instruments is displayed on a desk monitor while the observation takes place, which allows the astronomer to evaluate the data almost as soon as it is collected by the mirror. The observer has more control over the data-collecting process and receives more information about the observations as they are being made. For example, if the astronomer spots something particularly interesting in the raw data being received that demands a change in his plans, he can make alterations immediately. Before, he would have to study the information he collected for months. If he wanted more information, he would have to wait more months before he got a chance to use the telescope again.

The system has proved so useful on the 200-inch telescope that it is now being installed on the 60-inch telescopes at both Palomar and Mt. Wilson. By next spring it will also be installed on the 150-foot solar tower telescope at Mt. Wilson.

Complementing the computer system on the 200-inch is a $50,000 television setup to aid astronomers in sighting on their targets. Observers formerly used "blind offsetting"—locating with respect to the nearest visible bright objects the exact position in the sky of other objects too faint to be seen by the eye. With computer control there was still a certain amount of error, for although the computer system is very accurate—to within 10 seconds of an arc—most stellar objects cover much less than a second of arc.

The television view-finding system reduces this error by letting the astronomer see fainter objects than he would if he just looked through the telescope eyepiece. The television camera looks through the telescope and amplifies the image several hundred times before projecting it on a conventional television screen. A series of still pictures results. This system has the advantage over visual sighting because, like the photographic plate, it can accumulate images from faint objects over a long period of time. And it does not lose its ability to detect small details on dim objects as does the eye.

Through the 200-inch the human eye can see about 18½-magnitude stars. By contrast, as a standard television camera, the view-finding system can see 15th-magnitude stars. With a 6-second time exposure it can see 21st-magnitude stars, which is near the photographic limit of the 200-inch and 2.5 million times fainter than can be seen by the unaided eye without a telescope. So, in many cases, the system permits the astronomer to actually sight on what he wants to record.

Much of this effort to improve operational efficiency would be useless if there were not some means of extending the observational efficiency of the telescope—its ability to collect light. And modern astronomy is greatly concerned with objects at the very edge of the 200-inch telescope's photographic limit.

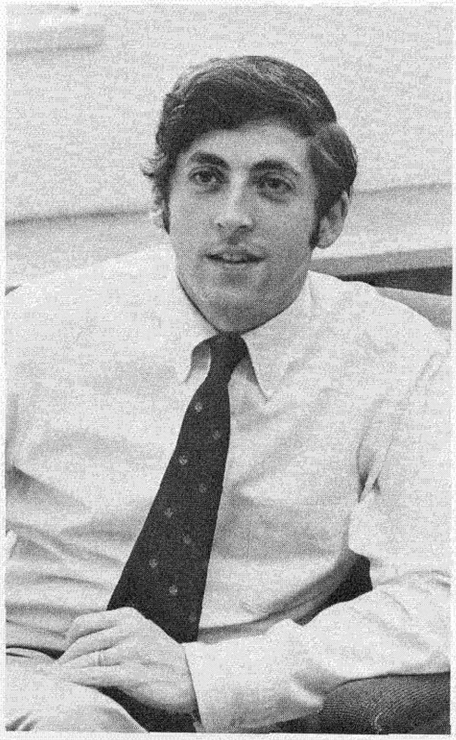
One new device is the photomultiplier tube, which converts optical signals into electric signals and amplifies them. It is 10 times more sensitive than the traditional photographic plate. However, the photomultiplier has the disadvantage that it can only observe one point on an optical image at any one time. And for observations involving many points, such as spectroscopic analysis, it has been more efficient to use the photographic plate. But, by using several photomultipliers simultaneously, it is possible to gather information on several points at once. One such system is a spectrometer on the 200-inch that has 32 photomultipliers operating together. This, in effect, improves the telescope's observational efficiency 32 times.

For many years astronomers have dreamed of the possibility of an image intensifier with a large number of picture elements, each having the same characteristics as a single photomultiplier tube. Ideally, such a device should have as many picture elements as are contained on a photographic plate—roughly 40 to 50 million. But a system that could handle even 60,000 to a million such picture elements would be suitable for many exciting astronomical problems.

Dennison and his group are working with a new system, an ultra-high-gain television camera, that reaches this lower limit. It collects light from a source and stores it as an electron image on a target. A microscopic beam scans the image, extracts the information, and stores it on a magnetic tape. Such a system will be used on the 200-inch telescope to measure 65,000 picture elements simultaneously.

Desirable as such observational improvements are, they also increase the pressure on Dennison and his co-workers to continue to improve the operational efficiency of the telescope. "It's a vicious circle," he says. "As reaching out to greater distances and detecting fainter objects combine to make telescope observing more complex, the need for simple, manageable observation systems becomes more important."

# The Month at Caltech



*John Seinfeld*

## Dreyfus Grant

John H. Seinfeld, associate professor of chemical engineering, is one of 17 young American scientists honored for achievements in teaching and research by the Camille and Henry Dreyfus Foundation of New York.

The Dreyfus grant program, which awards $25,000 to each recipient, makes it possible for distinguished young chemists, chemical engineers, and biochemists in the academic world to develop themselves further, as teachers and researchers, early in their careers.

Seinfeld will use his award to expand research on the mathematical description of air pollutant behavior. The mathematical models he is developing will enable pollution control districts to predict more accurately the intensities and composition of smog under various meteorological conditions.

The 30-year-old chemical engineer is the third Caltech faculty member to be awarded a Dreyfus grant. The awards were initiated in 1970, when Robert Bergman, associate professor of chemistry, was a winner. Jesse L. Beauchamp, also an associate professor of chemistry, was honored last year.

## Trustees

The month brought one loss and two additions to the Caltech board of trustees —and one of its long-time members received a humanitarian award.

Roy L. Ash has a new job because of the pressure of his appointment by President Nixon to head the office of Budget and Management. The president of Litton Industries has served on the Caltech board since 1967.

Richard P. Cooley and Gilbert W. Fitzhugh are new trustees. Cooley, a San Franciscan, is president and chief executive officer of the Wells Fargo Bank. Fitzhugh, a New York City resident, is chairman and chief executive officer of the Metropolitan Life Insurance Company, and president of the New York City Chamber of Commerce.

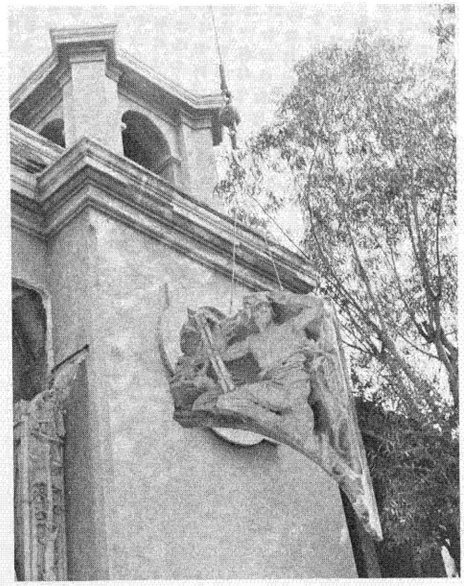
Harry J. Volk, a trustee since 1952, was given the Annual Human Relations Award of the Los Angeles chapter of the American Jewish Committee. Volk, chairman of the board of Unionamerica, Inc., was paid tribute by the speaker of the evening, Caltech President Harold Brown, and by business and civic leaders of the greater Los Angeles area.

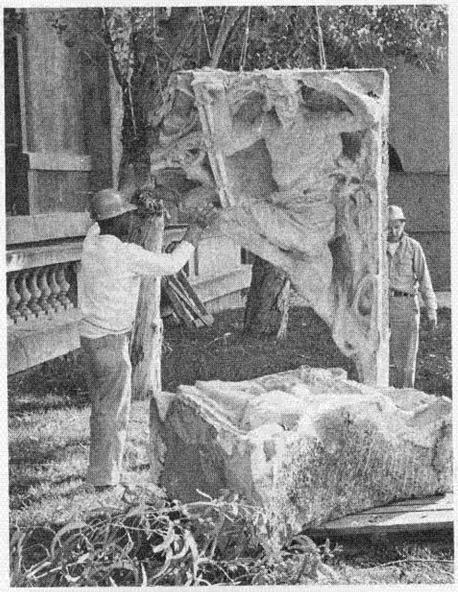
## Chemistry Chairman

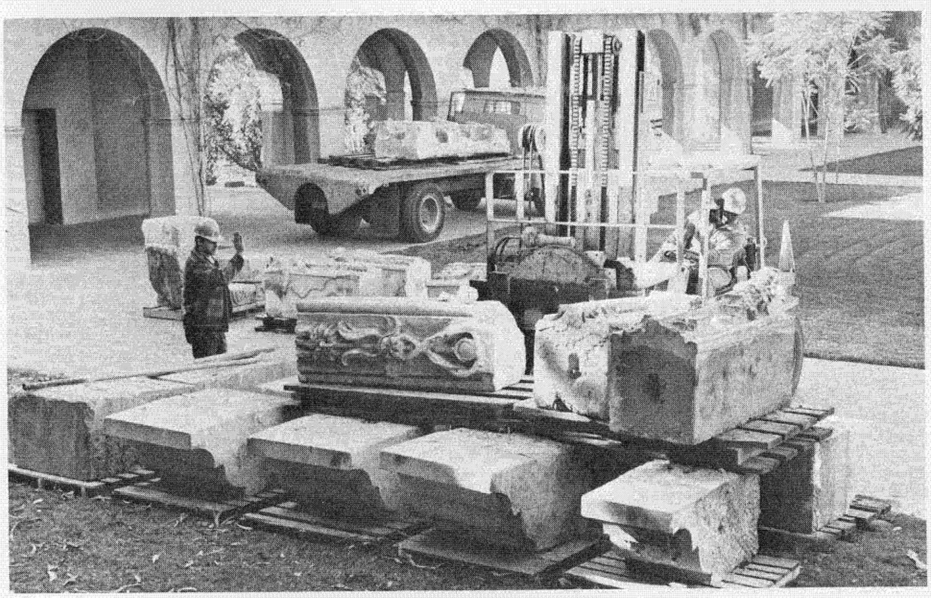
John D. Baldeschwieler has accepted the chairmanship of the Division of Chemistry and Chemical Engineering, effective July 1—or possibly earlier. He will leave his White House post as Deputy Director of Science and Technology to join the Caltech faculty.

The 39-year-old physical chemist, one of the youngest men elected to the National Academy of Sciences two years ago, is widely known for his work on problems involving both chemistry and biology—an increasingly important area of research at Caltech.

Before going to Washington, Baldeschwieler was a professor of chemistry at Stanford. He received a bachelor's degree in chemical engineering from Cornell University in 1956, and a PhD in physical chemistry at the University of California at Berkeley in 1959. Before joining the Stanford faculty in 1965 he was an assistant professor of chemistry at Harvard University.







## How Do You Know Till You Try?

When it was finally decided to tear down old Throop Hall (*E&S,* November-December 1972), it didn't look as if it would be possible to save the famous Calder sculptures over the front arches. But at the last minute the administration and the campus architect decided to give it a try.

To start with, a workman gingerly removed the big cement ball, representing the sun, in the heart of the center arch. At the first touch, the ball rolled out into the workman's hands.

The rest of the project was also relatively easy, although not quite so free-wheeling as the beginning. It was estimated that the work would take three days, but it was done in less than a day. All but one of the 46 pieces were down by mid-afternoon.

The pieces were then stacked on a truck and delivered to the City of Pasadena, which had agreed to preserve these relics of the community's past. The sculptures are in storage now, waiting for the city design commission to decide where, in or around the City Hall, they will be permanently installed.

## Front Yard Field Work

*When Professor Dan McMahon recently assigned an ecology project to his class in Organismic Biology (Bi 7), some of the students headed for the ocean, others for the desert—and a few stayed right on campus. This team is studying the distribution of oxygen in the fishpond outside Ramo Auditorium.*

## NASA Medal

Gerry Neugebauer, professor of physics and staff member of the Hale Observatories, has been cited by the National Aeronautics and Space Administration for his contributions to infrared investigations of the planets. He was responsible for the infrared experiments on the Mariner 2 Venus exploration in 1962, the Mariners 6 and 8 Mars probes of 1969, and the Mariner 9 Mars exploration of 1971-72.

Neugebauer was awarded NASA's Exceptional Scientific Achievement Medal.

## Leader of America

Those who knew Arthur Galston when he was on the biology faculty at Caltech from 1943 to 1955 were not surprised last year when they learned he was the first American scientist to visit the People's Republic of China. Galston's multi-directed and lively curiosity brightened the Caltech campus when he was a part of it, and does so again on January 18 and 19.

A professor of biology at Yale, where he has been since 1955, Galston reactivates the Caltech Y's "Leaders of America" series this month, speaking at an Athenaeum luncheon on "Education and Science in China" on the 18th, and that evening giving a public lecture in Beckman Auditorium on "Life in a Chinese Commune." Between speeches he is presenting a biology seminar on "Rhythmic and Photo Control of Leaf Movement."

Besides drawing a few deep breaths on the 19th, he meets for lunch with members of the Chinese Students Association and talks informally to student groups the rest of the day.

## Energy Conference

The way the reservations sailed in, the Environmental Quality Laboratory knew early in November that its December 9 conference on "Energy as a Scarce Resource" was going to outgrow the 415-seat Ramo Auditorium. And, as it turned out, 800 people gathered in Beckman Auditorium for the event, which was co-sponsored by EQL, the League of Women Voters, and the Sierra Club.

In the morning they heard from Lester Lees, EQL director; Hollis M. Dole, assistant secretary of the Department of the Interior; Michael McCloskey, executive director of the Sierra Club; and David Fogarty, vice president of the Southern California Edison Company.

At noon John Tunney, U.S. Senator from California, spoke to a capacity Athenaeum crowd on "Energy Policy: An Agenda for the 93rd Congress."

Five afternoon panels brought together a representation of academic, governmental, and industry people, and members of public interest groups to tackle such critical topics as electric power and fossil fuel conservation, energy uses in transportation, and public policy and economic factors in the conservation.

In assessing the conference, EQL staff members agreed that it brought together "disparate and sometimes hostile viewpoints in a dispassionate, factual, and environmentally sensitive discussion." Two overall conclusions emerged: first, that the idea of cheap and unlimited energy is a myth; and second, that more people than you might think are dedicated to finding new ways to conserve the energy sources we still have.

# Letters

## The Valkyries Ride Again

Maybe the rest of the world didn't know why the Houston Control Center played "The Ride of the Valkyries"—at full volume—to wake up the Apollo 17 crew on December 11, but no one at Caltech had any doubt. It's the traditional way to wake a student during final exam week at Caltech, and that was certainly the week it *was*, for Tech students *and* for astronaut and alumnus Jack Schmitt (BS '57).

It all came about after Mission Control at NASA's Manned Spacecraft Center in Houston tried to wake the Apollo crew on December 9 with the University of Kansas fight song, "I'm a Jay, Jay, Jayhawk." (Astronaut Ron Evans is a Kansas alumnus.) It got no rise from Evans or his somnolent fellow travelers, Schmitt and Eugene Cernan. Two Caltech undergraduates easily convinced Albert Hibbs, a JPL senior scientist and alumnus (BS '45, PhD '55), that Caltech could do better than that. Hibbs relayed the idea to NASA's Administrator James Fletcher (PhD '48). Fletcher carried through to a bravura Wagnerian finish.

## Science for Mankind

Caltech's five-year Science for Mankind fund-raising campaign, launched in November 1967, has now been successfully concluded—exceeding its $70.4 million goal by over half a million dollars.

The drive was instigated to provide additional support for endowing faculty salaries, for new buildings and renovations, and to cover increased operating costs of academic programs and the physical plant. During the campaign, seven new buildings were added and two more were started. Seven named professorships were established, most of them supported by endowments.

More than half of the campaign funds came from individual gifts, including $12 million in bequests. More than a quarter of the total came from corporations. Caltech alumni contributed more than $2 million, and the remainder came from foundations, societies, and other organizations.

Kitt Peak National Observatory
Tucson, Arizona

EDITOR:

On Pages 17-18 of the October 1972 issue of *E&S* you reported to your readers that Drs. Chapman and Ingersoll [Andrew Ingersoll, associate professor of planetary science at Caltech] published evidence in *The Astrophysical Journal* (v. 175, pp. 819-835) to indicate that the Dicke-Goldenberg measurements of solar oblateness can be explained in terms of bright faculae in the sun's equatorial region and do not leave evidence for a rapidly rotating core. You did not mention that the Chapman-Ingersoll paper was followed in the same issue of the *Journal* by a rebuttal by Dr. Dicke who said that neither the original Dicke measurements of faculae nor those of Chapman and Ingersoll show a significant enough contribution to cast doubt on the original interpretation of solar oblateness given by Dicke. The referee and editor of the *Journal* felt that the problem had not yet been resolved and that both statistical analyses should be published side by side.

Helmut A. Abt, PhD '52
Managing Editor
*The Astrophysical Journal*

*Dr. Ingersoll replies:*

An obvious controversy does exist and the issue is still far from settled. This fact should have been much clearer in my remarks in the *E&S* article. In view of this controversy the last sentence was misleading in stating that the sun "must be oblate by a much smaller amount than Dicke originally claimed." However, in his rebuttal Dicke presented a statistical analysis indicating that faculae contribute only a small part (10 percent) of the excess solar oblateness measured at Princeton in 1966. Chapman and I argue that the facular contribution may be much larger and have submitted a paper replying to Dr. Dicke.

London

EDITOR:

I was more than usually interested in the neat explanation of the application of scientific theory and principles to the nature of the universe in James Gunn's "The Shape of Space" in your issue back in May. I have often wondered why scientists seem collectively to accept the expanding universe proposition which depends so heavily on the observed "red shift." I wonder why we can be sure there is not some tendency for light waves to slow down in frequency, or to straighten out, when they travel over enormous distances? How do we know they don't suffer from some slight diminution of energy on their long curved path through space that would explain the relationship between distance and "redshift" as readily as the convenient analogy with the Doppler observations?

R. S. MacAlister, '47
Managing Director
Occidental Petroleum (U.K.) Limited

*Dr. Gunn replies:*

The acceptance of the expansion of the universe as an explanation of the redshift is not done lightly, or indeed, without much dissension among workers in the field. The whole aim of cosmology is to understand the universe in the large in terms of known physical theory. The various "tired light" ideas for the redshift are not consistent with present physical theory. This does not say, of course, that next year someone will not invent a theory that is consistent with all known laboratory data and which predicts a spontaneous degradation of the frequency of light over large distances, but no such framework exists today. One could simply postulate, out of any context, that the phenomenon occurs, but one in so doing removes any possibility of understanding the universe in terms of known and *verified* physical laws.

# Research Notes

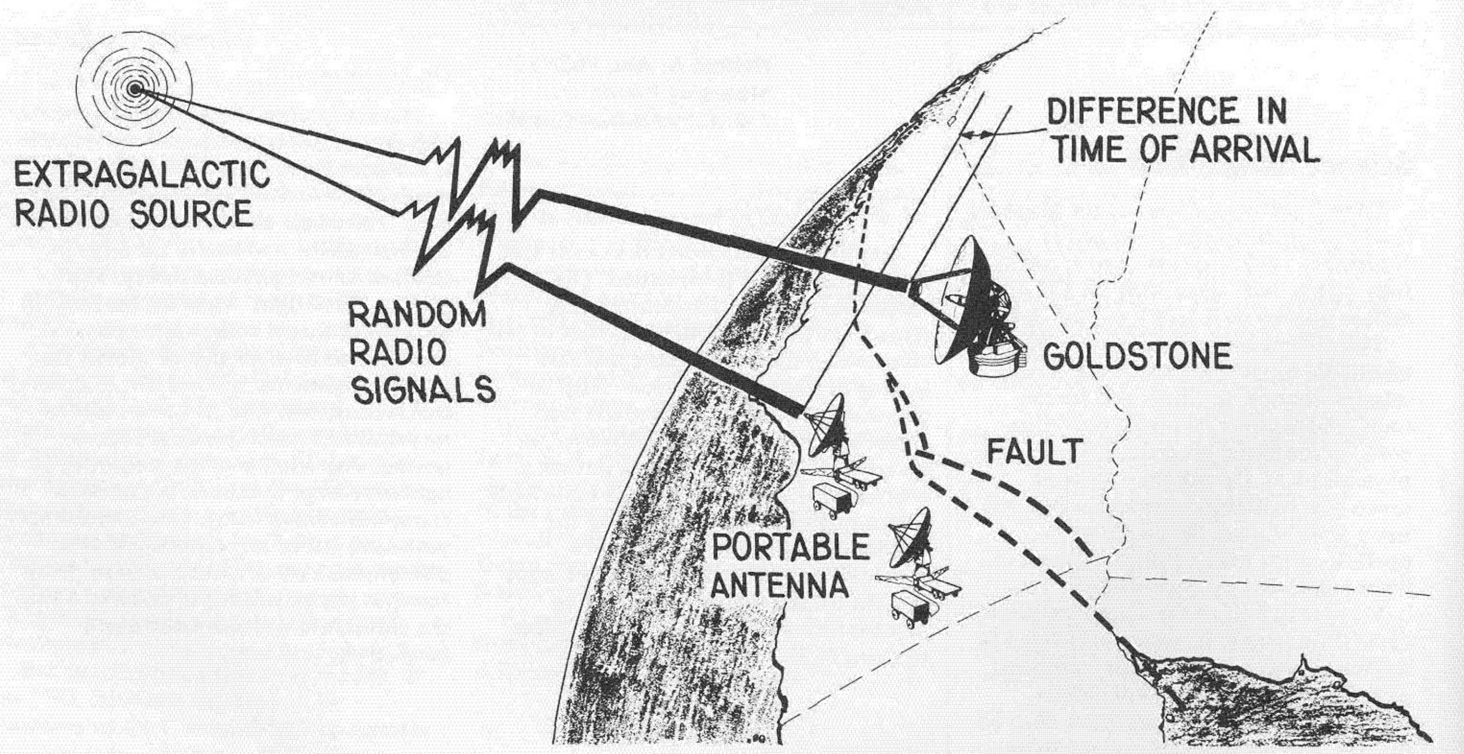
## Quasars and Quakes

A team of scientists and engineers at Caltech's Jet Propulsion and Seismological Laboratories is using quasars to measure movements along the earthquake-prone San Andreas fault. Quasars are so far away that their positions in the sky appear to remain fixed, making them extremely stable points of reference for measurements on earth.

The team includes Peter F. MacDoran, John L. Fanselow, J. B. Thomas, and Donovan Spitzmesser from JPL and James H. Whitcomb, a graduate student in geophysics, from the Seismological Laboratory. They are conducting experiments to test the new technique called ARIES (Astronomical Radio Interferometric Earth Surveying) using 64- and 26-meter-diameter antennas of the Deep Space Complex at Goldstone, near Barstow, California, and a smaller, transportable antenna. Basically the system involves measuring the difference in the time of arrival at two or more antennas of indentical radio signals from the same quasars. High-speed computers are then used to calculate the distance between the antennas, which can be separated by a space as short as a few miles or as long as between continents.

The ARIES concept was given a big boost when experiments in 1971 showed that measurements between antennas as much as 8,000 kilometers apart were accurate to within 1.5 meters. A series of experiments in 1972 with two Goldstone tracking antennas 16 kilometers apart refined the distance-measuring accuracy to 4 centimeters. The goal of the team's research is to measure movements of a centimeter or less along the entire 800-kilometer length of the San Andreas fault.

Measurements of this accuracy are important in determining the true rate of motion and energy buildup along the San Andreas fault—the line of contact

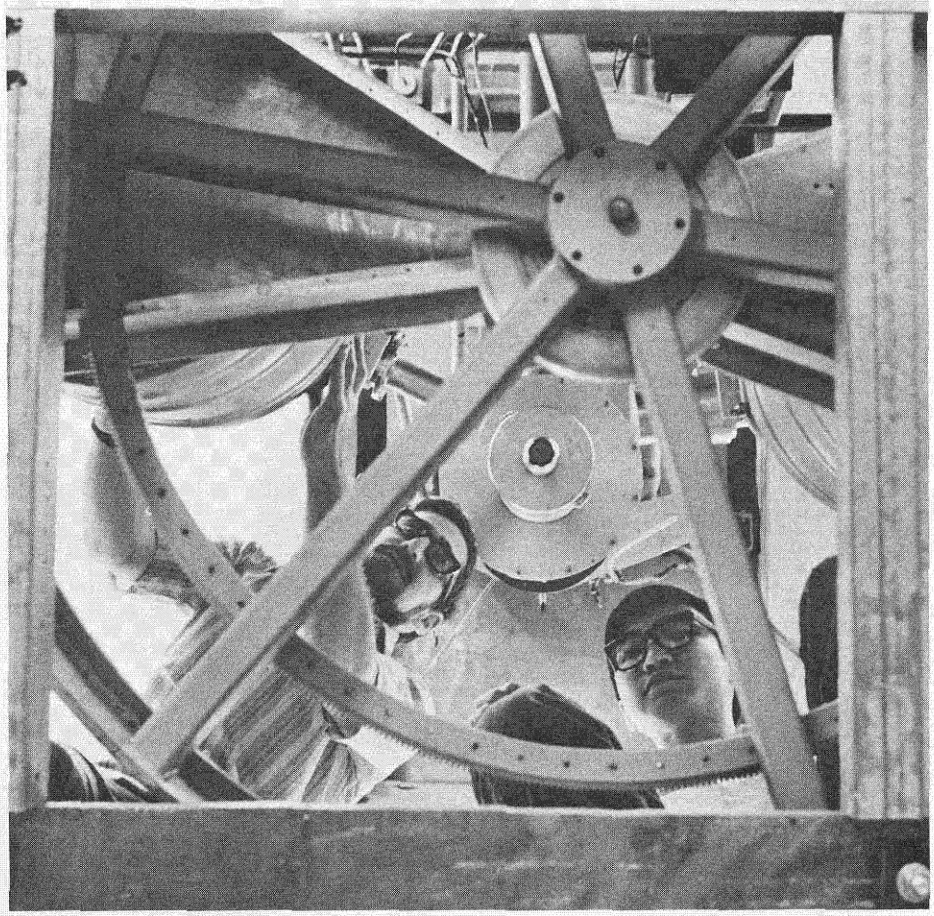



*Using signals received from quasars outside our galaxy, scientists at JPL and Caltech hope to use space tracking antennas positioned along the 500-mile length of the San Andreas fault to help determine its rate of creep—a critical factor in predicting the occurrence of earthquakes.*

between two of the world's major tectonic plates, the North Pacific and the North American. The North Pacific plate is believed to move north relative to the North American plate at 2 to 6 centimeters a year—and it is crucial in the study of earthquakes to know which figure is more accurate. For example, the San Francisco earthquake in 1906 was produced by a 4-meter slip along the San Andreas fault in northern California. Since then, that section of the fault has been moving, storing strain energy. If the rate of storage is 2 centimeters a year, it is not likely that an earthquake the size of the 1906 one would occur until about the year 2100. But if the rate is 6 centimeters a year, such an earthquake could occur at any time.

In order to determine the rate of buildup, geophysicists have developed a number of techniques to study motions near and across fault lines. They are accurate only for distances up to about 40 kilometers because the systems are line-of-sight limited; that is, they cannot measure beyond the horizon. Measurements of motions over several hundred miles of a fault as long as the San Andreas have been calculated by adding short measurements together. But this method gives inconclusive information about fault movements because of the effect of accumulated error in connecting the short line of-sight measurements.

ARIES, its developers believe, provides a good way of accurately measuring motions between points several hundred miles or more apart. They would like to start by using five or six movable dish antennas in conjunction with one of the large-diameter Goldstone dishes. The movable dishes would be set up on a network of reference points in California and the western United States. By making measurements of the distance between antennas at least once a year it should be possible to determine the general character and scale of the motion along the San Andreas fault in two or three years. Several extragalactic sources would be used as reference points: three quasars, 3C-273, 3C-279, and 3C-345, each of which is apparently about a billion light years away; and two quasar-like radio galaxies, 3C-120 and 3C-84, which are about 100 million light years from earth.



*Eri Cohen and N. K. Cheung work to position delicate particle detectors close to the base of a supercold "dilution refrigerator." The device is being used to test various aspects of the symmetry rule of physics.*

## Deep Freeze

The coldest place on the Caltech campus may no longer be the low temperature physics laboratory where researchers bring substances to within a few degrees of absolute zero. An even colder place is inside the specially designed "dilution refrigerator" in the nuclear spectroscopy laboratory of Felix Boehm, professor of physics.

Boehm—with Eri Cohen, research fellow in physics, and graduate student N. K. Cheung—uses the refrigerator to maintain radioactive nuclei at temperatures just a few tenths of a degree above absolute zero in a very strong magnetic field. In a 10-foot-high tapered cylindrical chamber, liquid nitrogen is used to insulate helium while it is cooled from a gaseous state to a liquid state about one degree above absolute zero. Cooling to the necessary few tenths of a degree above absolute zero is done by diluting one isotope, helium-3, by another isotope, helium-4, in a mixing chamber at the tip of the tapered cylinder. An iron disk about a fourth of an inch in diameter, impregnated with radioactive material, is introduced into this chamber and cooled to the proper temperatures. The system is set up to allow the experimenters to position instruments closer to the radioactive source than in other similar devices, which cuts down the amount of error.

Boehm, who was one of the first to discover the breakdown of the left-right symmetry in the weak interacting nuclear forces, is using the device to test another aspect of the symmetry principle—that of time-reversal invariance; that is, whether the physical laws governing a subatomic event would be invariant whether the interaction is run in reverse or not.

## Moving In On Neurons

Gilbert McCann, professor of applied science, has developed a new technique that should accelerate research on the brain and nervous system.

For many years scientists have studied the brain and nervous system in a variety of organisms—from insects to man—by studying the unit common to them all, the nerve cell or neuron.

These studies have yielded a good deal of important information, but no basic understanding of how the brain works will emerge until we learn more about the function of neurons as an integrated system.

This is not easy to do. The human brain and nervous system contain billions of neurons. Even the nervous system of the common housefly has about 1,500,000 neurons of about 350 different kinds. Until recently, it has been possible to study only about 10 of these different classes of neurons at one time. With the new concept he has developed, McCann has now studied, recorded, and analyzed 108 of the 350 classes of neurons in the housefly.

Using an on-line computer, McCann can record and analyze electrical impulses from the neurons in a living fly. Microscopic glass or steel electroprobes, linked by hair-thin wires to the computer, are inserted near a neuron. Usually several microprobes are used at the same time in one area. The computer's cathode ray tube shows the impulses emitted as a series of sharp waves or "spikes." Each variety of neuron has its own characteristic spike pattern. The computer sorts out each spike "fingerprint" from the jumble of signals that are recorded on magnetic tape and displays three-dimensional graphs on a cathode ray tube. The computer can change the orientation of the graph, using the dimensionality of the picture to help separate the spike patterns.

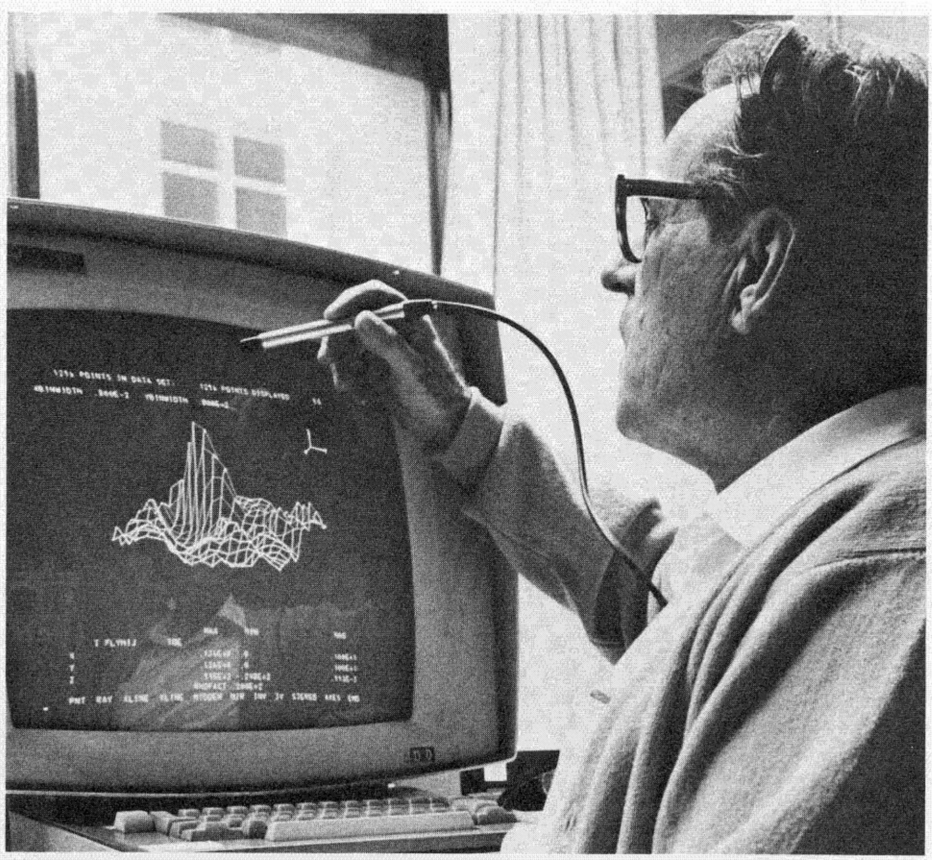
Once this is done, the spikes can be classified according to the type of neuron that emitted them. The computer's memory has a store of characteristic neuron-spike firing patterns recorded in response to test stimuli or visual patterns that represent each of the different neuron classifications. Matching the neuron's "handwriting" with that of one from the memory bank completes the classification.

The system allows a researcher at any time to quickly insert a substitute experiment to clarify new data or follow a new lead, or to design complex experiments that require computer modeling.

A particularly important function made possible by the system is to inhibit the activity of selected neurons to determine the effects on nervous-system functions. This activity of the computer is vital to a complete understanding of the principles of intelligence.

One of the most frustrating problems in studying a living nervous system is that you destroy it if you take it apart piece by piece for analysis. The new technique makes it possible, in effect, to take a nervous system apart without permanently altering it.

The research is supported by the National Institutes of Health.



*Using a light pencil and a computer terminal screen, Gilbert McCann, professor of applied science, alters a three-dimensional graph of a spike pattern that represents signals from a single neuron of the one and a half million present in a fly's brain. McCann has designed a computer system that can analyze and "fingerprint" these neurons.*

# notes & news

## There's a future in our diversity.

Bethlehem has traditionally been not only a steelmaker, but also a producer in more than 50 other steel-related manufacturing businesses. Now we have diversified into many new areas. Recently acquired subsidiaries produce a broad range of products—plastics, including toys and sporting goods, minerals, and residential properties. And there's more on our diversification horizon.

## The fight goes on.

We're continuing our environmental quality control investments at a $25-million-a-year clip. Recent examples: we just completed a $22-million water pollution abatement project at our Lackawanna Plant; improved air pollution controls have just been installed on electric furnace shops at Seattle and Bethlehem; and we're adding a $2½-million gas cleaning system at our Sparrows Point, Md., open-hearth department.

## A new product from R & D.

The development of new processes and products at Bethlehem's Homer Research Laboratories relies on a surprising range of science and engineering fields; metallurgy, chemistry, electronics, even biology to name a few. One of our new sheet steel products, Galvalume, was developed by the surface-chemists of our corrosion group. Galvalume is a coated sheet steel product with excellent heat and corrosion resistance imparted by an aluminum-zinc alloy coating. Galvalume sheets have a wide range of applications, especially in the automotive and appliance industries.

## Recycling? We've been doing it for years.

By now most students interested in the environment are aware that about 50% of all new steel is made from iron and steel scrap. Lots of folks overlook the fact that many other "products" of the steel-making process are recycled. For example, gas generated in the blast furnaces and coke ovens is cleaned. Some of it goes back into the stoves. The remainder serves as fuel for other processes in the plant. Iron ore particles trapped by pollution control devices monitoring the steel-making furnaces are collected, processed, and charged back into the furnaces.

## 265,000-dwt supertankers ordered.

Bethlehem has a $215-million contract for three large crude oil carriers, the largest commercial vessels to be built in the U.S. They'll be built in our huge (1,200 x 200-ft.) new building basin at our Sparrows Point, Md., shipyard. Each tanker will need about 50,000 tons of our steel products.

## Watch for our interviewers.

They'll be visiting your campus soon. Why not sign up for an interview and find out about a future in steel? In the meantime, pick up a copy of our Booklet, "Bethlehem Steel's Loop Course" in your placement office. Or write to: Director—College Relations, Bethlehem Steel Corporation, Bethlehem, PA 18016.

BETHLEHEM STEEL an equal opportunity employer

*continued from page 7*

HOOD: I'm wondering what is the nature of the pressure and how does it get reflected, because it certainly doesn't seem apparent from where I sit.

BROWN: That just shows that your division's not doing its job.

HOOD: Well, I think they go through all the motions, but I don't detect any real enthusiasm. But what really is the nature of the pressure; is it really serious?

BROWN: I think there is serious governmental pressure on the basis of the law—and on the basis of the executive order calling for equal opportunity in employment. I think there is serious pressure from the women's groups. And I think there is moral pressure from within our own consciences.

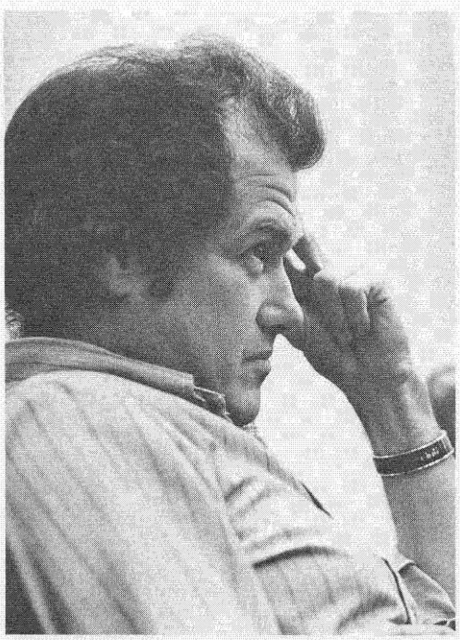
Interestingly enough, if you look at the number of PhD's in science, say, from members of the minority groups—blacks or Mexicans—the numbers are very small, so that the competition for those who have the qualifications is very large. And one can make a very good explanation as to why such groups are not represented in university faculties in numbers proportional to their numbers in the population; because the numbers are not the numbers of people, but the numbers of PhD's. That is not a way to excuse the facts, but to explain them.

In the case of women the situation is very different. There are quite a lot of women PhD's, particularly in biology and chemistry, and they're not represented on faculties in the same proportions. I think there has traditionally been, in some cases overt, in some cases tacit, discrimination against women. The argument is that "you can't count on women—they're always likely to do something strange, like getting married or having children, and dropping out of the market." And at the same time you have another difficult problem. The institution of marriage reflects the past societal arrangement that even in families where both husband and wife are professionals, they have gone where the husband's job is—and they still do. So long as that's the case, the wife's professional development is distorted and often stunted. And when they also, as often happens, agree that it's the woman who will retire from the job market while the children are young, that exacerbates the problem.

To get back to your original question, the pressures do come from the Department of Health, Education and Welfare, and from women's groups.

HOOD: What can HEW do?

BROWN: In the extreme, they can find an institution not in compliance with the executive order on equal opportunity, and cut off grants and controls. And at some institutions—at Michigan, for example, and Columbia—they've really gone right down to the wire on that question. We have had a somewhat different situation, partly because we are strongly technically oriented, and the pressures by women in those areas aren't quite as great. I think that we have to—and we are trying to—assure standard procedures—equal procedures—and carefully document them. I haven't found any way to avoid the question of judgment. People are appointed on the basis of judgments of the people who are here and of people elsewhere. And judgments are individual. They are sometimes hard to document. I think what we must do is look as hard as we can for qualified people, especially qualified minority people and qualified women. Once we have tried to get them here—to interview them—to make the judgment of them—to encourage them to come, I don't see what more we can do. I don't accept, and I think the federal agencies are not now claiming as they once were, that the criterion is: Do you have the same percentage of women as there is in the population?

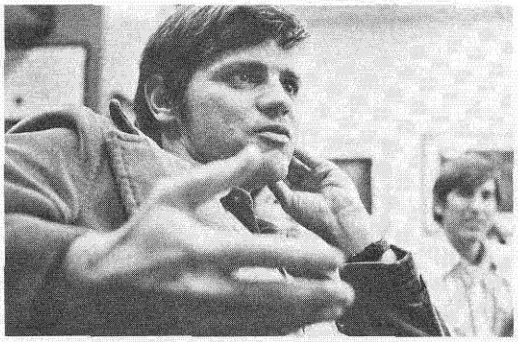


*Pine*

MORIN: As you pointed out, the undergraduate education is rather traditional in structure as well as content. It would seem that since Caltech is preeminent as a research institution, one way we could be innovative is to make undergraduate education more research-oriented. After a couple of years of classes maybe undergraduates could become attached to groups of faculty and grad students, pursuing their education at their own level, while doing research at the same time, and thereby being more prepared to continue in research when they got out.

PINE: The thing that impresses me about that comment is that that's exactly what's available now to the *few* people who are aggressive enough to go after it. And it seems to me they have to be *quite* aggressive because the faculty is not that generous with its time and concern for undergraduates. Is it your feeling, Joe, that this has to be formalized to get more faculty people opening up opportunities?

MORIN: Exactly. The problem is now that this kind of arrangement is available if you're *really* willing to put in a lot of time to try to prove to people that the research you're doing will cover the work you would be dealing with in three or four courses, which you'd have to drop. More often you have to keep the three or four courses and try and do your research above and *beyond* that. And it puts a lot of pressure on the undergraduate. A lot of people don't want to put themselves on the line that way.



Hood

BROWN: A number of Caltech faculty, including some who are really quite favorably inclined toward innovation and experimentation, have told me that one of the problems is that our students themselves are very conservative—very few of them are willing to gamble with their own academic careers. I'm not saying that this is bad. I'm saying it's an observation that I tend to believe.

MORIN: I would say that the undergraduates are more like the faculty than the graduate students these days.

BROWN: Well, you don't know the graduate students.

BEAUCHAMP: I think a lot depends on the option as to whether we can offer research opportunities to students. Many physicists tend to work by themselves, for example, while chemists have large research groups that can incorporate large numbers of undergraduate students. You spoke of wanting to shorten the curriculum. You know the chemistry option for the last three years has had no required courses other than one two-unit speech course, and I think this has had some success. It has allowed the student who is aggressive to formulate his own plan of study and to carry it out and benefit from this rather open structure. As a whole, however, the students have taken the same courses they would have taken under the previously required curriculum. They *are* conservative. They don't want to do anything that might damage their chances of getting into grad school, or now into med school.

BROWN: I don't think that's so terrible.

BEAUCHAMP: The open curriculum has had two real pluses though. More students have gotten involved in research. But the real benefit has been an evolutionary pressure on courses. The courses that have a reputation for being bad, the students don't take. So they're dropped, or they're changed and improved—and this has been the real benefit of an open curriculum.

BROWN: Tradition can't overcome revulsion.

BEAUCHAMP: The whole Institute could probably benefit from that. I had another question, though. The faculty gets a lot of feedback from students, from other faculty, from administration, and from outside the Institute, about the kind of job they're doing in teaching and research. What kind of feedback is a university president most sensitive to in terms of knowing whether or not he's doing a good job?

BROWN: I find that I am constantly seeking reassurance that people love me—and I don't do any better than the rest of you in getting it, except that the administration these days can probably regard absence of active signs of dissatisfaction as a pretty good sign. And the willingness of faculty members and students, if they've *got* a problem, to come in and talk to me about it, I regard as a happy sign. I *think* the word is around that my door is open. Those words are used in lots of places, and they may mean much or little. (The door can be open, but there can be all sorts of force fields operating to keep people out.) I do try to get out among students and faculty often enough so as to provide some opportunity for talking together. But I don't do what I know some students and faculty would like me to do. I don't go spend two hours regularly once a week in the coffee house, or two hours once a week having beer at the Athenaeum. I thought about whether I should do that, and concluded that if it didn't really appeal to me it wasn't going to work. I know I'm not close to *all* groups enough to make sure of feedback from them. Inevitably I rely for it to some degree from individual faculty members—wise old heads or well-connected younger faculty members. The outside community is a problem as far as feedback goes. It's always hard to tell whether any individual or any few people represent themselves or a much larger segment of opinion. The number of irate letters I get goes up and down. Over the past year it's been remarkably low, and I don't know whether that means apathy, or whether we're doing well, or what.

HOOD: Perhaps part of the problem of innovative teaching is the old tradition of tenure. What do you think about a young faculty member who comes in and does an outstanding job of teaching to the detriment of his research, and then it comes time in three years or six years for review and the faculty has to decide whether or not he merits tenure. We're a research institute and we're told that's our primary obligation. I don't sit on the tenure committee, and I don't know how they decide these things, but I'm curious to hear about it.

BROWN: My experience from having read what some of them have to say is that research competence always does come first, but that teaching counts too. And I can think of a few cases where exceptional teaching ability has made the difference. My own judgment is that using our present criteria of research, teaching, and service, in that order, but without fixed weights being given, has worked pretty well.

HOOD: What are your thoughts on tenure?

BROWN: I speak, of course, from the position of someone who doesn't have it. And that may color my thinking. I think the defenses of it, to which I subscribe, are correct: the independence it provides, and the assurance that you have been judged able enough so that your own judgment of what's worth pursuing and what you say about it are reliable enough to be the criteria that govern your work. I think those are good defenses. And they're the defenses that I present to the trustees or to outside people when they bring up the question. But those defenses, I think, either tend to leave out, or underplay, the difficulty and reluctance of the administration of a university to take action against a tenured faculty member who really isn't producing. Because it is a matter of individual judgment whether someone is not performing his assigned duties acceptably, or whether he's just kind of coasting in the job. Those aren't the same thing. Tenure has become more than protection of the individual faculty member's freedom of expression in his own field and freedom from retaliation against unpopular political opinions. It has become a kind of job security. I

*continued on page 32*

## An Interview with Harold Brown

*continued from page 31*

should note, in defense of academia, that in some industrial organizations (good ones, too) a high degree of job security exists, though it's not called tenure.

WARD: Do you feel there are any changes that need to be made in the graduate program, or anything to be done to improve it?

BROWN: I feel strongly that the graduate program has to be looked at by the faculty in each option, with specific attention to the question of what you are training graduate students to do. In the fifties and early sixties a larger fraction could be expected to go into academic research than you can expect in the seventies and eighties. And if that doesn't require some change in emphasis—then it's a remarkable coincidence.

DAVIDSON: I have a question that relates to fund raising—because the alumni fund drive is rolling along now. How do we tell alumni, or any potential giver, why they really should give to Caltech?

BROWN: What we say to individuals and foundations is that Caltech deserves to be supported because it is at the cutting edge of human knowledge. It turns out not only new facts, but new sciences. It produces really outstanding graduates, partly because the people it takes in are good, but also, we think, because of what happens to them while they're here. In the long run our national well-being, both in material terms and in terms of the intellect or spirit, depends upon the products, knowledge, and people in places like Caltech. And Caltech is among the very best—we feel it's *the* best—at what it tries to do.

Those are the answers we give in words. What we find is that when we bring people around here, we don't have to say all that. All they have to do is listen to some of our people talking about their work.

BECKMAN: Drs. Millikan and DuBridge both headed the Institute for about 20 years apiece. Do you see yourself as filling the office of the presidency in five years or ten—or going on to something else?

BROWN: Twenty years seems to me a very long time. I think the tradition of very long presidential tenure, if not now dead, is quite out of fashion, for understandable reasons. The pressures are substantial and they come from all sides. Things are changing more rapidly. And every time you make a decision, if you don't make enemies, you at least have some annoyed people around, and these just add up. After not too many years you've accomplished most of what you *can* accomplish. Whether this is in five years or ten years, I don't know. I don't feel so close to that time that I've started to speculate on what comes next. But I expect not to be president of the Institute for so long that I don't have career problems afterwards.

PINE: There's a sort of tradition of administration people teaching here. Would you like to teach?

**We feel that Caltech is the best at what it tries to do. But when we bring people here, we don't have to say that. All they have to do is listen to some of our people talking about their work**

BROWN: I am not quite comfortable enough with all my other duties yet that I could face up to that. But I would like to, in fact. It really would involve picking a subject and preparing enough material on it to cover a term's work. And when I would get a chance to do that, I don't know. I *have* agreed to serve on an independent study committee for one student, and that may be a good introduction to doing something.

HOOD: What's your impression of the student houses? Are they a good place for the students to live? Is there any way of making them better? What is the administration thinking in this regard?

BROWN: The student houses *represent* themselves as being each very different from the other. They have not to me seemed to offer enough alternative ways of living. I think that is what they ought to aim at, and I think it is the one thing perhaps the administration can encourage more. I'm not sure it can be done simply by trying to change the student houses. It may be more do-able by creating alternative living arrangements outside of the student houses. You know cooperatives have already been set up in three houses on Holliston Avenue. The Institute is also in the process of purchasing an apartment house which might be used for analogous purposes. Maybe some grads will want to live in some of the new houses acquired, and maybe some undergraduates will want to live in some of the graduate houses, where they would not have the advantage of having meals prepared, but probably would have more privacy. So I can think of four or five different kinds of living arrangements, of which the undergraduate student houses are one. And I think if you had those four or five, then the undergraduate houses would become more different than they are now.

BEAUCHAMP: Are there any questions you hoped we'd ask that we haven't asked you?

BROWN: Yes. There's one thing I wanted to get off my chest, so I'll both ask the question and answer it. What is it that you feel you've been unable to do that you very much wanted to do? And the answer is that I have wished ever since I came that I could sit down and spend a few weeks just looking at long-range plans for the Institute. I haven't been able to do that.