OCTOBER 1968

E&S ENGINEERING AND SCIENCE

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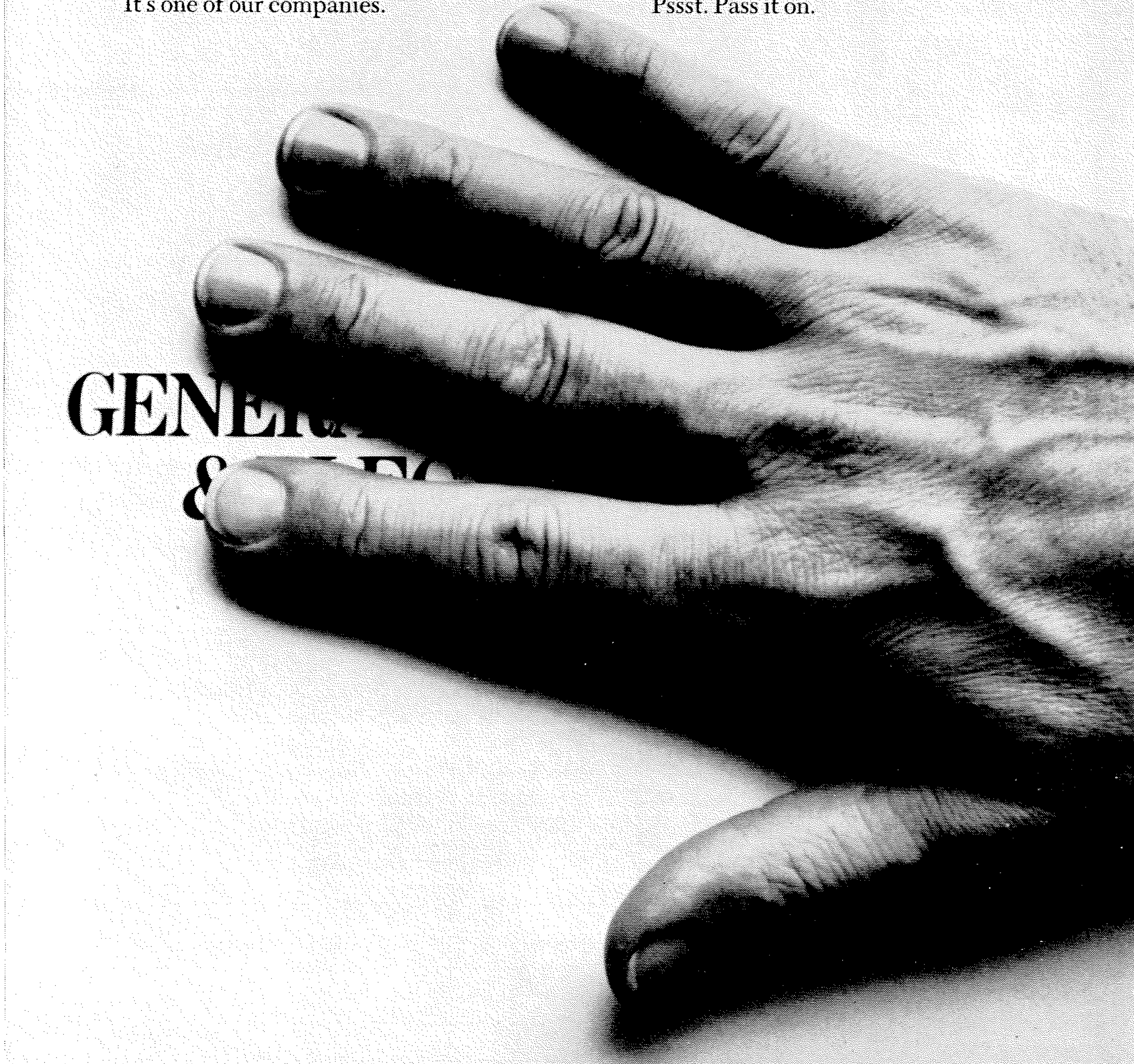

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ENGINEERING AND SCIENCE

OCTOBER 1968 / VOLUME XXXII / NUMBER 1

ON THE COVER

Wally Rippel, Caltech '68, about to start the Great Electric Car Race that ultimately took him and his colleagues from Pasadena to Cambridge, Massachusetts. For Rippel, who masterminded the contest to demonstrate electric propulsion as a way to reduce air pollution, the event was the culmination of several years of hard, extracurricular work. A detailed account of the race begins on page 10.

PHOTO CREDITS

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BOOKS

The Double Helix

by James D. Watson

Atheneum *$5.95*

reviewed by Robert L. Sinsheimer, chairman of the division of biology

This is a saddening book, for it reminds us of that which we would rather forget—that in *homo sapiens* brilliance need not be coupled with compassion, nor ambition with concern.

In reality this is two books. One is an account—lucid, honest, suspenseful—of the scientific events that led to the deduction of the molecular structure of DNA, which at one stroke provided a clear chemical basis for the results of 50 years of genetics and at the same time constituted the central support about which the whole structure of molecular biology could be built. Because it is in many ways a typical story of scientific discovery—with false trails, the fortuitous combinations of ideas, the ex-post-facto-obvious nature of the solution—with all the drama heightened by the importance of the goal—it could well serve as a model text for initiation of the young, were it not for the second book. It is fascinating even now to look back and to note how many of the essential facts were available (the Chargaff rules of the molar equalities of adenine and thymine and of guanine and cytosine, the knowledge from x-ray data of a helical structure with the phosphate-sugar backbone on the outside, the suggestion of complementarity as the necessary structural basis of gene replication); and yet the true solution, though but a small step from these, was by no means obvious.

This story is of such interest that one can overlook its atypical aspects, that Watson and Crick were relying upon cadged data from the x-ray studies of Franklin and Wilkins—overheard in seminars, pried out in conversations, even provided by Max Perutz from a privileged report. Or the somewhat bogus suspense provided—repeatedly—by the synthetic race with the demigod Pauling. "Caltech's fabulous chemist, Linus Pauling, was not subject to the confines of British fair play. . . . Our first principles told us that Pauling could not be the greatest of all chemists without realizing that DNA was the most golden of all molecules. . . . We had to face the bleak situation that the world authority on the structural chemistry of ions was Linus Pauling himself. . . . Then it would be obvious to the world that Pauling was not the only one capable of true insight into how biological molecules were constructed."

The second book, however—interwoven with the first—is a description of the private world of J. D. Watson during these historic events. And this is unbelievably mean in spirit, filled with the distorted and cruel perceptions of childish insecurity. It is a world of envy and intolerance, a world of scorn and derision. This book is filled with character assassination, collective and individual, direct and indirect. Even worse is the evidence that Watson believes the rest of humanity—save for the muddle-headed—sees this same world.

It is a world of intense ambition—for the mundane prize, not the advancement of truth nor the service of humanity. Thus, ". . . Francis [Crick] and I went over to the Eagle. The moment its doors opened for the evening, we were there to drink and toast to the Pauling failure. Instead of sherry I let Francis buy me a whiskey. Though the odds still appeared against us, Linus had not yet won his Nobel."

His mentor, Luria, is portrayed as an amiable simpleton. "He [Luria] positively abhorred most chemists, especially the competitive variety out of the jungles of New York City. Kalckar, however, was obviously cultivated . . ."

Of Chargaff: "Chargaff as one of the world's experts on DNA was at first not amused by dark horses trying to win the race. Only when John [Kendrew] reassured him by mentioning that I was not a typical American did he realize he was about to listen to a nut." Now everyone knows that J. D. Watson, Nobel prizewinner, is not and never was a nut, so what conclusion must one draw about Chargaff?

Or Randall: "Finding himself [Randall] overcommitted he had decided to send Maurice [Wilkins] instead. If no one went it would look bad for his Kings College lab. Lots of scarce Treasury money had to be committed to set up his biophysics show and suspicions existed that this was money down the drain."

Of biologists: "But even so they [biochemists] knew more than the majority of biologists. In England, if not everywhere, most botanists and zoologists were a muddled lot. Not even the possession of university chairs gave many the assurance to do clean science; some actually wasted their efforts in useless polemics about the origin of life or how we know that a scientific fact is really correct."

Of geneticists: "This is not to say that the geneticists themselves provided any intellectual help . . . All that most of them wanted out of life was to set their students onto uninterpretable details of chromosome behavior or to give elegantly-phrased, fuzzy-minded speculations over the wireless on topics like the role of the geneticist in this transitional age of changing values."

continued on page 6

Of scientists in general: "Many were cantankerous fools who unerringly backed the wrong horses. One could not be a successful scientist without realizing that in contrast to the popular conception supported by newspapers and mothers of scientists, a goodly number of scientists are not only narrow-minded and dull, but also just stupid."

Of Caltech chemists: "A number of his [Pauling's] colleagues quietly waited for the day when he would fall flat on his face by botching something important."

I could go on, but why bother. Apparently motive, like beauty, is in the eye of the beholder.

Several of the reviews of this book have commented on the strange vignette of the foreword in which Watson, climbing up a ski slope, sees W. Seeds, a collaborator of Wilkins, hiking down. Watson pauses to talk to Seeds, but the latter, on noticing Watson, merely remarks, "How's Honest Jim?" and passes on. These reviewers have felt that Watson, deeply stung by remarks of this sort, has written *The Double Helix* as an apologia. On the evidence of this book, I disagree. Watson *is* Honest Jim, believing he sees the world true, and "telling it like it is."

It is perhaps an interesting psychological question, if indeed these two books—the components of *The Double Helix*—are not in themselves complementary; if indeed the structure of DNA would have been discovered in this way had it not been for both the slanting brilliance and the skewed personality of J. D. Watson. Probably not. Although the discovery would not have been long delayed, it would have developed in a more conventional manner out of the x-ray studies of Wilkins, the model building of Pauling, the biochemistry of Kornberg. Ingenuity and clutching ambition bought a year or two in time—and fame.

But what will be the view of the scientific endeavor to be gained by the high school student who will surely read this? He will learn that it is a clawing climb up a slippery slope, impeded by the authority of fools, to be made with cadged data and a resolute avoidance of profound learning, with malice toward most and with charity for none. Is this really true? Not in my experience. Rather, it is a caricature and will do far more harm than we can soon undo with sincere words about the humane and esthetic qualities of science.

Numerical Methods for Two-Point Boundary Value Problems

by Herbert B. Keller

Blaisdell Publishing Company....$7.50

reviewed by Martin H. Schultz, associate professor of mathematics

Two-point boundary value problems have been important in engineering and science since the advent of the calculus. Recently these problems have become of prime importance in many engineering applications because of the development and growing importance of optimal control theory. Since the solutions of most of the two-point boundary value problems cannot be obtained or approximated by analytical methods, efficient numerical methods for approximating these solutions are necessary.

In his excellent monograph Herbert Keller, who is professor of applied mathematics at Caltech, introduces, describes, and analyzes three practical numerical methods for approximating the solutions of general nonlinear second-order problems and linear second-order eigenvalue problems. The first two methods, the initial-value or shooting method and the finite difference method, are also applied to problems for first-order systems of nonlinear equations. Much of the material on the shooting method is new. In particular, the first theoretical analysis of "parallel shooting" is given. The third method, integral equation techniques, is also analyzed for the first time. In addition, Keller adds an excellent chapter describing how the methods discussed in the text can be applied to some hard practical problems, even when the hypotheses needed for theoretical justification are not satisfied.

The book reads easily and can be understood by people with a background of advanced calculus, matrix theory, and elementary numerical analysis and differential equations.

Analysis of Numerical Methods

by Eugene Isaacson and Herbert B. Keller

John Wiley and Sons, Inc.........$11.95

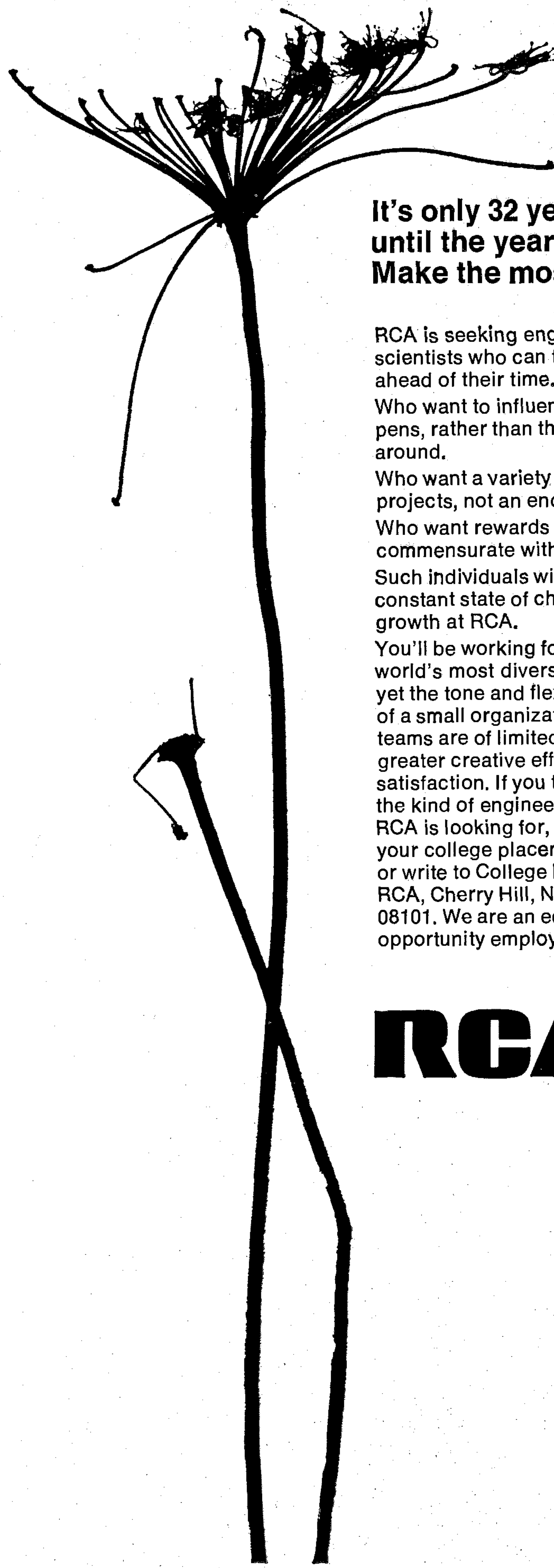
reviewed by Martin H. Schultz, associate professor of mathematics

Since the advent of the electronic digital computer, numerical computing has become essential not only in engineering analysis but also in current scientific research. This excellent text, a collaboration between Dr. Keller and his former colleague, professor of mathematics at the Courant Institute of Mathematical Sciences, New York University, introduces and discusses in detail many of the basic numerical techniques which are in current use.

The topics covered include numerical linear and nonlinear algebra, approximation and interpolation theory, numerical integration, and difference methods for ordinary and partial differential equations. Moreover, an excellent introductory chapter introduces the reader to the important concepts of norms in finite-dimensional spaces, rounding error analysis, and well-posed computations. The level of discussion is such that the book is accessible to people with an advanced calculus and matrix theory background.

Unlike many other numerical

continued on page 42



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Pasadena: 9 a.m., August 26—Wally Rippel gets a smooth start and hearty sendoff, and the Caltech car is on its way.

CAMBRIDGE OR BUST PASADENA OR BUST

Both teams in the Great Electric Car Race made it--and busted too.

For the last several years a persevering undergraduate has been Caltech's resident promoter of electric automobiles. Wally Rippel, '68, converted his 1958 Volkswagen bus to electric propulsion and drove it fumelessly around town in an attempt, he said again and again, to demonstrate an alternative to smog. His listeners smiled indulgently.

Now the smog remains and Rippel is gone, but the manner of his departure hinted that electric propulsion may not be such frivolous business after all.

At 9 p.m. PDT on August 26 the electri-

fied VW, with Rippel and some classmates, took off for MIT in Cambridge, Mass. At the same moment a group of MIT students started off for Caltech in an electrified 1968 Corvair. The event was the result of a challenge to race electric cars across the country issued in January to MIT students by Rippel.

Both sides figured to take up to 5 days for the trip. Neither did. The MIT car made it to Pasadena 7½ days after the start, and Caltech hummed into Cambridge 37 hours and 20 minutes after that. But by the time the judges finished assessing penalties for such activities as towing, recharging with a portable generator between official charging stations, and replacing parts, the tortoise had once more beaten the hare. Caltech's corrected time of 210 hours was 30 minutes less than MIT's.

Cost of the electricity used was about $25 for each car, but before you head for Chicago in an electric runabout, consider a few of the logistics associated with the Great Electric Car Race:

- *54 charging stations set up in advance by Electric Fuel Propulsion Company of Ann Arbor, Michigan, in cooperation with local utility companies along the route (US 66, the Indiana-Ohio-New York-Massachussets Turnpikes). Charge times ranged from 45 to 60 minutes.*
- *One or more "chase" cars supplied by each entry, carrying additional crew members (6 total for Caltech; 13 for MIT) and, in Caltech's case, towing a portable 220-volt generator.*
- *Ice for cooling batteries (50 pounds for Caltech, 350 for MIT) at most stops.*

In addition, for purposes of timing the entries (and also to carry additional spare parts and personal gear), each team had a judge and a station wagon supplied by Machine Design *magazine.*

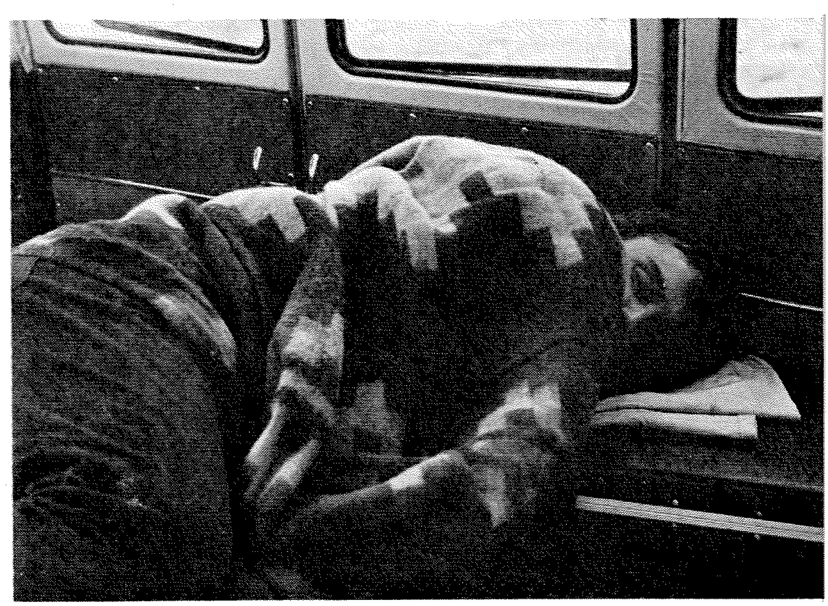
MIT's entry, developed more or less by their electrical engineering department, had a car supplied by General Motors and $20,000 worth of batteries supplied by Gulton Industries. It was considerably more sophisticated than Caltech's car, which really belonged to Rippel. The car and the batteries—$600 worth—are his, although he had received several donations of equipment and help from Caltech and outside enterprises as the race neared.

But MIT's sophisticated car was a laboratory model and had never been driven until shortly before the race. Reports from Cambridge were that the car would go faster than Caltech's and recharge in less time. Rippel, admitting that MIT had an edge in equipment, figured he would have a reliability edge because of simpler design and proven components.

Ultimately, that turned out to be the case, although once the race started the gremlins in both vehicles emerged.

Members of the MIT crew—who had a notion of what they might face after a last-minute trial run that almost burned up their set of nickel-cadmium batteries—had to tow their car about 250 of the first 500 miles. They had a constant heat problem, but they partially solved it by cramming the battery areas full of ice at each charging station.

Caltech's problems were less spectacular, but nonetheless vexing. The main problem, too, was heat, especially while recharging the lead-cobalt batteries. It forced the Caltech crew to slow down the recharging rate at first, wasting driving time.



Between Needles, Calif., and Kingman, Ariz.: VW buses have one important advantage over Corvairs—room to snooze.

To Caltech crew member Dick Rubinstein, '69, riding in the chase car, the trip went like this:

"I was a little uneasy when we started out, not knowing how things would go or what was going to happen. In the first stretch we found newsmen following us, even photographing us from bridges. There were so many things happening at every turn we really couldn't pay attention to everything.

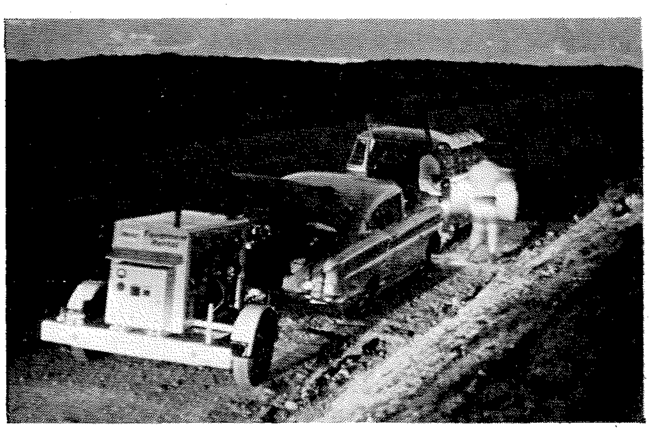
Our first charge stop—in San Bernardino—was a little awkward. The Edison Co. crew didn't know what to expect of us, and we didn't know what to expect from them, but that smoothed out after a few charge points.

Our next charging point, the Green Tree Inn at Victorville, went smoothly. We were able to eat and relax a little, while the batteries charged. We were having trouble with the batteries overheating, and we had this trouble through most of the first half of the race.

The people we met at these charge points were wonderful. We usually attracted small crowds, and everybody had questions. We had fun talking to the people, but we also had to chase around to eat and call ahead to other charge points.

I might add that through the desert we had more trouble with Andy Joseph's ['70] car overheating than we did with the electric car. But, it's a 1958 Chevy, and after all, it was towing that heavy portable generator.

After stops at Newberry and Amboy we did all right. I remember the service station attendant at Amboy. He thought it was all a joke and asked: 'What do you need an electric car for, anyway? *What* air pollution?'



Between Kingman and Seligman, Ariz.: Sunrise on the desert finds the portable generator reviving the batteries.

I remember waking up about six miles from Needles. Andy was on the two-way radio with Wally, and Wally said he only had about 90 seconds worth of power left, so get ready to use the generator. We didn't know how much farther the car would go, and it was slowing down. But after a minute—or maybe a little more—we rode over the crest of a hill, and it was downhill all the way to Needles. Wally used the downgrade to recharge the batteries with the motor, and we got into Needles with power to spare.

Meanwhile the MIT car was reported to have been towed to its first few charge points. The batteries didn't seem to hold enough power. Towing was allowed, but with a penalty of five minutes per mile according to the race rules.

We had to run around a little in Needles to find the charge point, but when we arrived, people there gave us soft drinks and made us welcome. I had to stop awhile and be interviewed on the phone by a wire-service reporter.

I caught some more sleep between Needles and Kingman. On the way we had to use the portable generator for the first time—a half-hour penalty. In Kingman we pulled up behind a school to the recharging point. It was after midnight, and while two of us were walking to a gas station, we were stopped by the police. They wanted to know what we were doing walking around town at that hour. We explained.

The doctor assured him it wasn't mumps.

Everybody was tired already, but from Kingman we moved on to Seligman. We had to stop twice to use the generator, but that was our fault. We thought we had enough power in the batteries to make it after the partial recharging, but we didn't.

Before we reached Seligman, Pat Silverthorne ['71] mentioned he wasn't feeling well. He said he had a swelling in his neck and cheeks but that the doctor had assured him it wasn't mumps. It was mumps. Sam Barnes, the fellow from *Machine Design* magazine who came along to judge our performance, drove Pat to the town of Williams to see a doctor, then on to Flagstaff. That's the last we saw of Sam Barnes for more than a day.

About mid-morning, disaster struck.

Well, anyway, just east of Seligman, about mid-morning, disaster struck. Wally was driving down a hill with the car in second gear, trying to put a little more charge into the batteries. From my point of view—I was half asleep at that point—we were coming down the hill and there was a very loud thud. The electric car slowed down abruptly, stopped, and somebody got out and ran around back. Wally said, 'I think we blew the motor.'

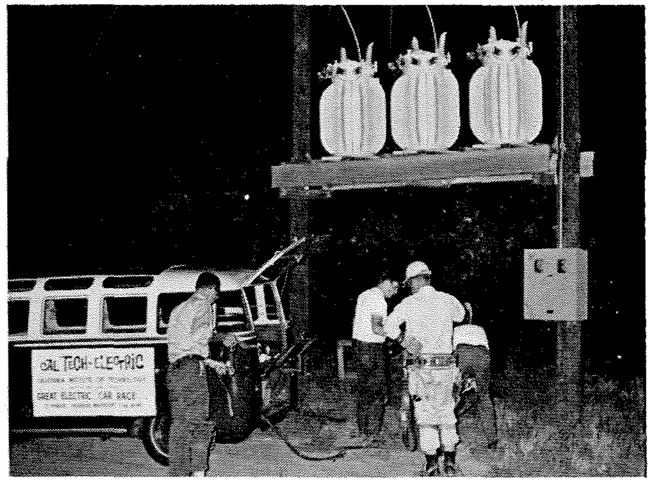
So we sat there, thinking. Then Wally and Andy got in the chase car and drove back to Seligman—about 10 miles—and got on the phone to Robert Aronson of the Electric Fuel Propulsion Co. in Michigan. Andy came back alone. Wally was still in Seligman calling everybody he could, and Andy went ahead to drop the portable generator at Ashfork. We took the motor out of the electric car when he came back.

It was a little hard trying to figure out how to get that 200-pound motor out gently, but when we did, it only took about ten minutes. George Swartz [a former classmate of Rippel's at Caltech] sort of caught it with his knees as we supported it by ropes.

Lots of people came by, too. Some stopped, wanting to see how we were doing. Of course we had plenty of time to talk now.

Andy, George, and I went back to Seligman

East of Seligman: George Swartz tries to decide how to remove the burned-out motor from Caltech's crippled car.



Winslow, Arizona: This charge station isn't as elegant as some, but amps are amps no matter how they're delivered.

where Wally was. Ron Gremban ['69] stayed with the car. Wally had finished phoning and found out we would get another motor, that it was being flown to Phoenix, and we could pick it up there.

Things weren't going much better for the MIT crew, either. They reported in just a few miles east of Buffalo, N.Y., where they were stalled after burning up a transformer. They were delayed seven hours, but after making repairs they began making good time across Ohio.

Repairs took a little longer for the Caltech machine, since the new motor was being flown all the way from New York.

We all sat down in Seligman and had a beer or two, and at one point Wally stepped outside to watch a train go by—he has a fascination with trains. Then we decided to go on to Flagstaff, leaving Ron with the electric car.

We were looking for Sam Barnes, too, since all our clothes and other stuff were in his car. We all looked grubby, but went in a restaurant anyway and had a good steak dinner. Then we found a place to stay—and we washed some clothes in the motel.

We all got a little sleep, but about 11 p.m. Andy and I took off for Phoenix to meet the plane. I slept most of the way, but when we got there we found it was a case of hurry-up-and-wait because the plane didn't arrive until 3:30 a.m., and it was another hour and a half before we got the motor. We carted it to Flagstaff, then slept while the others put the adaptor plate on it and took it to Seligman.

Albuquerque: With the motor catastrophe behind them, the Caltech crew enjoys the attention of early-morning pedestrians.

They must have found Sam somewhere, because he woke me up at the motel and we took off for Ashfork to meet the electric car. It sure was nice to see that thing pulling into town under its own power.

Apparently they had no trouble getting the motor in the car, especially since they were able to borrow a transmission jack to help.

From there on the going got smoother. We were still pretty disorganized, with everybody's stuff in the wrong places, but we soon worked all that out. We met Pat Silverthorne [the one with the mumps] in Flagstaff, where he was recuperating with an aunt who lives there.

Everything went all right through Winslow, Ariz., and Sanders, Ariz., but we had a minor problem in Gallup, N.M. Everything was fine with the electric car, but we had an eye problem in ours. Andy, who wears contact lenses, was getting ready to drive and was putting his eyes in when one lens disappeared. We spent about 40 minutes searching for it with no luck. After we gave up, he looked in his lens case, and there it was, where it had fallen.

Our next recharging station was in Grants, N.M., where the power company people had coffee and donuts waiting for us. They were talkative and friendly.

Getting into Albuquerque was an easy trip. It was sort of downhill going in, and our reception in Albuquerque was something else. They had the recharging station roped off on the sidewalk, a big sign was up, and they had a girl dressed up as Reddy Kilowatt. They provided us with showers, bought us breakfast, and gave us a red carpet welcome. In all we probably stayed in Albuquerque about a half an hour longer than we should have.

For MIT, the problems were compounding. The car caught fire when it was being recharged at Elkhart, Indiana. It was put out quickly, but damage was worse than first estimated, and the delay was more than 10 hours.

The MIT car was next reported in the area of Springfield, Ill., where they were having problems with the motor overheating. The method they chose for cooling it was to pour water on it.

Wally lightened the load by having Ron and George walk.

We soon ran into a great glob of traffic on the way out of Albuquerque. It turned out they were blasting on the road ahead, and we had to sit there at least 45 minutes. We spent the time discussing some method for cooling down the batteries during the charging process.

Our next recharging point was Clines Corners, N.M., but before we got there, Wally pulled over, complaining that a brake or something seemed to be dragging. We jacked the car up and checked, but nothing was wrong. We were afraid we didn't have enough battery power left to make Clines Corners, so Wally lightened the load by having Ron and George walk. It was only about two miles, but the car made it and it was a nice walk for them.

Along about the time we reached Santa Rosa, N.M., the weather started looking nasty. It became very, very windy in Santa Rosa, so windy we could hardly walk.

We had to use our portable generator before we got to Tucumcari, N.M. Also, we ran into a heavy rainstorm going into Tucumcari, and where we were charging, we found the streets were somewhat flooded. After Tucumcari, it got so that if you weren't driving you were sleeping.

Amarillo became another trouble spot for us. Somehow, when we were hooking up the lines, we got out of phase and blew out three diodes. That presented no problem except that Sam Barnes—who was driving without a relief driver since Pat Silverthorne got the mumps—couldn't be found. He was making a practice of driving ahead a stop or two to catch some sleep as we drove. We called everywhere but couldn't find him, and we even had the Texas Highway Patrol out looking. We found we could get the new diodes in Dallas, but boy, that was a long way off. Finally Sam got our message and came back. We charged up, ate breakfast, and took off again—after a delay of three or four hours. The weather was still kind of damp, too.

McLean, Texas: 50 pounds of ice cool overheating batteries.

We finally solved our battery overheating problem in McLean, Tex. While the car was charging, I went into town to buy some rubber tubing and a rubber syringe bulb. We got some small ice cubes and put them on the batteries, then used the tubing to siphon the water out of the battery enclosure. We used the syringe bulb to start the siphon. That was our handy-dandy cooling system, for which I blushingly accept credit.

It was also in McLean that a Texan came to our rescue. One of the bystanders walked off, then returned bearing a nice, ice-cold 50-pound watermelon. It was home-grown, and the best I've ever tasted.

MIT's recharging procedure might scare someone out of driving an electric car.

At Erick, Okla., we sent a telegram ahead to the MIT crew asking if they'd agree to stop awhile in Oklahoma City for a chat and rest, maybe something like 12 hours. But we actually met at Weatherford, Okla., the charge point west of Oklahoma City.

We'd finished charging at Weatherford when they were towed in. We waited there a couple of hours, and we saw their recharging procedure. It was enough to scare someone out of driving an electric car. It was amazing; there were probably 12 people involved, girls rushing around, dropping big bags of ice on the ground, everything helter-skelter, confused. And they refused to stop to talk. They took off right after recharging.

After Oklahoma City we got the batteries straightened out very well. We charged them slowly for four hours and got everything back in phase. This made it much smoother than it had been.

The charge point at Tulsa was near a big motel called the Camelot Inn. They really fussed over us

Pasadena: The MIT car is towed across the line on Labor Day, and the crew is deluged by reporters and TV crews.

there and gave us a room in the motel to take showers. We probably lost more time on this kind of thing than for any other reason, but it was great.

Going into East St. Louis, Ill., we got lost. We ended up waiting nearly an hour for somebody from the power company to find us and lead us to the charge point. They had 350 pounds of ice ready when we got there, but we only needed 50 pounds.

Monday morning—a week after we left Caltech—we were in Elkhart, Ind., and we learned that Pat Silverthorne was feeling better and would meet us in Cleveland. Of course in Cleveland [headquarters of *Machine Design* magazine] there were all kinds of people out to greet us. We met the race judges and the members of Sam Barnes' family. We also learned the MIT car was in California.

The MIT car was indeed in California. But here the problems multiplied. Crew members didn't like the charging setup at Newberry, so they elected to tow part of the way to the next point, Victorville. The driver, however, neglected to take the car out of low gear while being towed at 65 mph. The electric motor, turning over too fast, disintegrated.

The MIT crew notified the judges and others that they intended to tow the car directly to Caltech, bypassing the last two charge points. They arrived at 3:26 p.m. and crossed the finish line.

After Cleveland the stops were pretty smooth, and many looked just alike. The only place we encountered any problem was at the last stop before Cambridge. I called ahead to the power dispatcher at Charlton, Mass., but he almost refused to accept my call. He finally took the call but said it wouldn't

Cambridge: The eventual winners get the checkered flag on Wednesday morning, nearly nine days after they left Pasadena.

Cambridge: The weary Caltech crew collects some laurels, including congratulations from MIT President Howard Johnson.

do any good because he didn't want to call anybody out to work on overtime just to charge our batteries. I called Bob Byers, the public relations man at MIT, who called the power company, and they assured us we'd get recharged.

But it didn't work out that way. When we arrived, we found the point was six miles off the highway instead of the short distance we were told, and then we found he couldn't supply three-phase power. We ended up charging the batteries with the portable generator anyway.

Before we reached this last charge point, we had been met by an escort committee from MIT, and they led us right in to the campus. That was the end of our long, weary journey. ❞

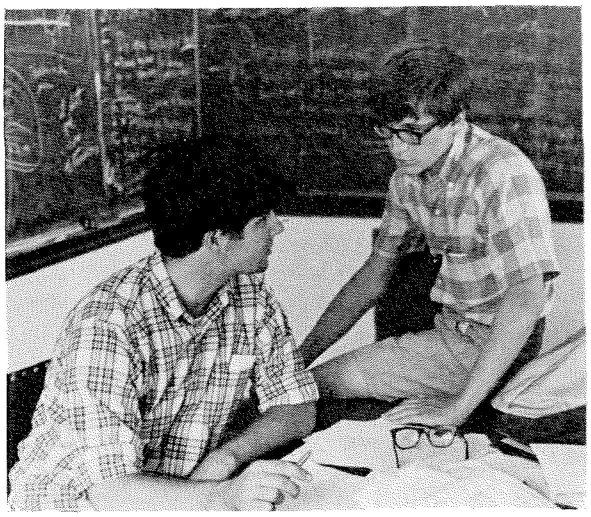
The boys were greeted on arrival—7:46 a.m. Wednesday—by MIT President Howard Johnson, then attended a news conference that afternoon and a banquet that night sponsored by Caltech alumni. By the time of the banquet they knew they'd won the race by half an hour.

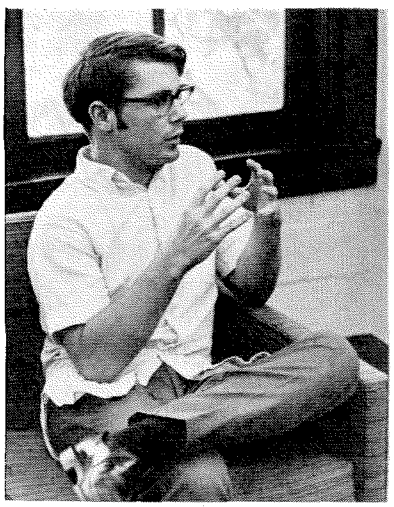
The following night—at the Tavern-on-the-Green restaurant in New York's Central Park—crew members of both teams were honored at a victory dinner. The celebration was arranged by Caltech alumnus Victor Wouk, PhD '42, of Gulton Industries, which had provided equipment (notably MIT's nickel-cadmium batteries) and advice to both teams. Wally Rippel was presented with a trophy for the "1968 National Electric Car Competition" given by the Edison Electric Institute and Reddy Kilowatt, Inc; he insisted it belonged not to him, but to Caltech, and had it forwarded to Pasadena.

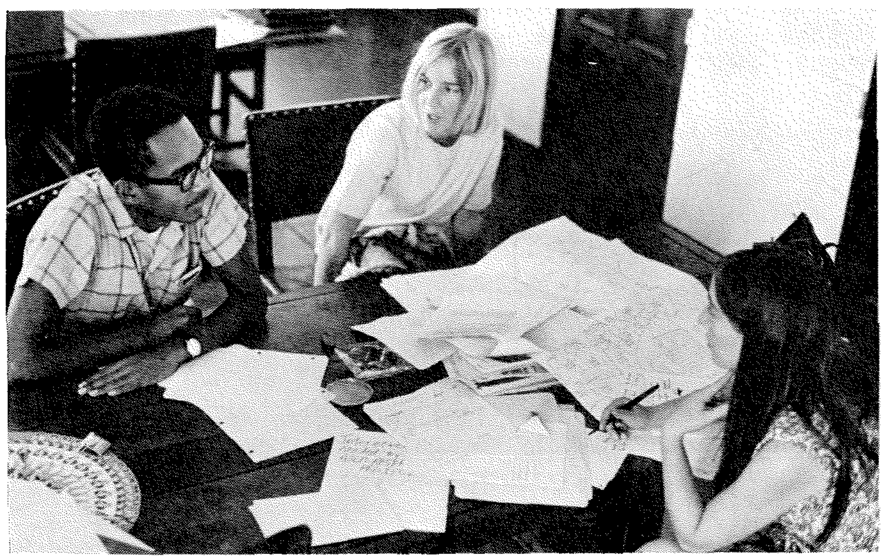
By Saturday both cars (Caltech's having been trucked from Cambridge, MIT's flown from San Bernardino) were on display at the Smithsonian Institution in Washington, D.C., highlighting a "Cars of the Future" exhibit sponsored by the U.S. Department of Transportation.

Wally Rippel has gone on to Cornell for graduate work, but Ron Gremban, one of the co-drivers, is already making plans for another race next summer. Electric Fuel Propulsion Co. has offered improved lead-cobalt batteries that will recharge faster and run as many as 250 miles between charges, and a new motor capable of speeds up to 90 mph. What Gremban still lacks is a car—preferably a VW squareback sedan—in which to install them.

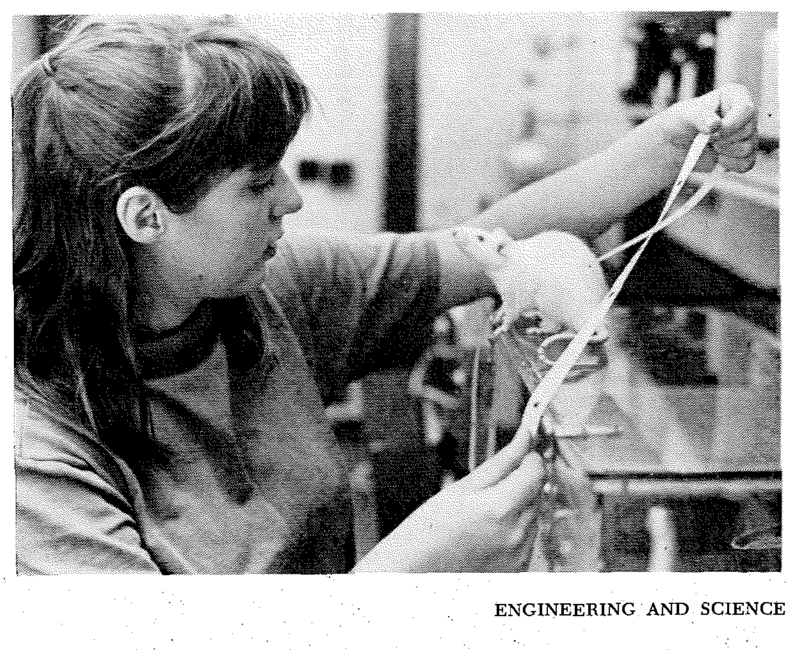
This year's race seemed, in some ways, to be more a test of endurance than performance. A second race might reverse that emphasis and make for an even more exciting contest. □







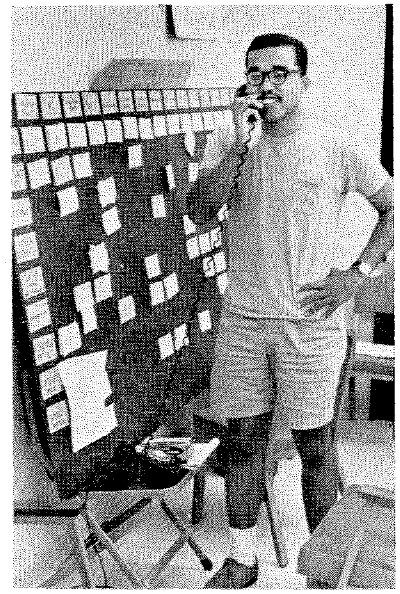
Undergraduate scientists and social scientists combined forces and goals in the many-faceted project. One group of students ran and tabulated a 10,000-piece mail survey to estimate the amount of property damage caused by smog. Others tested the effects of metals in smog on mice, the effects of a heavy ozone environment on rats, and the effects of a smog-free environment on rabbits.



The Student Smog Research Project

by Barry Lieberman '68

Caltech undergraduates and students from other campuses launch an ambitious educational experiment



Spearhead of the project, student body president Joe Rhodes.

The ASCIT (Associated Students of the California Institute of Technology) Research Project on Air Pollution did not originate because Caltech students felt a great desire to help alleviate the smog problem. Students chose the topic only after they kicked around the idea of a research project in the abstract. The project was envisioned as a unique expression of student activism consistent with Caltech.

Caltech students were concerned about the same issues that bothered students on other campuses. Many did not like the Vietnam war, and they did not want to be drafted because of it. Many worried about the terrible effects of racism and saw Pasadena's ghetto as a constant close reminder. Many experimented with drugs, and a small minority used them heavily. And finally, many expressed discontent with the Caltech educational experience.

Student anxiety, however, never came close to the point of forcing the type of open, disorderly confrontation that has plagued other universities.

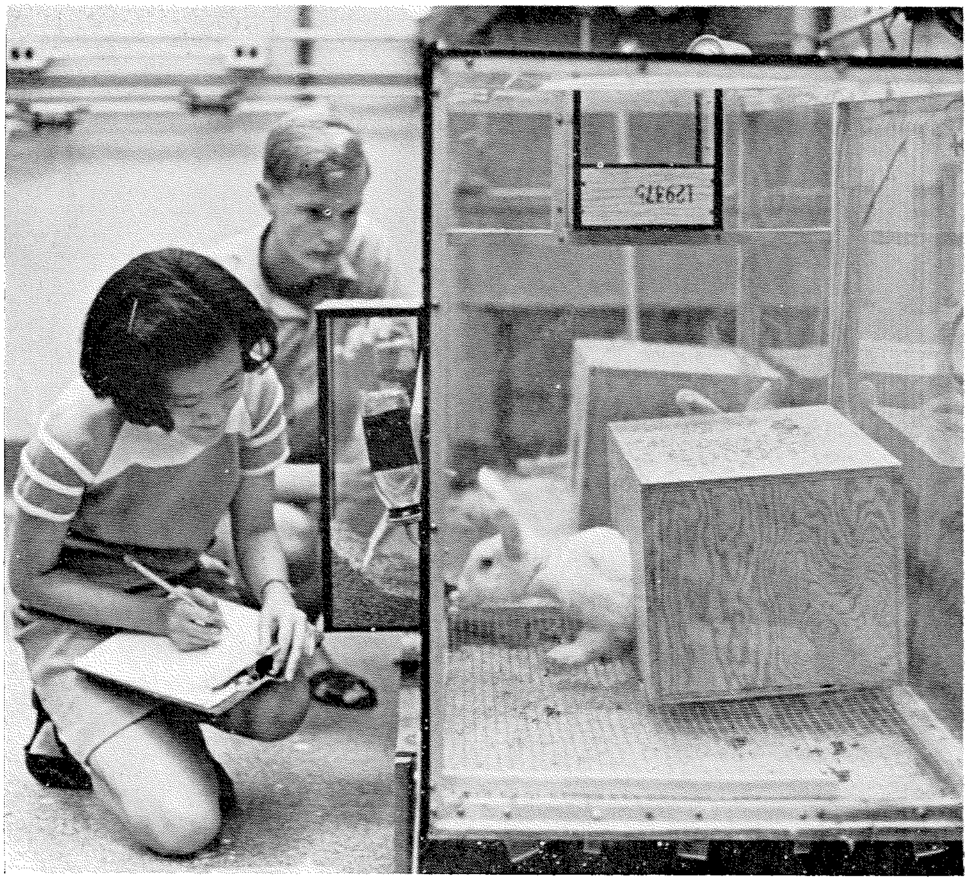
The only organized presentation of student grievances at Caltech came at a meeting of the student body in the spring of 1967. At that meeting students passed a number of resolutions asking for liberalization of the curriculum, increased voice in Institute decision-making through membership on faculty committees, and establishment of study committees to explore various areas of the undergraduate program. The faculty greeted these requests favorably, and steps were taken to implement some of the student proposals. But student body president Joe Rhodes, '69, saw that a research project could penetrate far beyond small academic changes, and he convinced other students to take the initiative to set up an alternative educational structure alongside the conventional one.

Committees formed when school reconvened in the fall of 1967. They faced the task of picking a research topic, articulating the goals of the project, attracting other workers, and filling in the details. This is when the hard work began.

At an early meeting students chose air pollution as the research topic because it was a crucial, local problem with both social and technical aspects. The project members were unrealistic about the contribution they could make toward solving the pollution problem. They showed little appreciation or understanding of the great amount of work the Los Angeles County Air Pollution Control District and others had already done. But at the same time project members brought freshness and enthusiasm to the problem. Since they started out knowing nothing, they were not prejudiced by old concepts.

Beneath the first musings over air pollution, the social and educational project goals began to become clearer in the minds of the creators:

► Give undergraduates a chance to do research



Project workers compare blood samples of rabbits in smog-free and smog-filled chambers. Results show that rabbits breathing smog have 25 percent more lead in their blood.

about real problems instead of just textbook problems.

- Rekindle the enthusiasm of Caltech students by giving them the chance to become involved in something which they themselves formulate.
- Expose Caltech students to social science and to social science students from other schools.
- Expose social science students to the natural sciences and to Caltech students.
- Introduce women to the Caltech campus.
- Devise a social community oriented toward the completion of an intellectual task, but also a community where the emotional interactions between people are dealt with consciously and openly—this to be accomplished through the use of basic encounter group methods.
- Demonstrate that the behavior of American college students is motivated by a deep concern for this nation and the world.
- Challenge the image of Caltech as an ivory tower by actively demonstrating how the resources of an academic institution can be put to work on social and community problems.

In November 1967, with research topic and revolutionary goals clearly in mind, project members began to assemble proposals aimed at raising money to finance the project.

At about the same time the faculty decided to keep its eye on the project, both to advise the students and to make sure they did not commit Caltech officially to anything. The faculty board appointed an ad hoc committee to investigate the research project, and the board voted, on December 15, to approve the project and "encourage the student body to proceed with their proposals."

Bad news followed this good news only one week later. The first formal request for funds—$33,000—was turned down by a California foundation.

Discouragement reduced project activity to its all-time low. Students who had worked from the beginning became disillusioned and quit. In attempting to obtain funds, the project had developed into a bureaucracy which did not appear to be making headway toward organizing around air pollution research. Many serious students who did not empathize with the educational goals refused to have anything to do with the project as long as research was secondary.

At the end of the tunnel, however, there was a dim light. In March, Joe Rhodes went to see S. Smith Griswold of the Department of Health, Education, and Welfare's Air Pollution Center in Washington. Griswold was impressed by the preliminary efforts and stopped at Caltech during a trip to the West Coast. He indicated that funds were available and that he thought the project could make a contribution to air pollution studies. He advised the students to rework their proposal and suggested areas of research to pursue.

Project members finally got down to the business of writing a serious research document. The final 88-page product asked for $68,000 to fund about 60 student researchers. It included the following areas of proposed investigation:

- ► Assess the domestic pollution cost by sampling consumer household expenditures in a polluted and non-polluted community.
- ► Assess the public concern by sampling opinion in a polluted and non-polluted community.
- ► Study the roles of government and pressure groups in pollution legislation.
- ► Study the feasibility of implementing wide-scale, computer-arranged car pools.
- ► Attempt to improve the photochemical model of atmospheric smog.
- ► Study the affects of atmospheric lead on living things.
- ► Study the costs and effects of various control measures.

In May the proposal was mailed to Washington. Everyone waited impatiently. Students from other universities, some in the East, were set to come to Pasadena if the project received funding. Many could not hold up their summer plans beyond the first of June. On June 6 the project learned it had gotten the money.

The planners had until June 24, the official starting date, to devise a structure for the summer. Little attention had been paid to summer organization because project members had channeled all their efforts into obtaining funds. On June 24 about 45 new participants would arrive. Many of them only knew that the project would study air pollution.

Fortunately the project got help from TRW Systems in Redondo Beach. TRW had trained some of its professional systems staff in basic encounter tech-

A girls' dormitory was set up in Blacker House for female project workers this summer. Some of the 25 girls came from as far away as Wellesley, Pembroke, Swarthmore, Carnegie-Mellon, and Radcliffe.

niques as a means of helping project teams within the company to run smoothly. Discussions with members of the TRW staff produced a number of goals and concrete proposals for organization of the Caltech research project:

- ► The project decision-making structure should be completely democratic. Every project member should clearly understand the organization and how he could affect it.
- ► The participants should not consider project work a nine-to-five summer job, but instead something that could produce great personal commitment, dedication, and involvement.
- ► Project members should be completely free to choose the type of work they would do.
- ► A clear framework should exist to allow project members to air any form of dissatisfaction, including problems of personal relationships. These problems should be dealt with immediately, before they could interfere with the work that had to be done.
- ► The project's organization should not be rigid; there should be constant reevaluation and, if necessary, modification of the organizational structure.

Following an intensive orientation week the project began operation within a structure that placed just about all activity within two types of groups—a task group and a family group. The task groups were the work groups, and there was one for each area of research. The family groups met as basic encounter groups, providing a place where problems could be discussed. Membership in family groups cut across task-group lines in an attempt to provide maximum mixing and communication.

The value of the project in teaching participants how to do research became apparent as the task groups grappled with the problem of defining and then attacking their work. Task groups at first had great trouble getting beyond a vague statement of their work (i e., "We are going to study the working of the government as related to pollution legislation" or "We are going to survey the public's attitudes toward air pollution"). From these abstract statements, groups had to formulate day-to-day tasks and plan the work for a 12-week time limit. Planning like this, however, was almost impossible without some intuitive understanding of the research problems. Such intuition comes from an exhaustive prerequisite understanding of the subject, plus experience. Project members lacked both, and thus faced the additional problem of becoming experts in a few short weeks. This prevented some groups from establishing a definite plan of attack until late into the summer. The groups that faced this problem remained on the verge of panic, worrying about whether their efforts would ever produce any results.

The task group-family group arrangement turned out to be only a partial success. Instead of working out personal antagonisms within the family groups or with the person involved, many project members confided in intermediaries and personal friends.

The project's group approach to research also had some shortcomings. Some people worked better independently and a few project members showed little initiative and needed even *more* direction than the group could provide. Even so, the open-ended, flexible atmosphere of the research project was far more successful in inspiring creativity and productivity than the rigid atmosphere of the classroom.

The one unqualified project success was its role in bringing 25 undergraduate women to campus. The scarcity of girls before the project, other than secretarial staff, made it easy for such a small number to have a great impact.

The research project did not produce any earthshaking results, but no one really expected it to. It did, however, do some honest research, and a report of that research will be published by the end of the year. More important, the project attempted to practice the goals that it preached. That made it not only a means to an end, but an end in itself.

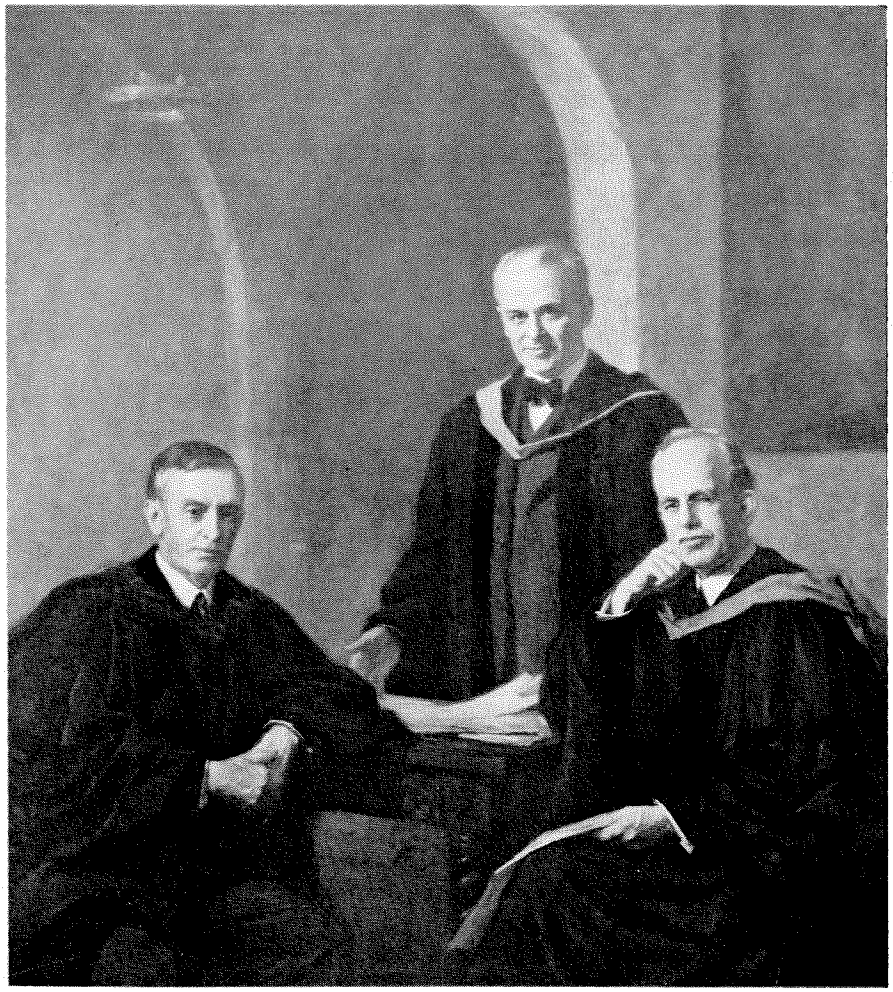
The project has a number of immediate implications for Caltech:

The faculty and students should continue to explore ways of reforming the academic program. New liberalizations, especially student-initiated projects, should be encouraged.

Caltech should seriously pursue development in areas other than the natural sciences. The project was consistent and anticipated all the directions in which Caltech has said it hopes to head.

The admission of women should be pursued with all due haste.

The project had shortcomings and limitations. It was student protest that saw an alternative and attempted to experiment with it. It is therefore essential that the experiment be analyzed in terms of what it proved and what it failed to prove. Only then can the results be applied and have lasting value.



Noyes, Millikan, and Hale—a painting by Seymour Thomas

A. A. NOYES

A tribute to his close friend and colleague

by Earnest C. Watson

As I look back upon a long and full life spent largely at Caltech, Arthur Amos Noyes stands out as the person whom I most respected, admired, and loved—not only as a scientist but as a man. And if I were to name the single individual to whom in my opinion Caltech owes the most, it would be he.

It is therefore, I believe, very fitting that Caltech's handsome yet functional new laboratory of chemical physics should be named in his honor. I can imagine no more fitting memorial, nor one that would have pleased Noyes more if he were alive.

The familiar painting by Seymour Thomas that hangs in the Athenaeum dining room portrays the three men, George Ellery Hale, Robert Andrews Millikan, and Arthur Amos Noyes, who were the founding fathers of the Institute. At the unveiling of that portrait I asked Mr. Thomas why he had not done justice to Arthur Noyes' really beautiful soft brown eyes, and Mr. Thomas replied, "I didn't dare. If I had, he would have dominated the picture."

Similarly I feel that if I, or anyone else, were to paint truly the early years of Caltech, Arthur Noyes would dominate that picture. This he would not have wanted, for he was a shy, modest, and retiring

This article has been adapted from a talk given at the dedication of Caltech's new A. A. Noyes Laboratory of Chemical Physics in May 1968 by Earnest Watson, Caltech professor of physics, emeritus.

man, entirely uninterested in his own personal aggrandizement. I shall therefore not attempt to paint the whole picture but will be satisfied if I can succeed in giving you some insight into the lovable personality and sterling character of this trail-blazing educational pioneer.

Arthur Amos Noyes came from pioneer New England stock, with a heritage of common sense, integrity, ingenuity, tenacity of purpose, fairness, courage, and love of nature—as well as the traditional New England reserve. From his father he learned Latin, chess, swimming, rowing, and sailing—accomplishments in which he took a certain amount of pride. It was probably his mother who was responsible for his appreciation of beauty and the arts, especially his passionate fondness for poetry, which he could recite from memory by the hour. I remember a day we spent hiking together on the glaciers of Mount Rainier. Noyes started off in the morning with a stirring recitation of "Sunrise on Mount Blanc" and continued all day in the same vein, almost without interruption.

"If I were to name the single individual to whom in my opinion Caltech owes the most, it would be Noyes"

Noyes entered MIT in 1882, and, excepting about three years of advanced study in Germany, remained there as student, faculty member, director of the Research Laboratory of Physical Chemistry, and acting president for more than 35 years. During much of this time he struggled—without success— to turn MIT into the sort of institution it has now become. It is not surprising therefore that when George Ellery Hale, one of his first students at MIT and later his closest lifelong friend, offered him the opportunity to do in California what he had tried so hard to do in New England, he came to Pasadena. He came to help build here something new in the educational world, "a college, graduate school, and research institute of science, engineering, and the humanities."

Although the unique center of education and research that Caltech is today was conceived by Hale, its development was due largely to the vision and careful, painstaking work of A. A. Noyes. Noyes not only originated most of the educational policies that made Caltech what it is, but he formulated them so carefully that they have served almost without change to the present day. These include the commitment to research and creative scholarship at all levels—undergraduate as well as graduate, postdoctoral, and faculty—that characterizes Caltech, and the conviction that research and teaching are so closely related that creativity can, nay must, be carried over into the classroom and become part and parcel of all the Institute's teaching.

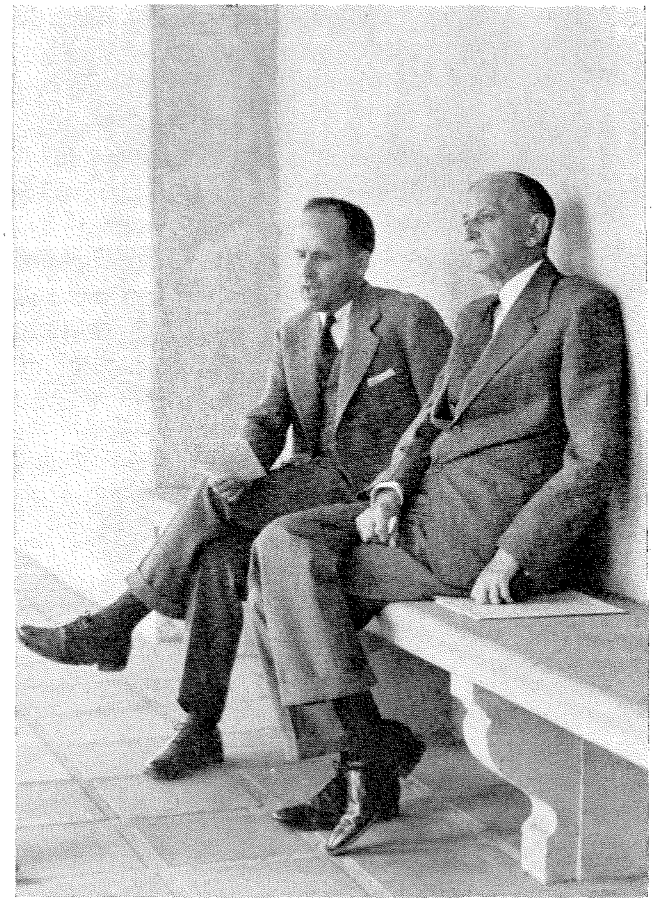
These policies also include the decision not to try to become a university but to concentrate upon the most fundamental fields of science; not to try to cover all areas of knowledge but to become outstanding in a few, and then not to expand into other fields until the right people can be found and adequate financing can be secured. They include moreover the emphasis upon basic rather than applied science and the attempt to train the creative rather than the operating type of engineer—to provide, in a word, education rather than training. They include the limitation on the number of undergraduate students and their careful selection; the requirement of courses in the humanities as a means of providing the students with a broader experience with people and ideas; the development of the student houses as a part of the overall educational process; the fostering of self-government for the students; and the attempt to provide a stimulating, creative atmosphere with close contacts between students and faculty both in and out of the classroom. They include the breaking down of departmental boundaries and the cultivation of interdisciplinary fields. All these and much more were largely due to Noyes.

It is hard to remember what engineering schools, even the very best such as MIT, were like 50 years ago, or to realize how great a change has taken place since Noyes provided at Caltech a model of an entirely new type of scientific and engineering school; for this model has been followed by almost all the best engineering schools in this country, and even by many abroad.

What has been the nature of this change? In the early decades of this century the better engineering schools were providing excellent technical training in civil, mechanical, electrical, and chemical engineering. They were turning out young men well trained to handle the purely technical problems assigned to them. But a few thoughtful scientists and engineers were beginning to realize that while these young graduates had indeed been taught their trades well, they did not have the breadth of view necessary to enable them to take over the larger administrative positions, nor did they have either the imagination or the training in fundamental science and research needed to enable them either to conceive new projects or to grapple successfully with the new types of problems that were already arising in our industrial society. As a result, some of these thoughtful men were advising their sons, when they were ready for college, to go to a liberal arts school for broad fundamental education before proceeding to graduate work in science or engineering—and to research. This is of course a possible solution to the problem, but Dr. Noyes believed that it was not the best solution. He felt that, since science and engineering are closer to boyhood interests than are the arts and humanities, at least a few of the ablest students should be put as early as possible into a research and creative atmosphere. The California Institute as he envisioned it was therefore to be a research institution of the highest quality, where able students would come into contact with creative minds and where the emphasis would be primarily upon the basic sciences of mathematics, physics, and chemistry. But the arts and humanities were not to be neglected or treated as mere requirements to be gotten out of the way before plunging into research. Instead, strong courses in these fields were to be provided, and all students from the beginning of their study were to be required to dig rather deeply into them.

This meant, of course, pushing the highly developed applied courses either entirely out of the curriculum or at least off into graduate years. I am sure you can realize what a struggle it was to bring this about. The engineering faculty felt very strongly that courses in the applications were necessary in the training of anyone worthy of the name of civil, mechanical, electrical, or chemical engineer. And in this they were strongly backed by their professional societies. They insisted that Caltech graduates educated in accordance with the Noyes plan would be unable to compete with graduates of other engineering colleges where more practical training was offered.

These arguments, compelling though they seemed at the time, were soon shown by experience



Physicist Earnest Watson and chemist Arthur Noyes confer outside the Gates Laboratory—1925.

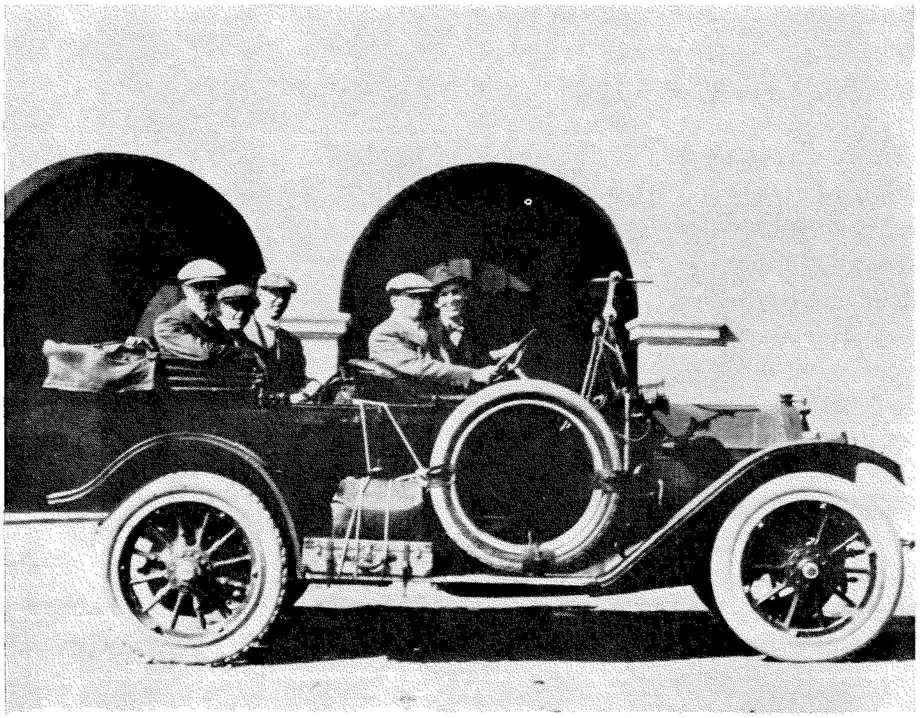
to be unsound. Caltech graduates, although sometimes in the early days at a slight disadvantage immediately upon graduation, have, thanks to their better grounding in basic science, gone further in the long run than their competitors and have been more able to branch out into new directions.

Noyes pushed his reforms through in the firm confidence that this would be the case, and he formulated the necessary policy statements with a compelling clarity. The literate and unambiguous phrasing of statements of all kinds was a passion with him. No slipshod statement ever got by his scrutiny. Indeed, I have actually seen him take out his pencil and revise a letter he had just received in the mail to make it fit, as he felt, for intelligent reading.

Noyes also saw the dangers of too strict departmentalization and realized the importance and interest of interdisciplinary fields. Having personally seen what could be done by the use of physical methods in attacking chemical problems, and having been largely responsible for the development in this country of the then new discipline of physical chemistry, he naturally enough also saw the possibilities of such fields as biochemistry, biophysics, and geophysics.

Actually, when he came to Caltech from MIT, he brought with him a physicist as a member of his own chemistry department; and very soon thereafter he pushed through the appointment of Richard Tolman as professor of theoretical chemistry and mathematical physics. It was Noyes more than anyone else who, after strong research in biology had been started at Caltech under Thomas Hunt Morgan, persuaded the Rockefeller Foundation that it should support work in the interdisciplinary fields between biology and chemistry and between biology and physics. All this was by then relatively easy and natural at Caltech because of the strength of the already existing departments of physics and chemistry and because a divisional rather than a departmental administrative system had been set up. It was also facilitated because of Noyes' high principles, idealism, and unselfish devotion to science and to the Institute as a whole.

Let me give you one example of the extraordinary unselfishness of this remarkable man. Noyes was the first topflight scientist to be brought to Caltech. He was the outstanding physical chemist in the country and had been the most highly regarded faculty member at our leading engineering school. When he came to Caltech, he was promised ample funds to build up an outstanding research center in chemistry. Then the opportunity to bring Robert Millikan to the Institute arose. But funds were not yet available for a broad development in both physics and chemistry. Noyes, being the kind of man he was, did not hesitate to step aside and allow the trustees to throw all their resources into physics and make Millikan the nominal leader. He placed himself wholeheartedly behind this move, telling Millikan that physics actually underlay chemistry as well as biology and engineering and that he was therefore willing to subordinate his own field temporarily and to help in any way he could in building up physics.



"Old Mossie" sets out on another expedition with Stuart Bates. James Ellis, James Bell, Noyes, and Howard Lucas. Noyes' old touring car was generally thought to hold the world's record for the standing broad jump because Noyes so often tried to start off in high gear.

This was much more than the act of self-effacing objectivity that Millikan thought it, for chemistry and its development was a passion with Noyes; and, as a bachelor who had no family, his feeling toward chemistry was almost that of a father toward a very promising only child. It therefore was an act fraught with deep emotion, the act of a rare soul and a very great man.

Noyes' ability to set aside his own personal interests and to work for the good of a cause was also demonstrated by his performance in Washington during World War I, when he assisted in the reorganization of the National Academy of Sciences and the organization of the National Research Council. While again Hale was the prime mover in these matters, it was Noyes' careful backstopping and infinite capacity for taking pains that made much of the difference between success and failure.

Noyes' interest in able students was phenomenal and became legendary. An astonishing number of the most creative scientists of this century in this country owe a debt to Noyes—for training, encouragement, stimulation, help of many kinds, often including financial. His reputation in this regard among his peers was such that James Conant, shortly before he became president of Harvard, accepted Noyes' invitation to work at the Institute for a few months partly because he was so intrigued by what he had heard about Noyes that he wanted to find out at first hand if it were true.

Noyes' favorite method of becoming acquainted with a student—or even with a new colleague such as myself—was to invite him to go on a camping trip in the desert or to spend a weekend at his beach house on the cliffs of Corona del Mar. These trips or visits were invariably stimulating experiences. Noyes would think aloud, so to speak, about whatever problem or idea was uppermost in his mind. Then he would draw upon his guest for advice or criticism. And from the interplay of ideas there frequently developed some new line of scientific investigation or new development at Caltech.

When Noyes first came to Pasadena, Hale gave him an old touring car—a Cadillac of early vintage that Hale was discarding—and this was used for the trips to the desert and the beach. The students came to call the car "Old Mossie," which was short for Demosthenes, in honor of its pronounced stutter. Old Mossie was generally thought to hold the world's record for the standing broad jump because Noyes would so often absent-mindedly try to start off in high gear. This may in turn have contributed to the frequent breakdowns which, Noyes said, gave him an opportunity to learn quite a lot about the ingenuity, initiative, and mechanical ability of his guests.

At the Institute Dr. Noyes spent a great deal of time working personally with the abler students, trying to steer them into careers in research. Every one of the Institute undergraduates who has since won a Nobel Prize was a person to whom Noyes at one time or another gave special attention. He worked regularly, for example, with the students who were selected each year to compete for European travel prizes, freeing them from routine work, encouraging them to undertake special projects, helping the winners with their travel plans, even providing additional funds from his own modest resources. In the selection of the winners he tried to get away from reliance on mere grades by taking into account the students' outside interests and accomplishments, even going so far as asking the students to rate one another upon a number of carefully selected personal qualities.

Noyes' interest in undergraduate students did not prevent his giving considerable attention to graduate and postdoctoral students. He advised many with personal as well as professional problems and often gave them financial assistance at crucial times. Once, jokingly, he suggested that he and I should collaborate on the writing of a book dealing with the personal problems of graduate students. As he put it, Mrs. Eddy had written *Science and Health* and become famous; Dr. Millikan had written *Science and Religion* and become famous. Why then shouldn't we write a book on *Science and Love* and become famous too? In a way I am sorry we never did.

Let me read from a resolution of respect to Dr. Noyes adopted by the Institute's board of trustees after his death. These lines seem to me to sum up quite beautifully what I've been trying to say about the ideals and character of Dr. Noyes:

> From 1919 until his death in 1936, Dr. Noyes was the most constructive influence in the development of the educational policies of the California Institute and in shaping its ideals and its program. The effect of his work had a very wide sweep. There has been no more significant figure in the development of chemistry in the United States than Arthur A. Noyes. The imprint which he made on both of the two institutions at which he spent his life, the Massachusetts Institute of Technology and the California Institute of Technology, have been far reaching and lasting. These two institutions as they exist today are in a very real sense the living memorial to the life, character, and ideals of Dr. Noyes. His extraordinary soundness of judgment, unselfish devotion to science, sweetness of character, thoroughness of analysis, and objectivity of approach made him an unmatched leader in every undertaking to which he devoted his energies. The Trustees of the California Institute herewith record their profound appreciation of his work here and of the world service which he rendered in setting an example to his generation of a life guided by reason, kindness, intelligence, and the unfaltering devotion to his own ideals. □

Portrait of Perpetual Zest

Solar astronomer Harold Zirin came to Caltech looking for ideal atmospheric conditions and brought an atmosphere of his own.

Solar astronomer Harold Zirin is known as "unchained energy" to the three postdoctoral fellows who work with him. This limitless energy, they say, makes for a man easily impatient with those around him who can't or don't work as prodigiously as he does. It also spreads a certain amount of dismay among the people in charge of astronomical equipment. (*They* say some of it buckles under Zirin's energetic approach.) And his co-workers admit that Zirin's perpetual zest results in occasional mistakes as he hacks his way through scientific underbrush to blaze a path to the sun.

In the same breath all these critics reveal, with considerable admiration, that Zirin will always cheerfully and candidly admit a *gaffe*—a quality, along with his generosity to colleagues, that is not invariably found among scientists. And a close co-worker, astronomer Robert Howard, adds that Zirin has not only brought solar observation to the campus, but is a never-ending source of provocative and stimulating ideas in the realm of solar physics.

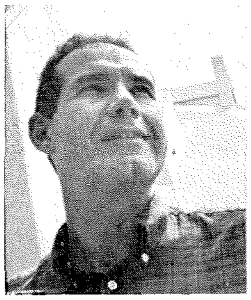
Zirin came to Caltech in 1965 from the High Altitude Observatory at the National Center for Atmospheric Research in Boulder, Colorado, largely because of Howard and Caltech physicist Robert Leighton. He had worked with them as a visiting professor at Caltech in 1963 and found it exciting. When he was invited to join the Caltech faculty in 1965, the timing was right. He was dissatisfied with the atmospheric conditions in Colorado, and Pasadena offered ideal ones (very stable air). In addition, he knew there was solid interest at Caltech in building a solar telescope somewhere in southern California. After three years, he is convinced that Caltech has the most stimulating environment that an astronomer can find anywhere.

The trio has been very productive at Caltech. They each have a particular interest in the structure of the sun's chromosphere: Zirin in cinematography and the morphology of the sun; Leighton in the theory of sunspot cycles; Howard in solar magnetism. Howard and Zirin have conceived and designed the large reflecting telescope system that JPL is contributing to the Apollo Applications Program. And all three were involved in the selection of the site for Caltech's new solar observatory now under construction at Big Bear Lake, with Zirin responsible for its funding and design.

Solar astronomy is a relatively small field; there are only about five active solar observatories in this country. Zirin estimates that the number of people really active in the field is no more than 50, so they work with each other as "cooperative competitors."

"I don't know why solar astronomy isn't as popular in the United States as it is in Europe," he ponders. "Every college has its little 16-inch telescope for stellar work, but they seldom have a solar telescope. They're relatively cheap—we get beautiful results with a five-inch photoheliograph that cost about $30,000—and we have all the benefits of daytime observing."

Solar astronomy has become more important re-



"When you study a distant star, its spectrum is just a track—a fingerprint. With the sun it's like seeing the whole man."

cently because of space exploration; intermittent solar phenomena can interrupt long-distance communications or injure astronauts. Then too, scientists who have been observing x-rays and cosmic rays are becoming more interested in the solar flares that produce them.

Zirin got his Harvard PhD in 1953 as a theoretician, but has long since become what he calls a "working astronomer." In fact, he refers to those who wear heavy trappings of theory as the *bêtes noirs* of solar astronomy—the phrase being loosely translated from the French as pains-in-the-neck.

"There are still too many people who are so wound up in mathematical analyses that they forget to think of the sun or stars as real. Until about 1910 astronomy was very classical, with no physics in it at all. Then, largely through the influence of Hale and others, the new physics came in and theory became important. In time a lot of the emphasis shifted from observation and interpretation to theory.

"Theory is great as long as it's physical theory. It's when it becomes giant mathematical exercises that there is danger. Now, if you look at an astronomical journal, you sometimes find about half the papers are just big calculations somebody did in order to get a degree or to publish. They're more academic exercises than steps forward."

Zirin thinks the biggest job in his field today is to *see* what is actually happening on the sun. He is convinced that most of its mysteries will be solved by physical thinking rather than by extensive mathematical analysis.

"One example," he says, "is solar flares. For years theoreticians tried to explain them when most had never seen one. They were like the blind men trying to describe the elephant."

He believes that the primary reasons for studying the sun are because it has such a great influence on the earth and because it is the one star that we can really see well.

"When you study a distant star," Zirin says, "its spectrum is just a little track—a fingerprint. With the sun it's like seeing the whole man."

One of the most absorbing features of his work is that the sun is always different, changing from day to day. Eventually he wants to see a chain of three coordinated solar telescopes in good locations to film the sun every minute of the 24-hour day. So far he has the funds for just one of them. The project ("one of a number that are dragging me down in the mire") has taken him all over the world in search of ideal sites. He considered Iran but ran into problems. He tried northern Sweden, but atmospheric conditions stymied him. He finally decided on Israel, where support facilities and trained people were available, but even there he hasn't found the going easy.

He took a telescope there in May 1967—a twin of his pet five-inch photoheliograph on the roof of the Robinson Laboratory of Astrophysics on the Caltech campus. It was all set up and ready to be used when the war broke out. (He considers it lucky that the instrument wasn't fired on by the Arabs; perched up on the roof of a building, it looks just like a cannon.) When the telescope was finally put into use this year, it didn't work properly, so he had to return to Israel this summer to straighten things out. He subsequently sent David Bohlin of his staff to do further work on it.

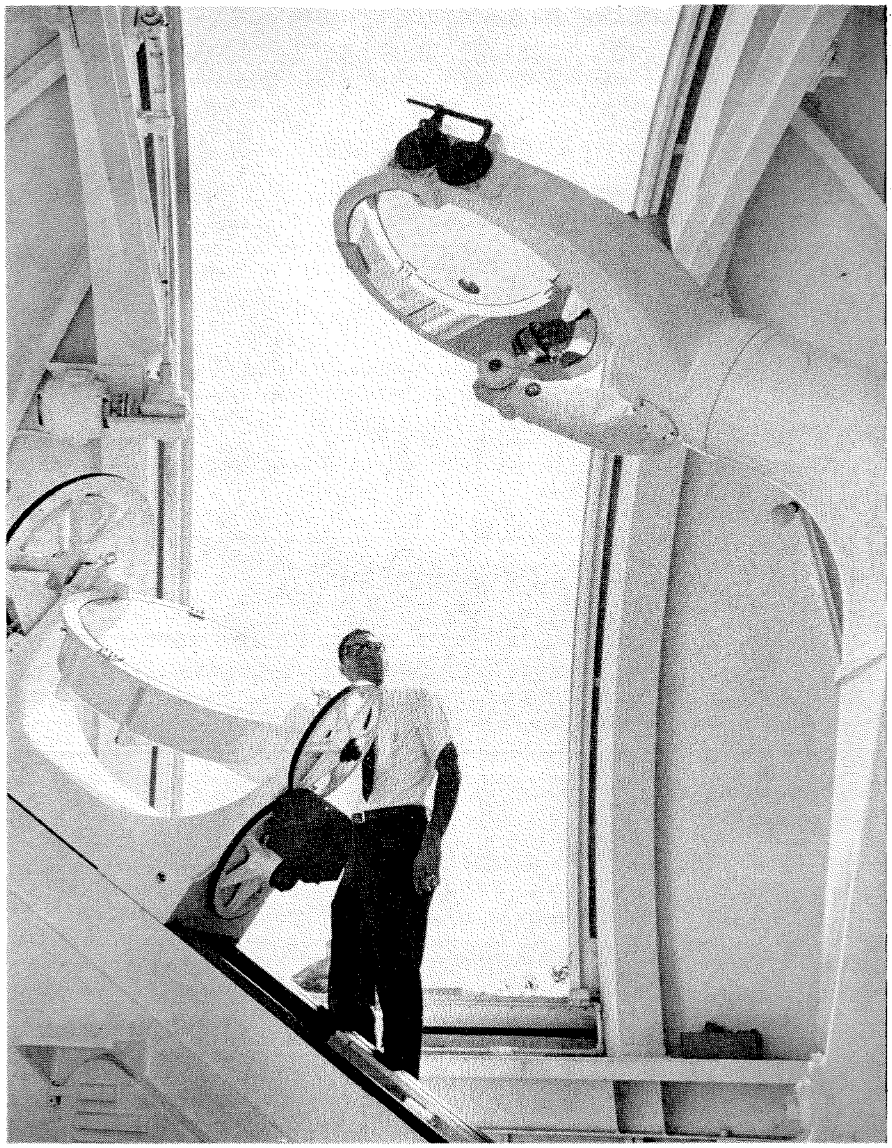
Meanwhile at Caltech he anxiously awaits completion of the new solar observatory at Big Bear Lake.

"We think it's going to be a terrific spot. This is the first time in history that a solar observatory was really chosen as the result of a detailed study, so we're expecting optimum conditions—air that is clear *and* stable.

"I'm still interested in spectroscopy and its interpretation. At Big Bear we hope, for the first time, to make rapid spectrograms so we can see immediately what we're getting."

He and his group are already using the new telescope, which will be moved to Big Bear but which is temporarily installed on the roof of the Robinson Laboratory. By the time it is finally on the site, the project will be four years old—and that's a long time in Zirin's frenetic life. He won't be surprised if the new installation will then have to be updated to meet the needs of the day.

"But," he says, "you have to be flexible—continually. Every *day* we change what we're doing with the telescope. Maybe I don't stick to one thing long enough. Maybe I change too often." □



George Ellery Hale's solar telescope comes to life at Caltech after 40 years.

RESEARCH NOTES

REBIRTH OF A SOLAR TELESCOPE

A solar telescope built at Caltech almost 40 years ago under the supervision of George Ellery Hale is being revived by astronomers here. The coelostat, a stationary telescope with an adjustable mirror to follow the sun, is the world's largest. It was designed and partly constructed in the Robinson Laboratory of Astrophysics in the early 1930's, but work stopped on the telescope when Hale became ill. He died in 1938.

The old telescope is being rehabilitated for use in the analysis of the fine structure of the sun's surface and for studying sun spots. The restoration is being done under the supervision of J. David Bohlin, research fellow in astronomy, with the support of a National Aeronautics and Space Administration grant. Harold Zirin, Caltech professor of astrophysics and astronomy, suggested the rehabilitation and obtained the grant. Cost of the restoration is about $10,000, a small fraction of what a new instrument of similar size and quality would cost.

The coelostat is mounted vertically on a 125-foot octagonal shaft. Sunlight is reflected in a fixed direction by a movable 36-inch-diameter flat mirror. A 30-inch flat mirror then directs the light downward to a fixed vertical telescope in the shaft. That telescope, a Cassegrain system with a 26-inch primary mirror 50 feet down the shaft, reflects the light upwards to a choice of secondary mirrors. These reflect the light back down, forming excellent solar images from 8 to 22 inches in diameter.

The dome and mirror guidance apparatus are mounted on top of the octagonal tower located on the roof of the three-story Robinson Laboratory. The shaft, which extends 80 feet underground, was originally intended for installation of a vertical spectroscope. The coelostat was so close to completion in the 1930's that all of the wiring was in and ready for the spectroscope, which was never built.

In restoring the instrument, the astronomers had to clean up the gearboxes and repaint some equipment, but the only things they had to replace were mirror mounting cells, which had been lost.

The rotating primary mirror, made in Holland before 1935, is a thin layer of glass fused onto metal. The glass and metal expand at the same rate when heated by the sunlight. The secondary mirror is a pyrex disc cast at the Corning Glass Works. It was the first of a series of discs made in preparation for casting the 200-inch pyrex mirror for the Hale telescope at Palomar.

Pasadena is a surprisingly good location for solar observations, according to the astronomers. Although the area has heavy smog, the conditions that lead to smog also lead to good seeing. The stable temperature inversion which keeps the smog from blowing away also reduces air turbulence—a major problem for solar astronomers.

The coelostat will be a facility of the Mt. Wilson and Palomar Observatories, which are operated by Caltech and the Carnegie Institution of Washington.

AN EMERGENCY CELL SOURCE

Nature has provided rabbits, rats, and probably human beings with a stand-by source that, in emergencies, produces red corpuscles at a rate which is several times faster than normal. Although this subsidiary source is in operation continuously, it normally produces only about 10 percent of the red blood cells in animals. However, Henry Borsook, Caltech professor of biochemistry, emeritus, has found that when there is an acute loss of blood production from the secondary source is stepped up markedly, and red cells can be assembled in about a third of the main source's time.

Red cell production in adult human beings normally takes place in the bone marrow. These cells—tiny packets of hemoglobin—transport oxygen from the lungs to the cells and help carry carbon dioxide waste from the cells to the lungs. During an emergency situation, such as a loss of blood, the primary production source of red cells increases its output considerably. Meanwhile, the secondary source produces a higher percentage (25 percent or more) of the total number of red cells and turns them out several times more rapidly. This secondary source requires only a day or two to assemble the finished product, compared with five or six days for the main source. However, Dr. Borsook has found that the red cells that emerge are about twice the normal size and do not live as long.

After the emergency subsides, both production sources resume their former, more conservative output. Erythropoietin, a hormone which Dr. Borsook and two colleagues were the first to synthesize, regulates this output.

Henry Borsook, Caltech professor of biochemistry, emeritus.

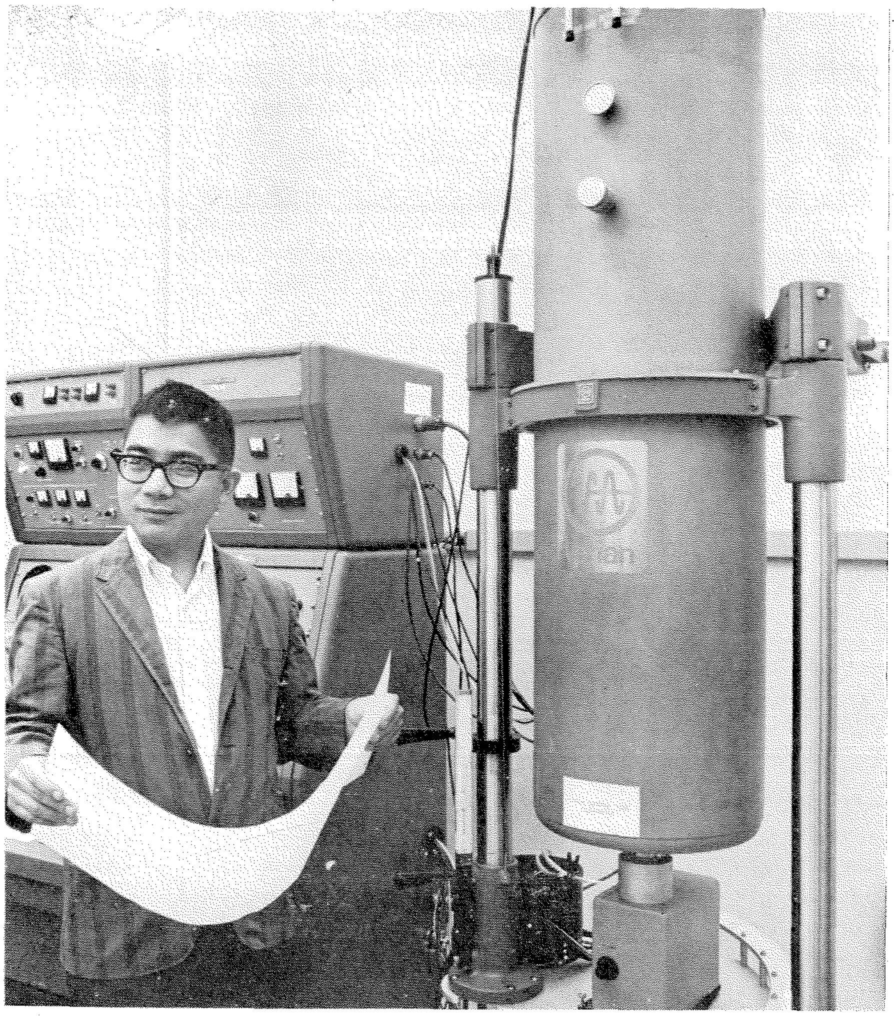
Dr. Borsook's associates in this research at Caltech were Mrs. Amelia Gunderson and Miss Dian Teigler. He is continuing the work at the University of California at Berkeley under sponsorship and support of the U.S. Public Health Service and the Atomic Energy Commission to determine the cellular pathway along which red cells are formed.

WHAT MAKES A MOLECULE

A powerful new research tool that helps scientists learn how complex molecules are constructed and how they are held together is now in use at Caltech. The device—an ultra-high-resolution nuclear magnetic spectrometer—is the first instrument of its kind to be used at an academic institution in the United States. Caltech is sharing the time on the new instrument with at least 13 other investigators from nine other institutions in southern California.

Sunney I. Chan, Caltech professor of chemical physics, is using the NMR to find some of the answers to problems of chemical bonding and molecular structure. With the aid of this new instrument, Dr. Chan and his colleagues are also trying to learn more about the precise manner in which small molecules bind to such biologically important macromolecules as nucleic acids and proteins. Through these experiments they hope to elucidate the physiochemical basis of the action of enzymes, mutations, carcinogenesis, and, perhaps, even the molecular basis of certain diseases.

Other studies planned include routine chemical analyses of complex chemical systems, including hydrocarbon fuels, boron-containing rocket propellants, natural products such as carbohydrates, sugars, ster-



Sunney Chan, professor of chemical physics, and the NMR spectrometer.

oids and terpenes, and even complicated mixtures such as those that have been exposed to intense radiation for long periods.

Operation of the NMR spectrometer is based on the principle that many atomic nuclei have associated magnetic qualities that tend to align them with an external magnetic field. These atomic nuclei, when aligned in the spectrometer's strong field, absorb certain radio frequencies beamed at them. An NMR spectrum of the substance under study is obtained by varying the frequency of the radio frequency transmitter or sweeping the magnetic field at which the radiation is absorbed. Locations of the peaks in the spectrum identify the atoms, while the heights of the peaks represent the number of atoms present in each environment. Interpretation of these data enables the investigators to determine molecular structure and also to find impurities if they are present.

The spectrometer was obtained on a grant of $216,000 from the National Science Foundation. Caltech will contribute a total of about $46,000 for related equipment and operation of the spectrometer.

A THREAT TO UNDERSEA FORESTS

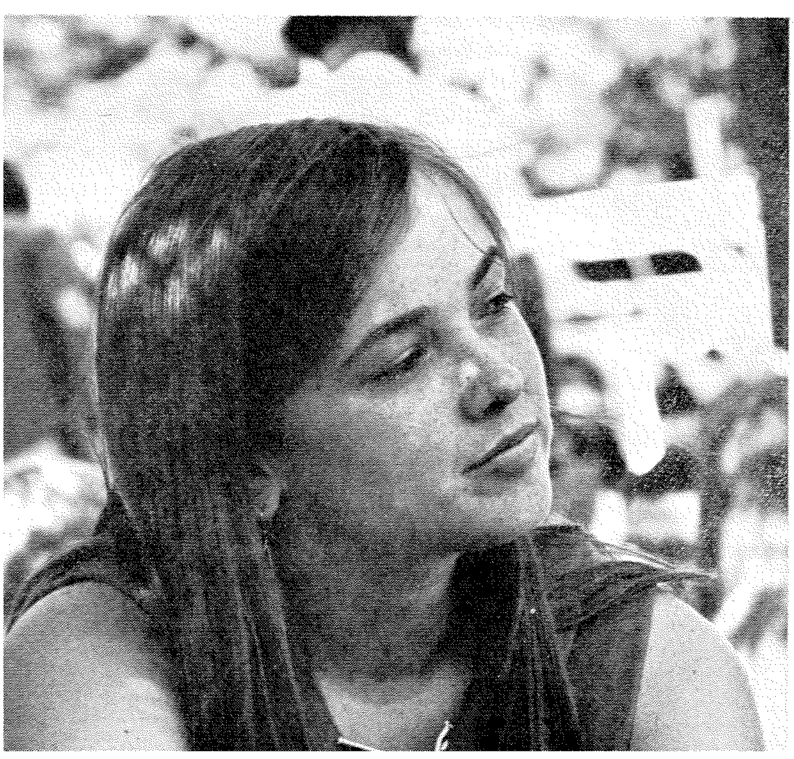
Nuclear reactors that will provide power for cities in the future may also change the character of coastal waters, modifying many marine communities. The huge generating plants are expected to raise the water temperatures along parts of the coast from three to eight degrees as they discharge water used for cooling back into the ocean. Even the generating plants already in use along the coast have raised water temperatures somewhat, although not over significantly large areas.

An increase in water temperature of only a few degrees, for example, in the past has caused deterioration of giant kelp beds and may also have a profound effect on other forms of ocean life. Wheeler J. North, Caltech professor of environmental health engineering, is currently trying to find plants that will survive when the coastal waters are warmer. If kelp that would grow despite temperature changes could be planted now, a future scarcity of the huge sea trees—an important economic resource—could be avoided. Kelp plants are harvested to obtain algin, a jelling agent used in paints, pharmaceuticals, and cosmetics.

Working much of the time at Caltech's Kerckhoff Marine Laboratory at Corona del Mar, Dr. North grows cultures of kelp plants in the laboratory and then places them in the sea to watch their progress. He has made several trips to semitropical Turtle Bay in Baja California to gather samples of marine life that grow well there. He is trying to determine if the vegetation will also grow in the coastal waters of southern California when the waters are warmed by power plant discharge.

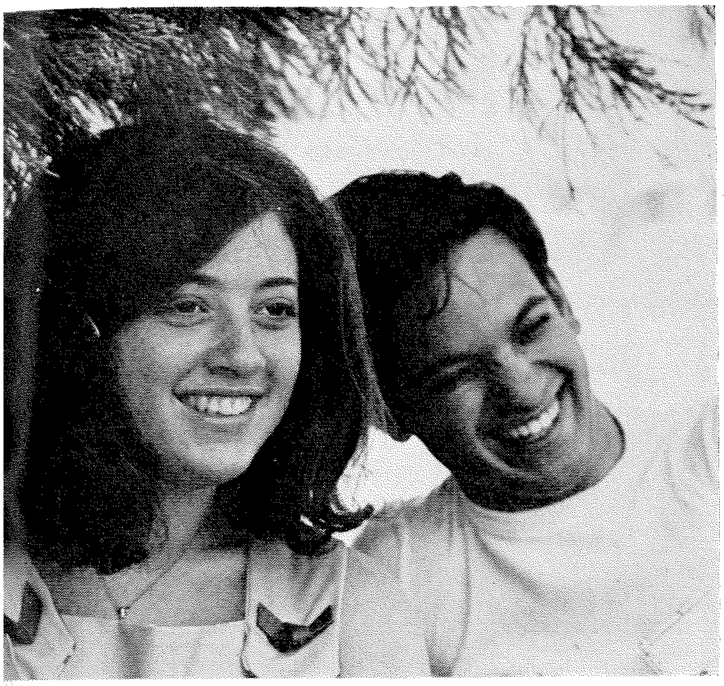
Dr. North believes that the expected warmer water could seriously affect local kelp, particularly where the plants are already under stress in areas exposed to pollution. Sewage dumped at sea indirectly may have contributed to the disappearance of much of southern California's kelp. The spiny sea urchin which feeds on the root-like anchor of the kelp plant may also feed on the sewage. Its natural predator, the sea otter, has been virtually eliminated by fur hunters and the urchin population has run rampant.

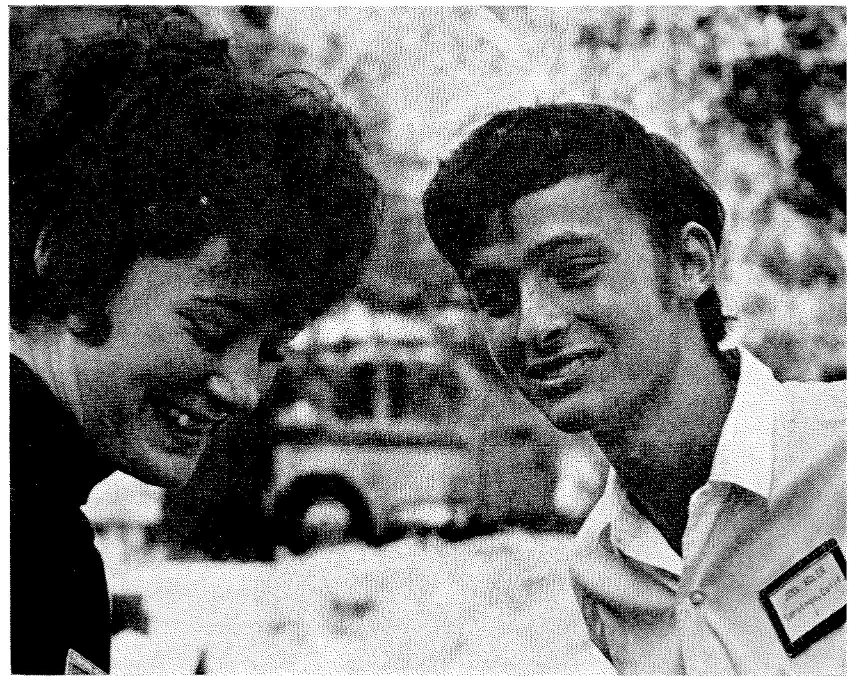
Freshmen at camp take part in small discussion groups with upperclassmen, faculty, and—if they're lucky—girls.



NEW STUDENT CAMP

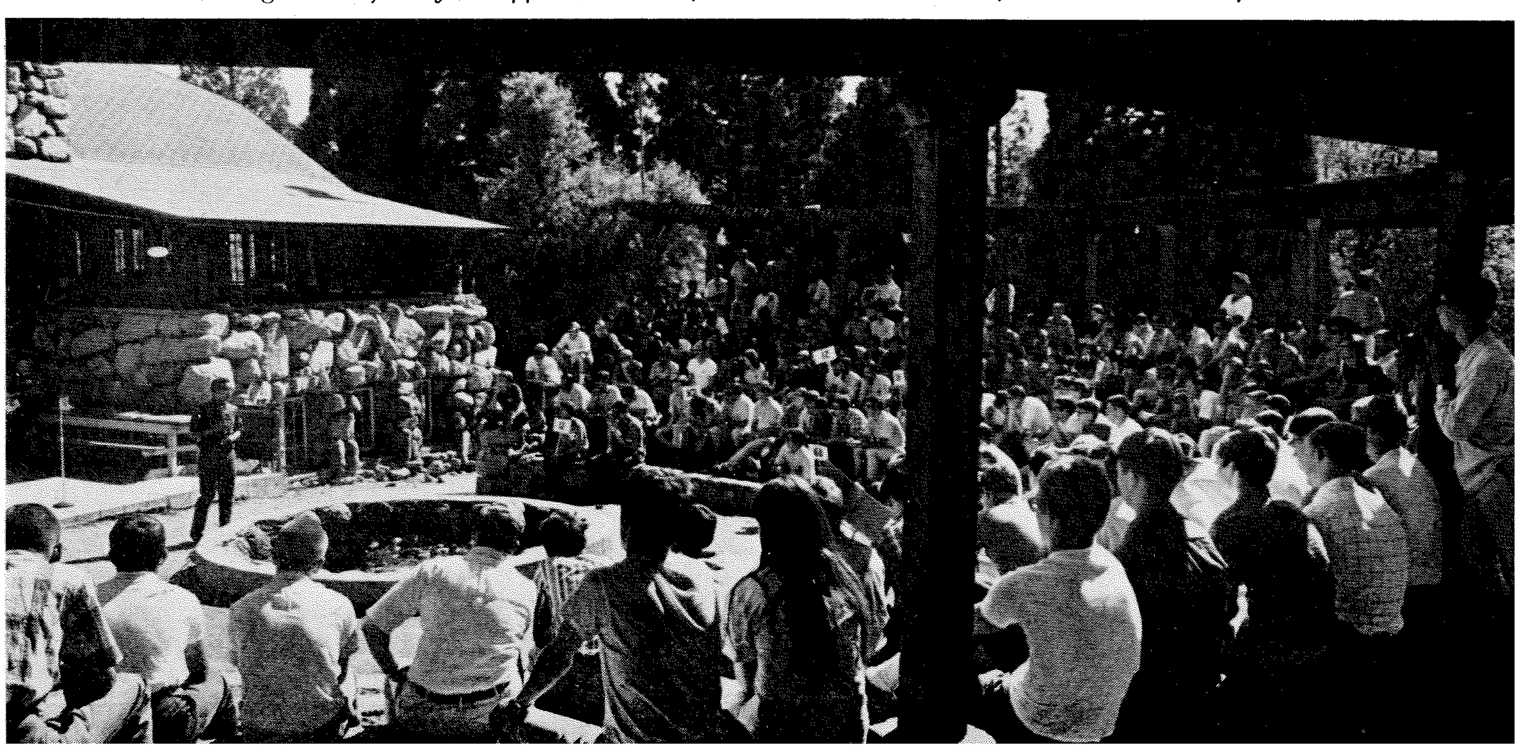
The place is familiar,
the time of year is the same,
the freshman are all here
--but what's this new look?

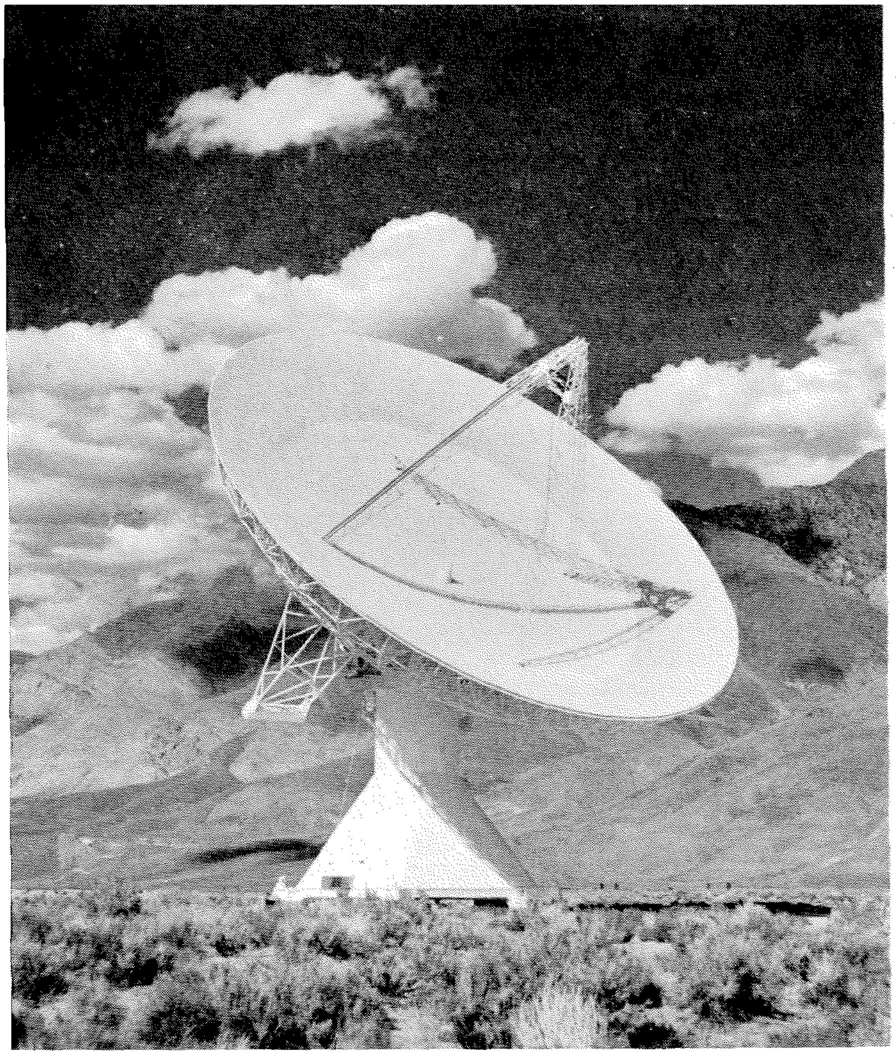




The new look at Freshman Camp this year was feminine. For the first time, the traditional introduction to Caltech, at Camp Radford in the San Bernardino Mountains, included girls. Actually there were only six of them, but their influence was tenfold. The girls were all members of Caltech's summer smog project (p. 18). Now on leave from their own schools, they have stayed on at Caltech to continue work on the project and to audit courses. Though the Institute board of trustees has yet to give formal consideration to the admission of women, it appears that the undergraduate student body has already admitted them.

Girls move into the background as faculty and upperclassmen dispense traditional advice to freshmen around the fire circle.





The 130-foot radio telescope, which is to be dedicated on October 18, is the third dish to go into operation at Caltech's Owens Valley Radio Observatory.

THE MONTH AT CALTECH

DEDICATION OF A DISH

A new 130-foot radio telescope is now in operation at Caltech's Owens Valley Radio Observatory. The giant parabolic dish antenna will be officially dedicated on October 18, with Robert Fleischer, head of the National Science Foundation's astronomy section, taking part in the ceremonies along with Caltech's president, Lee A. DuBridge, and observatory director Gordon Stanley.

The 130-foot instrument is the first of eight proposed units which will eventually be linked electronically to act as one powerful interferometer for use in making studies of radio sources in space. Meanwhile, the new dish will be operating in conjunction with the observatory's two existing 90-foot radio telescopes, which have been in use since 1958.

THE ACADEMY ON CAMPUS

The National Academy of Sciences holds its annual fall meeting on the Caltech campus October 27-30. The three-day program will include a symposium each morning in Beckman Auditorium—Monday, on computer-assisted learning; Tuesday, on problems of the earth's interior; Wednesday, on the chemistry of enzyme action. Thirty-eight papers will be presented at two afternoon scientific sessions held concurrently in Noyes Laboratory on Monday and Tuesday.

Caltech faculty members speaking at the Tuesday symposium include Don Anderson, director of the Seismological Laboratory, and Stewart W. Smith, associate professor of geophysics; on Wednesday, Richard E. Dickerson, professor of physical chemistry.

ENGINEERING CHAIRMAN

Francis H. Clauser, vice chancellor of science and engineering at the University of California at Santa Cruz and a Caltech alumnus, has been named chairman of the Institute's division of engineering and applied science, effective in July 1969. Frederick Lindvall, who has headed the division since 1945, will retire from his chairmanship in June but will continue on the faculty as professor of electrical and mechanical engineering.

Dr. Clauser received three degrees from Caltech, his BS in 1934, MS in 1935, and his PhD in 1937. For the next nine years he was director of aerodynamic research and design research at the Douglas Aircraft Company in Santa Monica. In 1946 he went to Johns Hopkins University in Baltimore, where he founded the department of aeronautics and was its head for nine years. In 1965 he became academic vice chancellor of the University of California at Santa Cruz, and two years later was made vice chancellor of science and engineering.

At Caltech's 75th anniversary celebration in 1966 Dr. Clauser was one of 23 men who received the first alumni distinguished service awards ever to be given by the Institute.

Francis H. Clauser

TRUSTEES

Deane F. Johnson, Los Angeles attorney, has recently been elected to the Caltech board of trustees. Mr. Johnson is a senior member in O'Melveny & Myers of Los Angeles (whose president, John O'Melveny, has been a Caltech trustee since 1940). He will attend his first board meeting at the annual national trustees meeting November 1-3, just one week before his scheduled wedding to Mrs. Anne McDonnell Ford.

Chester F. Carlson, Caltech alumnus (1930) and a member of the Institute board of trustees since 1966, died on September 19 at the age of 62.

Mr. Carlson was the inventor of xerography, the electrostatic copying process marketed by the Xerox Corporation that has revolutionized office duplicating procedures.

Two honorary trustees of the California Institute of Technology—P. G. Winnett and Edward R. Valentine—died in July. Mr. Winnett was 87; Mr. Valentine was 60.

P. G. Winnett, co-founder of Bullock's stores, was donor of Caltech's Winnett Student Center. He had been a trustee of the Institute since 1939 and was made an honorary trustee in 1961.

Edward R. Valentine was president of the Robinson Building Co. and a director of the J. W. Robinson stores. He joined the Caltech trustees in 1948 and became an honorary member in 1965. He was also a member of the Associates of the Institute for many years.

A NEW TEAM AT CALTECH

Caltech is one of the few universities whose faculty still interviews most of the qualified applicants for undergraduate admission. Each spring 15 men talk to about 500 high school students across the country—the survivors of the 1,100 who went through the initial round of evaluation in the quest to enter Caltech.

This year, for the first time, 200 of the applicants were interviewed by a combined faculty-student team. Largely as an outgrowth of student requests in 1967 for more participation in Institute affairs, three seniors and one sophomore took part in the undergraduate admissions program.

Each team (one faculty member and one student) interviewed about 50 applicants in the southern California area, then met to make a first cut of those who should obviously be admitted or turned down. The student interviewers were included in deliberations up to the final infighting about the not-so-obvious cases and the scholarship discussions. As it turned out, students interviewed about 25 percent of the class of 1972.

Undergraduates are now apparently a permanent part of the admissions program. Student interviewers will hit the road once more

WELCOME *More than 200 new graduate students and their wives and faculty hosts braved the nippy autumn weather to dine by candlelight in Winnett courtyard on the evening of October 4. It was the Institute's official welcome to its new graduate students, replacing the traditional afternoon reception at the Athenaeum.*

next spring, although they'll be working only in nearby areas again because of the time and expense of travel to other regions.

The four faculty interviewers agreed that their student partners made the interview process more productive for everyone. Applicants got better answers to questions about student and academic life and, in turn, were subjected to the additional scrutiny of a contemporary.

The effects of any changes in procedure can't be discerned until a freshman class has been around Caltech for a while. But director of admissions Peter Miller can already point to at least one tangible result of this year's innovations: a freshman who wouldn't have been admitted at all if the faculty half of the interview team had seen him alone.

Playboy Magazine © 1968, HMH Publishing Co., Inc.

PLAYBOYS *Whatever public image Caltech undergraduates have, it is definitely not that of the playboy. This minor fact did not daunt* Playboy *magazine. With a carload of high-style clothes, they came to the Caltech campus last spring looking for the men to fit their wardrobe. The result—the remarkable transformation of five Caltech students into fashion models for the August* Playboy's *"Back to Campus" feature. Left to right: Joe Rhodes, Mark Radomski, Ric Lohman, Sam Keys, and Lane Mason.*

CALTECH'S KINETIC ARTIST

Frank J. Malina, who played an important role in early rocket research at Caltech, ("The Rocket Pioneers," *E&S*—February 1968) will present a special lecture and film, "Kinetics: Science vs. Art," at 7:30 p.m., October 25, in the Pasadena Art Museum.

Dr. Malina was co-founder of the Jet Propulsion Laboratory and Aerojet-General Corp. Following his success in the field of aeronautics, he proceeded to achieve international recognition in the field of kinetic art—a unique combination of art and science in which paintings are luminous and mobile and controlled by electricity. He has lived in Paris since 1953 and his paintings have been exhibited throughout Europe and the United States. He is currently editor of *Leonardo*, an international journal of the contemporary artist, which he founded.

Program intern Pat Davis

FIRST LADY

Pat Davis, a 23-year-old graduate of Immaculate Heart College, has become the first woman staff member of the Caltech YMCA. Pat, who has taught seventh grade and been a novice in the order of St. Joseph's, got acquainted with Caltech last year when she helped set up a series of weekend sensitivity programs between her I.H.C. classmates and Caltech undergraduates. In the summer she moved to the Caltech campus as a member of the ASCIT smog research project, and now has prolonged her stay—as a program intern for the Y.

Her addition to the Y staff promises an increase in the activity of college women in the Y program. One step in that direction has already been taken. Pat and five ASCIT-project coeds went to freshman camp this fall—the first women ever to take part in that formerly monastic operation.

PRIZE PUBLICATION

Engineering and Science magazine has been judged by the American Alumni Council to be one of the top ten alumni magazines in the council's 1968 competition.

The top magazine this year is from Yale University. Others in the unranked top ten with *E&S* are published by the University of California at Berkeley, UCLA, University of Chicago, Hofstra University, University of Oregon, Rhode Island School of Design, MIT, and Washington University. ■

FACULTY AND ADMINISTRATIVE CHANGES 1968-1969

ADMINISTRATIVE CHANGES

JAMES N. BRUNE—*supervisor of the seismological network.*
ROBERT F. CHRISTY—*executive officer for physics.*
GEORGE S. HAMMOND—*chairman of the division of chemistry and chemical engineering.*
PETER M. MILLER—*director of admissions and of undergraduate scholarships.*
WILLIAM P. SCHAEFER—*assistant director of admissions.*
DAVID S. WOOD—*acting associate dean of students.*

PROMOTIONS

To Professor:

DON L. ANDERSON—*geophysics*
FRED C. ANSON—*analytical chemistry*
CHARLES J. BROKAW—*biology*
SUNNEY I. CHAN—*chemical physics*
PETER L. CRAWLEY—*mathematics*
RICHARD E. DICKERSON—*physical chemistry*
OSCAR MANDEL—*English*
GEORGE P. MAYHEW—*English*
BRUCE C. MURRAY—*planetary science*
WHEELER J. NORTH—*environmental health engineering*
THAD VREELAND, JR.—*materials science*

To Associate Professor:

CHARLES D. BABCOCK, JR.—*aeronautics*
DON S. BURNETT—*nuclear geochemistry*
GORDON P. GARMIRE—*physics*
PAUL C. JENNINGS—*applied mechanics*
DANIEL J. KEVLES—*history*
ALAN T. MOFFET—*radio astronomy*
WALLACE L. W. SARGENT—*astronomy*
WILLIAM B. WOOD—*biology*

To Senior Research Fellow:

GORDON L. HARRIS—*aeronautics*
PETER C. LOCKEMANN—*engineering*

To Assistant Professor:

BÖRJE J. PERSSON—*physics*
ROBERT A. ROSENSTONE—*history*
DAVID B. WALES—*mathematics*

NEW FACULTY MEMBERS

Professors:

MARSHALL H. COHEN—*radio astronomy*—from the University of California at San Diego.
LANCE E. DAVIS—*economics*—from Purdue University.

Associate Professors:

JAMES O. MC CALDIN—*applied science*—from North American Aviation.
MARTIN H. SCHULTZ—*mathematics*—from Carnegie-Mellon University.

Senior Research Fellows:

JAI-DING LIN—*engineering science*—from the University of Connecticut.
JOHN F. THOMPSON—*biology*—from Cornell University.
COLWIN B. TREVARTHEN—*biology*—from Harvard University.

Assistant Professors:

GARY A. LORDEN—*mathematics*—from Northwestern University.
GIORGIO INGARGIOLA—*applied science*—from the University of Pennsylvania.
DANIEL MC MAHON—*biology*—from the University of Chicago.
ROBERT E. VILLAGRANA—*materials science*—from Cambridge University.

Mt. Wilson and Palomar Observatories Staff Members:

JEROME KRISTIAN—from the University of Wisconsin.
GEORGE W. PRESTON—from Lick Observatory.
LEONARD SEARLE—from the Institute for Advanced Studies, Australian National University.

ON LEAVE OF ABSENCE

BYRD L. JONES—*assistant professor of history*—to Stanford University.
ARON KUPPERMANN—*professor of chemical physics*—to the Weizmann Institute of Science in Rehovoth, Israel, and the FOM Institute for Atomic and Molecular Physics in Amsterdam.
FOSTER STRONG—*associate professor of physics*—to complete a book of physics problems.
JOHN R. WEIR—*associate professor of psychology*—to study, write, travel, and consult.

RESIGNATIONS

ALAN J. ARDELL—*assistant professor of materials science*—to UCLA.
ARTHUR J. BOUCOT—*professor of geology*—to the University of Pennsylvania.
H. RUSSELL BINTZER—*vice president for institute relations*—to the John Price Jones Company, Inc., in New York.
MORRIS BROWN—*assistant professor of organic chemistry.*
EMERSON HIBBARD—*senior research fellow in biology*—to Penn State University.
DIN-YU HSIEH—*assistant professor of engineering science*—to Brown University.
DONALD E. KNUTH—*associate professor of mathematics*—to Stanford.
CALEB W. MC CORMICK—*associate professor of civil engineering*—to MacNeal-Schwendler Corp.
RUSSELL M. PITZER—*assistant professor of theoretical chemistry*—to Ohio State University.
ROBERT F. ROY—*senior research fellow in geophysics*—to the University of Minnesota.
BOB G. SANDERS—*assistant professor of biology*—to the University of Texas.
J. MICHAEL SMITH—*assistant professor of chemistry.*
ROBERT L. WOODBURY—*assistant professor of history*—to the University of Massachusetts and Amherst College.

Photography by W. Eugene Smith.

ALUMNI ASSOCIATION
CALIFORNIA INSTITUTE OF TECHNOLOGY
Pasadena, California

BALANCE SHEET
June 30, 1968

ASSETS		
Cash on Hand and in Bank		$ 3,844.49
Investments:		
Share in C.I.T. Consolidated Portfolio	$173,562.84	
Deposits in Savings Accounts	22,061.09	195,623.93
Investment Income Receivable		5,912.60
Postage Deposit, etc.		288.14
Furniture and Fixtures, at nominal value		1.00
Total Assets		$205,670.16
LIABILITIES, RESERVES AND SURPLUS		
Accounts Payable		$ 658.14
Deferred Income:		
Membership Dues for 1968-69 paid in advance	$ 17,875.00	
Investment Income for 1968-69 from C.I.T. Consolidated Portfolio (earned during 1967-68)	5,912.60	23,787.60
Life Membership Reserve:		
Balance, July 1, 1967	$122,901.81	
Life Membership Dues received during 1967-68	43,200.00	
Share of Gain on Disposal of Investments of C.I.T. Consolidated Portfolio for 1967-68	7,461.03	173,562.84
Reserve for Directory:		
Balance, July 1, 1967	$ 3,305.79	
1967-68 Appropriation	3,000.00	
1967-68 Directory Expense	(299.62)	6,006.17
Surplus:		
Balance, July 1, 1967	$ 3,219.13	
Excess of Expenses over Income for 1967-68	(1,563.72)	1,655.41
Total Liabilities, Reserves and Surplus		$205,670.16

STATEMENT OF INCOME AND EXPENSES
For the Year Ended June 30, 1968

INCOME		
Dues of Annual Members		$ 21,873.95
Investment Income:		
Share from C.I.T. Consolidated Portfolio	$ 6,140.85	
Interest on Deposits in Savings Accounts	1,187.21	7,328.06
Annual Seminar		5,592.75
Program and Social Functions		3,203.00
Miscellaneous		60.33
Total Income		$ 38,058.09
EXPENSES		
Subscriptions to Engineering and Science Magazine:		
Annual Members	$ 15,300.25	
Life Members	3,528.00	$ 18,828.25
Annual Seminar		5,875.60
Program and Social Functions		3,776.81
Directory Appropriation		3,000.00
Adminstration		4,811.61
Membership Committee		1,629.54
ASCIT Assistance		1,700.00
Total Expenses		$ 39,621.81
Excess of Expenses over Income		$ 1,563.72

AUDITOR'S REPORT

Board of Directors, Alumni Association, California Institute of Technology

I have examined the Balance Sheet of the Alumni Association, California Institute of Technology as of June 30, 1968, and the related Statement of Income and Expenses for the year then ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as I considered necessary in the circumstances.

In my opinion, the accompanying Balance Sheet and Statement of Income and Expenses present fairly the financial position of the Alumni Association, California Institute of Technology at June 30, 1968, and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

CALVIN A. AMES
Certified Public Accountant

October 1, 1968

analysis texts which merely describe and list methods, this book not only describes many modern methods but also seeks to give the reader a clear understanding of why, how, and when these methods work. Having finished this book, the careful reader will be in the fortunate position of being able to read intelligently the current literature in numerical analysis research.

Fluid Mechanics and Singular Perturbations. A Collection of Papers by Saul Kaplun

edited by Paco A. Lagerstrom, Louis N. Howard, and Ching-shi Liu

Academic Press *$10.00*

Perturbation Methods in Applied Mathematics

by Julian D. Cole

Blaisdell Publishing Company ..*$9.50*

reviewed by L. E. Fraenkel, Saul Kaplun Senior Research Fellow in Applied Mathematics

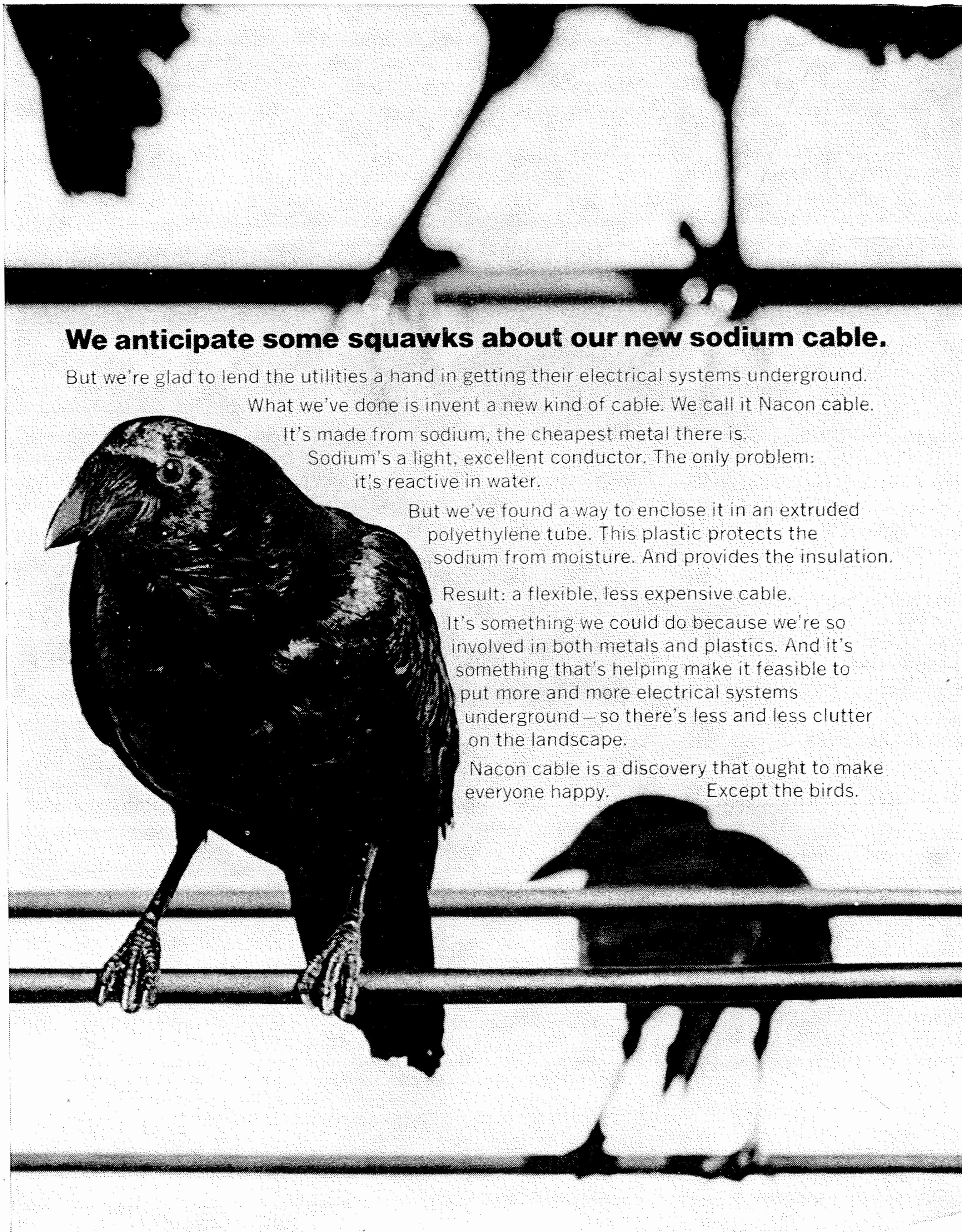
The theory describing the flow past bodies of a viscous fluid is a notoriously difficult one; the governing equations (Navier-Stokes) can be solved exactly and explicitly for only a few highly artificial cases, and approximation schemes invariably meet difficulties demanding and stimulating increasingly subtle mathematical techniques. In the years 1954-57 there appeared from Caltech four great papers which not only gave a fresh and clearer view of the various approximation schemes for very viscous and for nearly inviscid flow but which also systematized and extended significantly the mathematical technique implicit in Prandtl's boundary-layer theory. Indeed, these papers did much to provide the applied mathematician with new tools that have since then been applied to an astonishing variety of problems. These tools now form part of the subject known as "singular perturbations," a phrase used to describe methods for solving boundary- or initial-value problems which involve a small parameter in such a way that the "obvious" expansion in terms of that parameter fails to approximate the desired solution throughout the physical domain. Saul Kaplun, to whom Lagerstrom and Cole attribute the principal ideas in this work, died in 1964 at the age of 39.

Fluid Mechanics and Singular Perturbations is in two parts. The first contains Kaplun's three published papers and preliminary drafts of intended papers on his approach to singular perturbations and on the lift at low Reynolds number of two-dimensional bodies. The second part contains similar drafts of some of his extensive work on the problem of flow separation. The editors' work consisted of selection, of minor changes with respect to notation and errors of transcription, and of the provision of a most helpful commentary.

In 1955, when Julian Cole made his contribution to perturbation methods cited above, the techniques in question seemed the ultimate in sophistication (at least to this awe-struck reader). Since then the subject has grown enormously, and at the same time "model" problems and simple methods of presentation have been devised so that now an almost elementary course on singular-perturbation methods is given to graduate students at many universities. Of course, plausibility and consistency arguments, rather than strict proofs, tend to be used. *Perturbation Methods in Applied Mathematics* is intended, and is most suitable, for such a course, and readers will be happy that the material largely complements rather than overlaps that in Van Dyke's book on a closely related subject.

The book is primarily a set of examples chosen to illustrate the application of boundary-layer techniques and of "two-variable" (one "fast," one "slow") expansion procedures to the approximate solution of initial- and boundary-value problems for differential equations (linear and nonlinear, ordinary and partial). The clarity and modesty of the presentation disguise the fact that much of the material, particularly that on two-variable methods, comes from recent research at Caltech by Julian Cole and his co-workers. The examples include, among much else: the deduction, by simple means, not only of the limit cycle of a van der Pol oscillator with small damping but also of the progress from the initial conditions to that cycle; a novel treatment of the Sturm-Liouville equation with a large parameter and a turning point; a rather complete discussion of the role of "subcharacteristics" when the limiting form of an elliptic or hyperbolic, second-order, partial differential equation is of the first order, the subcharacteristics being the characteristics of this reduced equation; and applications to viscous flow, compressible flow past thin aerofoils, magnetohydrodynamic pipe flow, and elastic shell theory.

In each case the forms of the expansion and stretching transformation, which are seldom obvious a priori, are deduced lucidly and carefully from the physics of the problem and the structure of its equation; and features common to diverse problems are emphasized. The approximate solution is then pursued relentlessly and skillfully until a complete picture emerges. □



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LETTERS

Los Angeles

EDITOR:

Is it true that Police Officer Newton has retired? I can't imagine Caltech without him.

L. J. SIMMONDS

After 20 years on the same beat—the Caltech campus—Lieutenant A. G. Newton left the Institute in June, having reached the mandatory retirement age of 68. Officially he was campus security officer, but to generations of students, faculty, and employees familiar with his jaunty stride, his gravelly voice, and his all-too-genuine Brooklyn accent, he was "Fig," "Fuzz," or "Flatfoot"—the campus cop. At a farewell picnic on June 28, he told about 200 of his Caltech friends that he was "down in the dumps" about leaving, but he was cheered by the fact that "they're replacin' me with two men."

A. G. Newton, campus cop

Pasadena

EDITOR:

As a coeditor, I was delighted by Max Delbrück's favorable review in the June issue of *E&S* of "Structural Chemistry and Molecular Biology," a collation of essays assembled as a tribute to Linus Pauling. Professor Delbrück asserts that this rather gargantuan volume is a bargain at the price, which is incorrectly given, of $15.00. What a bargain is it then at the actual price of $10.00?

NORMAN DAVIDSON

BECKMAN AUDITORIUM

FALL CALENDAR

Caltech Lecture Series

James Thorpe, director, Henry E. Huntington Library and Art Gallery —"Responding to Style" —*October 14*

Robert E. Ireland, professor of organic chemistry—"The Road From Hither To Yon" —*October 21*

Eugene M. Shoemaker, chief scientist, U.S. Geological Survey, Center of Astrogeology, Flagstaff, Ariz.—"New Knowledge of the Lunar Surface" —*October 28*

Charles R. DePrima, professor of mathematics—"Hedgehogs, Ham Sandwiches and Fixed Points" —*November 4*

George W. Housner, professor of civil engineering and applied mechanics—"The Impact of Earthquakes on Industrial Development" —*November 11*

Richard H. Jahns, dean, School of Earth Sciences, Stanford—"How Firm is Terra Firma?" —*November 25*

Norman H. Horowitz, chief, bioscience section, JPL—"The Biological Exploration of Mars" —*November 25*

Concert and Drama Series

Rob Inglis in "The Canterbury Tales" —*October 18*

Young Uck Kim, violinist —*October 26*

Carlos Montoya, flamenco guitarist —*November 1*

The National Theatre of the Deaf —*November 8*

Leonard Pennario, pianist —*December 7*

International Festival of New Films

Program One—ten foreign and avant-garde San Francisco films —*October 15*

Program Two—ten films, including Peter Whitehead's "Let's All Make Love in London" —*October 22*

Program Three—ten shorts, including Yoji Kuri's "What Do You Think?" —*October 29*

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Visiting alumni cordially invited—no reservation.

ALUMNI HOMECOMING

Nov. 9, 1968

Tournament Park

11:00 a.m. Picnic Lunch, followed by
2:00 p.m. Football Game, Caltech vs. UCSD

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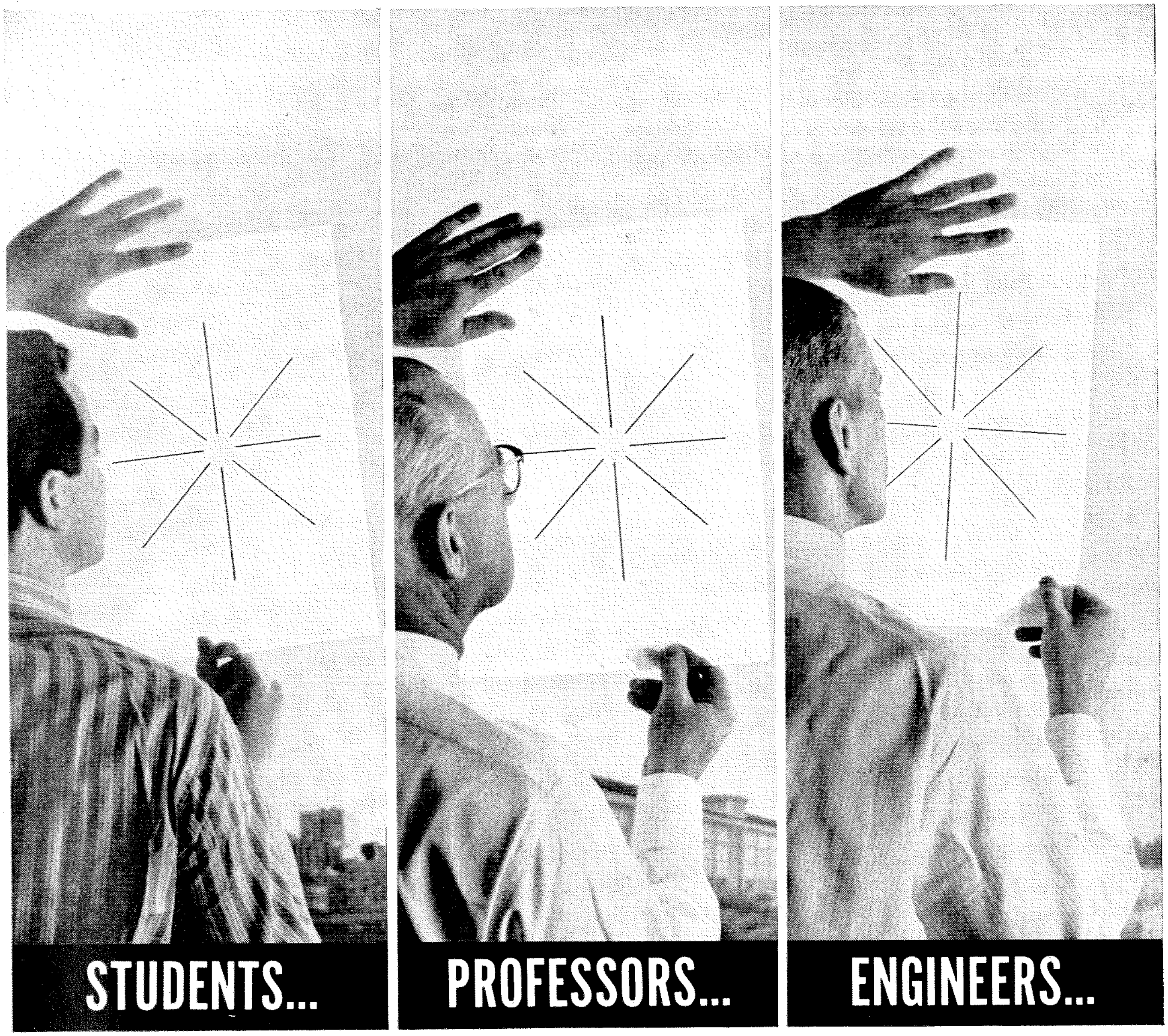

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