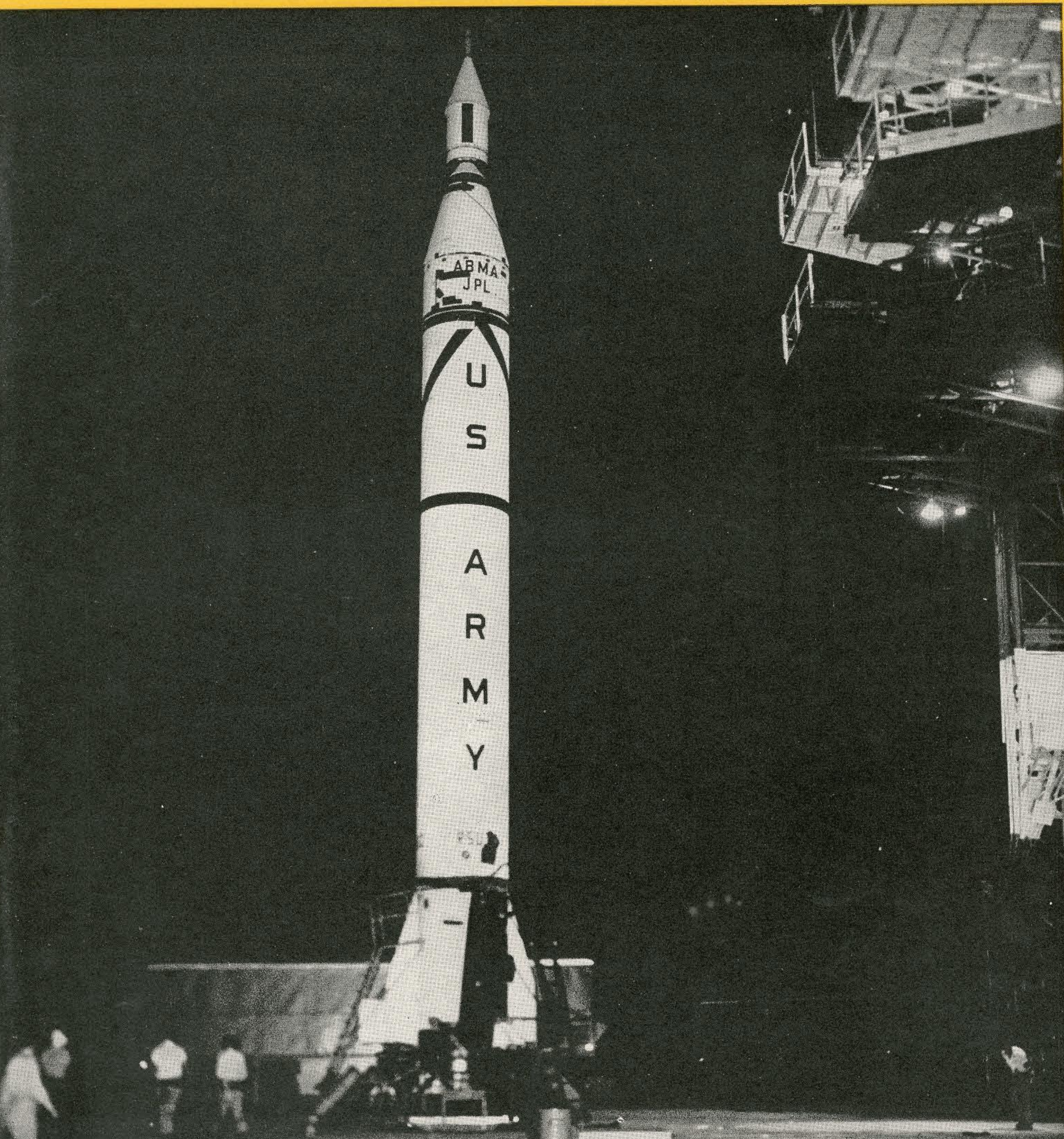
ENGINEERING AND SCIENCE

FEBRUARY/1958



Explorer . . . page 20

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

This is the look of boiling steel

The picture was taken with a camera that exposes 3,000 frames per second. One second of action takes more than three minutes to project at normal viewing speed.

The picture was taken looking into an open hearth furnace, and it discloses action that was only vaguely perceived before. This enables U. S. Steel scientists to develop a better understanding of the kinetics of heat transfer and chemical reaction at temperatures approaching 3,000° F.

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UNITED STATES STEEL

"They all agree..."

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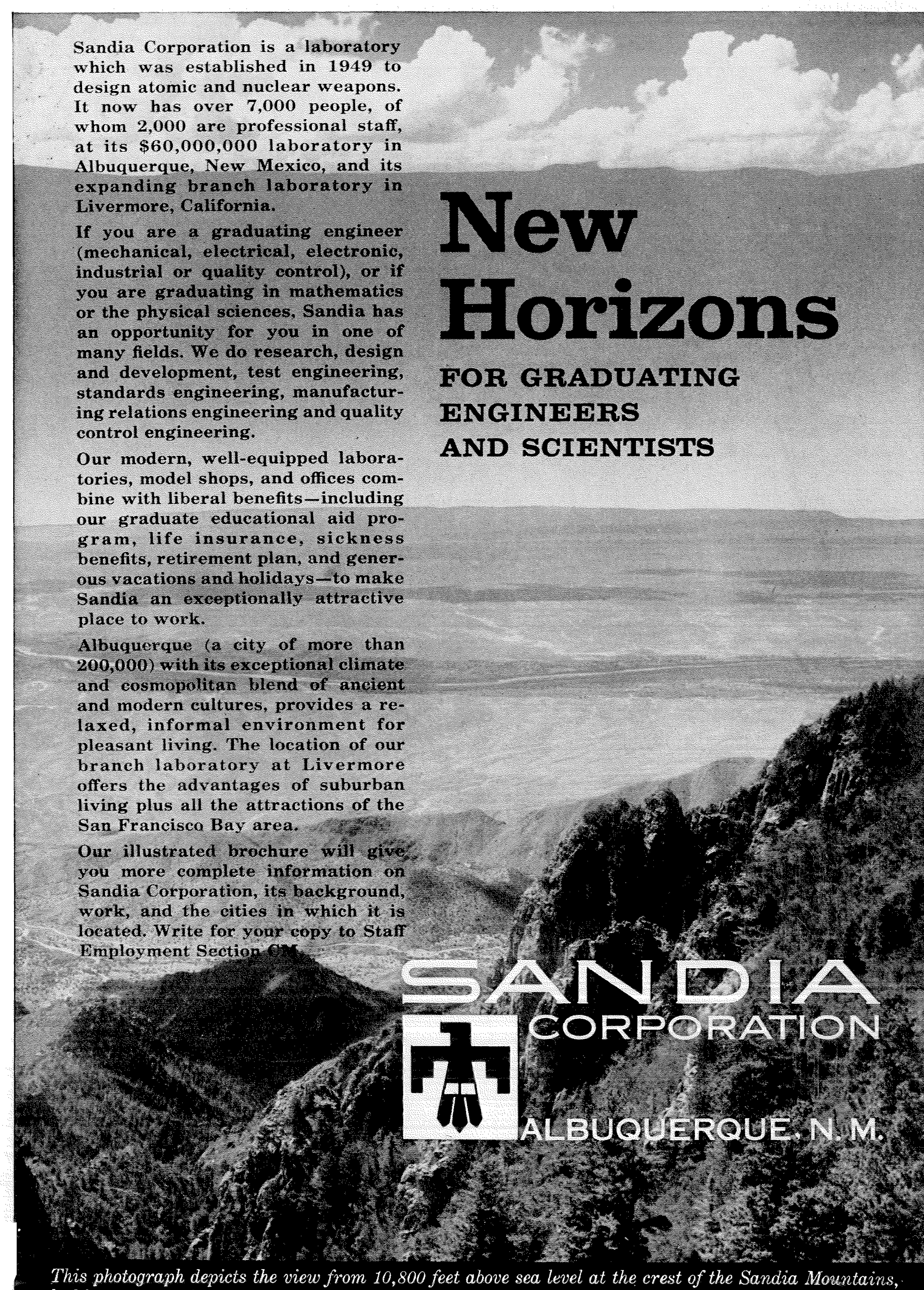
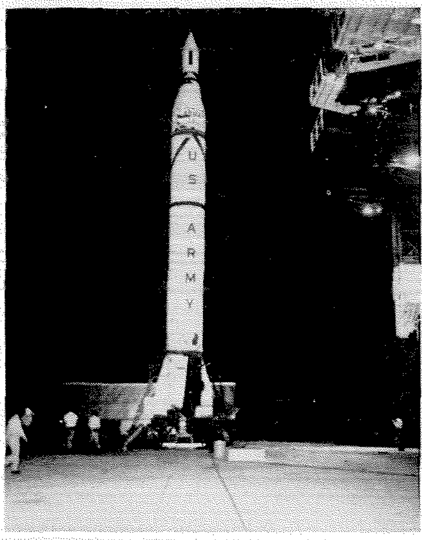
BUILDERS OF THE FIRST INTERCONTINENTAL GUIDED MISSILE



This photograph depicts the view from 10,800 feet above sea level at the crest of the Sandia Mountains, looking westward across the Rio Grande Valley and the northern limits of the city of Albuquerque.

ENGINEERING AND SCIENCE

IN THIS ISSUE



ON OUR COVER—an Army Jupiter C missile, on the launching platform at Cape Canaveral, Florida, similar to the one that fired the Caltech satellite, the Explorer, into orbit on January 31.

The Caltech Jet Propulsion Laboratory and the Army Ballistic Missile Agency of Huntsville, Alabama, joined in this first successful firing of a U.S. satellite. For more details on the satellite, and what Caltech had to do with it, see page 20.

PRESIDENT DUBRIDGE'S article, "The Challenge of Sputnik," started life as a talk given at Los Angeles Junior College in Van Nuys last November. It made such an impression on that audience that Dr. DuBridge is constantly being asked to repeat it, and it has been run in full in the Pasadena *Independent-Star News.* You'll find this timely, hard-hitting statement on page 13.

PICTURE CREDITS

Cover	U.S. Army
p. 20	*Elton Sewell,* Independent-Star News
pps. 25, 28	Journal of American Waterworks Association

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CONTENTS

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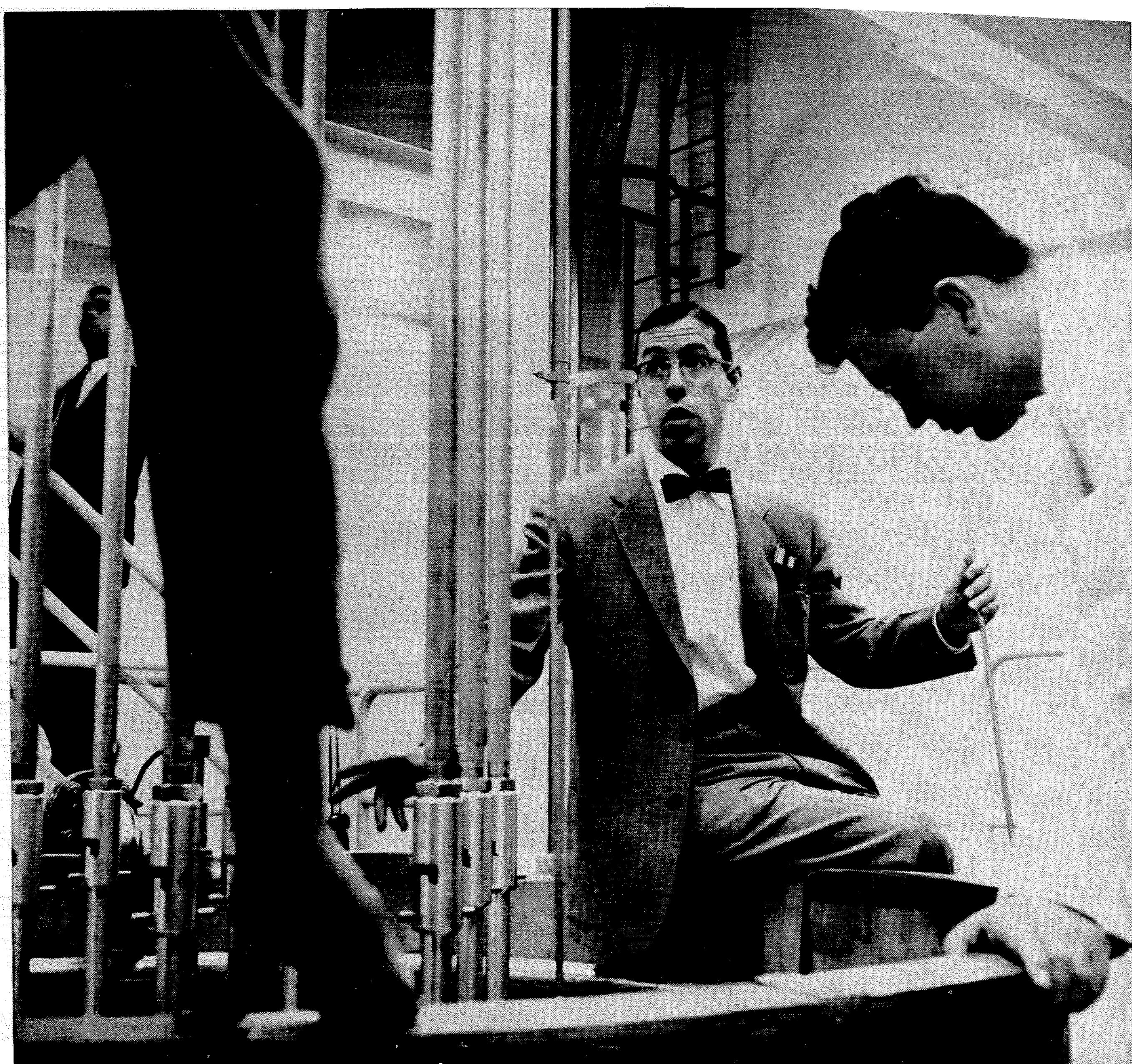


Harvey Graves (Dartmouth, BA '50, MSEE '51) discusses a reactor experiment at the Westinghouse Reactor Evaluation Center, in Waltz Mill, Pa. As manager of the Nuclear Design Section, Mr. Graves works with Dr. Wilfried Bergmann (Vienna, PhD '51), on right, and other young scientists who operate the facility.

Letters

Ann Arbor, Michigan

Sir:

After reading in the January issue of *Engineering and Science* Professor Zwicky's modest account of how he, with minimal help from the U.S. Government, inaugurated interplanetary travel, I am encouraged to tell you of a similar achievement of mine which if generally adopted would completely change the nature of warfare.

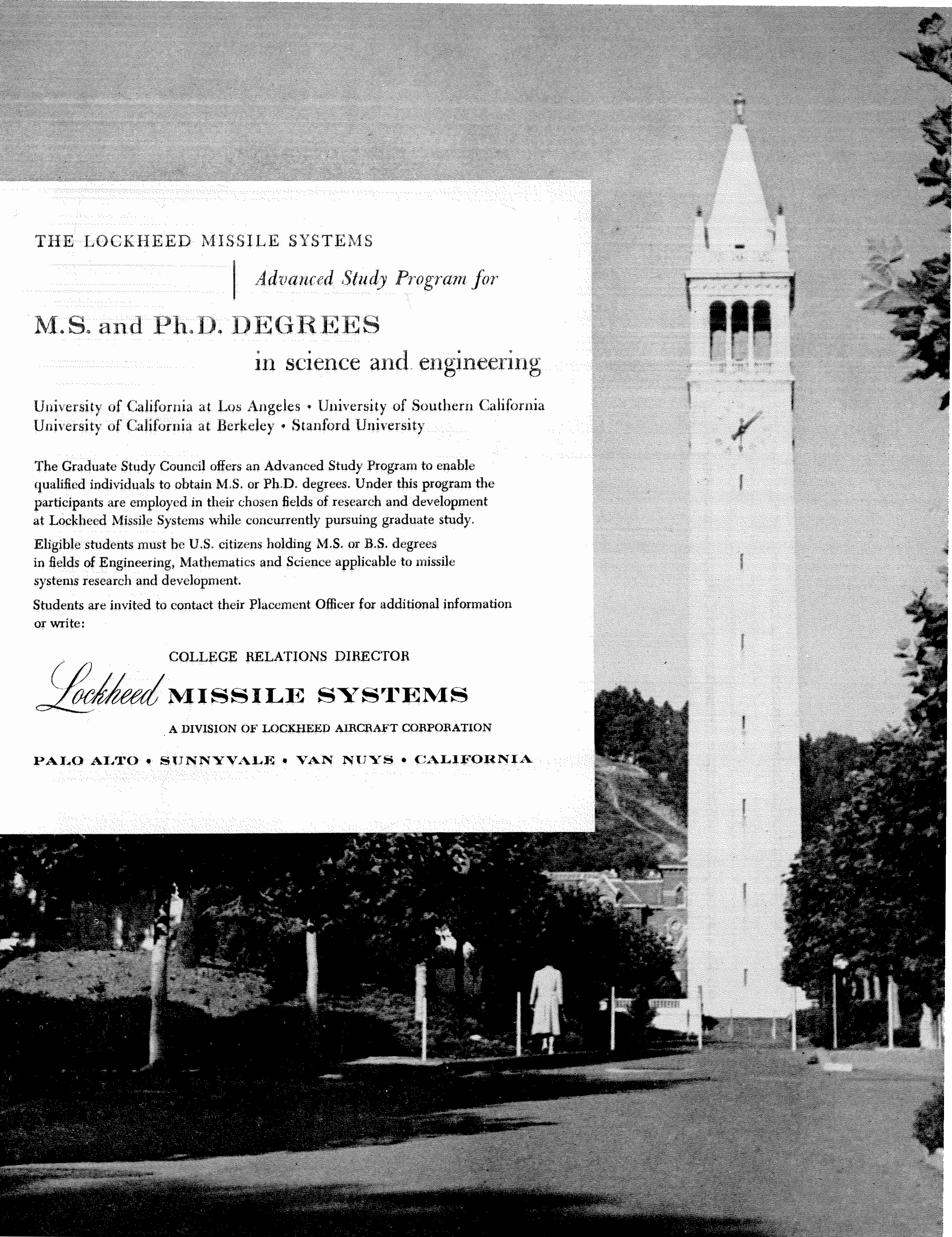
The device is brilliantly simple. It consists of a metal or plastic tube 30 cm. long. Its radius is determined by that of the missile to be projected through it. After exhausting the possibilities I have found that the most satisfactory ones are the dried seeds of the plant *P. sativum.* These do not have uniform radii, but the frequency of distribution is such that a tube 7 mm. in diameter will accommodate 93.8 percent of them.

To use the weapon the operator places between 20 and 25 of the missiles in his mouth, distributing them equally between both cheeks. Of course, if he uses an odd number of missiles the distribution must be only approximately equal. Then he puts one end of the tube between his lips. With a flick of his tongue he transfers one of the missiles from either cheek to the opening of the tube. After taking in a breath of 2 liters around, not through, the tube, he abruptly expels the breath through the tube. A rate of flow of 75 liters per sec. is optimal. The missile is ejected from the tube on a trajectory which can readily be calculated.

So far I have been unable to persuade the Armed Forces to substitute my weapon for more conventional ones, and I attribute this to the jealousy which those like Professor Zwicky and me so easily arouse in lesser minds. Perhaps if Professor Zwicky would use his influence, my weapon might be tried. I would be happy to demonstrate it to Professor Zwicky if he would just stand still for a moment.

I am, sir, your obedient servant,

Arnold Dempster, '35



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Left to right: Lou Bernardi, Notre Dame, '54; Norman Lorenson, Mich. St., '55; Ernest Schurmann, M.I.T., '53; Dick Swenson, Purdue, '50.

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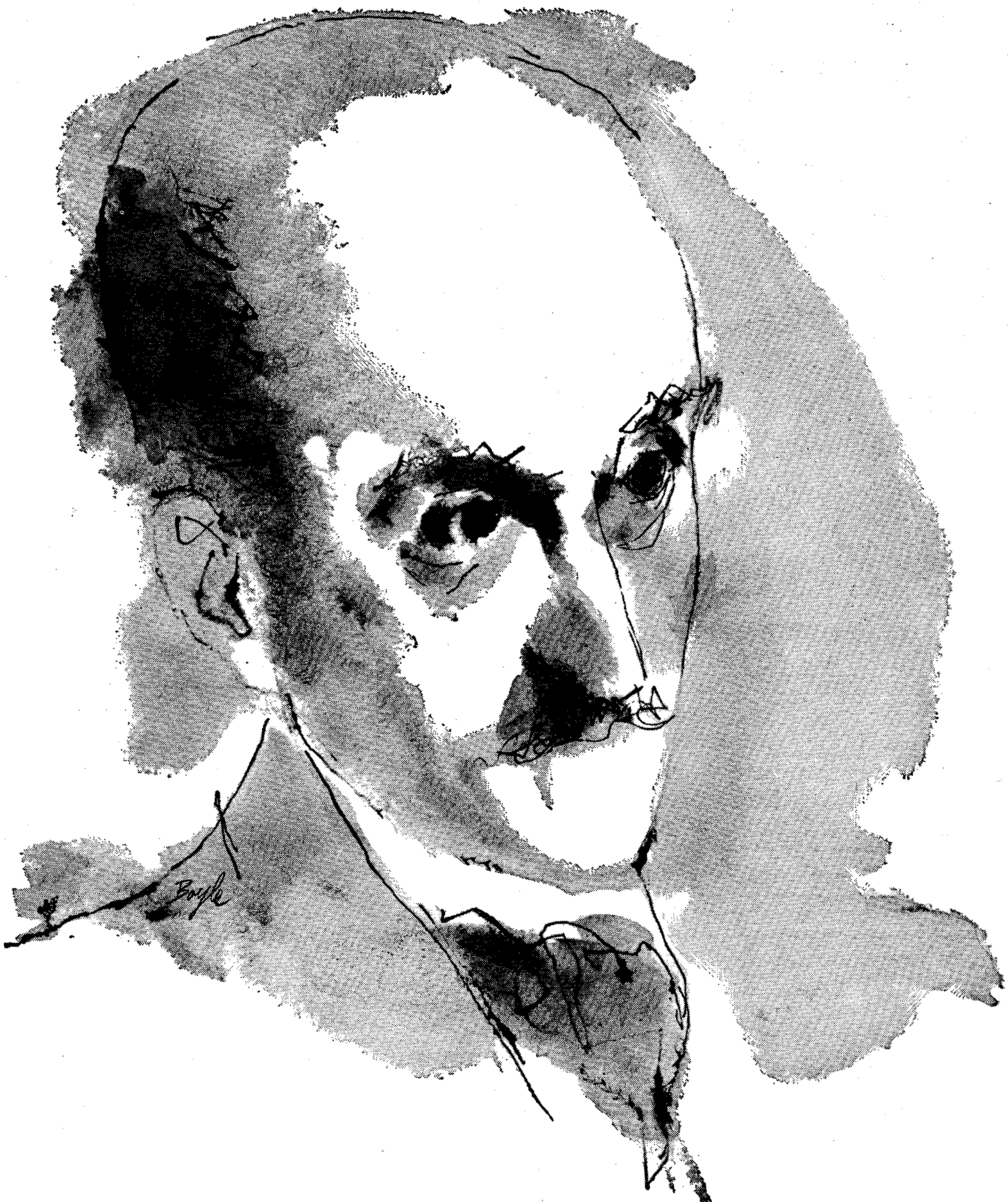

Boyle

The Challenge of Sputnik

by L. A. DuBridge

On October 4, 1957, the Russians announced that they had successfully launched an earth satellite; that a 180-pound object was circling above the earth at an average height of 300 miles or so. A month later Sputnik number two was in an orbit.

The reaction of the people of the world to these events was fabulous. To those scientists who had come to take it for granted that earth satellites would someday be launched—by both the U.S. and the U.S.S.R.—the fact that the Russians launched the first one came as a great surprise. However, it occasioned no more shock to them than having your home team lose a football game. The Russians put one over on us—fairly and squarely. O.K.—we will win the next round!

But to those who had not previously thought much about earth satellites the reaction was about as violent as though Russia had landed an atomic bomb on New York. To some it was more like the landing of a flying saucer from Mars. Astonishment, disbelief, hysteria, anger, recrimination, disillusionment, fear, and a hundred other emotional responses soon became evident. And then followed an unbelievable torrent of outraged denunciation and outrageous proposals for revenge on the Russians, for punishment of the guilty Americans.

In Europe and Asia there was confusion too, for a great idol had toppled from its pedestal; the carefully nurtured proposition that America was always first in all things technical suddenly collapsed. Europeans waited in vain for a word of explanation, of reassurance. But all they heard from America was the confusion of many voices—some of which declaimed that the end of the free world was now in sight, that Soviet superiority in all things technical, military, and even educational, was now proved; America, it was said, had lost the race for survival. Equally confused were those who treated with contempt or disdain one of the great events of man's history, who dismissed it as a mere bauble.

The Russians have capitalized on this situation by deriding our weakness and confusion, by bragging about their great triumph. They have announced that they intend to send rockets to the moon, that more animal experiments will be carried out, and that someday a manned rocket will be launched. An example of our hysteria was the headlining of a ridiculous rumor that a man had been hurled 186 miles into space in a rocket.

Now, of course, some people have been talking about space travel in this country for years—but they were dismissed as starry-eyed visionaries, or just plain nuts (as, indeed, some of them were). But when the Russian Government takes space travel seriously, Americans sit up and take notice. And now our disregarded astronauts are getting the headlines. Suddenly travel in space has become a subject of everyday conversation. People seriously expect, and some seem even to hope, that their children may someday live on the moon or on Mars.

Then on December 5 the American Vanguard launching failed—and hysteria broke loose again. I never expected to live to see the day when a leaky fuel pipe would be regarded as an international tragedy. Every engineer knows that accidents of this sort must always be expected in a new venture. Technological advances are not easy. In the early days of aviation, men found the conquest of the air to be a tough business—and scores of hardy pioneers sacrificed their equipment and even their lives to the task of making airplanes more reliable. Modern space rocketry has not claimed any lives yet—*but it will.* Large rockets are enormously complex devices, and no amount of human ingenuity will ever make them infallible. I am sure the Russians have had accidents. The Germans certainly had many. We have had some and will have more. But we will have successes too. A leaky fuel line or a defective turbine blade can hardly be taken as signs that the whole of our science and technology has suddenly collapsed.

In any case, we find ourselves in a time of great and astonishing events—and hence, inevitably, in a time of great confusion. Many terrible questions must be asked. Are we really in great and imminent military danger? Has Russia assumed technological leadership of the world? Have they proved that a dictatorship is superior to a democracy? Must we then adopt their methods to survive? Is our educational system obsolete? Are we hopelessly outclassed, outstripped, disgraced?

These and many other questions that Sputnik has raised have no easy answers. There are too many quantities still unknown. And, even where some things are clear, the question of what we should do about them is often unclear.

The best we can do at the present stage is to bring together the facts and separate the true from the false, the known from the unknown, and the certain from the uncertain. And then we must order our questions. We must recognize that some questions, such as the one, "Are the Russians ahead of us?", have no meaning. Ahead of us in what? As of what date? Does being ahead mean they can annihilate us? Other questions are unanswerable because we cannot possibly have the information—such as, "Do the Russians intend to attack us with ballistic missiles?" No one can read their minds. But some questions are real and do have answers. We should identify those questions, then seek their answers and try to comprehend their meaning.

Face the facts

First, however, let us look at a few facts. The Russians *have* launched the first two satellites. There is no doubt of that. And it is a great achievement. To launch an object into an orbit above the earth, the object must first be lifted well above the earth's atmosphere—say, 200 miles or so—then at that height it must be guided to a horizontal path, parallel to the earth's surface, aimed in the proper geographic direction, and brought up to a predetermined high speed. If an object is made to travel horizontally at 200 miles above the earth at a speed of about 18,000 miles per hour, it will circle the earth indefinitely, because the tendency of gravity to bring it down is exactly balanced by the centrifugal force tending to make it fly away from the earth entirely. A stable orbit is then followed. It may be a circular orbit or, more likely, if the speed is a bit too high or too low, an elliptical orbit getting farther from the earth at one side of its trajectory.

Some people ask: What keeps it going? What keeps it up there? In reply, let us ask what keeps the moon going around the earth? What keeps the earth going around the sun? The answer is simple. Nothing! Once an object has been started in motion, it tends to keep going forever —unless something tends to stop it. This great principle was discovered by Galileo in the 17th century, and was enunciated more precisely by Newton 50 years or so later. Every student of high school physics knows Newton's first law of motion (or does he?). Here on earth, of course, friction is always present to make things stop moving—so most people don't really believe that Newton's first law has any practical importance. But high above the atmosphere there is little or no friction, so the satellites keep on going. The Sputnik I rocket case lasted about eight weeks, the satellite itself about 12 weeks. The moon, 240,000 miles away, has been rotating in its orbit for at least four-and-a-half billion years!

Elementary physics

So, the questions which puzzle so many about satellite motions are answered by the most elementary principles of physics. And the widespread lack of understanding is sad proof of how few people have learned those simple principles.

There has been some discussion of how to bring down a satellite once it is up there. One congressman suggested we shoot them down! Other people asked how the little dog in Sputnik II was to be "let down." Again, some elementary physics must be recalled.

As I have said, once a satellite is in orbit it will stay there until something changes its motion. Friction will bring it down—very gradually at high elevations and very much faster as it comes into the atmosphere. But it is not easy to slow down a satellite suddenly so that gravity will pull it in at once. Shooting a bullet into it would damage the radio transmitter, but would not stop the motion. If you could make it collide head-on with another satellite going in the opposite direction, that would do it. But to achieve such a collision would be quite a trick. And, of course, a collision of two objects, each going 18,000 miles per hour, wouldn't have done the little doggie much good! That doggie was doomed from the beginning, and anyone who thought it could get back alive did not remember his physics.

What about a parachute? Since there is no air up there, there is nothing for the parachute to hang on to. Even if the little dog could jump out of the satellite with

Why, then, does it give us such grave concern?

his oxygen supply on, he would simply keep on sailing around the earth; he would be another satellite. There is just nothing there to slow him down enough so that gravity can overcome centrifugal force.

If a satellite could be equipped with an extra rocket motor and plenty of fuel so that the rocket blast could be fired in a direction to slow it down—that, of course, would do the trick. It takes a rocket to speed the thing up; it takes a rocket to slow it down. A rocket blast is about the only propulsion scheme we know which will work in a vacuum, above the earth's atmosphere. Maybe someday we will have satellites large enough to carry the slowing-down rocket, together with its fuel and the necessary equipment to fire it at the desired time.

Returning satellites

As a falling missile or satellite comes into the atmosphere, a new problem arises. Because of the enormous speed, the friction of the air will generate a great deal of heat. This is the "re-entry" problem. As President Eisenhower said in his first TV science talk, this re-entry problem has been solved for a military bomb—i.e., for an object that can stand some heat and that can hit the ground at high speed, or an object that is intended to explode before striking. But we do not yet know how to bring a dog to earth gently enough, and cool enough, so that it will survive. All the energy of the many tons of fuel required to lift the rocket originally will now appear as heat on the way down. And thus a returning satellite will usually have the same fate as a meteor; it will probably be burned up—and what is left will strike the ground with a terrific impact.

This raises the question of whether, if you launched a satellite with a bomb in it, you could then drop the bomb to hit any place on earth as the satellite passes over it. The answer, of course, is *no*. If a bomb were simply ejected from the satellite—say, by a spring or a small charge of gunpowder—it, too, would become another satellite. For the bomb to drop, it would have to be propelled backward by a huge rocket charge to reduce its kinetic energy. And, even then, it would spiral toward the earth in a curious path, and the accuracy of a hit would hardly be great.

Sputnik in itself, then, is hardly a military weapon! Why, then, does Sputnik give us such grave concern?

The main reason, of course, is that a rocket and guidance system good enough to put a 1000-pound satellite into an orbit is certainly good enough to shoot a 1500-pound hydrogen bomb from Russia to the United States. The guidance accuracy might be only 50 miles. Such accuracy is not good enough to destroy an airbase, but a hit any place within 50 miles of New York or Los Angeles would be pretty bad. And the accuracy will eventually be improved.

So the Russians are clearly very good rocket engineers. This is the main thing that Sputnik proves. They have put great effort on large rockets, and they were willing to use some of their military rockets for scientific experiments of great propaganda value. That is something we were not willing to do.

Granted they are good rocket engineers, what kind of military rockets do they have? Are they any better than ours? Are they in production, or still in the experimental stage? Will they have 100 next year, or in 5 years? In any case, how big a threat to us is *one* rocket? 10? 100?

These, of course, are all unanswerable questions—and hence they are the ones that everyone speculates about. Unfortunately, the Russians have not told us precisely just what type of military rockets they have, when they will have them, or how many there will be. They have made a few proud boasts, but only the U.S. Central Intelligence Agency knows how accurate those boasts are. And CIA is not telling what it knows.

By the same token, in spite of all the press releases, the U.S. Defense Department has not told the full story of our rocket technology either. The President did say that we have over 30 types of guided missiles in development, and many of them in production. Sputnik alone does not reveal the full military strength of either country. It has revealed simply that the Russians are better rocket engineers than most of us thought. Hence, they may have now, and certainly will have someday, enough military rockets to be a serious threat to us.

U.S. missiles

But of one more thing we can be sure: The United States has not been asleep in the guided missile field either. Our Nike anti-aircraft missiles, for example, are certainly a powerful protection against the Soviet bomber. Many scientists feel that there have been too many missiles developed in this country. It might have been better to concentrate on a smaller number and not have tried to make them all so perfect. But it is a typical American habit—if there are several ways of doing a thing, we will try them all! And we will push each one to a high state of perfection. We certainly have acquired a very large and diversified missile technology in the past 10 years. And if we wish now to concentrate a large effort on one or two major projects, we could certainly get them into production fast. In fact, Caltech's Jet Propulsion Laboratory, using existing Army equipment, launched the first U.S. satellite, the Explorer, less than 12 weeks after the project was authorized.

The notion that Russian rockets could suddenly, *to-*

Has Russia now, before all the world, challenged us to an intellectual contest which we are not prepared to win?

night, destroy all American bomber bases all over the world and render us immediately defenseless is absurd. Such a feat would require the accurate and simultaneous striking of hundreds of long-range missiles—all making effective hits. To run the risk of not hitting even a few bases would be dangerous, for even a few H-bombs that we could launch can do tremendous damage. Thus our bomber force will be a serious threat to Russia for a long time to come.

But that fact should not give cause for complacency—and I know of no informed person who is complacent. As Dr. Killian, the President's new special assistant, has said, "We need a sense of *urgency without despair.*"

What, then, should we do now? What must we do later?

The first demand which the Sputnik situation puts on us, of course, is to examine our military situation. Though the wild statements that the Russians have suddenly zoomed into a position of military supremacy are wrong, it is certain that there are grave dangers. Clearly, everyone now realizes that we need to accelerate our efforts to counter that Russian threat.

At the same time, it is clear that our military strength is only one aspect of our national strength. Military technology is one branch of technology; it can be no stronger than the main structure of technology itself. Rockets and radar and atomic weapons are not invented by generals and admirals; they are invented by civilian scientists and engineers working in laboratories—often in laboratories where the Government is paying the bills. These civilians draw on all available knowledge in the world of science and engineering to develop weapons and techniques which the military services require. For a nation to be successful in military technology, it must have two things:

1. Enough well-trained scientists and engineers to man the military-sponsored laboratories; and

2. An active *non*military science and technology to supply the new knowledge, and materials and new devices which military technology will require.

The shock to America is that Russia has so quickly attained these two goals. Russia, we now realize more clearly than before, is rapidly attaining a position of great technological strength. Russia is no longer the nation of illiterate peasants that many of us had supposed.

How did they get this way? How did we let the Russians get ahead of us in the satellite game? Paradoxically, it was not the shortage of engineers in this country that was responsible. It was, if anything, a shortage of psychologists! Actually, the possibility of launching a satellite had been under discussion in the United States for a long time. And the Russians had, long ago, also announced that they would launch one—date unspecified. Most people in this country regarded the satellite launching as an interesting scientific project, but it was repeatedly emphasized that it must not interfere with any military project. Hence, it could use no military hardware. So it was not pushed or given any priority. If someone could have visualized the tremendous psychological impact the first satellite would have on world opinion, and if they could have persuaded the Government of its propaganda importance, the project could easily have been accelerated. But not even the congressmen who are now shouting for blood ever told the National Science Foundation that the satellite project should be given top priority. Almost no Americans thought there was any rush. In the meantime, the Russians kept their plans secret until, suddenly, the job was done.

The first step

Our first lesson is that we must bring to the top levels of our Government better information and judgment about the potentialities of new scientific and engineering achievements, and their possible psychological effects on world opinion and their effects on the U.S. position of leadership. The appointment of Dr. J. R. Killian is a good step in the right direction—but he will need the help of many scientists, engineers, psychologists and experts in many areas of world opinion to do the full job.

Our next task is to realize the enormous advances Russia has made in science and technology in recent years.

Now that Sputnik has made us look at Russia more closely, we see very plainly—what we could have easily seen long ago—that for 30 years Russia has been systematically building an educational system that would give rigid technical training to a large number of scientists and engineers, who, under the communist system, would then be available to serve the needs of the state.

Soviet leaders foresaw, or soon learned, that you could not force people to be good scientists. There must be powerful incentives for every young person to develop any scientific talents he may have. So the Soviets turned to capitalistic methods and developed an elaborate system of financial incentives to encourage scientific training. Young men and women are paid to go to college—if they qualify. They are paid even more to go to graduate school—if they qualify. They are paid still more when they go into active scientific or engineering work—again if they pass rigid qualifying tests. Finally, the successful scientist or engineer is paid a very high salary, gets a car, a home in the country and extra food rations. And he is showered with medals to recognize his achievements. It's all very simple capitalism—large rewards to the able and the ambitious. And in this country we have been doing just the opposite—seeing to it that scientists, engineers and teachers do *not* earn too much!

The net result is that the U.S.S.R. has attained a position of great technological strength, and by concentrating large resources of men and money on military technology—nuclear bombs, submarines, aircraft and missiles—she has attained a position of great military strength, too.

No longer is it true—if it ever was—that automatically and inevitably and forever is the U.S. technically superior to the U.S.S.R. in the military field. Whatever the exact balance may be today, the Russians are certainly moving ahead very fast.

This is a sobering thought and requires sober attention. For this fact profoundly affects our foreign policy, our military posture, the nature of our defense effort and the distribution of our resources.

And if Russia can achieve these results in the military field, can she not attain similar goals in industry, in agriculture, in public health? Can she not, in short, attain in time a standard of living for her people comparable to ours? Can she not thus challenge throughout the world the superiority of a democratic system of government in providing for the welfare of its people?

That is the real challenge of Sputnik. It is not a question of how good Russia's rockets are, compared to ours. We can have good ones too. The question is whether Russia has now, before all the world, challenged us to an intellectual contest which we are not prepared to win. Can the communist system develop and use the brains of its people to a better advantage than our system?

Our intellectual resources

The challenge of Sputnik is that we must now take stock of our intellectual resources and how we are using them.

Arnold Toynbee, the historian, has advanced the proposition that the survival of nations and of civilizations depends on how they meet the challenges which they face. Blindness or complacency in the face of danger leads to collapse from without. Hysteria may lead to collapse from within. But foresight, courage and determination may conquer and challenge.

Can we, as a nation, bring these qualities to bear on the challenge we face?

Even though the challenge may not be in the form of an immediate military danger, it is clear that a rival power is surging ahead so rapidly on so many fronts that we must begin now to accelerate our pace.

How do we start? First, we must remember that back of any great new military, industrial, or technological achievement, back of any nation's material strength, lie the minds of many people. The most important resources of any nation are its intellectual resources. New developments come from new ideas. New ideas develop in the minds of men. Any single new idea, in fact, develops in the mind of a single man; the pooled ideas of many men constitute a nation's intellectual resources.

Our first task, then, is to strengthen our intellectual resources. The one great overpowering question which we need to ask is whether we are now developing and utilizing to the maximum extent, consistent with democratic principles, the full intellectual and spiritual strength of our people. If we are—we need have no fear. *If we are not—we are risking grave danger.*

Is America fully utilizing its intellectual resources? The answer is *no*.

Not one of us can honestly say that he is using his own intellectual resources fully. From the time we are children, until we die, most of us use only a fraction of the mental powers we have. We do not drive ourselves to use them; we do not encourage our children or friends and neighbors to use theirs. Oh, yes, we want our children to do well in school—but not too well! Johnny mustn't be different! And he mustn't be frustrated!

Instead of incentives

Instead of offering every possible incentive to intellectual achievement at all levels, in all fields, by all people, from the cradle to the grave, we offer—what? Tolerant amusement? Indifference? Or antagonism? ("Don't be an egghead!")

That is the challenge America faces now, today—that all of us (citizens, taxpayers, parents, teachers, workers) shall be aware of the importance of intellectual achievement. This challenge existed long ago, of course. But now a great question mark has been projected high in the sky for all the world to see. Are American intellectual resources going to be brought to life in a great surge of dynamic enthusiasm? Or is another more monolithic type of society going to be able to drive its people to a pace we cannot match?

I think many of our people have now become aware of the importance of raising the intellectual level of our attainments. They now seek guidance: Where shall we start? What shall we do? Unfortunately, there is no single move, or even any small group of moves, which *will solve this problem.*

The intellectual resources of our people are developed and nourished in many places—in our homes, our churches, our schools; in the universities, in libraries and museums; in industrial and government laboratories; in newspaper and magazine editorial rooms, and (we hope) in radio and TV broadcasting rooms.

In all of these places, higher intellectual standards must be encouraged and achieved. Better teachers' salaries alone are not enough, but they are necessary. More classrooms and laboratories in schools and colleges are not enough, but they too are necessary. We need to insist that every course our children take in school has a good solid intellectual content and that Johnny and Mary are held to the highest standards of which they are capable, even if they get frustrated once in a while. To say that all our schools have been destroyed by the philosophy of John Dewey is unfair to many schools and is too flattering to Mr. Dewey. But it is equally wrong to say there is no room for improvement. Our task is not to return to the 19th century little red schoolhouse, but to find a new and vigorous educational climate which will fit our children of today to meet the problems of the 21st century—which most of *them*, and not many of *us*, will live to see.

To meet the challenges of the year 2000 A.D., our nation will need to attain an enormous new surge of intellectual vigor.

How can we hope to achieve this when those engaged in intellectual pursuits find themselves at the bottom rung of the economic ladder? I do not claim it is wrong that a movie actress should earn 100 times as much as a professor because her bust and waist measurements have the correct ratio. But I do worry about the future of a society where the best brains are held in low esteem. I know that, to a teacher, other things are more important than salary. But, just to prove to our young people that a life of intellectual endeavor is important to our nation, let's increase our teachers' salaries—at least a little.

A little emphasis

Then, too, how can we have a vigorous intellectual climate when so few high school students get any adequate exposure to mathematics and science? Yes, I know people will insist that we must not have overemphasis on science. And I agree. But, before we complain about *over*emphasis, let's have a little emphasis. The fact is that science and mathematics, in many schools throughout the country, have been all but ostracized as legitimate subjects of study. They are too hard, or too technical, or "too remote from life." Bad counseling, bad administration, and bad teaching have all helped in this decline—and I think now is a good time to reverse the trend. It's time to give every youngster a chance to test his mettle on some good tough subjects—mathematics, language, economics, science—so he can find out where his talents lie and choose his future interests accordingly.

Today we are confronted with the political issue of what role the Federal Government should play in rejuvenating the vigor of our educational system. There are those who believe in no federal activity at all; others believe in very large federal subventions. Actually, I believe the recently proposed administration program is about right. It is large enough to underline the federal interest in education; it is small enough to avoid federal control. It will, by no means, solve all problems, but it will stimulate states and local communities to get busy on a few. It emphasizes the importance of the student and the teacher and seeks to help both.

The Federal Government can take leadership in other aspects of an intellectual reawakening. It can encourage improved higher education and graduate study; it can stimulate and support research and scholarship in many fields; it can make more efficient and effective use of manpower in its own activities.

But, in America it is the people themselves—not the Government—that determine their future. They set the intellectual standards; they create the intellectual climate; they determine relative values of intellectual and nonintellectual pursuits; they support the educational system; they are responsible for their own children; they pay the bills. They will determine whether or not America responds adequately to the challenge we face. I hope the American people will now get busy!

A triple responsibility

Finally, I should like to suggest that the universities of America must play a critical role in responding to this challenge. They have, in fact, a triple responsibilty.

They have a responsibility, first, to assist the Government in immediate technological problems. They carry on research and development in many fields related to national defense and national welfare.

Second, they have a responsibility in seeking new knowledge. It is the new scientific understanding gained today which is the foundation of our strength of tomorrow. The nation's relatively few centers of basic research in the country are precious assets indeed. It is essential that they be kept strong and made ever stronger. The universities are dedicated to the task of maintaining centers where the best minds in the country can effectively attack the deepest and most profound problems in every scholarly field.

Finally, the universities have a responsibility in educating men—men who will be leaders in pure and applied science, in education, in business, in politics. The research men, the university teachers, the leaders in industrial technology must be men of high ability, superbly trained. If it is an intellectual challenge that this nation faces, our success in meeting it will be determined by our success in producing great intellectual leaders.

A former officer of a Rockefeller Foundation Board used to say that the most important task in American higher education was to "make the peaks higher." Where high quality is found—make it still higher. Where strong leadership is developing—make it still stronger. Where outstanding men are found, help them work to the full limit of their talents. As the grandeur of a mountain range is determined by the height of its highest peaks, so we must give most devoted attention to those institutions at the pinnacles of scientific and educational achievement.

Every citizen in the nation can join in this endeavor.

WILLIAM W. HUSE

A Tribute by Harvey Eagleson

Suddenly and without any real warning, Bill Huse died on Friday, January 31. As someone has said, only the good die that way.

William Woodman Huse, professor of English literature at the California Institute of Technology since 1947, and a member of the English department since 1929, was born in Rockford, Illinois, on May 25, 1898. Until he settled at Caltech he was somewhat of an academic wanderer. He started his college education in Chicago, received his AB from Stanford, his MA from Princeton. He taught at Washington University in St. Louis, Princeton University and the University of Kansas. He published the usual professorial articles, a text book and several witty short stories. But it is not for these things that Bill will be remembered by his many, many friends all over the United States.

First, perhaps, they will remember his sense of humor. It was intricate, subtle, learned and sharp. The little jingles, quips and epigrams he tossed off apparently without effort were the delight of many an Athenaeum luncheon, many a faculty party, and many a classroom hour.

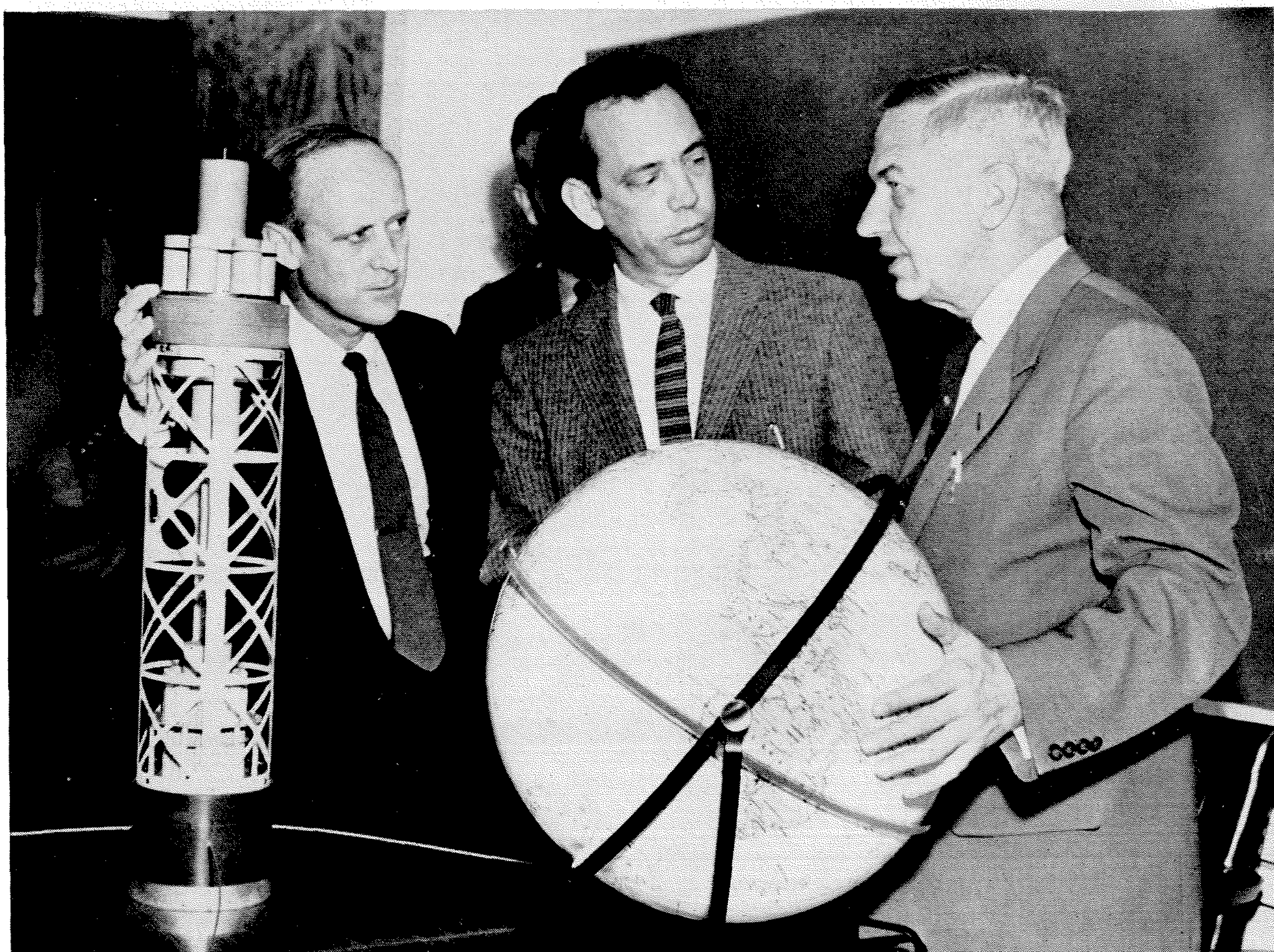
Second, perhaps, they will remember him for his gentleness and kindness, his ability to give himself to others. The uncomplaining patience with which he did small tasks for his sick or elderly friends, which they were unable to do for themselves, was almost "saintly," as one of his friends once said, though no one would have deplored that term more than Bill, for it must be admitted that like Chaucer's Doctor "His studie was but litel on the Bible."

Third, perhaps, they will remember him for his wide variety of interests that made him a friend of so many different kinds of people. There was his scholarly interest in early California history, Pepys, in Fielding—with whom he had much in common, both in his sense of humor and his attitude toward life. He liked to garden, carve in wood, to play games and swim. He liked parties, formal and informal, expected and unexpected, and the good food and drink that go with them. He liked to travel, enjoying equally the luxury hotel or a sleeping bag in the mountains or on a Mexican beach. He liked the theater and his taste was catholic, everything from *Hamlet* to the clowning of W. C. Fields. He read enormously, novels, plays, essays, philosophy, science, criticism, detective stories. His collection of books on the drama, architecture and furniture is impressive and valuable. He liked clothes and his accumulation of neckties is almost as impressive as his collection of books. But above all he liked his friends.

Perhaps the best tribute to him comes again from Chaucer who was one of his favorite poets and whom he was re-reading when he died.

"And gladly wolde he learn, and gladly teche."

Hail and farewell, Bill Huse.



After the successful launching of the Explorer I—William H. Pickering, director of the Jet Propulsion Laboratory; J. E. Froehlich, director of the Laboratory's satellite project; and Caltech President L. A. DuBridge.

The Month at Caltech

Explorer

Caltech scientists played a vital role in the successful launching of the first U.S. satellite, the Explorer. After the combined efforts of Caltech's Jet Propulsion Laboratory and the Army Ballistic Missile Agency, a Jupiter C launching vehicle shot the satellite into space on January 31. The missile was fired in a southeasterly direction from Cape Canaveral, Florida, down the ocean missile lane in the direction of South Africa.

A team of JPL scientists under the direction of William H. Pickering, head of the Laboratory, managed to do the job in just 80 days from the time the Department of Defense directed ABMA and JPL to go ahead with the project. Dr. J. E. Froehlich, chief of JPL's design and powerplants department, was put in charge of the high-speed stages of the multistage vehicle, the satellite, the satellite instrumentation and the collecting of information gathered by the satellite.

The basic vehicle for launching the satellite was already in existence. JPL and ABMA had redesigned the rocket originally intended for the Army proposal, "Operation Orbiter," into the Jupiter C and had made successful firings with it. This main stage vehicle weighed about 65,000 pounds and was more than 60 feet long and about 6 feet in diameter. Attached to the top were two more stages containing high-speed clusters of solid propellant rockets. The fourth stage consisted of the satellite package redesigned by JPL and fitted into the cylindrical shell. Part of the instrumentation consists of two radio transmitters which broadcast information about the occurrence of cosmic rays outside the earth's atmosphere, measurements of micrometeorites, and temperatures of the inner instrumentation and outer skin of the satellite.

One of the most useful types of information expected to be gained from the satellite in its 90-minute trips around the earth is a more precise measurement of distances between continents. This is done by simultaneous observation of the satellite from two stations. By measurement of the angles to the satellite, plus knowledge of the satellite's position, scientists can calculate back to the distance between the stations.

By careful measurement of the rate of precession, accurate calculations of the precise shape of the earth can be made—to find out how much of it is flattened at the poles and to what degree it bulges at the equator. Also, by measurement of changes in the satellite orbit, the density of the air through which the satellite is passing can be calculated.

Plans are now being made for the launching of a second satellite with much more involved instrumentation. JPL has made an official announcement that the launching will take place before April 1.

Eastman Professorship

George W. Beadle, chairman of the division of biological sciences, has been appointed Eastman Visiting Professor at the University of Oxford, England, for 1958-59. The Eastman Professorship was founded in 1929 by George Eastman to bring senior American scholars to Oxford University for a year. In the past, the appointment has gone to such men as Felix Frankfurter, Arthur H. Compton, John Livingstone Lowes, Linus Pauling, Wallace Notestein, and Harold C. Urey. The current (1957-58) Eastman Professor is George Kennan, former American Ambassador to Russia, and a member of the Institute for Advanced Study at Princeton.

Leaders of America

Clarence B. Randall, special consultant to President Eisenhower in the field of foreign economic policy, visited the Institute on February 10 and 11 as the first 1958 guest in the YMCA's Leaders of America program. Mr. Randall is not a newcomer to the campus; he delivered the commencement address here in 1955.

Mr. Randall, who is now a director of Inland Steel, was president of the company for a number of years and has also served as chairman of its board. He has been a special consultant to President Eisenhower since 1956.

The second visitor in the Leaders of America program will be the Reverend Martin Luther King, president of the Montgomery, Alabama, Improvement Association, and leader of the negro bus boycott in Montgomery. Dr. King will be on campus from February 25-27. Dr. Sarvepalli Radhakrishnan, vice-president of India, is scheduled to be here from April 2-4. And, as the final visitor in this year's program, Victor Reuther, assistant to the president of the CIO, will arrive on campus on May 12.

Plumian Chair

Fred Hoyle, visiting professor of astronomy at Caltech, and Fellow of St. John's College, Cambridge, has been appointed Plumian Professor of Astronomy and Experimental Philosophy at the University of Cambridge. The appointment is a lifetime chair, established by Thomas Plume (1630-1704), who left most of his wealth to the University for the founding of an observatory, the chair of astronomy and a home for the professor. The first occupant of the Plumian Chair was Roger Cotes, in 1707. Successive occupants have been Robert Smith in 1716, Sir George B. Airy in 1828, James Challis in 1836, Sir George H. Darwin in 1883, Sir Arthur Eddington in 1913, and Sir Harold Jeffreys in 1946.

National Conference

President DuBridge was the principal speaker at a national conference on "America's Human Resources to Meet the Scientific Challenge" at Yale University this month. Sponsored jointly by President Eisenhower's Committee on Scientists and Engineers and the William Bent Foundation, the meeting brought together 100 key representatives of science, education, industry, government, mass communications, labor, and religious and minority groups to examine America's competitive position in world science and technology. Other Caltech representatives were Harrison Brown, professor of geochemistry, who was chairman of a panel discussion on "The Scientific Revolution: Challenge and Promise"; and Frederick C. Lindvall, chairman of Caltech's engineering division and president of the American Society of Engineering Education.

Nuclear Petition

Linus Pauling, chairman of the division of chemistry and chemical engineering at Caltech, acted as spokesman for more than 9,000 scientists last month when he presented a petition opposing nuclear weapons tests to Dag Hammerskjold, Secretary General of the United Nations. The signers included 36 Nobel prize winners, 101 members of the National Academy of Sciences, 216 Members of the Soviet Academy of Sciences and 35 members of the Royal Society of London.

Ten Caltech scientists signed the petition: Frits Went, professor of plant psychiology; A. H. Sturtevant, professor of genetics; Howard J. Lucas, professor of organic chemistry; Verner Shomaker, professor of chemistry; E. T. Bell, professor of mathematics emeritus; Max Delbruck, professor of biology; Seth B. Nicholson, staff member of the Mount Wilson and Palomar Observatories; Matthew L. Sands, associate professor of physics; Harden McConnell, associate professor of physical chemistry; and W. Barclay Ray, assistant professor of geology.

Desalting the Pacific

A progress report on how we are tackling the problem of getting fresh water from the oecan

by Jack E. McKee

From the earliest days of recorded history, man has dreamed of using the vast quantities of ocean water for drinking or for irrigation. Of all of the water on the surface of this planet, over 99.99 percent occurs in the ocean. If it were piled on the land, it would stand over 2 miles deep. In comparison, the total yearly rainfall over the entire land surface is only about 24 inches, and all of the moisture in the atmosphere is equivalent to only about 2 inches. Yet, the great bulk of water has been locked away from us because it is too saline for our use, and we haven't discovered how to convert it at reasonable cost.

Certainly, the desalting of sea water is one of the most challenging and fascinating problems ever faced by scientists and engineers. Until recently, its solution was not too urgent; but with increasing pressure from population growth throughout the world, and with larger and larger per capita use of fresh water as our civilization becomes more industralized, the problem has been brought into sharp focus.

In military activities, where expense is not a consideration, the desalting of sea water is a practical and accomplished fact. Special kits are available on life rafts, employing the ion-exchange process, which produce fresh water from the ocean at a cost of about $5.00 per pint. On Iwo Jima, during World War II, the entire supply of drinking and cooking water for more than 30,000 Army, Navy, and Marine personnel was produced by various types of distillation units. This method of producing fresh water is also used aboard many ships. It is certainly cheaper to haul one gallon of fuel oil than the 100 gallons of potable water that can be produced from the heat of such oil.

Distillation units are already employed for municipal water supply where no other sources are available. At Curacao in the Dutch West Indies, a population of 45,000 is supplied with fresh water by a 6-stage evaporator having a capacity of 770,000 gallons per day (gpd). At Kuwait on the Persian Gulf, and at Aruba, near Venezuela, similar distillation units are employed to supply these oil-producing communities. Even in California, the Pacific Gas and Electric Company distills 144,000 gpd of fresh water from the ocean. The cost of such water, however, is approximately $2.15 per thousand gallons or $700 per acre foot.

At this point it might be wise to pause and consider the standardization of price quotations. You may read one promoter's claim that his scheme for getting fresh water from the ocean costs only 15 cents per ton of fresh water, which sounds ridiculously cheap. More frequently, you will see a figure such as 60 cents per thousand gallons, which still appears to be quite inexpensive. The same price, when expressed as $600 per million gallons sounds prohibitive. Here in the West, we are accustomed to the term "acre foot" (AF). Any rancher or waterworks operator knows how much he can afford to pay for an acre foot of water; therefore, I shall confine all price quotations here to dollars per acre foot. If you are accustomed to other yardsticks you might remember that water priced at $10/AF is equivalent to:

	$30.70 per million gallons
or	3.07 cents per 1000 gallons
or	2.30 cents per 100 cubic feet
or	¾ cents per ton

Thus, the quotations of 15 cents per ton or 60 cents per thousand gallons, as mentioned before, are both equivalent to about $200/AF.

It is also important to standardize methods of computing costs to take into account maintenance, deprecia-

"Desalting the Pacific" has been adapted from a talk presented to the Arizona Bankers Association on November 16, 1957

tion, and interest on the capital investment, as well as power or heat costs. Often you will see a ridiculously low price quoted for desalting sea water. If you can pin down the source you will probably discover that the cost is for power only, and then probably at an impossible rate.

To minimize rash statements that may lead to false hopes, the Department of the Interior's Office of Saline Water has established a realistic standardized cost-estimating procedure. It includes amortization based on a 20-year plant life and 4 percent interest. Power is rated at ½ cent per kwh, heat at 25 cents per million Btu, and steam at 55 cents per 1000 lbs. Land costs are figured at $3 per gpd capacity and storage is provided for 10 days production of water. Most of the cost figures in this report comply with this standardized procedure.

The three large categories of water uses in the United States are irrigated agriculture, domestic use, and industrial requirements. Let us take a look at the prices that these three groups are accustomed to paying.

TYPICAL RATES FOR WATER

	Approximate Water Rates per acre foot		
Beneficial Use	*Lowest*	*Common*	*Highest*
1. Irrigation water			
a. Bureau of Reclamation	$1-2	$ 2-6	$ 27
b. Independent districts	2-5	5-10	40
c. Individual wells	2	10	20
2. *Municipal Water*			
a. Raw water cost to city	2	10	50
b. Owens Aqueduct (Los Angeles)*	—	19	—
c. Pasadena, MWD water* (1956)	—	44	—
d. Retail Cost to consumers	5-10	50-80	200
3. Industrial water	2	50-100	1000

*Total costs, including amortization of bonded indebtedness and treatment.

Irrigators are accustomed to cheap water. Most sales by the Bureau of Reclamation are at rates $2-6/AF, and the highest at $27/AF. To pump water from underground basins generally costs $4-5/AF per 100 foot lift. Many ranchers pump 150 to 400 feet, at a cost of $6-20/AF.

When considering municipal water, one must recognize the difference between the cost of raw water to the city, and the cost to the consumer of the treated and distributed water at the tap. Most raw water costs are comparable to those of irrigation water. From a study of water rates around the country, it is apparent that the retail consumer pays a price considerably higher than the raw water cost, with most householders paying about $50-80/AF. Note that the cost to the consumer at the tap is two or three times the cost of the raw water. In other words, it costs more to distribute the water than to obtain it initially.

Insofar as industry is concerned, the value of water depends entirely upon the nature of the industry. Paper, textile, tannery, and steel mills must have abundant and cheap water, probably as cheap as irrigation water. Most industries can afford delivered city water, that is at $50-80/AF or even more. Some highly specialized industries need small quantities of fine-quality water, and they can afford to pay a premium price for it. Or, they may treat the water by expensive means, at costs up to $1000/AF or more. To industry, water is a raw material. For this reason, many industries tend to locate where water is abundant, cheap, and of good quality.

At the beginning of the Saline Water Conversion Program of the Department of Interior in 1952, two arbitrary cost goals were set, one for municipal water and one for irrigation water. The goal for municipal water was set at $125/AF and that for irrigation water at $40/AF. As the table (left) indicates, however, these goals are still at the upper end of the scale for the typical rates now being paid for municipal and irrigation water. If these rates can be obtained by practical sea-water conversion units, such water will begin to become competitive with alternate existing supplies in a few localities.

The salinity of ocean waters is fairly uniform at about 3.5 percent solids, or, in the concentration term most commonly used, 35,000 milligrams per liter (mgpl). In the Persian Gulf, however, it is nearly 40,000 mgpl, and probably almost as high in the Gulf of California. In Chesapeake Bay it is about 15,000 mgpl and in the Baltic Sea only 7,000 mgpl. When considering the Pacific Ocean, 35,000 mgpl is a suitable figure. It may be broken down into the most common constituents as shown in the table below.

MAJOR SALTS IN SEA WATER

		Concentration Expressed as	
Substance		*mg/liter*	*lbs/1000 gallons*
Cations:	Sodium	10,722	89.5
	Magnesium	1,297	10.8
	Calcium	417	3.5
	Potassium	382	3.2
	Strontium	14	0.12
Anions:	Chlorides	19,337	161.2
	Sulfates	2,705	22.6
	Bicarbonates & Carbonates	*104*	*0.9*
	Bromides	66	0.5
	Borates	18	0.2
Trace ions		17	0.2
	Totals	35,079	292.7

When the sea water is desalted, how pure must the fresh water be? The drinking water standards of the U.S. Public Health Service specify that the total dissolved solids should not exceed 1000 mgpl. The USPHS also specifies that the magnesium should be less than 125, the chlorides less than 250 and the sulfates less than 250 mgpl.

For irrigation water, it is desirable to keep the total dissolved solids less than 650 mgpl, and certainly less than 1200 mgpl except for the hardiest crops under the most favorable irrigating conditions. In addition, chlorides should be less than 200 mgpl and boron less than 0.5 mgpl. Sodium is particularly detrimental in irrigation water, especially when the ratio of sodium ions to total cations on an equivalence basis exceeds 60 percent. The table below shows a summary of these water quality criteria for domestic and irrigation waters.

SOME APPROXIMATE LIMITS OF WATER QUALITY

	Concentrations in mg/liter	
Substance	*Domestic*	*Use Irrigation*
Total dissolved solids	1000	650-1200
Chlorides	250	200
Sulfates	250	500
Magnesium	125	—
Boron	—	0.5
Sodium ratio (Na/Ca+Mg+Na)	—	60%

Based on total solids, these criteria show that over 97 percent of the salts must be removed from the water; but this would still leave the sodium concentration at 320 mgpl and the sodium ratio far greater than 60 percent. For domestic use and irrigation, such high sodium concentrations would be prohibitive. It appears, therefore, that almost 100 percent of the salts must be removed from sea water.

For industrial water, the requirements for purity vary tremendously with the characteristics of the industry and the use to which the water is put. For example, high-pressure boiler feedwater must be close to distilled water in quality. On the other hand, sea water itself can be used for once-through cooling water. For most industries, water that meets the domestic criteria will be suitable as a source of raw water, although the industries may have to modify this water somewhat for special purposes.

Until a few years ago, research in the desalting of sea water was sporadic and uncoordinated. In 1952, however, the Congress of the United States recognized the importance of this problem and passed Public Law 448. This act authorized the Secretary of the Interior to develop practical low-cost means of producing from sea water, or from other saline waters, fresh water of a quality suitable for agriculture and for industrial, municipal, and other beneficial consumptive uses. The initial appropriation was $2,000,000 for a five-year period, extending to June, 1957. The last Congress extended the program for an additional five years, and has increased the money value of the research to a total of $10,000,000 or $2,000,000 per year. To assist the Secretary of the Interior in broad policy matters, an advisory group was named consisting of nine qualified persons in various fields related to the program. One of this advisory group is Caltech's President Lee A. DuBridge.

Within the Department of the Interior, an Office of Saline Water was established. This office administers the program by research and development contracts with many private agencies.

Various methods have been investigated for the desalting of sea water. Utilizing principles of thermodynamics and physical chemistry, it is possible to calculate the absolute minimum free energy required to separate salt from water, regardless of the method used. This is a theoretical energy requirement which is a property of the molecular forces holding the salt in solution. At 25°C this minimum free energy is 2.89 kwh per 1000 gallons, or 940 kwh/AF.

This is the work required when operating an *ideal* process, infinitely slow, with an infinitesimal fraction of fresh water from a huge volume of sea water, with no heat losses and no inefficiencies. To recover one gallon of fresh water from every two gallons of sea water, the minimum free energy is about 1200 kwh/AF. The best overall efficiency we can hope for is 33 to 50 percent, making this energy requirement 2400 to 3600 kwh/AF. Costs for amortization and maintenance of the plant must be added.

According to a recent OSW report the actual minimum energy requirements have been calculated for two methods of desalinization, taking into account the rate phenomena, plant costs, and several other factors, but still excluding many losses in energy conversion devices and the water transport requirements. This report computes theoretically that the minimum energy requirement will be about 3500 to 4000 kwh/AF, or about four times the theoretical ideal minimum. On this basis, with power at 0.5 cents per kwh, the minimum cost would be about $18/AF. To allow for energy losses and other inefficiencies, this figure would probably be doubled to about $35/AF.

Desalting processes

All processes for desalting sea water can be divided into two categories; those that extract the water from the saline solution and those that remove the salts from the solution. The costs of processes that extract water will be relatively independent of the salt concentration except for problems of scaling. For processes involving the removal of salts, the cost will be approximately proportional to the concentration of salt.

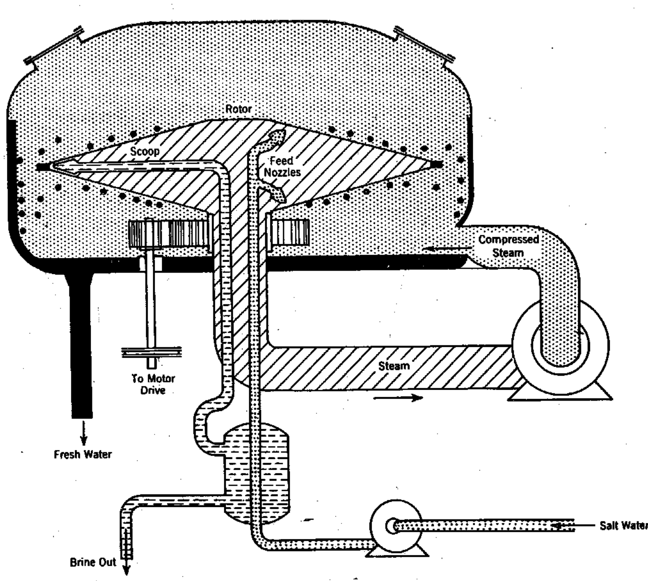
Methods of desalinization have been divided also into physical, chemical and electrical processes. Among the most prominent of the physical processes are the various distillation methods, solar radiation, temperature-difference processes, nuclear-energy adaptions, freezing, ultrasonics, and osmosis. Chemical processes include precipitation of salts and ion exchange. Electrodialysis constitutes the most significant electrical process.

Simple distillation operates like a conventional laboratory still, but it is not nearly as useful for salt-water conversion. The heat required is equivalent to about 900,000 kwh/AF or about 1000 times the minimum free energy. Needless to say, the cost is prohibitive.

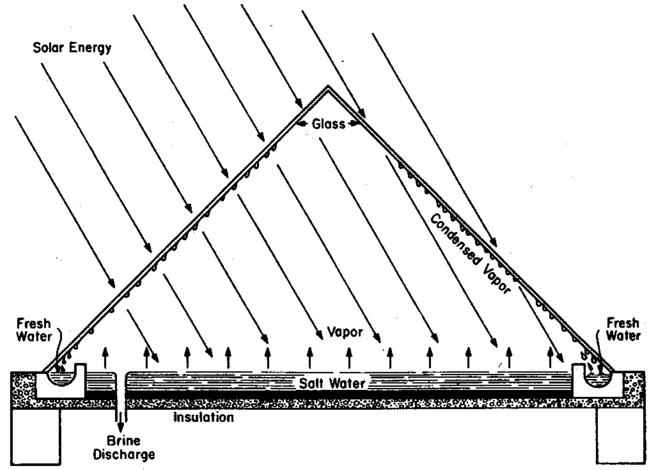
Engineers discovered long ago that the efficiency of distillation could be improved by several stills in series. Multiple-effect distillation utilizes the vapor from each still to heat the next still at a lower pressure, which is maintained by vacuum pumps. Heat requirements have been cut to about 200 times the theoretical minimum, but costs are still in excess of $700/AF. W. L. Badger of Ann Arbor, Michigan, has proposed a multiple-stage long-tube vertical evaporator of the type used by the salt industry. The cycle requires completely scale-free operation. If this can be achieved without the use of acid or non-ferrous metals, Badger feels that fresh water conceivably *might* be produced at $130/AF. Before this optimistic estimate can be accepted, the process must be tested adequately.

If the vapor from a still is compressed it will condense at higher temperature and can be used to heat the sea water. This process is known as vapor-compression distillation. With the aid of heat exchangers, the heat input can be greatly reduced, but expensive electric power is required. During the war, water from such equipment cost about $400/AF, but with technological improvements this cost might be cut appreciably. One such improvement is the Hickman rotary still (below). Here the feed water is spread by centrifugal force in a thin film over the surface of a conical rotator. This action increases the rate of heat transfer from 500 up to 3500 Btu per hour per square foot per degree F. Inasmuch as salt water at temperatures as low as 125° F can be sprayed on the inside surface of the rotating drum, the probability of scale formation is minimized. A pilot plant designed to produce 25,000 gpd is under construction and there is promise that the cost *might* be reduced to $115/AF, but this remains to be demonstrated.

As far back as 1930, a Frenchman named Claude proposed that the difference in temperature between cold deep ocean waters and warm surface waters could be used to produce power and fresh water. When warm sea water is taken in under reduced pressure, some of it evaporates. This vapor can be used to drive turbines and generate power to help operate the pumps. Then the vapor is condensed by cold sea water. Where deep ocean canyons are close to shore, this process may prove to be feasible. At present, such a plant is being planned by French engineers at Abidjan in West Africa to produce 150,000 gpd of fresh water, The French engineers estimate costs of about $150/AF now and possibly as low as $100/AF in the future.



The Hickman rotary still combines vapor-compression with evaporation from a thin sea-water film maintained by centrifugal action.



In a solar still, vapor formed by evaporation condenses on the underside of the glass and flows into the trough.

Why not copy nature and use solar heat for vaporization? Solar stills of the type shown above will produce fresh water at the rate of one pint per day per square foot of exposed surface in sunny climates. Expressed otherwise, one acre of stills will yield 6 acre feet of fresh water per year. At this rate, one acre of stills would be needed for every 2 or 3 acres of irrigated land or residential area!

In the Southwest, the energy received on a horizontal surface is about 2000 Btu per square foot per year. A solar still will collect about half of this energy, but its efficiency in vaporizing water is less than 1 percent. Furthermore, the cell operates only 6 to 8 hours a day. By using the ground as a storage bank for the sun's heat, or by combining solar stills with multiple-effect or vapor-compression distillation, it is hoped that some of these disadvantages can be overcome. Other proposals include a 10-stage sandwich-like arrangement of alternating absorbing and condensing layers on a sloping surface, which shows promise of a five-fold increase in the production rate. Former costs were about $900/AF but present estimates with improved stills range from $325 down to $165/AF.

Another way to copy nature is to freeze water, inasmuch as the concentration of salt in ice frozen from sea water is considerably less than in the original water. Slow freezing combined with centrifugal action can be used to produce water relatively free of salt, and by successive cycles in this fashion, water of acceptable quality can be produced. Inasmuch as the heat removed in the freezing of water is only one-seventh of that required to boil water, one might anticipate that freezing would be considerably less costly than distillation. A further advantage lies in the reduction of scale and corrosion.

Unfortunately, however, low-temperature refrigerating machinery is inherently more expensive than high-temperature heat-exchange equipment. The University of Washington has made a careful economic study of all

continued on page 28

Full-time, off-the-job GRADUATE

STUDY CENTER. New York's Coliseum Tower houses one of three special study centers set aside for W.E.'s Graduate Engineering Training Program. Other centers are in Chicago and Winston-Salem, N. C. Product design principles are one of the many technical subjects our engineers cover in *Introduction to Western Electric Engineering*, the first phase of the program.

existing and potential equipment for freezing sea water. An ideal arrangement of such units could provide fresh water at a cost of approximately $750/AF.

The Carrier Corporation is conducting research to determine the economic feasibility of a method to combine freezing and evaporation. Another new approach, known as "zone freezing," is being evaluated by the Battelle Institute. There have been been reports of pilot-plant studies on the freeze-evaporation system developed by Zarchin in Israel, and the process was studied analytically by the University of California, but the university could not reconcile its cost estimates with the enthusiastic ones of the inventor.

Miscellaneous physical processes

As any student of high school physics knows, water molecules will pass through a permeable membrane from a zone of fresh water into a zone of salt water by a process known as osmosis. If sea water and fresh water are placed on opposite sides of a permeable membrane, the water surface on the sea-water side will be about 850 feet higher than on the fresh-water side. In other words, the osmotic pressure of the sea water is about 350-400 lbs/sq. in. This phenomenon can be reversed, and water made to flow from the salty side to the fresh side by superimposing a tremendous pressure. With cellulose acetate membranes, 90 to 95 percent of the salt can be removed from the water in one operation. To get drinking water, two or more passes would be required. From an engineering point of view, there are many practical disadvantages to such an operation, especially when large pressures and membrane clogging are involved. Cost estimates for this process are not available, but they are known to be prohibitive.

It has been suggested that saline water conversion can be combined with nuclear power generation to reduce the energy cost. At present, however, the cost of power or heat from nuclear energy is not competitive with that from fossil fuels such as coal and oil. Nuclear energy is not likely to become cheaper than conventional sources of energy until the latter are nearing depletion. It is possible, however, that there may be ways of using nuclear reactors primarily to produce low-temperature steam or by utilizing the power during the off-peak periods. The Fluor Corporation has just undertaken a study of the applicability of combining nuclear energy processes with saline water conversion.

Up until now, we have considered methods by which the water is removed from the saline solution. Would it be cheaper to take the salt from the sea water?

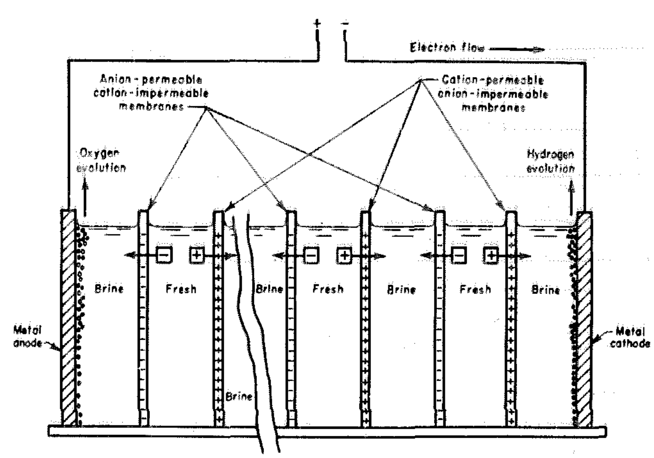
It is possible to remove salts from solution by chemical precipitation; for example, chloride ions can be removed by precipitation with silver. Chemical treatment of sea water requires the use of many different salts, some of which are quite expensive. The cost of the salts alone would amount to over $10,000/AF. Obviously, this method is beyond any further consideration for large-scale desalting processes, although it was used on life-rafts during the war.

The principle of softening by ion-exchange resins can be extended to the removal of all salts from sea water. What is more, these resins can be regenerated and re-used. Unfortunately, this regeneration requires large quantities of chemicals. The cost of these chemicals alone has been estimated at $6,000 to $8,000/AF of fresh water produced. Thus, it appears unlikely that any known chemical method for desalting sea water will be economically practicable.

When electrodes are placed in a saline solution and subjected to an electrical potential, cations in the solution will migrate to one electrode and anions to the other. If the container is divided into three compartments by means of two porous diaphragms, the center compartment will soon become free of ions that have migrated in either direction. To accomplish this purification, a high proportion of the ions must be neutralized at the anode or cathode, with a large expenditure of electrical energy. Minimum cost has been estimated at over $500/AF.

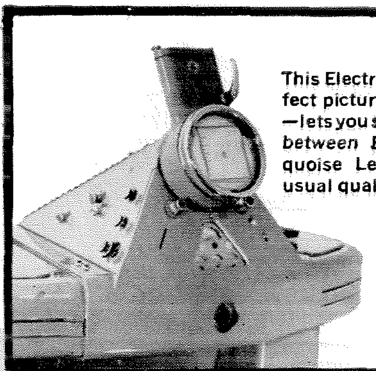
A new type of membrane, consisting of sulfonated polystyrene divinyl benzene or similar resins, was developed a few years ago. These membranes can be negatively charged so as to permit the passage of cations but not anions, or they can be positively charged so as to permit the passage of anions only. They provide a means whereby the costly neutralization of the ions at both electrodes can be minimized by the use of multiple channels (below). Any ion can pass through one membrane but not through two in succession; consequently, every other channel becomes fresh, while the alternate ones get twice as brackish.

continued on page 32



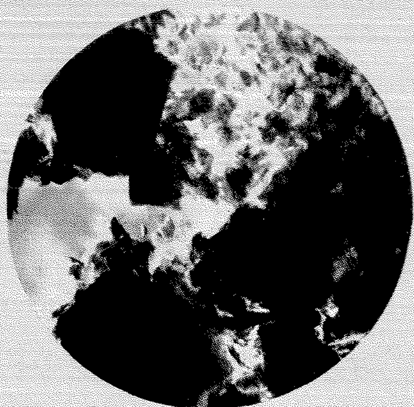
Costly neutralization of ions at both electrodes is minimized because no ion can pass through two charged membranes. Alternate channels then become free of ions.

Eagle Turquoise sharp drawings



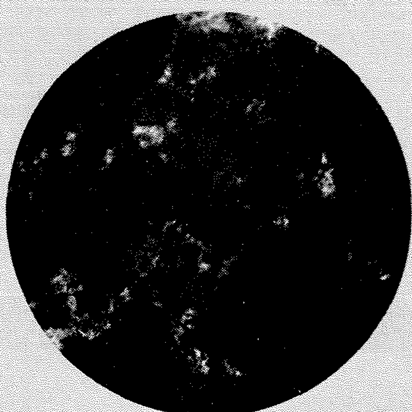
This Electron Microscope takes perfect pictures 7,500 times actual size—lets you see the startling difference between *Eagle's "Electronic" Turquoise Lead* and the lead in the usual quality drafting pencil.

Photographs courtesy of Ladd Research Industries, Inc.



Relatively large, irregular particles of graphite make a rough-edged line. Drawings will be inferior.

...AND MARKS LIKE THIS

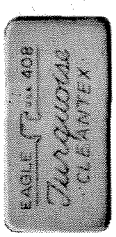


Tiny, more uniform particles deposit as a clean-edged, solid line. Drawings will be perfectly sharp, clearly defined.

...AND MARKS LIKE THIS

WRITE FOR FREE SAMPLE DEMONSTRATION KIT
(including Turquoise wood pencil, Turquoise lead, and Turquoise "skeleton" lead) naming this magazine. Eagle Pencil Company, 703 East 13th Street, New York, N. Y.

• **TURQUOISE DRAWING PENCILS:** ®"Electronic" graphite. 17 grades, 6B through 9H.



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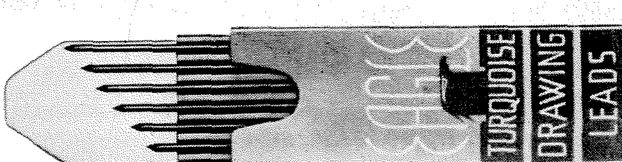

• **TURQUOISE DRAWING LEADS:** Fit any standard lead holder. Grades 5B through 9H.

• **TURQUOISE LEAD HOLDERS:** Hold any grade of Turquoise lead.

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PENCILS AND LEADS

are the largest-selling in the United States!

The announcement of this process a few years ago was greeted by enthusiastic "armchair" estimates as low as \$100/AF. Recent figures, based on pilot-plant experiments, are far less encouraging. Because the electric power requirements are proportional to the concentration of salt, the process does not look promising for concentrated sea water, but it appears to offer some good prospects for brackish waters. For a flow of 1.0 mgd, the cost of changing the salt concentration from 4,000 mgpl to 500 mgpl has been estimated at \$260/AF. For desalting sea water, this method now appears to be completely uneconomical.

Other potential methods of desalinization are being studied, but the experimental work has not progressed to the state where reliable cost estimates can be made. For the methods just described, the table below shows a summary of the estimated costs based on large-scale installations. You will note that present costs are considerably in excess of the two goals described previously—\$125 for municipal water and \$40 for irrigation water. It is possible, however, that refinements in these processes will eventually bring down the costs to the neighborhood of \$125-150/AF.

ESTIMATED PRODUCTION COSTS

Estimated Production Costs for Large-scale Sea Water Conversion Processes (in dollars per acre foot)

Process	*Present*	*Possible Future*
Multiple-effect distillation	\$700	\$130
Vapor-compression distillation	400	115
Temperature-difference vaporization (French)	150	100
Solar distillation, with combinations	325	165
Freezing, with combinations	750	?
Chemical precipitation	10,000	10,000
Ion exchange	8,000	6,000
Electrolytic action	500	500
Ion-permeable membranes (for brackish water only)	260	260

The major cost factor in the water supplies of our large cities, such as Boston, New York, San Francisco, and Los Angeles is attributable to the transportation of the water; that is, to the amortization of the large aqueducts. Fortunately for most of these cities, the water has its source in mountains, and flows to the city by gravity. When fresh water is produced from the ocean, however, it will have to be pumped to a municipality or irrigation district. The cost of such pumping, and the amortization of the necessary pipelines, will cost 30 cents to 70 cents/AF/mile. To pump water from the Gulf of California to Phoenix, for example, will cost \$50-\$100/AF, depending on power rates, amortization, and type of aqueduct. Transportation costs such as this must be included in the total cost of fresh water from the ocean delivered to a city or irrigation district.

This question is often asked: In addition to fresh water, can't we also recover magnesium and other valuable chemicals from sea water? The answer is yes, but let us examine the practicability and the economic feasibility. Already there are plants in the United States where sodium chloride, magnesium salts, calcium sulfate, and bromine are obtained from sea water. In addition, most of our domestic iodine is recovered from oil-field brines which are more saline than sea water. None of these processes involve the simultaneous production of fresh water.

The evaporation processes described previously do not remove *all* of the water from the saline solution. In fact, care must be taken not to remove too much because of scale formation and corrosion problems. To evaporate the sea water to dryness, or to a very concentrated brine from which chemicals might be recovered, would add greatly to the cost. Furthermore, there would be a high cost for separating the mixed salts and purifying them for marketing. Finally, the average water demand corresponds to over 5 *tons* of by-product salts per year per person.

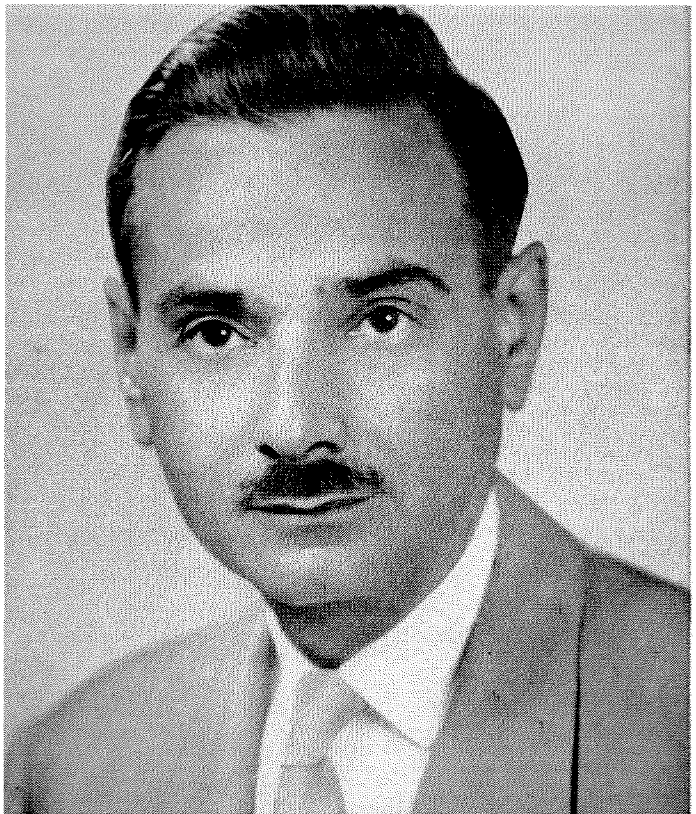
In his book, *Fresh Water from the Ocean*, Cecil B. Ellis has analyzed other economic facets of this problem and has reached the conclusion that the profits from recovery of by-product chemicals would lie between zero and \$6/AF of fresh water produced, provided only that no more than one plant of 1000-mgd capacity were built. Further plants would flood the market with chemicals.

Conclusions

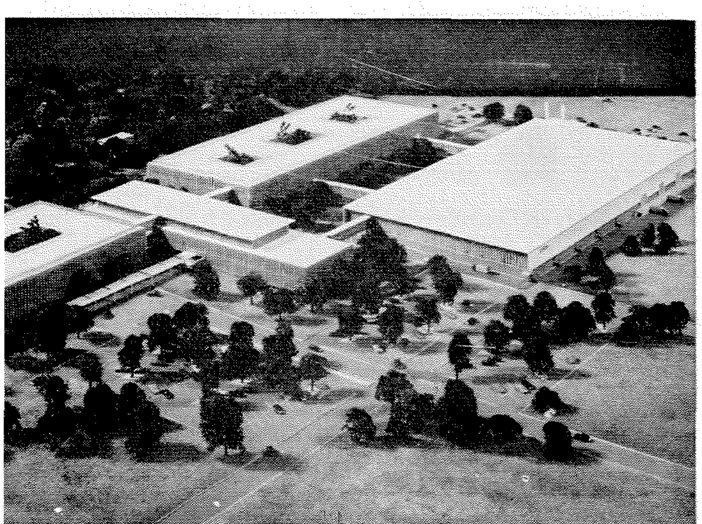
By technological improvements, it is remotely conceivable that desalinization of sea water can be accomplished for \$125-150/AF in the next five or ten years. Such water might find a market in certain industries or isolated communities located at sea level. For inland communities, the cost of transportation must be added.

Based on the theoretical considerations of thermodynamics and physical chemistry, it should be possible to produce fresh water from the ocean at costs of about \$35/AF at sea level. This is an ideal figure, however, and to date no known process gives promise of approaching it, barring a major "breakthrough" of science and technology. In essence, we haven't the fundamental knowledge at present, we haven't studied enough, and we haven't researched enough. On the other hand, we haven't proved that it can't be done either.

Waterworks officials, ranchers, industries, and everyone interested in abundant supplies of fresh water at reasonable cost must recognize that *cheap water from the ocean is not around the corner.* On the other hand, by encouraging an accelerated program of basic research we are justified in adopting an attitude of conservative optimism.



J. W. Marchetti, Director, Avco Electronics Research Laboratory



Pictured above is our new Research and Development Center now under construction in Wilmington, Massachusetts. Scheduled for completion in early 1958, this ultramodern laboratory will house the scientific and technical staff of the Avco Research and Advanced Development Division.

CREATIVITY

If there is a single word that can best describe the aim and purpose of AVCO's Research and Advanced Development Division, it is creativity. We at AVCO have assembled those elements and that atmosphere which we believe are most conducive to true creative effort.

Our future progress depends on an early recognition of the difference between an *important* new idea and just a new idea. It is mere quibbling with words whether we call these things new discoveries, breakthroughs, or basic research. They are, in fact, merely the signposts of our future. The world in 1980 and the year 2000 will, in its technological aspects, be vastly different from what we know today. Yet locked somewhere on our present scientific frontiers is the knowledge that will spell out this difference. It is our purpose to help in the unlocking of that knowledge and to contribute our part to the over-all progress.

The most important ingredients of creativity are curiosity and a real will to work hard. Of only slightly lesser importance is the feedback, or close working relationship between theoretician and observing experimentalist. We at AVCO also realize that a single creative effort is the output of a man, or, at the most, of a small group of men at any one time. It is, therefore, continuously subject to the criticism of other men and some even more stultifying forces. Some of these are economic or organizational and others are of a more subtle variety. We of the AVCO management consider it our responsibility to be alert to both positive and negative factors affecting creativity. We consider the ability of our men to create for the future, the most important function of the AVCO Research and Advanced Development Division.

J W Marchetti

J. W. Marchetti,
Director, Avco Electronics Research Laboratory

Avco's new research division now offers unusual and exciting career opportunities for exceptionally qualified and forward-looking scientists and engineers in such fields as:

Science:
Aerodynamics · Electronics · Mathematics · Metallurgy
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Write to Dr. R. W. Johnston, Scientific and Technical Relations, Avco Research and Advanced Development Division, 20 South Union Street, Lawrence, Massachusetts.

AVCO
Research & Advanced Development

All About Elections

February is ASCIT election time. Once again the Associated Students of the California Institute of Technology will issue a thunderous mandate to their chosen representatives. Having been a candidate last year, I've had occasion to observe the thunder in its finer details. It's an awesome process.

The campaign actually begins sometime in January. Would-be candidates attend the previously deserted Board of Directors meetings, anxious to demonstrate their civic zeal. The value of this maneuver is doubtful, since only other zealous candidates and the case-hardened directors are present. The meetings are interesting, however, since many of the directors know they will be running against each other in the coming election. Such seemingly innocuous statements as, "Mr. President, I do not think the situation would be fully implemented at this time by the gentleman's proposal," can better be interpreted as, "Ha! It's obvious that idiot doesn't know what he's talking about. Elect *me* next month, and keep him from ruining ASCIT."

The nominating assembly officially opens the campaign. A golden rule here is, "Be nominated by a man from another house—someone with lots of campus prestige." This is supposed to show that you have the support of the campus leaders. Actually it shows that you're adept at buttonholing people, but again the difference is small, since only nominators and nominees are present. The speeches have a certain element of suspense. Since one man will often nominate several candidates, there's a good chance for an embarrassing mixup. Assuming that all goes well, though, the president thanks the speaker and asks the nominee if he accepts. After a few seconds pause, perhaps to steel himself for the duty that lies ahead, the candidate does accept, in the interests of better student government.

Now it is the candidate's duty to write a letter for our campus newspaper, *The California Tech*, expounding on the issues that have forced him to run. It is perhaps the *Tech's* proudest boast that it has been able to survive this yearly influx of enthusiasm.

About a week before elections, the signs go up. Now the true test of votesmanship begins. A poster like this one, for instance, is a sure loser:

Vote
CLYDE T. ALLAMERICAN
for ASCIT DOORMAT

Cleancut	**Dependable**	**Absorbent**
Intelligent	**Courageous**	**Thrifty**
Experienced	**Athletic**	**Obedient**
Handsome	**Durable**	**Kind**

Clyde's opponent will counter with:

Vote
JOHN DOUGH
for ASCIT DOORMAT
modest

It's a safe bet that Clyde will lose votes. This doesn't necessarily mean that John will *gain* votes, but he's really not expecting to. Generally speaking, votes are lost, not won, and the race goes to the one who started with most and lost least.

Here is another example of poor votesmanship: a hypothetical inexperienced candidate meeting a not-at-all hypothetical Caltech phenomenon, the analytic voter.

> Analytic Voter: Why are you *really* running for ASCIT Ground Hog Day Chairman?
>
> Inexperienced Candidate: I — uh — well, that is—because I want to serve the Student Body as best I can.
>
> Analytic Voter: Ha! (He walks away unconvinced, with a smile on his face.)

Here's how an experienced candidate handles the same question:

> Experienced Candidate (in loud, confident voice) : I'm power mad, old chap. Napoleon complex. Runs in the family, you know.

The analytic voter is trapped. He's met the type of person he most admires—warped as they come, but straightforward about it.

Speeches are made in the various student houses. They're on about the same level as the newspaper articles, but a little harder to avoid. The best part of the campaign is saved for the last night before elections, the night of the Election Rally (or, as it is often called because of the intellectual stimulation it provides, the Erudition Rally.) Here the young Disraelis present short skits, illustrating the pressing socio-philosophic problems of this and other times. The weighty intellectual atmosphere is interrupted only for the serving of tea and for brief periods of modern interpretive dancing.

A few hours of voting, and it's all over. The newly elected officers are usually shocked to find that their jobs involve doing things, as well as talking. Some of them never recover from the shock.

—*Brad Efron* '60

Personals

1921

Allin Catlin, Jr., senior engineer with the Pacific Telephone and Telegraph Company, died of a heart attack on July 6. He had worked for the telephone company for 36 years. From 1937 to 1939, he was a member of the board of directors of the Caltech Alumni Association. He is survived by his widow; a son, John, who lives in Burbank; a daughter, Jean Kennedy, of Youngstown, Ohio; and eight grandchildren.

1922

Edmund T. Groat, coordinator of mining sales for the General Electric Company in Chicago, writes that "last July I was trapped into going back onto the school board to fill an unexpired term to April '58. The superintendent of schools took a bigger job so I've been through superintendent-hiring for the third time—and now more building and another referendum coming up. I also work for a *living*."

1925

Tracy L. Atherton, who is coordinator of mapping and surveying for California's Department of Water Resources, returns this month from a leave of absence as a consultant for the Khuzistan Development Service in Iran.

1928

Ralph W. Cutler, MS '29, has been named manager of engineering of the Kaiser Steel Corporation in Montebello.

1930

Emory L. Ellis, MS '32, PhD '34, writes that he's moved to Washington, D.C., and is now on the staff of the Institute for Defense Analysis. (President DuBridge is one of the Institute's incorporators and H. P. Robertson is a director.)

1931

Jeffrey A. Wineland, chief of the design branch, Region 2, of the Bureau of Reclamation in Sacramento, has left the bureau after working for them for 26 years. He is now supervising engineer for the design and construction of dams in the division of resources and planning of the California Department of Water Resources. Jeff still makes his home in Sacramento.

1932

Guy Waddington, PhD, director of the National Research Council's Office of Critical Tables in Washington, D.C., recently received the Southwest Regional Award for 1957 from the American Chemical Society for his research on the thermodynamic properties of hydrocarbons.

Brig. Gen. William R. Shuler, U.S. Army, received a commendation from the U.S. Senate last summer "for the outstanding manner in which he presented the Army portion of the FY 58 Military construction authorization bill to the Subcommittee on Military Construction of the Senate Armed Services Committee.

"Due to Gen. Shuler's excellent performance in his assigned duties," said the chairman of the subcommittee, "our legislative review responsibilities have been materially assisted. More than that, his frankness and capability have instilled confidence in, and reflected great honor on, the professional service which he honorably represents."

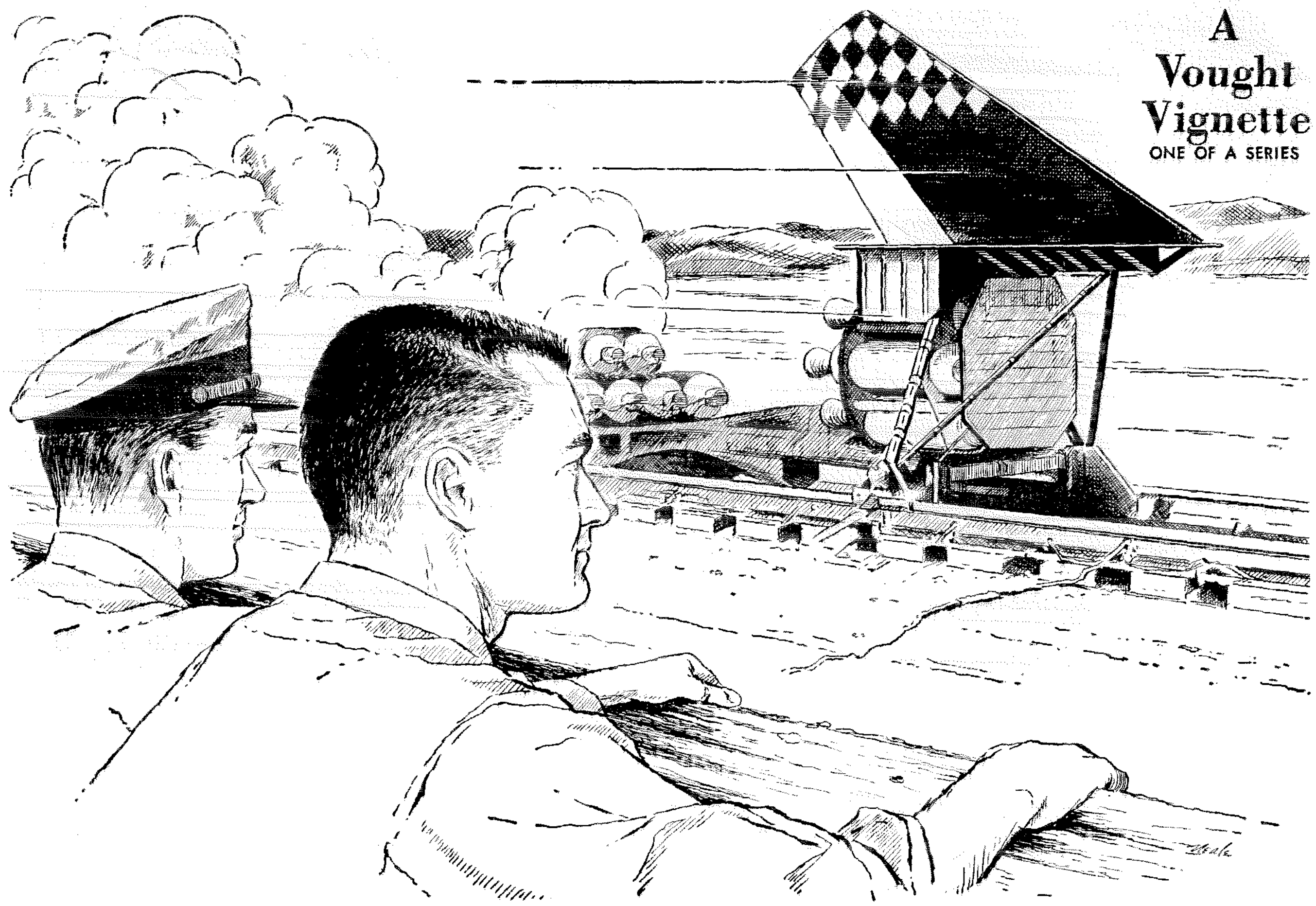
John R. Macarthur, Caltech professor emeritus, who sent a copy of the commendation to *E&S*, writes: "As freshman dean, I had Bill Shuler in my group and kept in touch with him throughout his course. After graduation he received an appointment to West Point where he was captain of the football team in his senior year—then was appointed football coach for the next year. However, World War II broke out and he was sent overseas. He was seriously hurt in the front line, flown to a hospital in England, then returned to America where, upon recovery, he was assigned to a number of increasingly important desk duties, steadily rising in rank and in importance."

Donald E. Marshall, MS, manager of power tube development engineering at the Westinghouse electronic tube division in Elmira, New York, has been elected a fellow in the American Institute of Electrical Engineers. Don received his award for "basic contribution to gas type electronic tubes and ignitron rectifiers."

1933

Robert D. Fletcher, MS '34 ME, MS 35 My, writes that "for several years I have been holding down the job of Director of Scientific Services of the Air Weather Service, USAF, in Washington, D.C. In this capacity, I am continuously running into graduates of the CIT meteorology courses of the '30's and '40's. I am also completing a two-year term as president of the American Meteorological Society, which represents our discipline's scientific and professional people, private and governmental, throughout the Americas. The awakening public and military interest in science has greatly increased the challenges inherent in both jobs.

"Last month I completed a five-week trip around the world with these highlights: a trip through the private gardens of the palace of the Emperor of Japan; participation in a ceremony commemorating the 25th anniversary of the Meteorological Society of Japan, where I received a



The structures engineer who found a fast detour

"Advise and assist on structural problems. Do what you can to keep the program moving . . ." With this outline of his liaison duties, Stress Analyst Ed Clay accompanied Vought's Regulus II missile to its desert test site.

On the desert, Ed found a dearth of structural problems. Regulus II reliability gave the flight test program tremendous momentum. In quick succession the missile notched 10 flights. When time came for a critical high-speed test, the program was three months ahead of schedule!

Then, the very fact that things had moved so fast threatened to rob the program of the time it had gained.

As Vought had planned, a wind tunnel flutter test had to precede the upcoming high-speed flight. But Vought's prearranged date at a government tunnel was over a month away. The facility was booked solidly up to the appointed day. And Vought's own Mach 5 tunnel was under construction.

Then Ed revealed the scope of his liaison. It had ranged to the rocket test track at nearby Edwards Air Force Base. There, with the help of a cooperative track project engineer, Ed had spotted a rusting rocket sled, left behind from a radome test. Now, if the sled could be rigged to carry that spare Regulus fin, Ed figured, they might get flutter data before the tunnel test.

That changed Ed's state of liaison. All Vought was suddenly at *his* service. Shopmen reworked the sled to mount the fin. Instrumentation technicians fitted the fin with gages and transducers. Vought's top flutter men double-checked, raised their eyebrows, then endorsed the whole thing.

At the track, moments before the rockets exploded, Ed had a twinge of doubt. His sled was a monster, indeed. Air loads would be terrific . . .

Then the sled shot off on the first of two successful trips that revealed all the data required.

At Chance Vought, there's liaison in spirit as well as in name. It allies engineers of many specialties and viewpoints against mutual problems. It builds channels instead of walls between diverse technical areas. It's another reason why top engineers are choosing Vought — *to keep abreast of all fields while advancing in one.*

CHANCE VOUGHT AIRCRAFT
INCORPORATED · DALLAS, TEXAS

Personals . . . *continued*

beautiful bouquet of flowers from the even more beautiful Miss Kyoko Otami, Japan's Miss Universe of 1957; and participation, as a National Academy of Sciences delegate, in the 9th Pacific Science Congress in Bangkok. Also attended a most interesting meeting last spring in Stockholm where the use of electronic computers for weather prediction was discussed.

"My son, Bob, Jr., 21, is a junior at RPI studying æronautics. Another son, John, 16, is a high school junior, studying sports cars and swing music.

"As to a few of our 'lost alumni,' *Col. Don McNeal*, MS '35, still lives, I believe, in Dayton, Ohio; *Maj. Gen. Harold H. Bassett*, MS '36, *Maj. Gen. William Stone*, MS '38, and *Col. John Feeley*, '41, can be reached through WAF Hq. in Washington, D.C.; *Col. Wilson Neal*, MS '39, is director of plans at Hq, Air Weather Service, Andrews AFB in Washington, D.C., and *Col. Delmar Crowson*, MS '41, is in the Pentagon (USAF)."

1934

Ernest R. Howard, MS '35, is now working with the Truflex thermostat metals sales and engineering staff of the general plate division of the Metals and Controls Corporation in Attleboro, R.I.

1935

Donald N. Chamberlain, formerly vice president in charge of sales at the Southern Pipe & Casing Company in Azusa, is now executive vice president of the company.

1936

Arthur L. Bishop is now assistant superintendent of The Texas Company's Puget Sound refinery, under construction at March's Point, Washington. He was formerly area supervisor at Texaco's Los Angeles refinery.

Hugo Meneghelli writes from Akron, Ohio: "After I accepted a job as manager of the tire construction development department of the tire development division of General Tire and Rubber Company, my wife and I celebrated by spending a week in Mexico City . . . The move to Akron has been an uprooting experience for our two sons, Lance and Leonard, but they are taking it very well. Lance is going to high school and Lennie is in parochial school."

1938

Delbert Van Ornum, MS, writes that he has moved to Newport Beach, California, from Altadena. "The move," Del writes, "is the upshot of my work as a project director for the Giannini Research Laboratory during the past year. The lab is just south of Santa Ana, so driving from Altadena got to be a chore."

1940

Kiyo Tomiyasu, consulting engineer at the General Electric Microwave Labora-

tory in Palo Alto, California, is also editor of IRE's *Transactions on Microwave Theory and Techniques.* One of the members of his editorial board is *Perry H. Vartanian, Jr.* '53.

1941

Joseph W. Lewis, manager of Arnold O. Beckman, Inc., in South Pasadena, has been appointed assistant to the president of Beckman Instruments, Inc.

1944

James M. Ploeser died of cancer on November 18 in a San Jose hospital. He was 36.

A research biochemist at the Stanford Medical School, Jim had lived in Saratoga for the past 3 years. He is survived by his wife and three children—Christine, Monica and Stephen.

During World War II, Jim did penicillin research at Cornell University. He received his PhD degree in biochemistry at Stanford University in 1948. From 1948 to 1954 he was a senior lecturer at the University of Otago at Dunedin, New Zealand, on a Fulbright Fellowship.

Clifford I. Cummings, division chief of systems engineering at Caltech's Jet Propulsion Laboratory, is now at the Pentagon for a year of temporary duty as a member of the Institute for Defense Analysis.

Eberhardt Rechtin, PhD '50, is now chief of the guidance research division at JPL. He was formerly chief of the electronic research section and has worked at JPL since 1949.

Robert J. Parks has been promoted to the position of chief of the guidance and electronics department at JPL. He is also project director of the Sergeant, a second generation missile developed by JPL for the U.S. Army Field Forces.

Fred W. Morris has set up Electronic Engineering and Management consultant offices in Palo Alto, California. He has been active in the engineering and management consulting field for some years. His most significant assignment in the past, he writes, "was as a member of the Project Lamp Light Study staff at MIT in 1944-45. This was a special study concerning the defense of North America and was advisory directly to the Secretary of Defense."

Rev. J. Robert Nicholas is now director of the Western Town and Country Church Institute, besides taking care of three Episcopal churches in Weiser, Idaho. He writes that "the purpose of the Institute is to train men studying for the ministry in the Episcopal church in actual 'live' situations — a chance to experiment, develop and refine methods for training men most effectively for their job."

1945

Charles E. Lamar, sales engineer for the Southern Pipe & Casing Company in Azusa, has been made assistant manager of sales.

1946

Laurence O. Haupt, MS '47, is now manager of the Procter & Gamble plant in Sacramento. He had formerly been in charge of process operations. Larry has been with P&G since his graduation from CIT.

1947

Irving Michelson, MS, PhD '51, is head of the department of æronautical engineering at the Pennsylvania State University. The Michelsons have two children—Ann, 2, and Louis, 1.

Arthur J. Critchlow, is manager of the applied research department of IBM's Corporate Research Laboratory in San Jose. He has been with the company since 1952. The Critchlows and their three children live in Los Gatos.

1949

William A. Sylvies, BS '49 ME, BS '50 CE, is still working for the Idaho Department of Highways and is in charge of the development of preliminary design speci-

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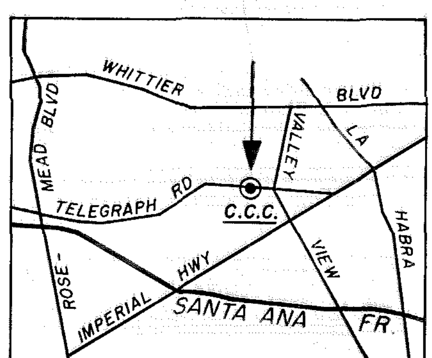

ALUMNI DINNER-DANCE

February 22, 1958

Follow the map to the Candlewood Country Club
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Cocktails at 7 — Dinner at 8 — Dancing at 9:30

Tickets $5.50

For reservations, call Caltech's Alumni Office
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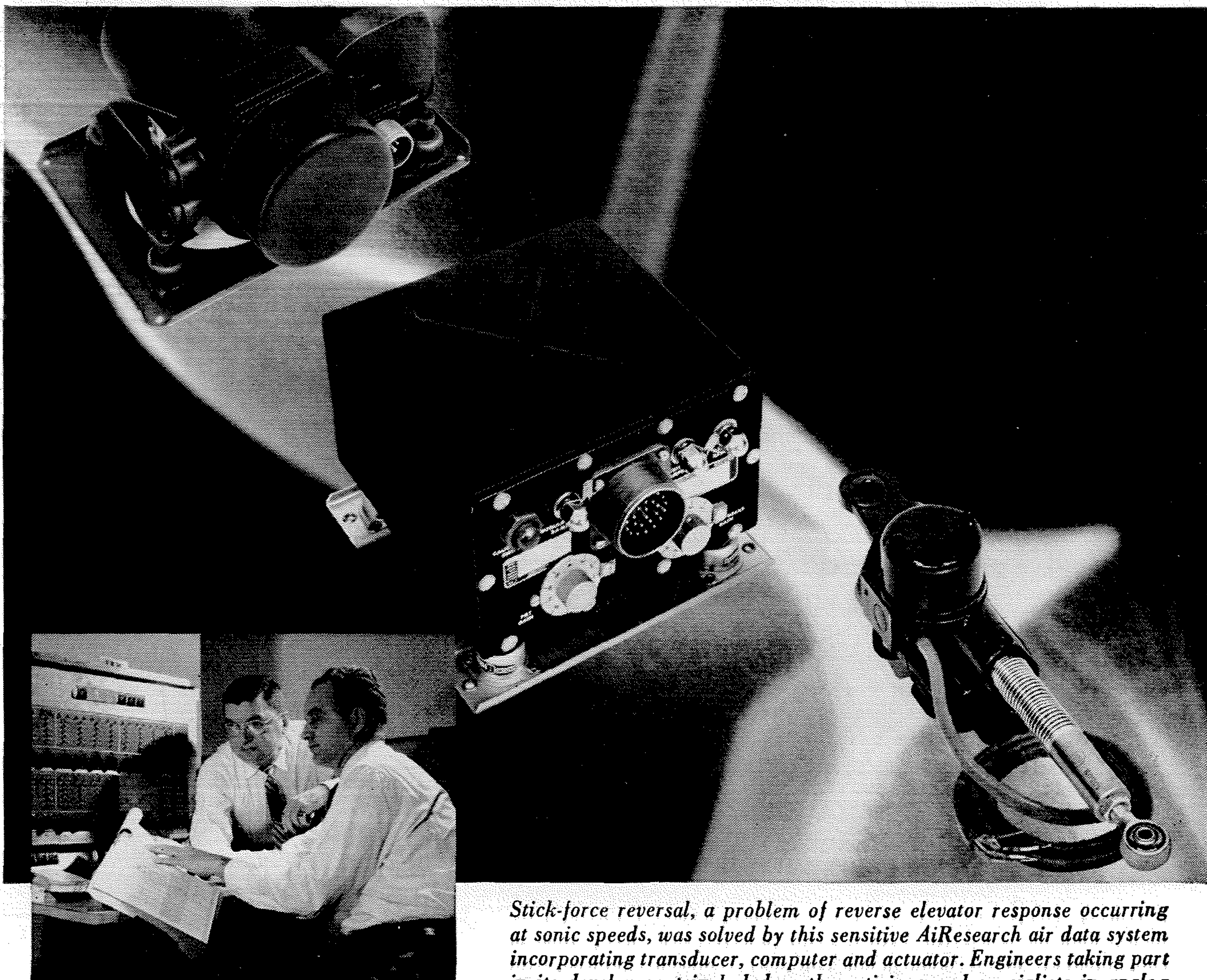

Stick-force reversal, a problem of reverse elevator response occurring at sonic speeds, was solved by this sensitive AiResearch air data system incorporating transducer, computer and actuator. Engineers taking part in its development included mathematicians and specialists in analog computation, preliminary design, fractional hp motors and gears.

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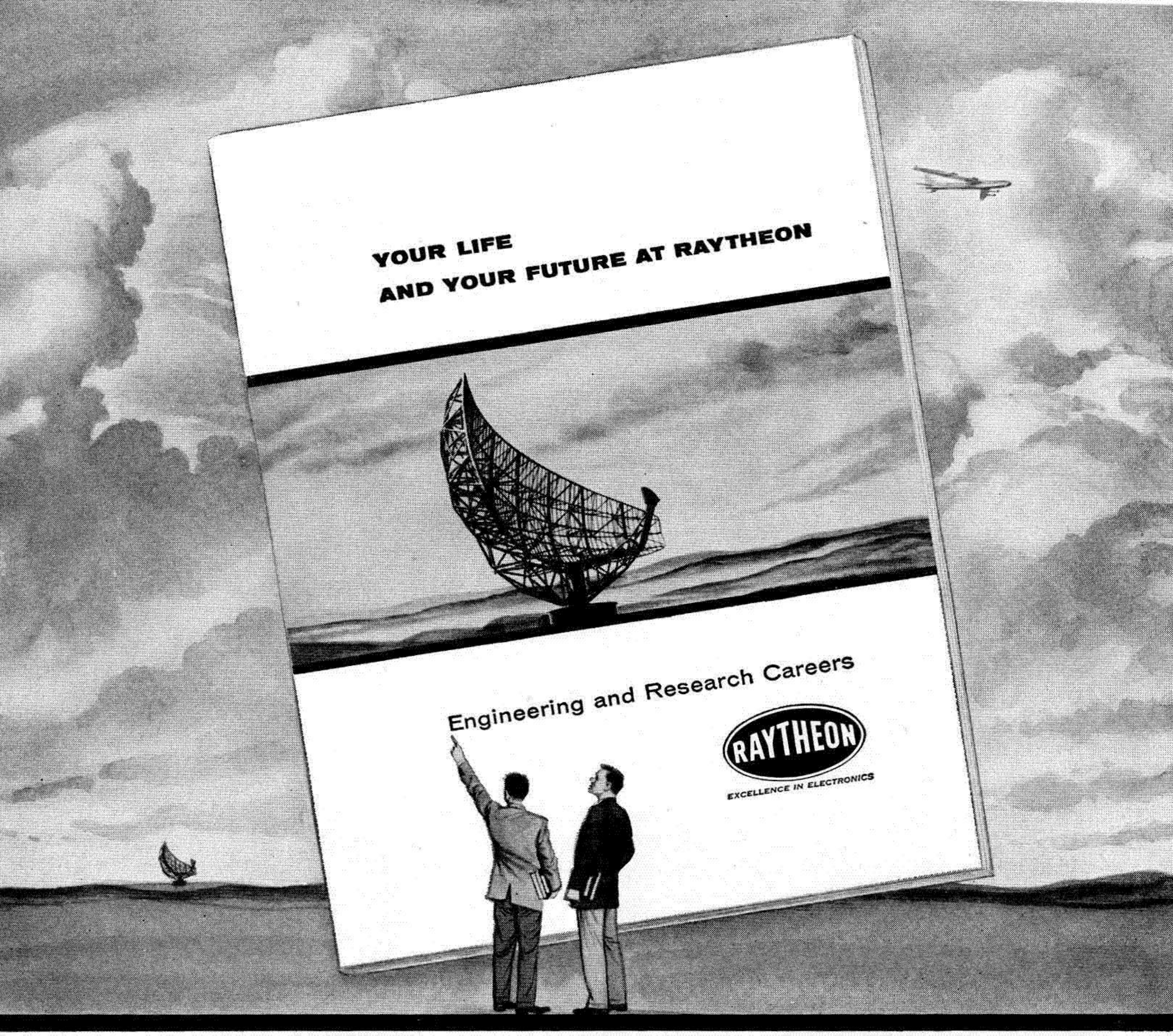
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fications for several highway projects. He received his professional license in civil engineering last year.

Dean A. Watkins, professor of electrical engineering and director of the electron tube laboratory at Stanford University, has been named president of the newly-formed Watkins-Johnson Company in Palo Alto. He will retain his position at Stanford. The new company will deal in the research, development and manufacture of electron devices. The Watkins', who live in Portola Valley, have three sons—Clark, 10, Alan, 7, and Eric, 4.

1951

Arthur Cuse writes about the complex problems in starting a small business in Mexico City in an article in the Summer, 1957, issue of the Harvard Business School *Bulletin.* Art became head of a machine tool company three years ago which was in the red; now they are making a profit for the first time. Sales have jumped 500 percent. The company, called Cia Vimalert de Mexico, is unique in that some of their best workers are deaf mutes.

John F. Kinkel, associate technical director of Northam Electronics, Inc., in Altadena, California, has been appointed vice president of the firm and elected to the board of directors. *Eugene Bollay*, MS '36, is president of Northam, which is a subsidiary of the Norris-Thermador Corporation in Los Angeles.

Thomas E. Ferington, MS, received his PhD in chemistry at Princeton University in November.

1952

J. Crawford Noll, MS '53, writes "Since I left Caltech, I have been working in the transmission systems development department at the Bell Telephone Laboratories in Murray Hill, N.J., as an electrical engineer. Although it's a far cry from mechanical engineering, I've been working on broad band coaxial cable systems, a microwave radio system and, presently, on a pulse code system for use at millimeter wave frequencies—all this since I finished the Lab's communication development training program."

1954

Simon Tammy, MS '55, writes that "my wife and I have settled down in Los Angeles again after spending the past two years in Chicago. I have taken a job with the Byron Jackson division of the Borg-Warner Corporation as supervisor of research and development. We are working on new equipment for the oil fields. It's good to be back in L.A. You really have to stay away for a while to appreciate it."

William A. Neville, PhD, assistant professor of chemistry at Grinnell College in Iowa, has been awarded two grants totaling $11,400 for support of his research in the field of organic mechanisms relating to cyclobutane carboxylic acids. A National Science Foundation grant of $9,500 is for research covering a three-year period and the remaining $1,900 is from the Research Corporation's Cottrell Fund, on a renewable annual basis. Bill joined the Grinnell faculty in 1956 after military duty at the Army's Chemical Center in Edgewood, Md.

1955

Lt. Frank C. Michel of the 512th Fighter Interceptor Squadron, is now in England flying F-86D's at Bentwaters RAF Station in Suffolk.

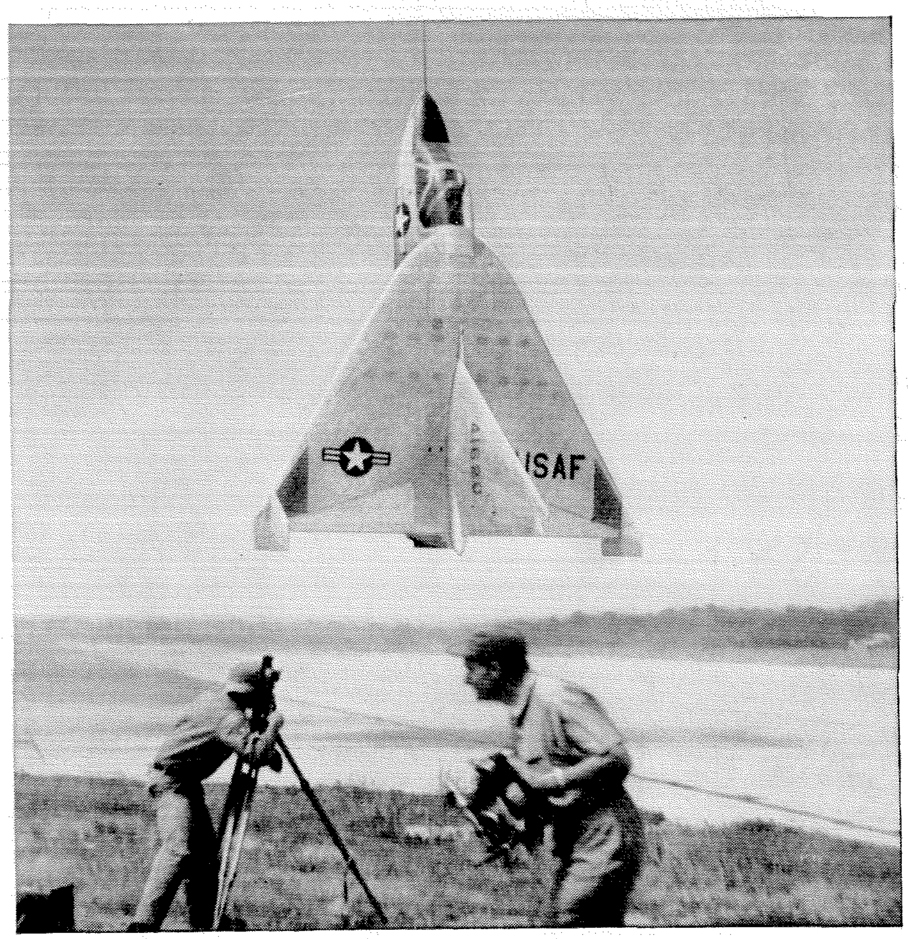
1956

Edward E. Hershberger writes that "since graduating from Stanford last June with an MS, I have become married, joined the Navy, gone through OCS, and received a commission in the CEC as an ensign. From temporary duty at Port Hueneme, California, I have been ordered to Argentia, Newfoundland, as an assistant officer-in-charge of construction."

Abe Sklar, PhD, is now assistant professor of mathematics at the Illinois Institute of Technology.

REPORT FROM RYAN

Ryan's Diversification Creates Wide Opportunity for Engineers



X-13 Vertijet Adds New Punch to Airpower

Washington—*Unveiled in an unprecedented flight at the Pentagon, the* Ryan X-13 Vertijet gave military officials a glimpse of the future of airpower. Like a huge bat, the Vertijet unhooked itself from its nose cable, hovered vertically, then whipped over into horizontal flight and roared out of sight.

World's first jet VTOL aircraft, the Vertijet combines the flashing performance of jet power with the mobility of missile launching. It frees supersonic airpower from runways and airports. Without landing gear, flaps, actuators, the X-13 concept means less weight—more performance in speed and climb.

In the words of a top Air Force General, "The Vertijet has provided military planners with a new capability for manned aircraft of the future."

Achieved in close cooperation with the Air Force and Navy, the Vertijet is based upon Ryan's unsurpassed 2¼ million manhours of research, development, and test in VTOL aircraft.

Navy, Army to Use New Ryan Navigator

San Diego—Navy aircraft—piston engine, jets and helicopters will soon be equipped with Ryan lightweight automatic navigators and ground velocity indicators. Lightest, simplest, most reliable, most compact of their type, these systems are self-contained and based on continuous-wave radar.

The navigators provide pilots with required data such as latitude, longitude, ground speed and track, drift angle, wind speed and direction, ground miles covered and course and distance to destination. Ryan is also developing guidance systems for supersonic missiles.

More Orders for Ryan Firebees

San Diego—Nearly $20 million worth of Ryan Firebee jet drone missiles have been ordered by the Air Force and Navy in 1957. In operational use, the Firebee is the nation's most realistic "enemy" target for evaluating the performance of air-to-air and ground-to-air missiles. It possesses the high speed, altitude, maneuverability and extended duration needed to simulate "enemy" intercept problems.

America's number-one jet drone, the Firebee is another example of Ryan's *skill in blending aerodynamic, jet propulsion* and electronics knowledge to meet a challenging problem... answer a vital military need.

Ryan has immediate career openings for engineers

Look to the future. Look to Ryan ... where you can grow with an aggressive, forward-looking company. You'll find a variety of stimulating projects. Ryan engages in all three elements of modern flight—airframes, engines and electronic systems.

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CALTECH CALENDAR

Alumni Events

February 22	Dinner-Dance
April 12	Annual Seminar
June 11	Annual Meeting
June 28	Annual Picnic

Athletic Schedule

SWIMMING

February 14
Santa Monica JC at Caltech

February 21
Fullerton JC at Caltech

February 28
Long Beach State at Caltech

BASKETBALL

February 14
Pomona-Claremont at Claremont

February 15
Cal Poly (Pomona) at Cal Poly

February 18
Pasadena College at Caltech

BASEBALL

February 22
Cal Poly (Pomona) at Cal Poly

February 28
UC, Riverside at Caltech

March 1
Westmont at Westmont

TENNIS

February 22
Occidental at Occidental

February 25
Cal Poly (Pomona) at Caltech

March 1
Pomona-Claremont at Caltech

Friday Evening Demonstration Lectures

LECTURE HALL
201 BRIDGE, 7:30 P.M.

February 14
Liquid Air—
by Dr. Earnest C. Watson

February 21
A Demonstration of Critical Phenomena—
By Dr. Bruce Sage

February 28
Archeological Explorations for Prehistoric Ruins in Northern Arizona
by William Miller

March 7
Vorticity—
by Dr. Donald Cole

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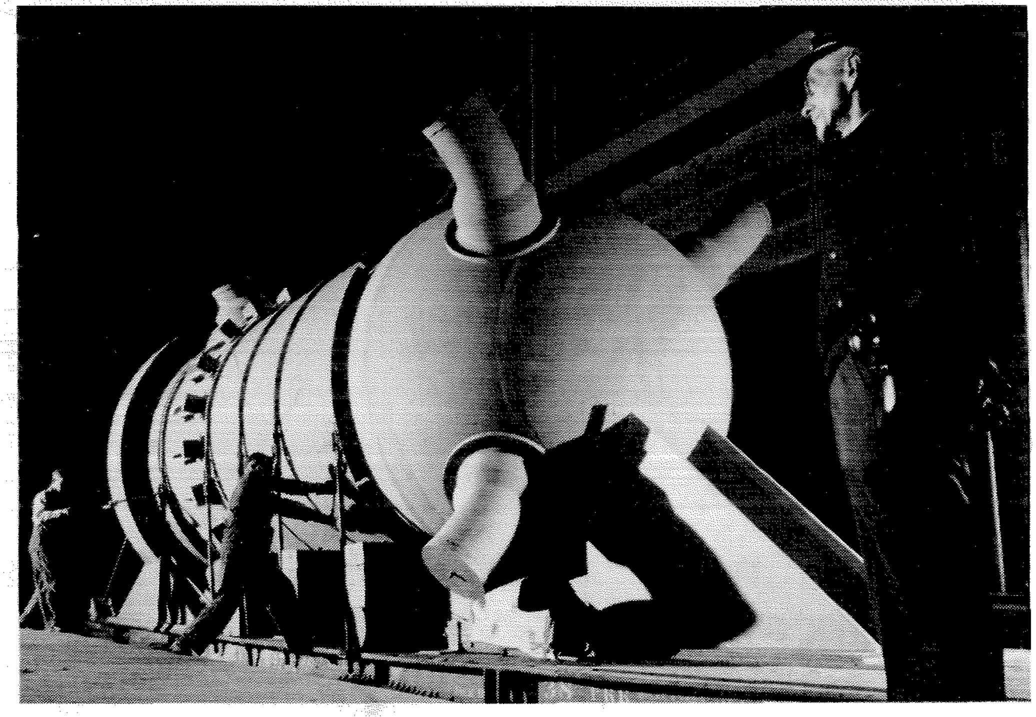
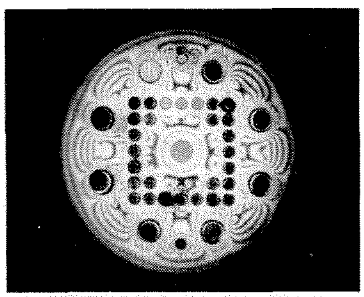
PHOTOGRAPHY AT WORK—No. 25 in a Kodak Series

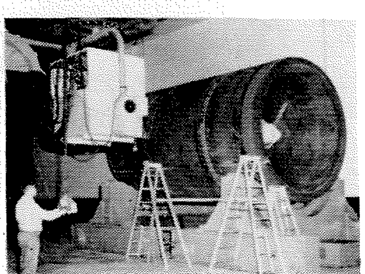


Nuclear reactor vessel for Shippingport, Pa. power plant designed by Westinghouse Electric Co. under contract with the A.E.C. for operation by Duquesne Light Company.

Where atoms turn into horsepower



Photograph showing patterns of stress concentration. It was taken of a plastic model of a reactor vessel loaded to simulate the strains a real reactor vessel would undergo.



Radiographs of the reactor vessel welds were made with a 15,000,000-volt betatron. Every bit of the special steel, every weld had to be proved sound and flawless.

Combustion Engineering designed and built this "couldn't-be-done" reactor vessel for America's first full-scale nuclear power station. And photography shared the job of testing metals, revealing stresses and proving soundness.

COUNTLESS unusual—even unique—problems faced Combustion Engineering in creating this nuclear reactor vessel. Nine feet in diameter with walls 8½ in. thick, it is 235 tons of steel that had to be flawless, seamed with welds that had to be perfect. And the inner, ultrasmooth surface was machined to dimension with tolerances that vie with those in modern aircraft engines.

As in all its construction, Combustion Engineering made use of photography all along the way. Photography saved time in the drafting rooms. It revealed where stresses and strains would be concentrated. It checked the molecular structure of the steel, showed its chemical make-up. And with gamma rays it probed for flaws in the metal, imperfections in the welds.

Any business, large or small, can use photography in many ways to save time and money. It can go to work in every department—design, research, production, personnel, sales, and accounting.

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