ENGINEERING AND SCIENCE

JANUARY / 1958

Blue Glacier Project . . . page 18

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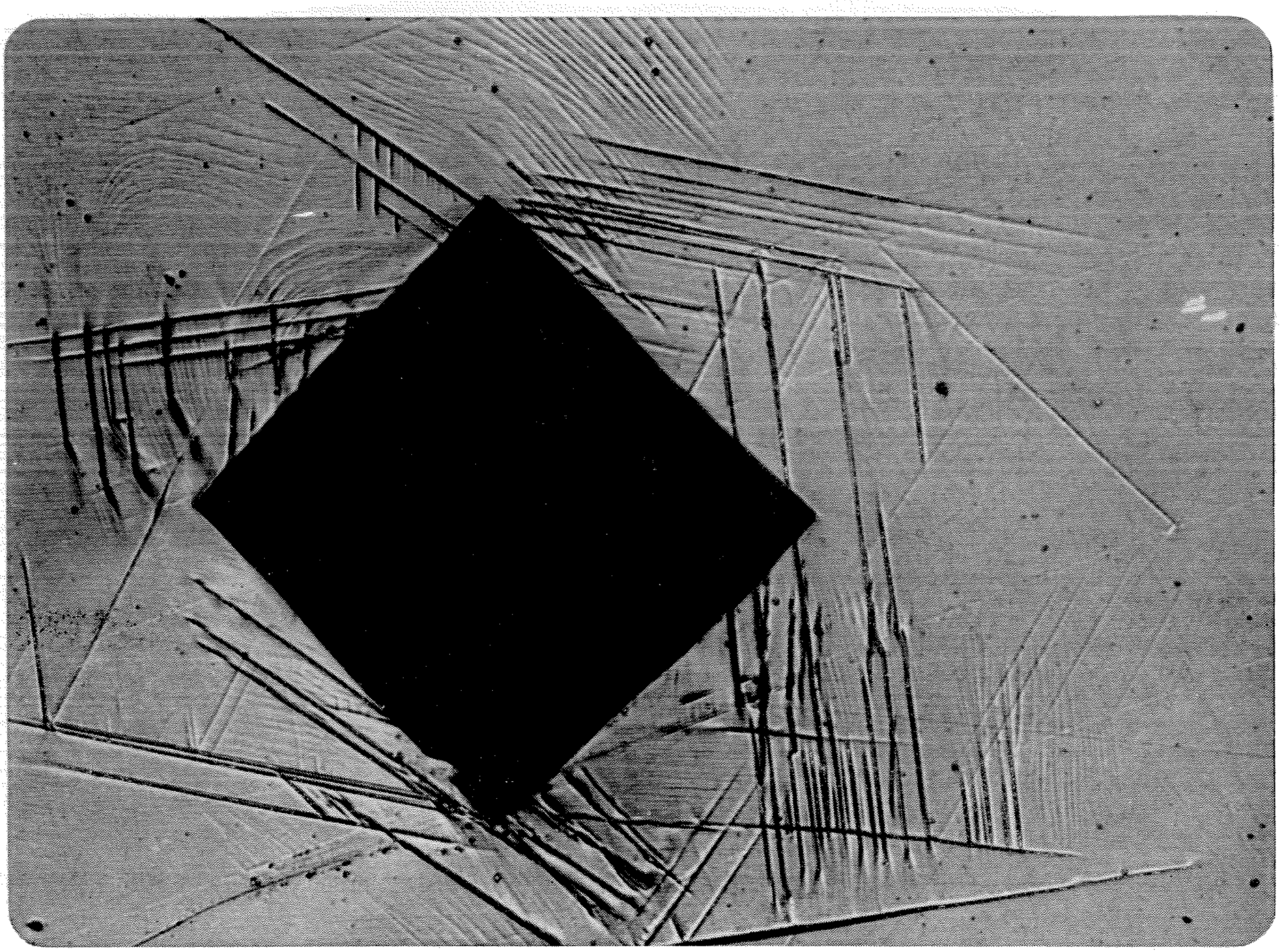

ENGINEERING AND SCIENCE

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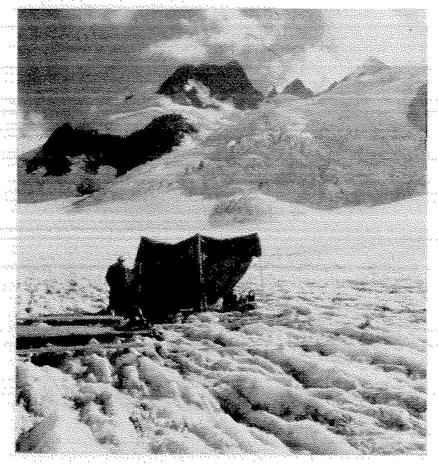

ON OUR COVER—Dr. James Savage, one of the seven Caltech geologists who set up a research project last summer on the Blue Glacier in northwestern Washington. Dr. Savage is working at the bore hole site near the middle of the glacier, where pipe is driven down through the ice to check the glacier's flow.

The Blue Glacier Project is part of the IGY program, and is under the direction of Robert P. Sharp, professor of geology and chairman of the division of geological sciences. You'll find some of his crew and some of their activities pictured on pages 18 and 19.

THEODORE M. GREENE, professor of the humanities at Scripps College, visited the Caltech campus from December 3-5 as a guest of the YMCA. An author and lecturer in the philosophy of religion, art and education, Dr. Greene spent much of his time here in discussions with students, but also gave some formal talks—like the provocative sample on page 13.

PICTURE CREDITS

Cover	Robert P. Sharp
pps. 18, 19	Robert P. Sharp
p. 22	U.S. Air Force
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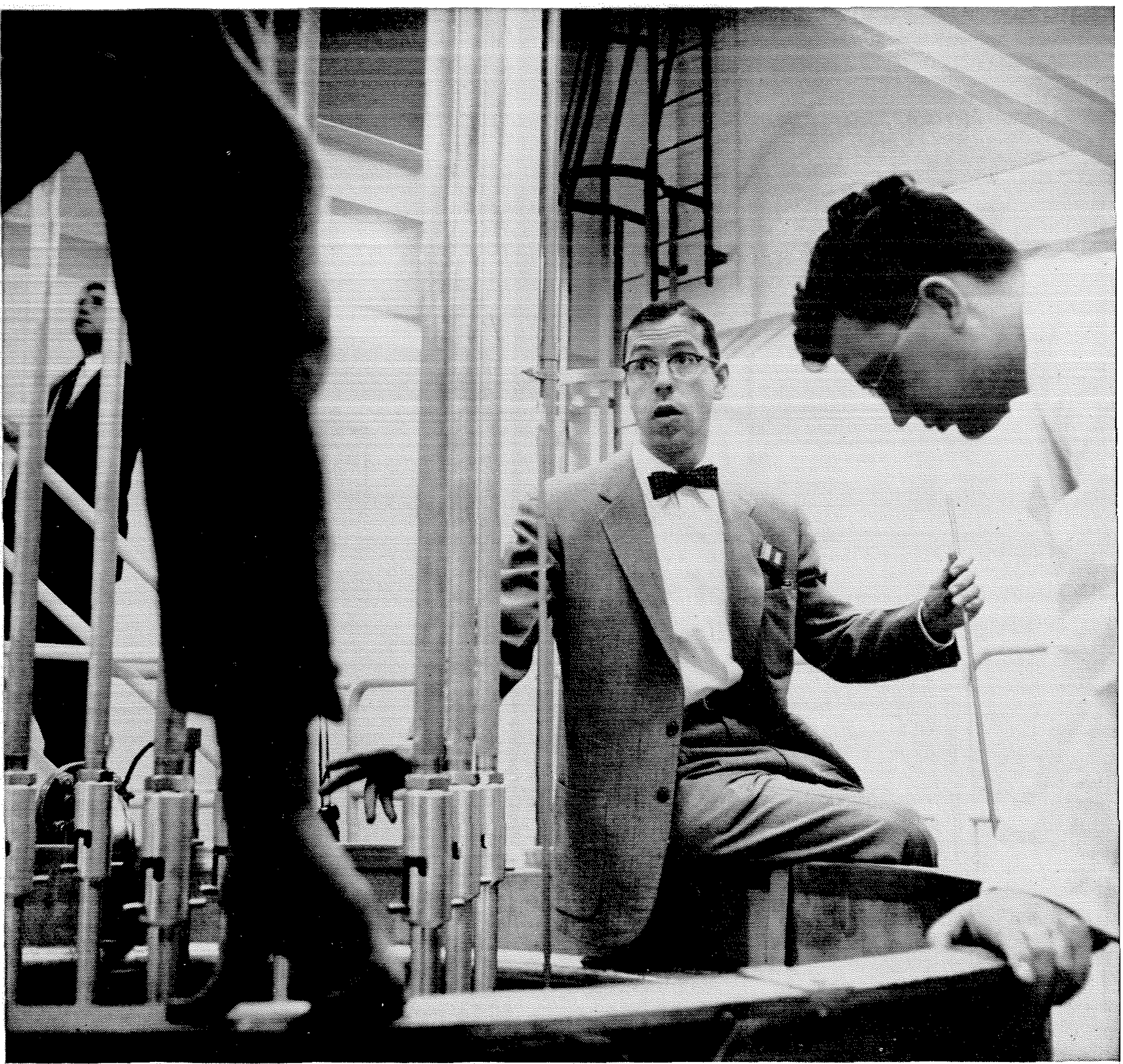
Left to right: Lou Bernardi, Notre Dame, '54; Norman Lorenson, Mich. St., '55; Ernest Schurmann, M.I.T., '53; Dick Swenson, Purdue, '50.



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.

At 30, Harvey Graves directs nuclear design of two major Westinghouse reactors

After completing the Westinghouse Student Training Course in 1951, Harvey Graves attended the Westinghouse Advanced Design Course* and was sent by Westinghouse to the Oak Ridge School of Reactor Technology for one year. Back at Westinghouse again in 1953, Engineer Graves did advanced work on nuclear reactor development.

In 1955, he was promoted to supervisory engineer on the Belgian reactor project. In 1956, he was again promoted to Manager, Westinghouse Nuclear Design Section. Today, Mr. Graves' 24-man section is developing and designing the nuclear portion of commercial reactors for the Yankee Atomic Electric Company and the Center d'Etude de l'Energie Nucléaire in Belgium.

*Fully accredited graduate school

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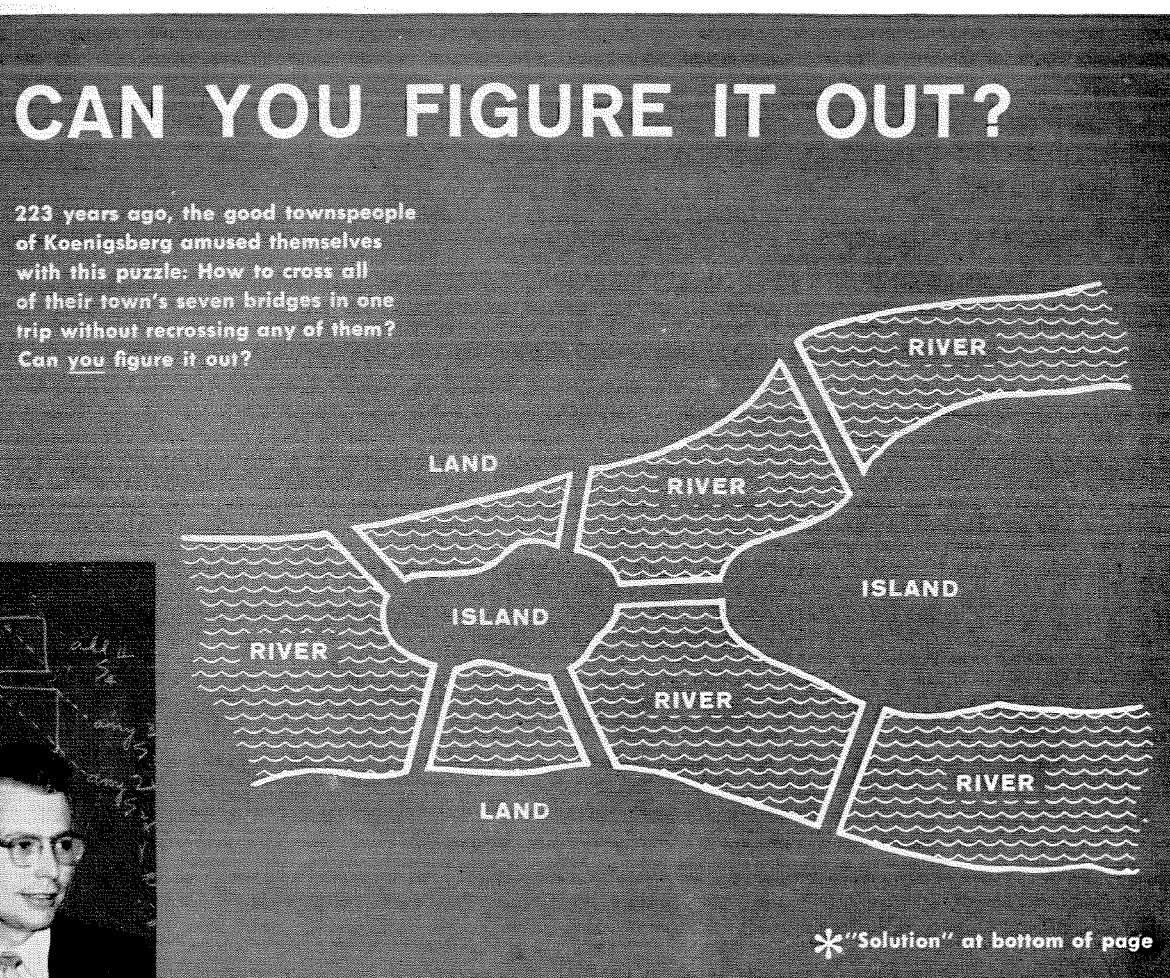
In 1956 the editors of *Scientific American* launched a series of paper-backed books with the publication of five titles—*The New Astronomy, The Physics and Chemistry of Life, First Book of Animals, Automatic Control* and *Atomic Power*. The books were made up of articles from the magazine, re-edited and grouped together to form reasonably comprehensive reports on specific fields of research. These first books were so well-received that the editors have now come up with five new titles.

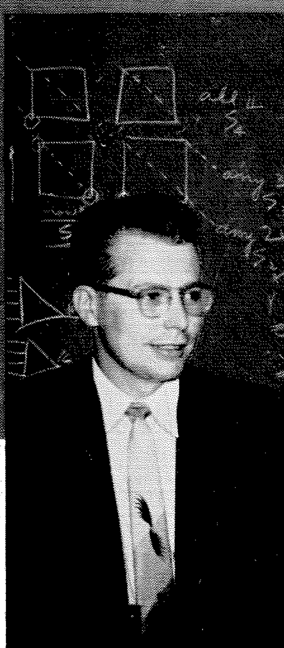
The new books cover cosmology *(The Universe)*, geophysics *(The Planet Earth)*, research with plants *(Plant Life)*, new developments in the field of chemistry *(New Chemistry)*, and a collection of biographies of scientists *(Lives in Science)*.

The articles in the new books are as clear and comprehensive as those in the original set, and the subjects covered this time should prove even more interesting to the general reader. The list of authors reads like the roster of *American Men of Science*, and Caltech is well represented in two of the volumes.

Plant Life includes articles by Frits Went, professor of plant physiology; James Bonner, professor of biology; and Frank Salisbury, who got his PhD at Caltech in 1956—and started his science-writing career in the same year by winning the *Engineering and Science* writing contest.

The Universe includes a collection of spectacular Palomar photographs; articles by H. P. Robertson, professor of theoretical physics; William A. Fowler, professor of physics; Fred Hoyle, visiting professor of astronomy; and Walter Baade, Rudolph Minkowski, and Allan Sandage, staff members of the Mount Wilson and Palomar Observatories.





Robert G. Hildenbrandt tells what it's like to be . . . and why he likes being . . . an Electronic Circuit Designer with IBM.

FIGURING OUT A CAREER?

Selecting a career can be puzzling, too. Sometimes, as with the seven bridges, the answers aren't always available. In engineering and research, it's just as important to discover that no solution may be possible as to find the solution. It is equally true in career selection that some companies can provide solutions . . . opportunities for growth . . . not always available in all companies. Here's how Bob Hildenbrandt *found* the solution to his career problem—at IBM: "Since joining IBM," Bob says, "I've seen some amazing developments in advanced circuitry. In my opinion, transistorized digital airborne computers represent one of the most progressive assignments in electronics today. As we enter the missile age, the technology of packaging and miniaturization will take on increasing importance. Transistorized computers offer an excellent chance for development work in computer circuits . . . high-frequency power supplies . . . magnetic amplifiers, regulators, storage devices. Challenge? It's tremendous—for we're working not only on present systems, but those of the future!"

* * * *

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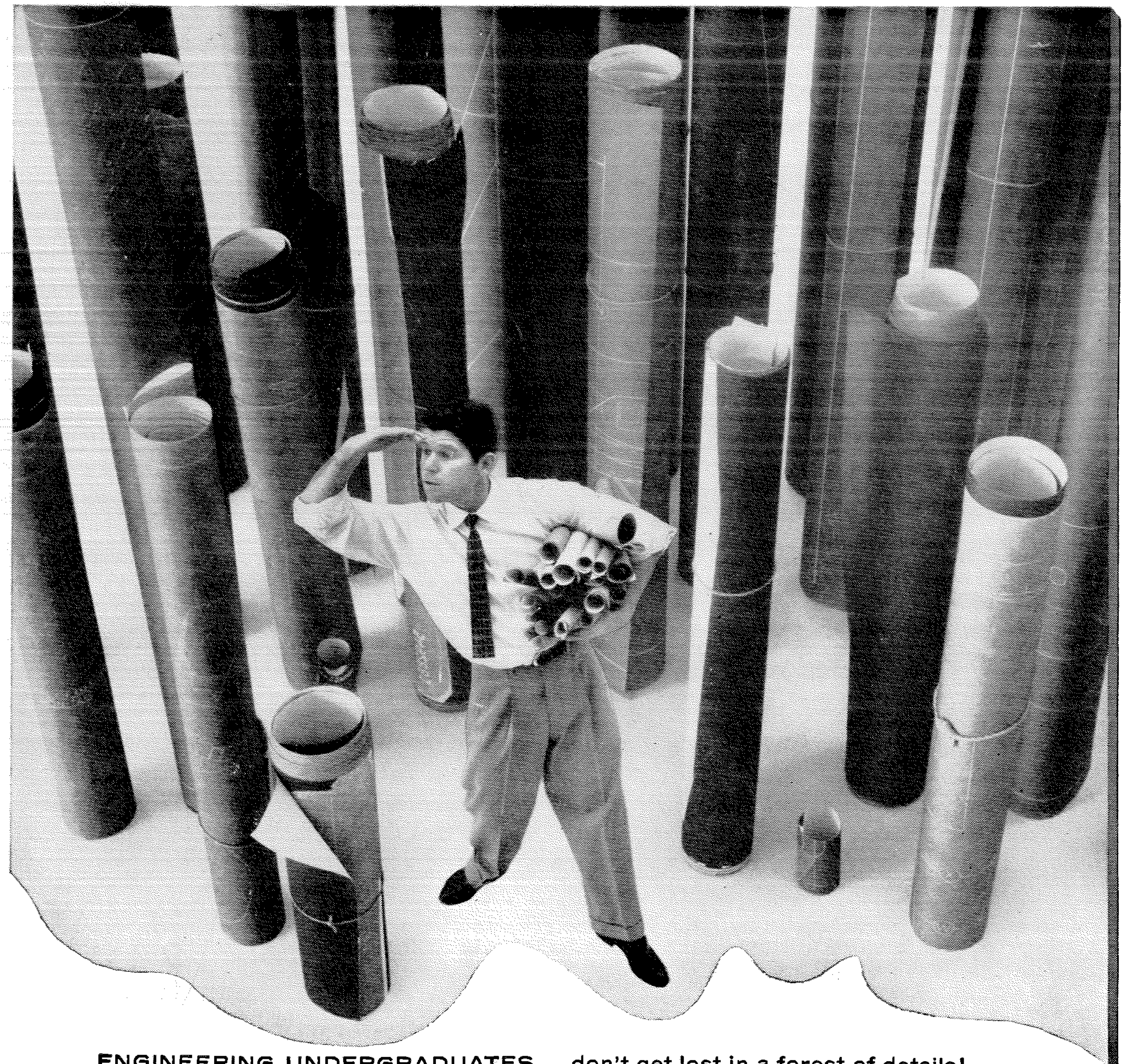

Major Philosophical Issues of the Modern Age

A consideration of some of the things that trouble us most in our most thoughtful moments today

by Theodore M. Greene

THE THINGS THAT TROUBLE US most in our most thoughtful moments today tend to relate themselves to each other; they have a common core and a common base; they are facets of a deep central concern. What is this concern? My answer may puzzle you. I think it is the problem of human existence.

Your immediate response may be, "For heaven's sake, what do you mean by the *problem* of human existence? We exist while we live, and when we die we cease to exist. Where is the problem?" You might go on, in criticism of my suggestion, by saying that, in one sense, man has always worried about how to stay alive, and that therefore our desire to stay alive is perennial, not new.

We today, in this fortunate land of ours, are indeed acutely aware of the danger of modern technology—that is, of possible wholesale annihilation. This is one contemporary problem of survival, but this is not the problem I have in mind when I speak of the problem of human existence.

Men have not always only wished to survive—to keep alive; they have tried to live well, to have as many of the good things of life as possible. We today, in this country, are also interested in the good life—the physical comfort, sensuous satisfaction, æsthetic delight, athletic excitement, sex, food, the satisfaction of intellectual curiosity—in short, everything that might be included under the large rubric of "culture." We too concern ourselves about political questions and prize our freedoms. We too discuss our economic problems and prize our high standard of living. We too cultivate our enjoyments. But the problem of how to attain these values is the cultural problem of human welfare rather than the more basic problem which I have labelled the "problem of existence."

If this problem of existence is not the problem of survival and not the problem of welfare, what is it? We are today asking ourselves with unusual anxiety questions that undercut these questions of survival and welfare. In our more thoughtful moments we tend to

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"Major Philosophical Issues of the Modern Age" has been adapted from a talk given by Dr. Greene at Caltech on December 3, 1957. Dr. Greene is professor of humanities at Scripps College.

"We don't know how to figure out the wherefore and why of human life, though we are learning more and more about the what of human life."

ask ourselves not merely, "How can I survive?" but "*Why* should I survive at all?" We ask ourselves not, "How can I get this, that or the other value?" but (in our more thoughtful and anxious moments), "What real value do these values which my society and I value really have? Aren't these all pipe dreams? Are not all our Western values merely subjectively or socially conditioned prejudices to which we are all prone but which, when we really come to examine them, won't stand examination?"

You remember the famous lines from *Hamlet:* "To be, or not to be: that is the question . . . To die, to sleep: No more; and by a sleep to say we end the heartache . . . 'Tis a consummation devoutly to be wished."

Here the Prince of Denmark, able, young, and in good health, is so bedeviled by his problems that, for the time being at least, he can't face life. "How weary, stale, flat and unprofitable," he cries, "seem to me all the uses of this world." You will also recall his eloquent expression of the logical outcome of what we today call naturalistic reductionism: "What is a man, if his chief good and market of his time be but to sleep and feed? A beast, no more."

All of you will have heard, and some of you may seriously have defended the proposition that, when you get right down to it, man is nothing but a very complicated kind of animal. It was this reductionism that led Shakespeare to declare that life, so conceived, is "full of sound and fury, signifying nothing."

Shakespeare was prophetic in the lines which I have just quoted. Life itself has become a problem for us, or, to put it somewhat differently, we have become a problem to ourselves. We don't understand ourselves; we don't know how to figure out the wherefore and why of human life, though we are learning more and more about the *what* of human life. This bafflement gives rise (usually inarticulately) to our sense of deep anxiety, frustration and anguish. It is this, I submit, that constitutes the central, cultural, spiritual problem of our time.

I think I can anticipate your immediate reaction. "What a fantastic thing to say! Wouldn't you expect that from a philosopher! Isn't this just a case of abnormal misanthropy issuing from an unhealthy brooding of a neurotic soul?"

You may be right, but you must admit that I am one of very many who feel this way today. Most of the sensitive poets, novelists, artists, theologians and philosophers of our time are distraught by this anxiety.

It may seem to you to be very strange that I should talk this way—of all places, in America, whose culture is the most prosperous the world has ever known, and here at Caltech, located in the most prosperous city in the most prosperous part of the most prosperous state of the Union. Isn't "America" practically synonymous with prosperity, power, scientific and technological advance and political freedom? Have men ever had it as good as we have it? Aren't we all healthy, successful and happy? True, we have a few minor problems such as the possibility of wholesale annihilation and an indefinite armament race, mounting racial tension and widespread international unrest. Still, need we healthy, optimistic Americans, supporting our local Optimists Clubs, worry our heads over these transient problems? Surely, we have what it takes!

That is a question. *Do* we have what it takes? What does "it" refer to? What have we got to face?

This at least is clear—that we cannot merely live our own lives, individually; or merely in small self-sufficient groups; or even in larger self-contained groups. What we have to face is *life* in our total, social, global, natural, cosmic environment. Our human nature is what it is; and we are living in an actual total universe, whatever its nature may be. These two factors constitute our problem and we are slapped down *hard* whenever we make a mistake in assessing ourselves and our universe. We are also duly rewarded when we assess ourselves and our universe wisely and when we act accordingly.

What then does reality, subjective and objective, demand of us? What does "life" demand of us? What will life slap us down for if we don't rise to its challenge?

Our answer to this question will depend upon three variables. We have different objectives, and our answer will depend in part upon our objectives—what we expect of life. It will depend in part upon our view of the universe of which we are a part. And it will depend in part upon our own estimate of ourselves as human beings. As we know, when we have three variables to manipulate we can get a large number of combinations.

Let me give you one or two examples. Suppose we are old-fashioned enough to expound, in 1957, a strictly mechanistic view of reality and man. This view has now become largely outmoded, but it is still held in some quarters. It implies a kind of fatalism which asserts that thought—taking thought—makes no difference. If you really accept this view it will dictate a distinctive answer to the question, "What does it take?"—namely, that everything we do and are is wholly and rigidly determined by our heredity and environment and that we, as moral agents, have no real responsibility for our actions.

Suppose, alternatively, that we do not accept this mechanistic determinism. Suppose that we believe that, somehow, taking thought *does* make a difference, that it is possible to select and work for meaningful goals and that man as a moral agent can and should seek such goals. This belief will force us to conclude that despite all hereditary and environmental influences we are somehow genuinely free and responsible as human beings.

A perennial unsolved problem

What then do we mean by "freedom" and "responsibility"? This is one of the perennial unsolved problems which thoughtful, morally sensitive people have tried to solve for centuries. I *feel* free; I act *as though* I were were free; I treat other people *as though* they were free—and yet, when I try to answer the question, "How, precisely, is such a thing possible?" I feel that it is very hard to find a satisfactory answer. This is the puzzled state of mind in which many thoughtful people find themselves today, and their bewilderment is often a source of acute anxiety.

Or again, if we believe that taking thought does make a difference, we can presumably deliberate upon, and select, the objectives or values which we shall strive to realize. This implies that some goals or values are superior to others. And this, in turn, implies that values are in some meaningful sense "objective" and "real"; that we can more or less adequately apprehend them; and that it is important to try to discover and actualize them.

Yet, in philosophy as well as in the social sciences, the prevalent tendency in recent years has been to *reduce* all values to the status of *mere* socially, culturally and individually conditioned prejudices. Men have tended to deny that there are such things as objective values in any significant sense, and therefore to deny the very possibility of authentic value insights. They have the possibility of real scientific insight, but the claim that moral, aesthetic and religious insights are also possible has been widely challenged and often repudiated.

I. A. Richards, the distinguished British student of literature and language at Harvard, has for years been preaching this doctrine. Values, he has insisted, *merely* reflect man's subjective, socially conditioned, irrational prejudices which, in turn, can be expressed *only* in emotive utterance. We merely prefer this or that to something else, and there is in principle no way of deciding whether *any* human preference is right or wrong. Nothing is in itself good or bad, beautiful or ugly. This is the position of normative nihilism; there *are* no objective values; all we have are irrational, indefensible, subjective and social preferences or evaluations.

Some years ago, while I was still at Princeton, Bertrand Russell visited us and gave us one of his characteristically brilliant and witty lectures, followed by a discussion. During this discussion we said to him, "Mr. Russell, do you believe in democracy?"

"Why, of course, I do."

"Do you really believe that democracy is valuable?"

"Well, I like it. I prefer it."

"Do you think that democracy is superior to communism?"

"What do you mean by 'superior'?"

"Do you mean that your preference for democracy is purely an irrational preference?"

"Why, of course."

"Then why do you go around lecturing and writing in defense of democracy?"

"Because I prefer to have other people share my prejudices."

"Then you are not arguing in defense of democracy?"

"Of course not. It is impossible to argue rationally in support of any value."

"Then you are merely indulging in emotive utterance?"

"Why, of course."

"But suppose somebody else emotes louder and more effectively than you do—then what?"

"All you can do is to try to hit them over the head before they hit you."

A symptomatic man

What impresses me in all this is the extraordinary disparity between Bertrand Russell's philosophy and his actual behavior. He has lived and suffered, worked and fought for values all his life; yet, as a philosopher, he has developed a philosophy that makes all values, including his own, utterly nonsensical. What sense is there in that kind of philosophy? Yet, if I were a sociologist, I would write a chapter on Bertrand Russell as a man who is very symptomatic of our age. He has expressed very eloquently the corrosive doubt, so widespread today, in the reality or objectivity of all the values our Western culture has developed and cherished for centuries.

Let us push this analysis one step further. Suppose I were to say to you that I had quite an experience crossing your campus just now—that I heard a noise in the bushes, and, on investigation, discovered a couple of Caltech boys beating a small child to death with obvious satisfaction. Why would we be profoundly shocked by such an occurrence?—because we still believe that all life is precious, and that human life has an intrinsic value and dignity. This belief has come to us from our Western culture, partly from the ancient Greeks, but chiefly from our Hebraic-Christian tradition.

The characteristically religious way in which this belief has been expressed has been that all men are beings of intrinsic worth because they are children of God. Since the Renaissance, God has become increasingly incredible, nebulous and unimportant; but we have continued to assert the humane conclusion while discarding the theological premise. We still like to think of ourselves as brothers, one to another, and we still try to respect one another even in the absence of a beneficent Father.

Yet, how deeply rooted in our culture and in our hearts today is this conviction that each of us is a being of infinite intrinsic value? Can we really believe that, in a hostile or a neutral universe, man is allowed to exist, with intrinsic value, to flourish on this earth until he is permanently snuffed out? If so, is this not a belief in the miraculous emergence of human value out of a valueless cosmos? What could be more fantastic than that man should have real intrinsic value in a universe that knows nothing whatsoever of value!

A basis for anxiety

When I stated my theme at the beginning of this talk it may well have sounded very implausible. Yet, when we raise these specific questions regarding freedom and responsibility, value and human dignity in our universe, our anxiety regarding the ultimate meaning and value of existence appears to be not unfounded. In our thoughtful moments we are profoundly puzzled and uncertain regarding our freedom and our human value; we are also increasingly persuaded that our universe itself is meaningless and valueless. How long can doubts of this magnitude persist without driving us to the desperate conclusion that all human life is ultimately absurd, as Sartre believes; or even obscene, as Celine insists?

I repeat: Our greatest cultural problem today is expressed in the question, "What, in the light of our dominant beliefs and disbeliefs, can we make of our lives?" This is the main concern of many of our leading writers—men like Kafka in his novels *The Trial* and *The Castle;* or Camus, who recently received the Nobel prize; or Celine; or Sartre, who feels that the harder you look at life honestly, the more you are filled with nausea—the title of one of his novels; or O'Neill, who strove mightily to find some answer to the enigma of life and died without having found it; or Faulkner, who comes pretty close to saying, in his most optimistic moments, "They endure"—referring chiefly to ignorant religiously-benighted negroes.

We find the same concern expressed, in one way or another, in modern music and painting and in much current philosophy and theology. This, I submit, is the central problem of our age; I do not believe that only a few "intellectuals," eggheads or æsthetic freaks feel this way.

I have been teaching for some 35 years and have been in close touch with undergraduates all that time. The change in the climate of opinion among thoughtful undergraduates during this 35-year period is very marked. Many thoughtful undergraduates today echo this same anxiety or distress. So does the thoughtful businessman or member of one of our leading professions. It is more eloquently true of juvenile delinquents and of the increasing number of psychiatric patients who are pouring into our mental hospitals. True, we Americans are prosperous, comfortable, and apparently happy—but we don't have much zest for life. We are too puzzled about ourselves and our human destiny to enjoy a sense of real assurance and peace.

If I am right in my cultural diagnosis, this deep and pervasive anxiety gives rise, in turn, to widespread secondary symptoms. Contemporary superstitions are a case in point. The Los Angeles *Times* runs a column on astrology every day, and many businessmen, I am told, will not sign a crucial contract without consulting their astrologer.

This same basic anxiety reflects itself, very differently, in our vaccilating foreign policy and in our attitude toward suffering humanity in other lands. We loudly proclaim our respect for all human life and welfare, yet we spend millions of dollars storing our surplus food while millions of people in India and elsewhere are literally starving to death. This goes on year after year, yet we Americans are only mildly uneasy. If we can have really deep moral convictions regarding the basic values we talk about, would we allow this to happen?

Racial tensions

Or again, what underlies our current racial tensions? Why is it that so many white Christians in predominantly negro communities find it almost impossible to take a strong stand for desegregation? Are we not pusillanimous because we have lost our deep basic convictions in this area of moral and social justice?

Or, as a final illustration of our cultural malaise, we love to talk about the importance of education, and liberal education, in our democracy. Yet, as a matter of fact, we are spending far more money on liquor and tobacco and gadgets than we are on education. Education in science is likely to receive more support during the next few years, but what likelihood is there that liberal education, and particularly education in basic human values, will receive the corresponding support which is so desperately needed?

Can there be any serious question that our greatest need today is normative, is the field of values and goals? You scientists have made us supreme in science and technology; thanks to you we still lead the world in this important area. But do we lead the world in significant democracy? How strong is our respect for human life, our passion for moral decency and justice? This is the question mankind is asking, and we betray our grave doubts and deep anxieties regarding the problem of existence by our uncertain and ambiguous answer.

You will note that I have not offered any solution to this problem. I did not promise to do so, but I should at least indicate the direction in which I think we must look and strive to cure ourselves of these ills. I'll have to state my case very briefly, at the risk of sounding dogmatic.

I would start with the major premise that no man has ever solved his problems by withdrawing from life, and that no community has ever achieved or maintained its cultural vitality by adopting an escapist attitude. We are essentially dependent upon one another; we are all subject to the same cosmic laws, physical and spiritual. Unless we learn how to live with our fellow men and our universe, we are bound to warp our own private lives and impair our corporate welfare.

Healthy relationships

I am also deeply impressed by the truth of the Biblical insistence that "He that would save his soul will lose it." The answer to the problem of existence is not individual or collective egoism. The answer must be sought in the direction of re-establishing a more healthy relation with our fellow men, with the world of nature, and with whatever ultimate mysterious forces may be operative in our universe.

In the Middle Ages, at their cultural best, it was generally assumed that there was a God of righteousness and love, that this God was more or less knowable, and that man could therefore significantly relate himself to God. Authentic, honest reverence for the Diety was still possible, though there were, of course, a great many people who fell short of such reverence. It was therefore much easier for men to respect one another as the sons of God, created in His image. Human respect was still a valid ideal, even if it was not always practiced. It was also possible for men in the later Middle Ages to respect and commune with nature, to feel for nature what came in the 17th and 18th centuries to be referred to as "natural piety." So long as man could live in a community in which reverence for God, respect for man and natural piety prevailed, it was easier for him to relate himself significantly to God, nature and man. He could live his life within an assurance of belief and be confident in the possibility of living a meaningful life on earth.

What happened historically was that at the end of the Middle Ages, despite the Reformation and Counter-Reformation, significant religious faith became increasingly difficult. Then, with the advent of modern science and technology, as nature came to be better understood, nature was first progressively mastered and then exploited. *And the more nature was exploited, the more* was man tempted to lose his respect for it; natural piety became increasingly difficult and rare. In the 19th century, as the social sciences began to imitate the natural sciences in their study of man, man himself came to be regarded as part of nature and therefore (witness high pressure advertising today) as available for predatory exploitation. As a result, it is very hard for us today to find anything in the universe which we can honestly reverence, to find any reason why we should really respect one another or ourselves, or to respect and commune with nature.

We must therefore try to re-establish, somehow—not in medieval terms, but in mid-20th-century terms—a significant working relation with whatever is objectively real *and* valuable or meaningful in ourselves and in our universe. This is the difficult task which faces us. It demands of us all the intellectual and spiritual integrity, all the realism and honesty and humility we can muster. Above all, it requires of us an attitude of reflective commitment or critical belief.

Only the uninformed believe that anything significant can be proved to the hilt, either in science or in the field of values. We are surrounded by mystery; life is, inevitably, a gamble. We must live by faith. Our only option *is to rely on a faith that is crude, superstitious and un*informed, or to achieve a faith that is critical, reflective and more or less informed. Our chief concern should therefore be to cultivate the art of reflective and critical commitment in every walk of life and area of belief. This, of course, requires individual effort, but such effort will not suffice. No significant advance in human culture has ever been brought about by a single individual working in isolation. It is the confraternity of scientists that has slowly built up the mountain ranges of science which, in turn, have made possible the peaks of distinguished individual scientific discovery. The most brilliant of scientists would be helpless without the continuing tradition of cooperative scientific endeavor. The same is true in art and literature, in the social sciences, and in history, philosophy and religion.

The sense of community

We must therefore find a way of banding ourselves together in corporate endeavor in every area of common concern. We must try to visualize common goals, devise methods of effective cooperation, and develop adequate languages for self-expression and communication in art as well as in science, in the fields of moral endeavor and religious quest as well as in social and political reform. We must strive to recapture the sense of community, to build interlocking communities—stable yet flexible, rooted in tradition yet progressive and creative, socially oriented yet congenial to responsible individual freedom.

This is no easy task. Our future as a culture, and therefore our individual futures as individuals, are precarious. We are not bound to succeed, but neither are *we doomed to fail. Our "problem of existence" is not* insoluble. We can, if we are wise and courageous enough to do so, benefit from our existential anxieties. We can achieve through them a deeper and more honest understanding of ourselves and one another, of nature and our cosmos. Such growing maturity, in turn, can enable us to achieve an idealistic realism and a reflective faith sufficient to enable us to revitalize our culture and to render our individual lives meaningful and useful. This is our task in a period of cultural crisis.

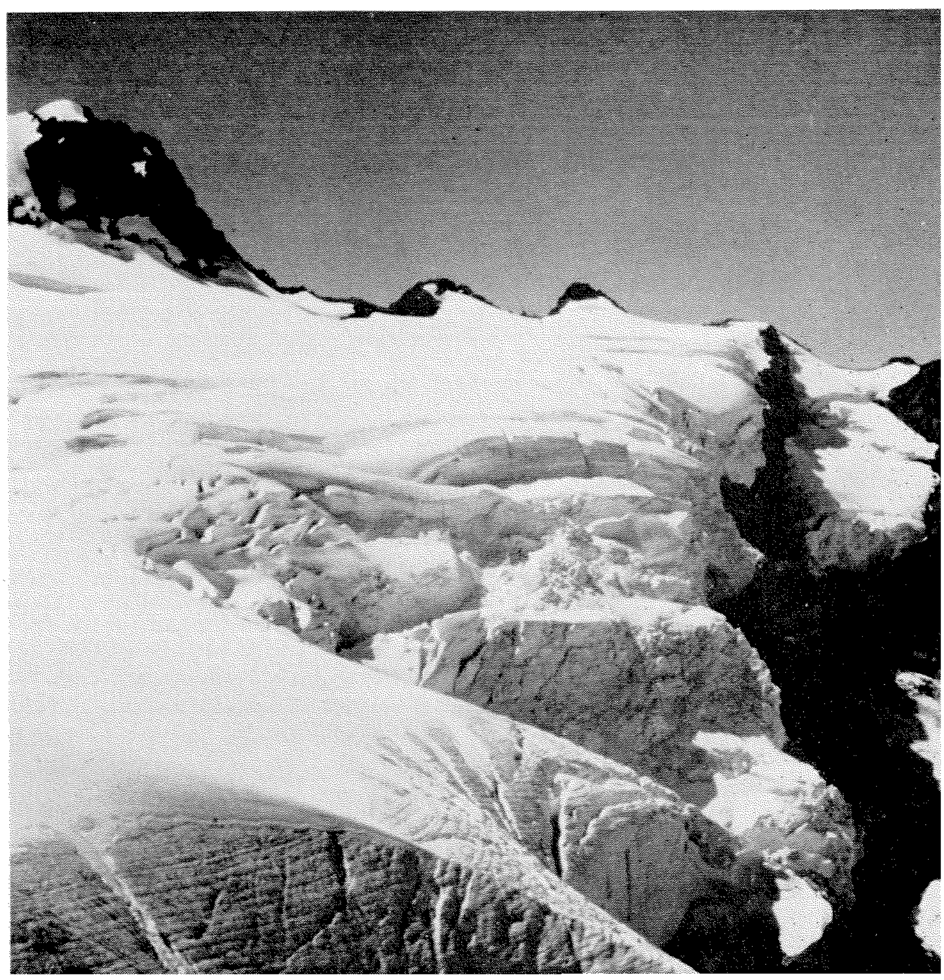
An airview of the Blue Glacier, which is located just below the 7,954-foot summit of Mount Olympus in Washington.

Blue Glacier Project

GLACIER MOVEMENT has long been a source of interest to geologists because ice is a rock which undergoes solid flowage on the earth's surface, where the process can be observed. Last summer, as part of the IGY program, Caltech geologists started a study of the ice on the Blue Glacier in northwestern Washington. They set up a network of 50 markers on the surface of the glacier to measure the surface velocity and surface strain distribution, took seismic soundings to determine the thickness of the ice and configuration of the floor, and used a hotpoint bore to penetrate the depths of the ice to 740 feet to determine the vertical velocity profile of the glacier. Next summer the team will return to the Blue Glacier to continue their research.

W. Barclay Ray and Clarence Allen, both assistant professors of geology, and Ronald Shreve, instructor in geology, check the thickness of the glacier ice from a seismogram which records, photographically, the wave soundings from detonations.

Clarence Allen, assistant professor of geology, gets ready to make a dynamite charge for seismic wave soundings. The depth of the glacier is exactly 910 feet.



The edge of the ice field on Snowdome which feeds into the Blue Glacier—the immensity of the field can be gauged by the size of the two men on the lower right.

The First Shots Into Interplanetary Space

by Fritz Zwicky

ON OCTOBER 16, 1957, at five minutes past 10 o'clock Mountain Standard Time, the first man-made pellets ever to escape from the earth were propelled into interplanetary space from an Aerobee rocket at the Holloman Air Force Base in Alamogordo, New Mexico. The development which led up to this event started in 1945 as part of a comprehensive program proposed for the exploration of extraterrestrial space.

The experiment of October 16 was first suggested in a note by me in the *Publications of the Astronomical Society of the Pacific* (Vol. 58, 260, 1946) on June 3, 1946. It read, in part:

"Properly conducted detonations of shaped charges* can be used to impart to all slugs of matter velocities which, in order of magnitude, are the same as the velocities of detonation of these charges; that is 10 to 15 kilometers per second. If the slugs are launched at the proper moment by shaped charges from rockets at high altitudes, they will be expelled at heights where the atmosphere is so tenuous that the air resistance is very small. *Such particles may be hot and luminous on launching*, or they may become heated by friction with the tenuous air, if their speed is high enough relative to the atmospheric density. These particles will consequently assume the appearance of meteors; thus a multitude of interesting tests present themselves. Some of the particles may have velocities equal or superior to the velocity of a 'close' satellite of the earth (about 8 km/sec), or these velocities may even surpass the speed of escape from the earth (11.2 km/sec). Some of these particles may consequently be launched into satellite orbits of the earth, while others may escape into interplanetary space.

"If artificial meteors are bright enough, photographic observations of them with telescopes of large focal ratios, such as Schmidt telescopes, combined with auxiliary equipment such as objective prisms and gratings, intermittent shutters, and so on, should furnish new data on the physical and chemical properties of the upper atmosphere. Such observations would also give new information on the problem of natural meteors."

Later on, and particularly in my Halley lecture at Oxford, England, in 1948 (see *Observatory* Vol. 68, p. 121-143, 1948) I generalized my program to include the following projects: 1) First throw a small bit of matter into interplanetary space, 2) then a little more, 3) then a shipload of instruments, 4) and then ourselves. 5) Follow up the invasion of interplanetary space by an attempt to reconstruct the solar system so as to make the planets and their satellites habitable by man.

Since 1946 my efforts have been unceasingly directed toward the realization of this five-point program. In the spring of 1946, when I was a member of the Scientific Advisory Board of the U.S. Air Force, I wrote to General G. M. Barnes, then Chief of Army Ordnance, suggesting that one of the V-2 rockets brought from Germany be fired at night, and that artificial meteors be ejected from it by means of shaped charges, such as those used in rifle grenades.

This request was granted and Colonel (now General) H. N. Toftoy made all the necessary arrangements for the firing, which took place at White Sands Proving Grounds, New Mexico, on the night of December 17, 1946. The rocket flew to a height of 117 miles, and valuable scientific data were obtained on the spectral characteristics of the main jet of the rocket, as well as on the luminosity of the hot graphite vanes immersed in the jet for purposes of steering. The shaped charges, however, which should have been ejected from the main rocket and fired at heights of 120,000, 150,000 and

*Explosives that deliver their force in one direction, determined by the actual shape of the charge itself.

180,000 feet did not ignite, apparently because of a malfunctioning in the firing circuit.

This failure proved to have most unfortunate consequences, since several experts subsequently voiced the opinion that the shaped charges would not perform as claimed, and that ground observations with available telescopic equipment would not succeed in recording the tracks of the particles or pellets ejected from the metallic inserts of the shaped charges. Although the firing of October 16, 1957 at Alamogordo finally proved that these experts were mistaken, their earlier objections were heeded by various agencies of the U. S. Government and the Armed Forces, and for ten years it proved impossible to obtain the means and the permission to repeat the fundamental experiment.

The Navy authorities, however, made possible some ground-testing of the jets from shaped charges at Inyokern, China Lake, California. Some results were reported in *Ordnance*, the journal of the Army Ordnance (July-August, 1947). These results showed, in particular, that the transportable 8-inch Palomar Schmidt telescope was quite powerful enough to photograph, at distances of hundreds of kilometers, the jets extruded from small shaped charges. The cameras, equipped with either objective gratings or prisms, also gave much information on the spectral characteristics of the jets, and consequently on the reactions within the jet and the chemical nature of its surroundings. Furthermore, it was learned that the shaped charges and the inserts should be geometrically as symmetrical as possible if fast jets containing only a few pellets—rather than a spray of particles—were to be achieved.

In this connection, my associates at the Aerojet Engineering Corporation in Azusa, Calif., and I developed a most useful liquid explosive, consisting essentially of nitromenthane CH_3NO_2, doped with a small amount of an amine, such as diethyl amine $(C_2H_5)_2NH$. This explosive, commercially known as Jet-X, is naturally more uniform than a solid explosive, and through its use as a shaped charge most efficient extruded particle jets have been obtained. During the preliminary ground tests it was also found that, with various configurations, pellets with speeds of 12 kilometers per second or more could be achieved, which is quite sufficient to have these pellets escape from the earth's gravitational field if they are launched at sufficiently great heights.

In elaboration of the idea that jets of fast particles should be *hot and luminous on launching*, Joseph F. Cuneo—patent attorney and industrial chemist of Covina, Calif.—and I developed a series of alloys for the inserts of shaped charges which, on detonation, are ejected in the form of ultrafast hot and self-luminous pellets. Some of these inserts which produce self-luminous artificial meteors are:

a) An easily oxidizable insert, containing metals such as aluminum, magnesium and lithium. These metals would partly oxidize and generate much heat while reducing H_2O, CO, CO_2 gases which are generated in the explosion of the shaped charge. As a result, hot and luminous particles or liquid droplets are expelled which are visible in a vacuum.

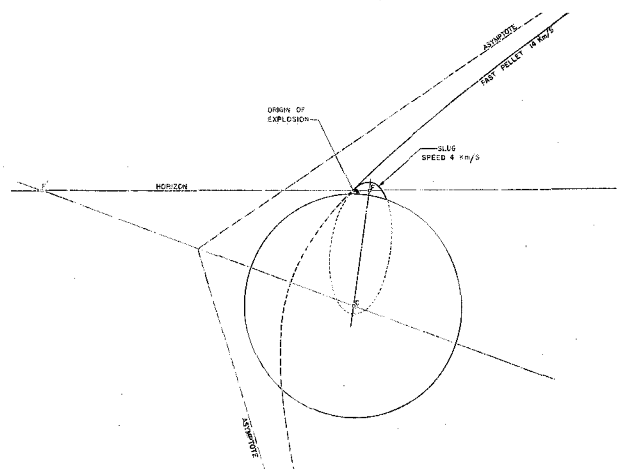
b) A second type of heating may be achieved by surrounding the pellets, oxidizable or not, with a reactive material producing much heat on ignition by the detonation of the shaped charge.

c) The most effective method of producing exceedingly hot particles, however, is to use what we call "coruscatives" or "heat explosives" for the inserts. These are combinations of solid or liquid reagents which react fast, generate much heat and produce solid reaction products. Upon ignition, then, coruscatives develop little or no gas, and so they do not fly apart as conventional explosives do. One of the well known combinations of reagents which constitutes a coruscative is iron oxide (Fe_2O_3) plus aluminum, forming the welding mixture known as thermit. On ignition, this mixture reacts and produces iron and aluminum oxide, with a resulting temperature of about 4000 degrees centigrade.

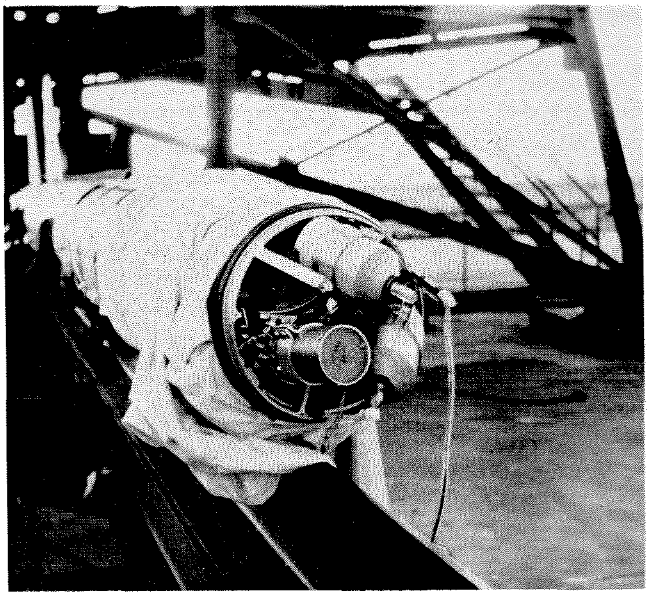
During the past few years we have successfully developed a number of compressed powder coruscatives which have been used to form conically-shaped inserts for shaped charges. Particles composed of the hot reaction products of these coruscatives retain their high temperatures for many minutes. When they are ejected at high altitudes, with speeds of 10/km sec or greater, they should therefore be visible up to thousands of kilometers above the surface of the earth.

On the basis of the results achieved with shaped charges, Captain W. C. Fortune of the U. S. Navy got interested in the project of launching artificial meteors at high altitudes. In 1955 he arranged for a series of tests from balloons, which led to additional valuable knowledge of how to conduct ultimate experiments with artificial meteors.

The first of these ultimate experiments came about in



Ultrafast pellets ejected at 14 km/sec, from 200 km height, and at a 45° angle, follow the hyperbolic trajectory with foci C and F' until they are bent into elliptical orbits around the sun. The heavier slug, ejected at 4 km/sec, describes the elliptical trajectory with foci C and F and falls back to the earth. Debris from the casing falls at a short distance from the explosion.



Three shaped charges, pointed in different firing directions, mounted in the top part of the instrument head of an Aerobee rocket.

a most casual way. Dr. Maurice Dubin, of the Geophysical Research Directorate of the U. S. Air Force, had been visiting Pasadena off and on since 1954 and had interested himself in the artificial satellite project. Someday he hoped to make room for the shaped charges in the instrument head of one of the many Aerobee sounding rockets which were being fired for other scientific projects, such as cosmic ray studies, the study of the processes in aurorae, and the analysis of the physicochemical properties of the upper atmosphere.

The first chance came late in the summer of 1957, when Dr. Dubin informed Cuneo and me, as well as two other experts on shaped charges—Drs. T. C. Poulter of Stanford University and John S. Rinehart of the Smithsonian Astrophysical Observatory in Cambridge, Mass.—that around October 15 an Aerobee rocket would be fired in whose tip some extra space would be available to install three small shaped charges.

Dr. Poulter's group conducted some experiments to show that the three charges, if properly mounted and connected to the same detonator, could be fired without interfering too much with one another—an interference which, of course, could endanger the formation of really well-defined fast particle jets.

Dr. Poulter's preference was a very narrow conical, or practically cylindrical, insert in his shaped charge. This configuration is known to produce the fastest jets so far achieved, reaching velocities of ejection of up to 30 kilometers a second. These cones, however, produce high velocities at the expense of mass in the jet, which often is entirely gaseous. Dr. Poulter chose aluminum as the material for his insert, relying on the low-density diatomic and monoatomic oxygen in the high atmosphere to oxidize his jet in part, while the high speed of the latter also produces some luminosity because of frictional heating. In addition, there is some oxidation of the aluminum from the more easily reducible oxides of the explosive gases accelerating the aluminum insert—which makes the particles hot and luminous even in a vacuum.

Dr. Rinehart also chose an aluminum cone which, however, was cuplike and massive—about one centimeter thick. From such a cone, more massive but slower pellets can be expected than from Poulter's narrow-angle cone and thin inserts. Solid cast explosives were used for both Poulter's and Rinehart's cones.

Cuneo and I used a 1.5-millimeter-thick aluminum cone of 60° apex angle, and about seven centimeters in diameter, to back a compressed cone of a special fast reactive coruscative cone of the same configuration, but of about 3 to 4 mm thickness. From this type of configuration, an exceedingly hot jet of massive particles may be expected, consisting of slags of aluminum oxide and other refractory-like compounds, retaining their heat well and radiating it away at a high temperature relatively slowly, so that long trajectories become observable. The explosive used for our shaped charge was the putty-like composition called C_3, furnished by the Air Force.

All three groups were on location at the Holloman Air Force Base to install their charges themselves. The charges, during the upwards flight of the Aerobee rocket, were all pointing downward, but in three different directions. Since the main section of the instrument head carried other types of instruments, the tip of the rocket, in the shape of a dunce's cap, had to be detached, kicked off and turned over in free flight away from the rocket, in order to direct the ejection of the artificial meteors in directions above the horizontal plane. The kick-off mechanism and the timer for firing the shaped charges were installed by the crew of the Geophysical Research Directorate of the U. S. Air Force, under the direction of Dr. Maurice Dubin, and according to his designs.

The sequence of events was as follows:

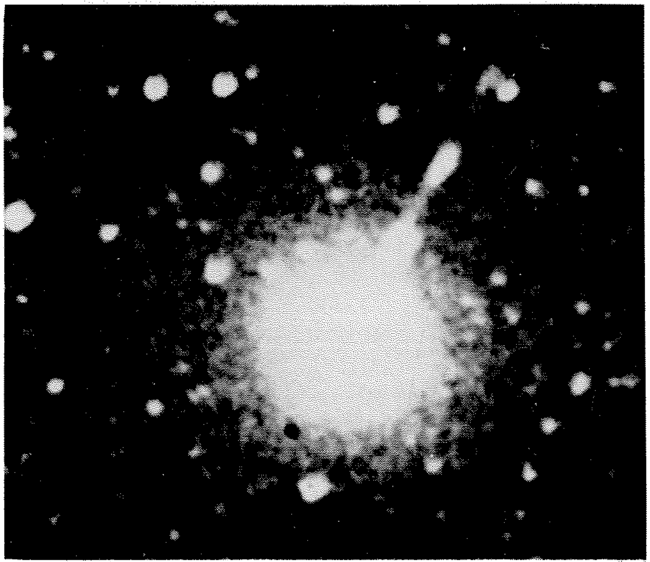
The Aerobee rocket was launched from its tower at Holloman Air Force Base at about 10:05 MST. Propellant burnout was 45 seconds later, and the tip of the rocket, with the shaped charges, was kicked off 55 seconds after launching. The tip coasted for another 36 seconds and slowly turned over. The charges, then, were fired 91 seconds after launching of the rocket, and the artificial meteors were ejected at a height of about 85 kilometers.

A very bright green flash was observed by all, but only some experienced observers saw one of the fast jets streaking off toward the north north east. The brightness of the initial flash, as seen from the ground, was about minus tenth visual astronomical magnitude. This flash was also observed from Palomar Mountain by my assistant, Howard S. Gates. At this distance of exactly 1,000 kilometers the flash appeared to be of minus fifth to minus sixth magnitude.

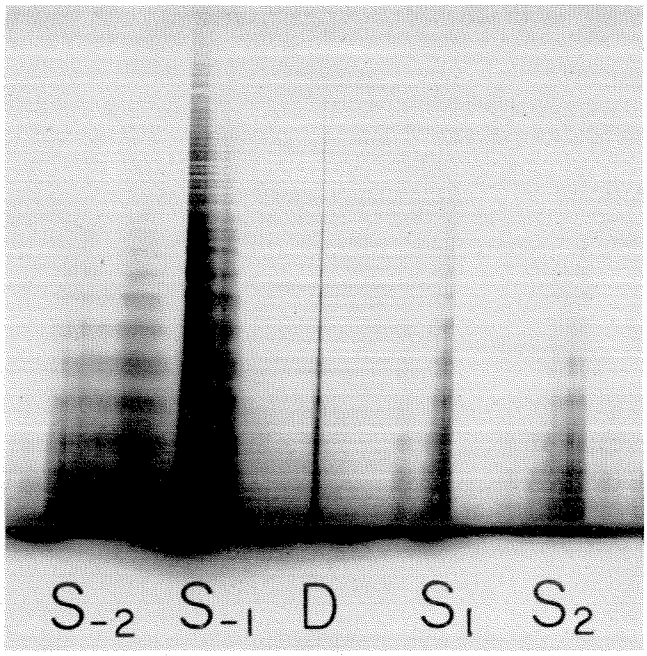
On most of the photographs taken with the super Schmidts on Sacramento Peak, about 30 miles east of Alamogordo, and with the cameras stationed in the Alamogordo valley, the flash appears as a bright blotch, while two sharp short trajectories of two of the artificial meteors emerge from its center. The brighter of these tracks appears with clearly marked interruptions on the photograph (below) taken by one of the super Schmidts with its fast interrupting shutter.

The evaluation of all the available data showed that the speed of the pellet of closely bunched particles in the brighter jet was at least 15 km/sec and that two jets went clearly upward, away from the earth. Since the pressure remaining at 85 km is roughly one millionth of the pressure on the ground, a fast particle one millimeter thick would have lost less than one hundredth of its kinetic energy in traversing the remaining atmosphere. Since the particles, from the analysis of the brightness of their trajectories, were clearly more massive than that, and since they possessed almost twice the kinetic energy necessary for escape from the earth, it is certain that they got away from the gravitational pull of the earth to become tiny satellites of the sun, describing orbits around the sun, which, except for effects of light pressure and loss of mass by evaporation, must be essentially elliptical.

The firing was being photographed from the Palomar Observatory by Dr. M. L. Humason, using the 48-inch Schmidt telescope, and by Howard S. Gates with the 18-inch Schmidt. On the 48-inch Schmidt plate there appears a long, peculiar and slightly curved track originating approximately, but not quite exactly, in the point of explosion of the shaped charges. The origin of this track is still in doubt. It is, however, possible that it can be explained as being due to one of the *slow* slugs ejected from any shaped charges fitted by a solid insert. Indeed, it should be remembered that three types of particles were ejected in the experiment: (a) the fast particles travelling with velocities greater than the velocity of escape from the earth (11.2 km/sec), (b) the slow and heavier slugs with speeds of 3 to 5 km/sec, and (c) the debris from the casing used to hold the explosives. Both the heavy slugs and the particles of the debris might have been sprayed over an area the size of the American continent or greater.



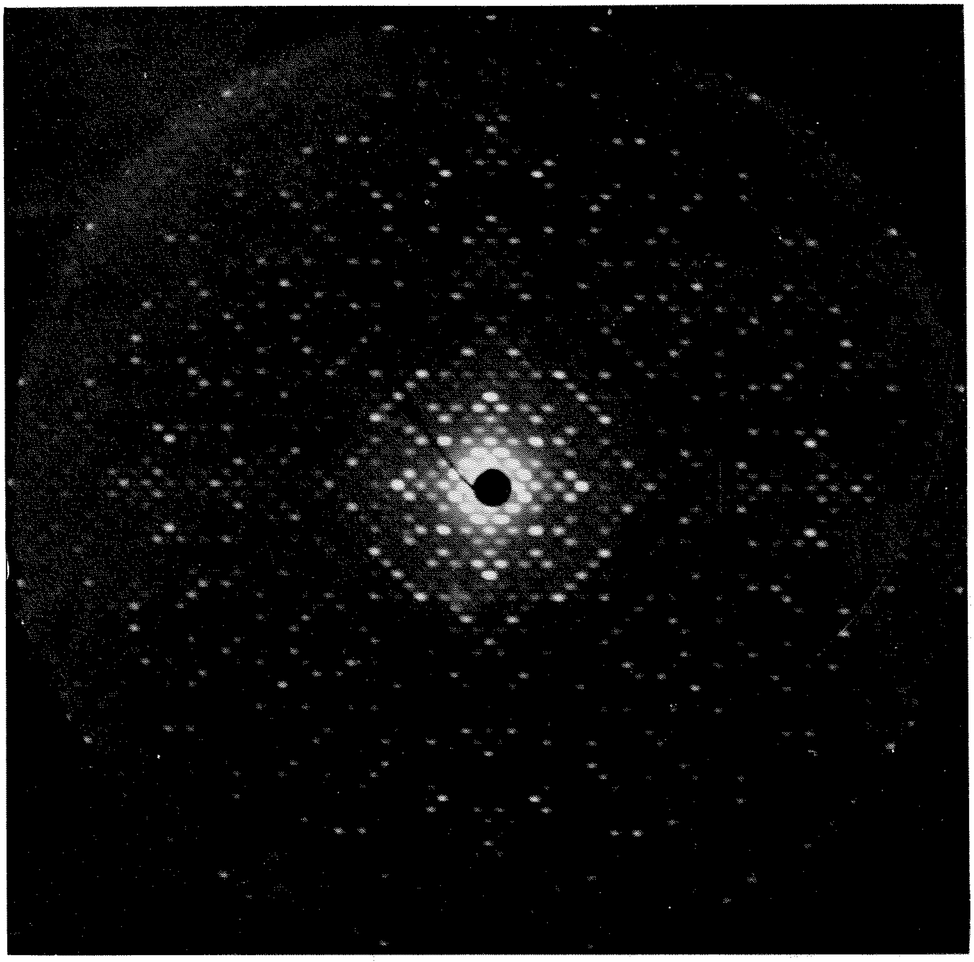
One of the ultrafast luminous pellets emerging from the flash of the coruscative explosion. In this photograph, made with a super Schmidt camera equipped with an interrupting shutter operated at 1800 cycles per minute, the distances between the interruptions of the track allow calculation of the speed of the pellet.



Spectrum of track of ultrafast particle of copper photographed with 3″ lens and echelette grating. D is the direct track, S_{-2}, S_{-1} and S_1, S_2 are, respectively, the strong and the weak first and second orders in the spectrum.

As a result of this experiment, made possible by the whole-hearted cooperation of Dr. Maurice Dubin, of the U.S. Air Force, we can now maintain that:

1. Small man-made projectiles were launched away from the earth for the first time, never to return.
2. The initial tracks of these artificial meteors could easily be photographed with ordinary cameras at a distance of 100 kilometers and it would be possible to record them with large telescopes at many thousands of kilometers.
3. The firings proved that coruscative inserts can be ignited by detonative shear ignition in the relative vacuum at the height of 85 kilometers, and that ignition does not depend on the jets hitting an oxidizing atmosphere.
4. As to the usefulness of the continuation of the Holloman experiment—such experiments will give information on the density of the atmosphere hundreds of kilometers above the earth's surface, on its state of chemical composition and decomposition, on the number and character of the excited states of molecules, atoms and ions in the ionosphere, on the origin of the aurorae, on the electric and magnetic fields far from the earth's surface, on certain characteristics of the moon's surface—and they will pave the way for direct experimentation with all the planets and their satellites in the solar system.



X-ray diffraction pattern of the crystalline enzyme, lysozyme, the structure of which is now being studied by Caltech chemists. This protein occurs in body fluids. When a crystal of lysozyme is placed in an x-ray diffraction camera and irradiated by a beam of x-rays, the crystal acts as a diffraction grating, producing this characteristic diffraction pattern.

An Anniversary

Caltech celebrates the 40th anniversary of the first American papers in x-ray crystallography

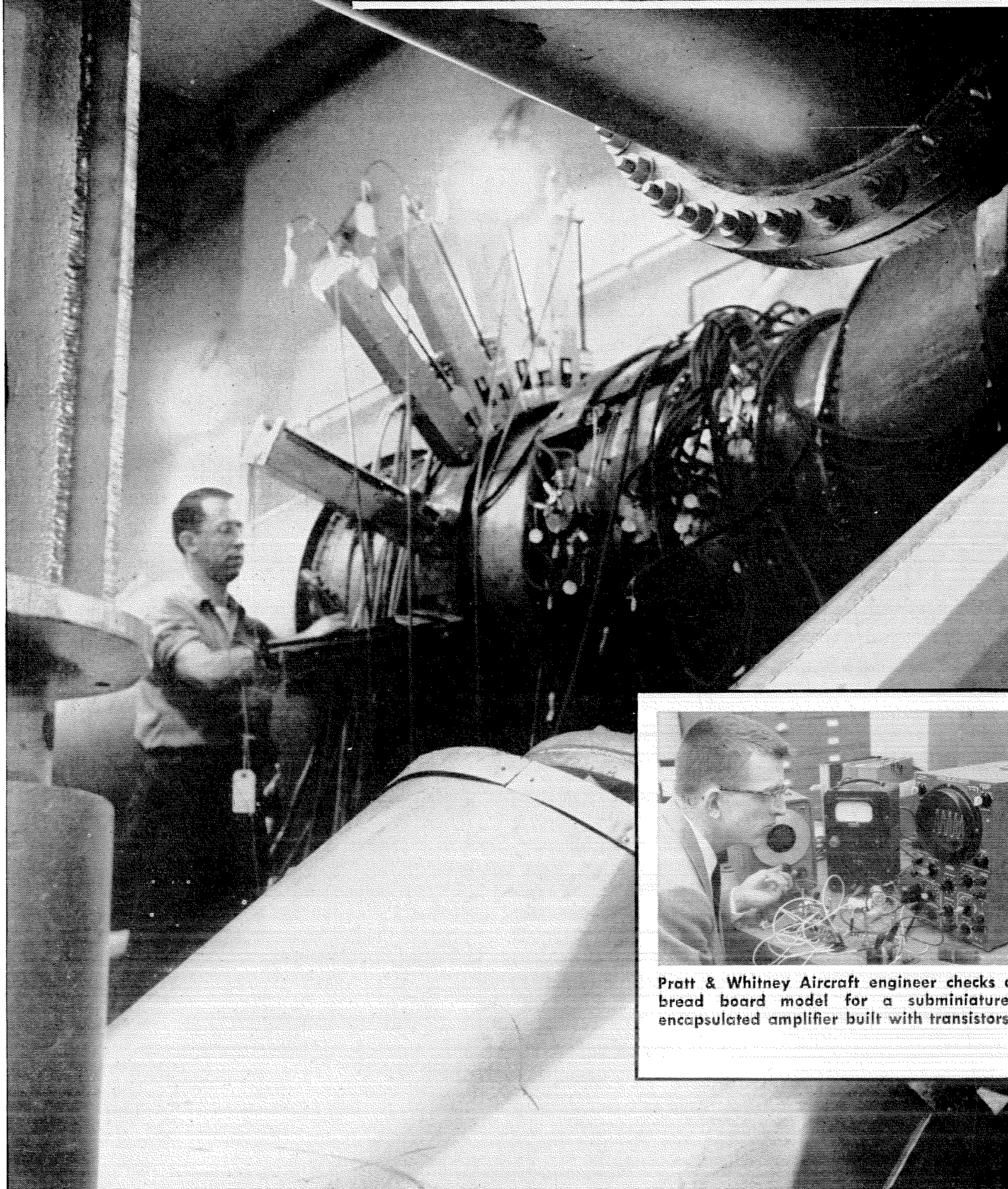
CRYSTALLOGRAPHERS from all over the country came to the Caltech campus on December 16 to celebrate the 40th anniversary of the first American papers in x-ray crystallography. Caltech was one of the first two centers in America (along with the General Electric Company) to initiate studies in x-ray crystallography, and the first two papers in this field were published in 1917—by Prof. J. H. Ellis and Dr. C. L. Burdick at Caltech, and by Dr. A. W. Hull of General Electric.

Dr. Burdick was on hand for the 40th anniversary celebration last month, to report on the beginnings of x-ray crystallography, and Dr. Dorothy Hodgkin, who conducts research at Oxford University, England, was the main speaker on current research in the field. Dr. Hodgkin is probably the most distinguished crystallographer in the world; with her students, she is responsible for two of the biggest jobs ever completed in the field of x-ray crystallography—the determination of the structures of penicillin and of vitamin B-12. She is now working on the structure of insulin.

X-ray crystallography is a science concerned with the determination of the positions of atoms in crystals. A tiny crystal is mounted in an x-ray diffraction camera and rotated in a beam of x-rays. The crystal acts as a diffrac-

continued on page 28

WHAT'S DOING at
Pratt & Whitney Aircraft . . .



Pratt & Whitney Aircraft engineer checks a bread board model for a subminiature, encapsulated amplifier built with transistors.

A rig in one of the experimental test cells at P & W A 's Willgoos Laboratory. The six large finger-like devices are remotely controlled probe positioners used to obtain basic air flow measurements within a turbine. This is one of the techniques for obtaining scientific data vitally important to the design and development of the world's most powerful aircraft engines.

tion grating, scattering the rays to a photographic emulsion which surrounds the crystal. After several hours, the film is developed and the spots where the diffracted x-rays struck show up as a pattern of dots. From precise measurements the chemist can then determine the size and shape of the crystal's minute units. The intensity of each of the hundreds of dots is measured and is used in the determination of the positions of the atoms in the crystal.

The technique has been used at Caltech to determine the structure of molecules in crystals of metals, minerals and many organic compounds, especially those related to proteins and other substances of biological interest. The determination of a relatively simple molecule usually takes one or two years to complete.

The study of crystallography dates back as far as the 16th century, but until x-rays were discovered by Roentgen in 1895 the research was conducted mainly by mathematical measurement and visual study. The results obtained from these methods were close to guesswork, but even so, many researchers in the pre-x-ray period came very close to the correct atomic count later proved by x-ray study.

For 17 years after x-rays were discovered the nature of these radiations remained controversial. Finally, in 1912, Professor Max von Laue of Munich University proved that they were like visible light except for their short wave length. His investigations, which changed the whole study of crystallography, got under way after some informal discussions with a student who was preparing his doctoral dissertation on the passage of light waves through crystals. He surmised that the separations between atoms in crystal were of the same magnitude as the probable lengths of the x-rays about which so much controversy existed. And he suggested that crystals would serve as a naturally-made grating for the diffraction of x-rays, in the same way that artificially-ruled gratings made by scratching lines on glass with a diamond will diffract ordinary light. Experimental tests proved this to be true.

Later in the year 1912, Sir William Bragg and his son, Sir Lawrence, began the first x-ray crystallography studies. Since von Laue had used crystals to study x-rays, they figured, it should be possible to reverse the process and use known x-rays to study unknown crystals.

Von Laue received the 1914 Nobel prize for his discovery, and the Braggs' work won them the prize in 1915. The 40th anniversary of their pioneer papers in x-ray crystallography was celebrated in England in 1952 —and Dr. Dorothy Hodgkin was one of the main speakers at these ceremonies, too.

Work on x-ray crystallography started in the United States in about 1916, and the first papers were published the following year. The first of these was written by Dr. A. W. Hull. In 1915 he was doing electronics research at the General Electric Company in Schenectady when he heard a lecture by Sir William Bragg that interrupted his electronics research for several years. Sir William described his new work on the study of crystal structure by means of x-rays. After the talk Hull asked him if he had ever found the structure of iron, and Sir William admitted they had never been able to work it out. Though he was totally unfamiliar with both x-rays *and* crystallography Hull went back to his laboratory and began getting apparatus together to find the crystal structure of iron. In 1917 his paper recorded his success.

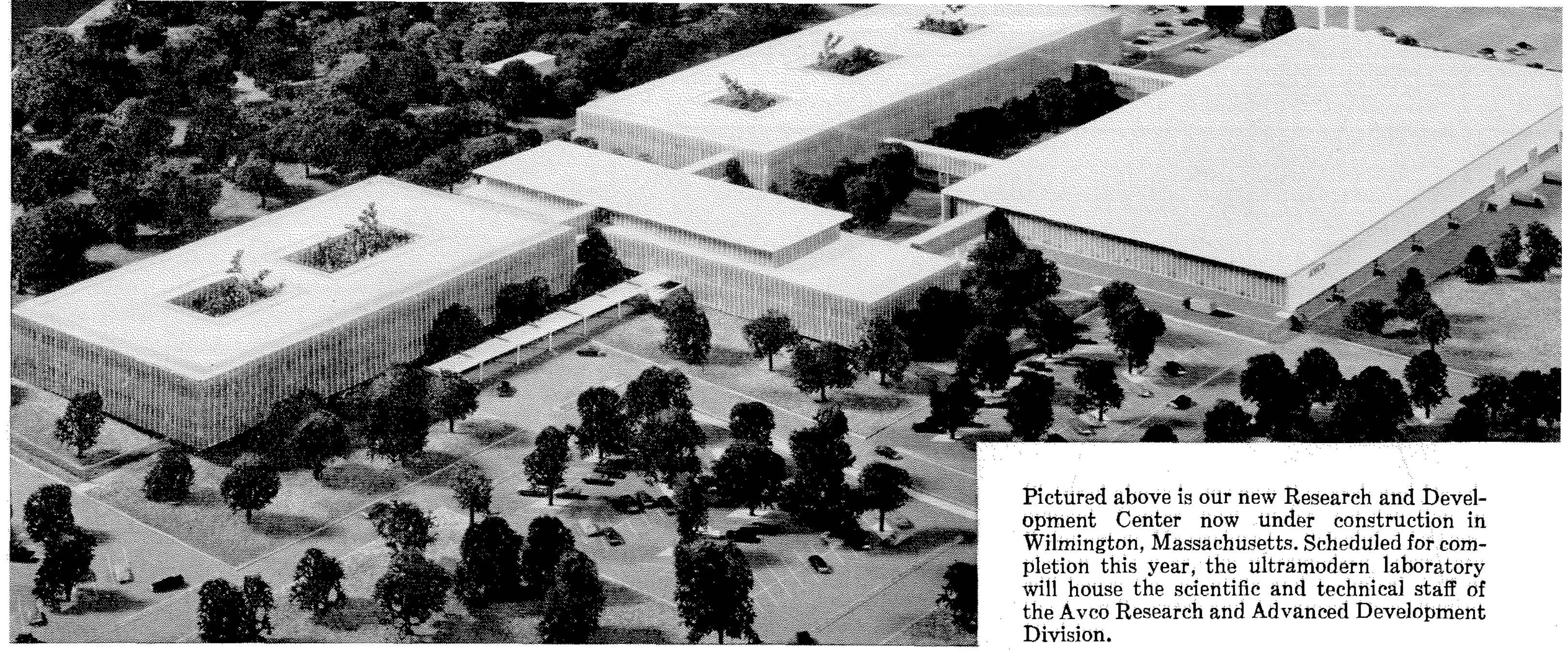
The second paper in the field was written by Prof. J. H. Ellis, in the chemistry department of what was then the Throop College of Technology, and Dr. C. L. Burdick. Burdick was a graduate student of Dr. Arthur A. Noyes' at the Massachusetts Institute of Technology. In 1916, at Noyes' suggestion, he spent six months in the x-ray laboratory of Prof. William Bragg at University College in London.

On his return to MIT, Burdick's assignment from Dr. Noyes was to build a Bragg x-ray spectrometer with any improvements which the state of the art would permit. Late in the year, when Noyes left for his annual tour of duty as visiting professor at Caltech, he asked Burdick to come along with him. The uncompleted spectrometer was abandoned in Boston, and work on a new one got under way in Pasadena.

This machine, which was used to determine the structure of the mineral, chalcopyrite, was the subject of the Burdick and Ellis paper. The paper is #3 in the chronological list of papers published from the Gates and Crellin Laboratories at Caltech. Today the list includes 233 papers in x-ray crystallography (out of a total of more than 2,000 papers in all branches of chemistry) and the x-ray crystallography laboratory at Caltech is one of the largest in the field, turning out as much work as any laboratory in the world.

Dorothy Hodgkin, one of the world's leading crystallographers, studies an x-ray diffraction pattern in the Caltech laboratories.


challenging



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

Science and Progress at Avco—1957

Truly significant discoveries and technical progress are the goals of the Avco Research and Advanced Development Division. Some of the Avco RAD record of accomplishments are contained in professional papers in scientific and technical journals. Much of it is classified for reasons of military security. But the following public announcements serve to outline some of the steps taken by RAD—the "Breakthrough" Division of Avco—in pursuing its goal for 1957:

February 11, 1957.....Site Prepared for Avco RAD Center

April 5, 1957.........Avco to Make Hypersonic Shock Tubes for Industry, Universities, Other Research Groups

July 1, 1957.........Avco to Develop New Radio Pack Set for Marine Corps

July 2, 1957.........Prime $111 Million Contract Announced for Development by Avco of Nose Cone for Intercontinental Ballistic Missile

August 28, 1957......Avco Shock Tube Research Has Produced Theoretical Breakthrough on 5000-Mile Air Force Ballistic Missile

November 23, 1957....Tiny "Building Blocks" Revolutionize Computer Design and Construction

December 3, 1957.....Avco to Build Air Force Combat Computer

Avco's record during the past year is significant from scientific, technical and business points of view. It has been made possible by sustained effort at RAD to maintain an atmosphere conducive to creative thinking and production of the highest order.

AVCO

Research & Advanced Development

Avco's new research division now offers unusual and exciting career opportunities for exceptionally qualified and forward-looking scientists and engineers.

Write to Dr. R. W. Johnston, Scientific and Technical Relations, Avco Research and Advanced Development Division, 20 South Union Street, Lawrence, Massachusetts.

The Month at Caltech

AGU Meeting

THE ANNUAL PACIFIC Southwest regional meeting of the American Geophysical Union will be held on the Caltech campus from February 6 to 8. Vito A. Vanoni, Caltech professor of hydraulics and chairman of the Pacific Southwest Regional Committee of the AGU, will act as chairman of the program. James F. Bonner, professor of biology at Caltech, will speak on "World Population and Food" at a luncheon for the whole group on the opening day of the meeting. Some 200 guests are expected to attend the sessions which will be mainly concerned with new developments in oceanography, meteorology and hydrology. The AGU, a national organization of scientists and scientific workers in earth sciences, was established in 1919 by the National Research Council of the National Academy of Sciences.

On Leave

RICHARD JAHNS, professor of geology, is now on a leave of absence at The Pennsylvania State University where he will spend six months in the College of Mineral Industries. Working on a National Science Foundation grant, Dr. Jahns will carry out experiments in synthesizing certain kinds of rocks to find out under what conditions these rocks form and how ore-forming fluids might separate from rock-forming melts.

Defense Science Chairman

H. P. ROBERTSON, professor of mathematical physics at Caltech, is now chairman of the Defense Science Board in Washington, D.C., a group of 28 men chosen from civilian life by the Assistant Secretary of Defense. The advisory panel is making a study of new scientific research and development and its application to combat-worthy weapons systems for the Department of National Defense.

Dr. Robertson, who received his PhD from Caltech in 1925, has been on the faculty here since 1947. A member of the National Academy of Sciences and Fellow of the American Physical Society and the Royal Astronomical Society, he is recognized for his researches in differential geometry, the history of relativity, cosmology and applied mechanics. From 1950 to 1952 Dr. Robertson served the Government as the Director of Research, Weapons System Evaluation Group, in the Office of the Secretary of Defense. From 1954 to 1956 he served as the scientific advisor to the Supreme Allied Commander in Europe. He is now also serving the Office of the Secretary of Defense as a member of the Technical Advisory Panel on Ordnance and acts as a consultant to other Government agencies as well.

AUFS Checks In

ON JANUARY 6 the first of four representatives of the American Universities Field Staff came to Caltech to report on political, social and economic conditions in foreign areas. Willard Hanna, reporting on Indonesia, was on campus from January 6 to 15. James G. Maddox, agricultural economist, will report to students, faculty and friends of the Institute on current conditions in Mexico from January 20 to 29. Richard H. Nolte, specialist on the Arab nations of the Middle East, will be here from March 3 to 12, and Phillips Talbott, whose field is India and Pakistan, is scheduled to be here from April 3 to 12.

All four men have just completed 18-month periods of study in their chosen fields, under the auspices of the AUFS, which is sponsored by Caltech and nine other major universities.

Faculty Changes

The following promotions have been made in the Caltech faculty, effective January 1.

TO ASSOCIATE PROFESSOR:

Charles A. Barnes—Physics
Harden M. McConnell—Physical Chemistry

TO ASSISTANT PROFESSOR:

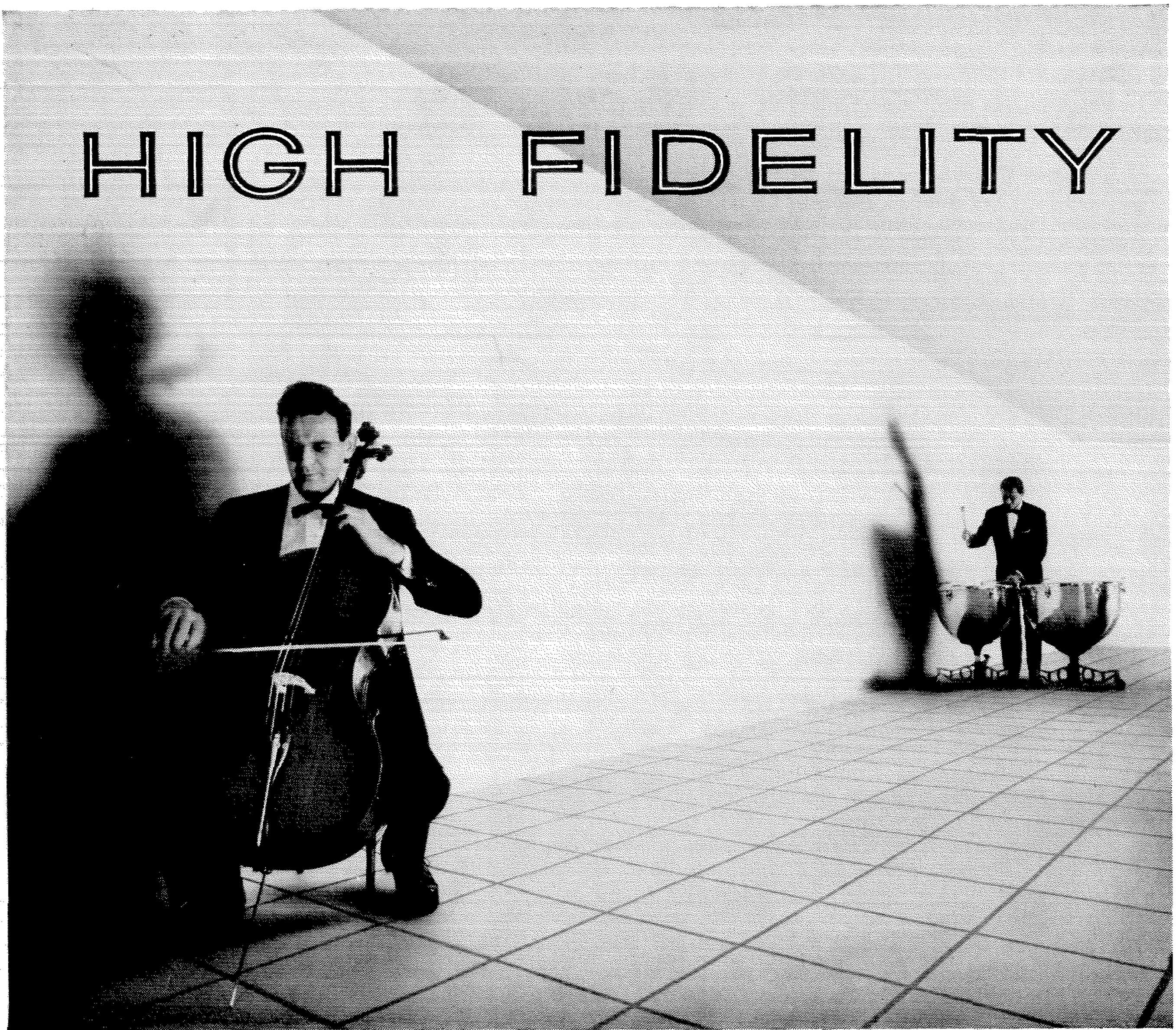
Felix H. Boehm—Physics
Vincent Z. Peterson—Physics

TO SENIOR RESEARCH FELLOW:

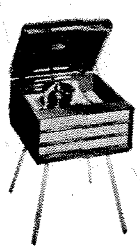
H. Hollis Reamer—Chemical Engineering

New Trustee

JOHN S. FLUOR, Los Angeles industrialist, has been elected a member of the Caltech board of trustees. Mr. Fluor is president of the Fluor Corporation, Ltd., an engineering and construction firm founded by his father, the late John S. Fluor, Sr.



How RCA brings a richer, wider range of musical sound to your home



Before high fidelity, the sound of recorded music was limited—much as piano music would be if you could hear only the notes played on the center of the keyboard. No rich bass notes, no keen, vibrant highs.

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RCA offers careers in research, development, design, and manufacturing for engineers with Bachelor or advanced degrees in E.E., M.E. or Physics. For full information, write to: Mr. Robert Haklisch, Manager, College Relations, Radio Corporation of America, Camden 2, N. J.

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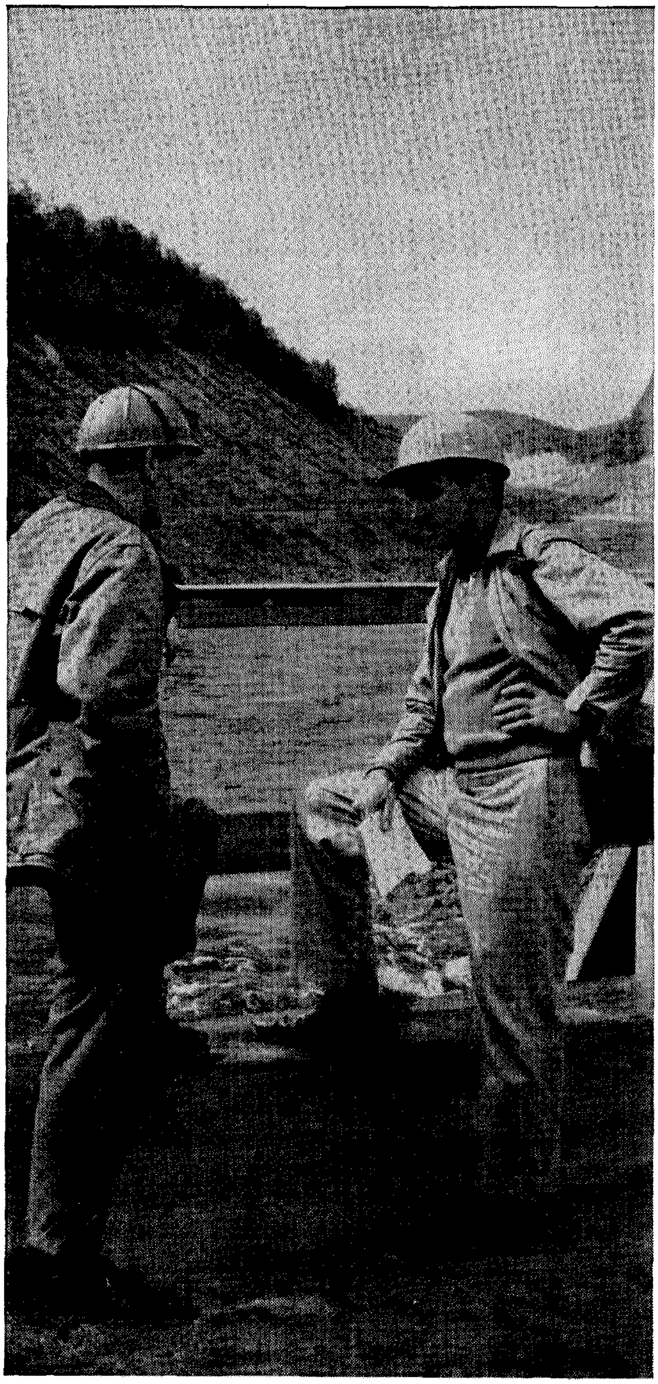
This can be YOU...

Art Fox, B.C.E., Manhattan College '47, reaches 77,000 engineers and construction men as a Senior Editor of McGraw-Hill's ENGINEERING NEWS-RECORD

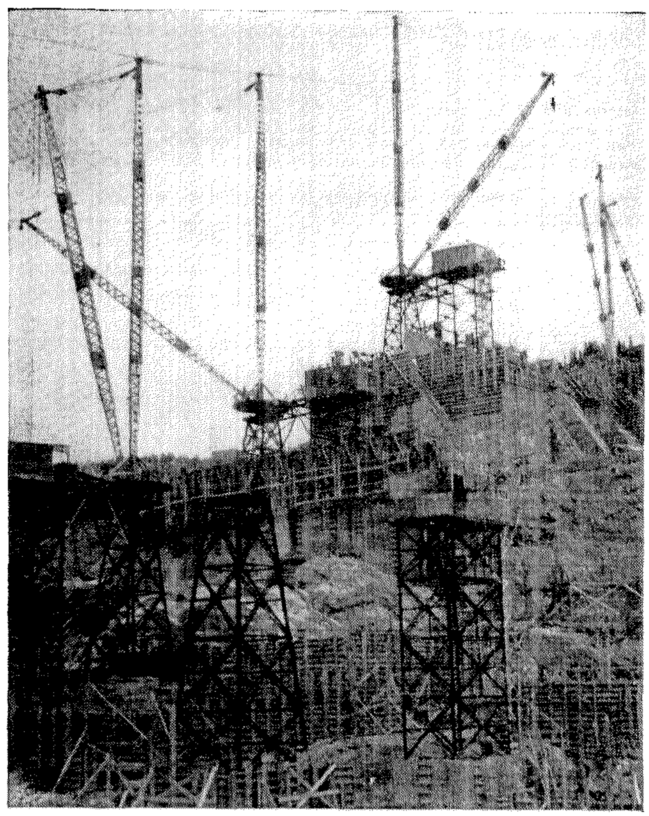


An Editor with a Hard Hat. Art, pictured above at right with Assistant Resident Engineer McCormack, observes progress at the Beaumont Rapids power dam at St. Maurice River, Quebec.

In ten short years, Art has climbed rapidly in his profession. Just back from a 2,500-mile editorial trip to Canada, here's what he has to say:

"To me, journalism is a form of teaching. Backed by the world-wide resources of McGraw-Hill, through travel, by working with leading engineers, I report on what's new and significant in engineering and construction. I try to make my articles more than instructive—to inspire readers to tackle and solve projects they might otherwise shy away from."

Other than preparing reports in college, Art had no early writing experience. Immediately after graduation, he was employed by a leading firm of consulting engineers. While on the job his appreciation for the inspiration-power of the industrial magazine



Cranes and Concrete. Another view of the Beaumont Rapids project. Art drove 1,800 miles from Montreal to get three on-site stories. Like other McGraw-Hill editors he got his story *firsthand.*

Alumni News

RPI President

RICHARD G. FOLSOM, '28, MS '29, PhD '32, has been elected president of Renssalaer Polytechnic Institute in Troy, New York. He moves into his new job on March 1. For the past five years, Dr. Folsom has been director of the Engineering Research Institute and professor of mechanical engineering at the University of Michigan.

Dr. Folsom joined the faculty of the University of California at Berkeley in 1933 and rose through the academic ranks to become professor of mechanical engineering. From 1947 to 1953 he was chairman of the mechanical engineering division, and in 1952-53 he was also director of the university's mechanical engineering laboratories.

Lecture Series

HOWARD S. SIEFERT, PhD' 38, and staff engineer for the guided missile research division of The Ramo-Wooldridge Corporation in Los Angeles, is the organizer of a statewide series of lectures now being presented by the University of California's extension division. The series is sponsored jointly by UC's departments of engineering and physical sciences and by Ramo-Wooldridge.

The lectures, which started on January 13 and will run through May 14, deal with the fundamental principles of very long range ballistic vehicles and cover all fields of science active in this research. The complete series will be given in San Diego and San Francisco as well as Los Angeles.

Among the lecturers taking part are a number of Caltech alumni and faculty members, including Lester Lees, Caltech professor of aeronautics; Ernest Sechler, '28, MS '29, PhD '33, Caltech professor of æronautics; Eberhard Rechtin, '46, PhD '50, chief of the electronics research section of JPL; William H. Pickering, '32, MS '33, PhD '36, director of JPL; Martin Summerfield, MS '37, PhD '41, professor of aeronautics at Princeton University; Jack H. Irving, '42, special assistant to the vice president of Ramo-Wooldridge; George P. Sutton, '42, MS '43, chief of the preliminary design engineering section of Rocketdyne; Millard V. Barton, '32, manager of the engineering mechanics department of the guided missile research division of Ramo-Wooldridge; Frank Lehan, '44, associate director of the electronic research and development division of Ramo-Wooldridge; and William T. Russell, '47, PhD '50, manager of the inertial guidance department of Ramo-Wooldridge.

Space Labs

SIMON RAMO, PhD '36, and research associate in electrical engineering at Caltech, has relinquished his duties as executive vice president and secretary of The Ramo-Wooldridge Corporation in Los Angeles, to devote full time as president of the new Space Technology Laboratories, an autonomous operating division of Ramo-Wooldridge. He remains as a board member of the parent company.

The new division is an outgrowth and extension of the company's guided missile research division, which was responsible for the technical direction and systems engineering of the Air Force ballistics missiles Atlas, Titan and Thor. Designed primarily to aid in expanding the Air Force space weapons programs, the new laboratories will have their own completely separate personnel, facilities and services, and will not engage in manufacturing operations.

Other top officers in the Space Technology Laboratories include Louis G. Dunn, '36, MS '37 ME, MS '38 AE, executive vice president and general manager, and Ruben G. Mettler '44, MS '47, PhD '49, vice president and assistant general manager.

At the same time, The Ramo-Wooldridge Corporation and Thompson Products, Inc., of Cleveland, Ohio, announced the formation of a new subsidiary corporation to be known as Thompson-Ramo-Wooldridge Products, Inc. Dean E. Wooldridge, PhD '36, president of Ramo-Wooldridge, will also serve as president of the new Los Angeles company which will concentrate its efforts on industrial process control, including the marketing of its first major product—the RW-300 digital control computer. Joseph F. Manildi, '40, MS '42, PhD '44, has been named general manager. New products in the field of industrial process control will be undertaken for the new corporation by The Ramo-Wooldridge Corporation, which will also manufacture equipment in its newly activated manufacturing facility in Denver, Colorado.


INSTITUTE
OF THE
AERONAUTICAL SCIENCES

Personals

1922

Ray W. Preston is an electrical consulting engineer in Portland, Oregon, although his work takes him to all parts of Oregon, Washington, California and Idaho.

1926

William A. Lewis, Jr., MS '27, PhD '29, is now research professor of electrical engineering at the Illinois Institute of Technology in Chicago. This is a special chair in electric power systems engineering, supported by three electric utility companies and two electrical manufacturers. Bill is also chairman of the AIEE Standards Committee for 1957-58. His son, William C., who graduated in electrical engineering, from Cornell last June, has three children of his own now.

1929

William G. Young, PhD, vice-chancellor of UCLA, was re-elected to a three-year term as regional director of the American Chemical Society last month. Bill has been a member of the UCLA faculty since 1930 and was chairman of the chemistry department from 1940 to 1948 and dean of the division of physical sciences from 1946 until last year, when he became vice-chancellor.

1933

Ray H. Cripps, vice president of American Electronics, Inc., in Los Angeles, died of a brain tumor on September 14. He leaves his wife and a son, Dale. Ray and *Arthur Lamel*, '33, were two of the three founders of American Electronics in 1945.

1934

Franklin Offner, MS, president of Offner Electronics, Inc., in Chicago, writes that he was married on September 22, 1956 to Janine Zürcher in Geneva, Switzerland. They have a son, Laurens, five months old.

1935

Norwood L. Simmons, MS, chief engineer of the west coast division of Eastman Kodak's motion picture film department in Los Angeles, has been named assistant manager of the division. He's been with the company since 1937. The Simmonses, who live in Pasadena, have five children.

1936

Reuben E. Wood, PhD '39, is doing research for the National Bureau of Standards in Washington, D.C. His most recent work in the Bureau's electrochemistry laboratory has been on wax-electrolyte batteries, at the request of the Army's Diamond Ordnance Fuze Laboratories.

1937

Rear Adm. Frederic A. Berry, USN (ret.) MS, is now in the meteorological research division of Aerometric Research, Inc., the research affiliate of North American Weather Consultants in Santa Barbara. Fred formerly headed the meteorology department of the U.S. Naval Postgraduate School. The Berrys have four children—a daughter, 11; two sons attending the University of Virginia at Charlottesville; and a married daughter living in Alexandria, Virginia.

1939

Curtis M. Lee has been transferred from the Sparrows Point Plant of the Rheem Manufacturing Company to their water heater research and development division in Chicago. He is now manager of the water heater test laboratory and writes that he's "enthusiastic about Chicago — but homesick for California."

Gustav A. Albrecht, MS, PhD '40, writes that "teaching chemistry by day and being a music critic at night gives me a sort of double life with many rewarding features. Recently when I wrote an article on science for the Pasadena *Independent*, an irate reader wrote to complain, saying I should stick to my field—music.

"This is my fourth year at Glendale College and my fifth as music critic for the *Independent*. It's a wonderful contrast to leave a faculty meeting and drop in at the paper, where people express themselves tersely, and without lofty sermons."

Martin Eichelberger, MS, former geophysical supervisor with Geophysical Service, Inc., in Dallas, Texas, is now a geophysicist in the airborne geophysics division of the Aero Service Corporation in Philadelphia.

1941

Alex E. Green, MS, writes to correct our December item about him which said he was "*formerly* with Florida State University." "Actually," he reports, "I am on a leave of absence from there (I am professor of physics and scientific director of the Tandem Van de Graaf Laboratory), to the theoretical division of the Los Alamos Scientific Laboratory where I am a physicist."

John J. Paulson, who has now been promoted to section chief of the electromechanical development section at Caltech's Jet Propulsion Laboratory, writes that "my wife and I just adopted our second child, Karla Jean, who has red hair and blue eyes and is just 4 months old. Jackie, her 4-year-old brother is very proud of her."

1942

Cdr. Jack J. Tomamichel, USN (ret.) died very suddenly last June 24, from a probable heart attack. He leaves one daughter, Joan. Jack had served in World War II and the Korean War before his retirement from the Navy in 1951.

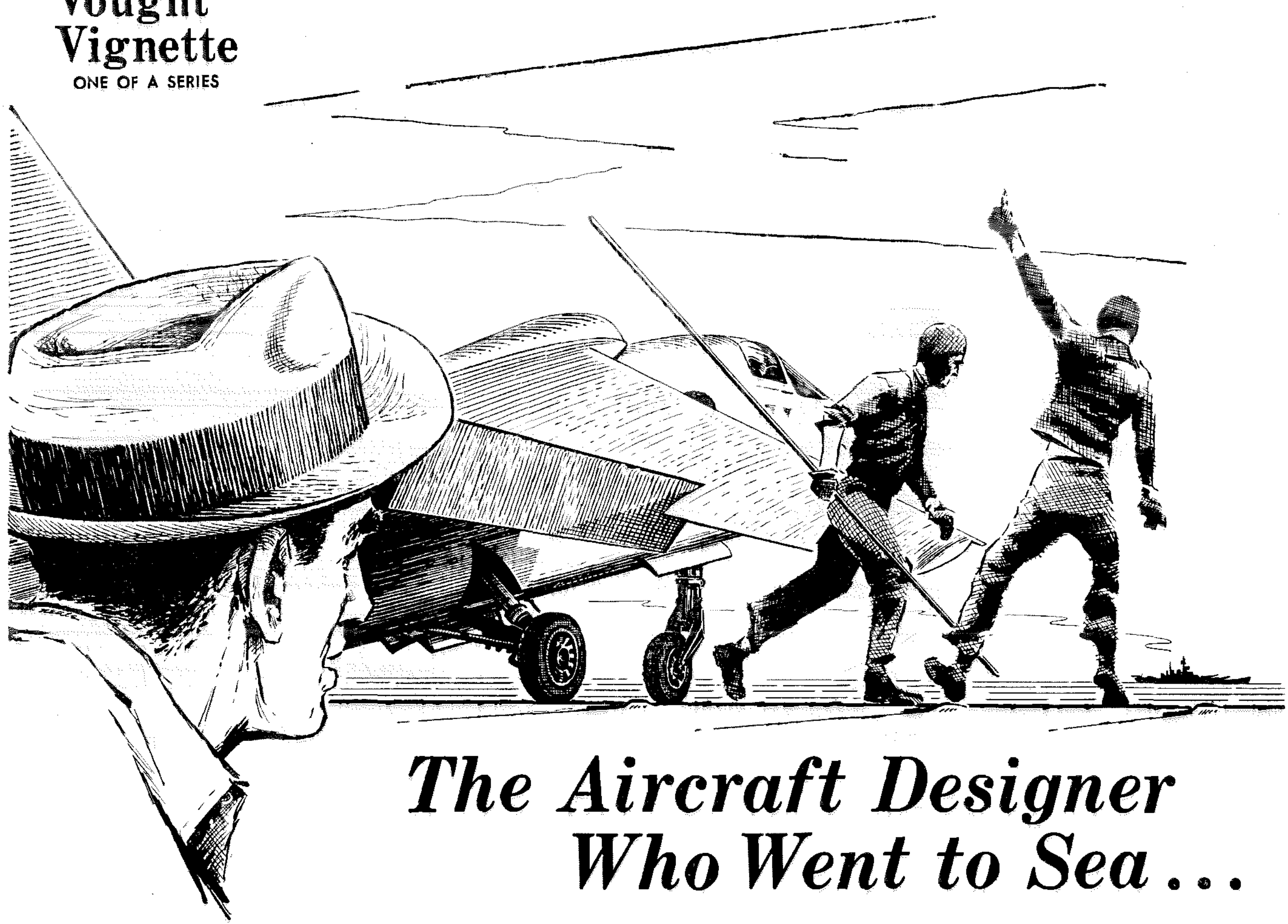
1945

Raymond Chuan, MS, AE '48, PhD '53, is conducting the installation of a new

continued on page 44

A Vought Vignette

ONE OF A SERIES



The Aircraft Designer Who Went to Sea . . .

IT WAS A ROUTINE CRUISE for the *Bon Homme Richard.* But for Wayne Burch, it was a memorable climax to months of hard work. Aboard the carrier with the Chance Vought design specialist was the white-lacquered fighter he'd worked on so long.

★

Wayne had joined the Crusader dayfighter project in Preliminary Design, on alighting and arresting gear. He'd transposed his initial drawings into detail design and, later, he'd watched his gear pass jig and aircraft drop tests. At the Navy Test Center, the Crusader's gear absorbed maximum sink speeds and arresting tension, and Burch once more was there.

★

Now, Navy pilots on the *Bon Homme Richard* were taking the Crusader to sea, and Burch was going along. This time his assignment was simply to watch, and this time the Crusader was to be just part of the picture. Vought wanted him to experience carrier life and to see how his new weapon fitted in. For Wayne, whose sea log began and ended with one day's fishing from a 20-foot launch, it promised to be an eye-opening voyage.

For six days the designer shared quarters with Navy fighter pilots and had coffee with maintenance men. He studied aircraft spotting and catapulting, and he learned the sign language of the LSO (Landing Signal Officer). He marveled at the fingersnap timing of the Navy's deck handlers and at the *Bon Homme Richard's* mid-voyage refueling of two bobbing destroyers.

★

Wayne calls it "one of the most enjoyable weeks of my life" . . . and, as other sea-going Vought engineers have discovered, "one of the most profitable, too.

"Now I know the pilot's job, what maintenance wants . . . how really big the operation is.

"It's something you don't get if you stick too close to design.

"I guess you'd call it *perspective.*"

At Chance Vought the designer stays in touch with his product . . . Contact begins in development, extends through test and includes, when possible, a study by the designer of the tactical environment in which his weapon will serve.

CHANCE VOUGHT AIRCRAFT
INCORPORATED · DALLAS, TEXAS

wind tunnel at USC, to be used for industry studies of outer space and high speed travel problems. His chief assistant on the project is *K. Krishnamurty*, MS '52, PhD '56. The wind tunnel is based on a new concept of Ray's (an outgrowth of his PhD thesis) which allows testing of tremendous air speeds and high altitude studies under controlled conditions in a small building without pumps, fans or other paraphernalia generally associated with wind tunnels. The test conditions are produced by a process of freezing air.

Arthur C. Wilbur is currently employed by the American Can Company in their research department in Barrington, Illinois. He writes that "we are temporarily residing in State College, Pennsylvania, where I am attending the AEC-sponsored International School of Nuclear Science and Engineering. The first half of the course is given here at Penn State, or at North Carolina. We will be leaving for Argonne National Laboratory at the end of January for the second half of the course. Also with me are my wife and two children—Laura, 9, and Curtis, 5."

1947

Robert M. Stewart writes that "I am leaving the Jet Propulsion Laboratory (where I am currently on the director's staff) after 7 years, to join the Ramo-Woodridge Corporation's technical staff. Will also move from Altadena to Encino. Following the death of my wife four years ago, I have been a bachelor father with two children. Hence I've been doing considerable research on the nature of housekeepers (all 16 of them!)."

Jarvis L. Schwennesen, MS, chief of the Chemical Processing Branch, Idaho Operations Office, of the U.S. Atomic Energy Commission in Idaho Falls, received the AEC's "Outstanding Service Award" in 1956.

1949

Don Hibbard, a district geologist with the Seaboard Oil Company, has been transferred to Caracas, Venezuela, where he and two other geologists are opening a new office for the company. He writes: "Things seemed to get off to a good start when a well our 3-company group is drilling in Lake Maracaibo came in for 7,200 barrels of oil per day. We have our fingers crossed that this kind of luck will continue.

"We like Caracas very much. It is a beautiful modern city with a climate about as ideal as you can hope for. If we can survive the inevitable delays and some of the Venezuelan ways of doing business, everything will be all right. As far as the family goes, we've just had our third child, Marisa, now 3 months old."

Hugh C. Carter, President of the Hugh Carter Engineering Company in Long Beach, will teach an extension course in mechanical estimating at USC this spring. The course is designed for engineers, architects and contractors interested in estimating all types of building and engineering construction materials.

Major Thomas D. Blazina, MS, who had been in the U.S. Air Force ever since he left Caltech, was killed in a plane crash at Landstuhl, Germany, on November 5.

Rolf M. Sinclair is now on leave of absence in Europe from the Westinghouse Research Laboratories in Pittsburgh, where he is a physicist. Recently he finished a year's appointment at the University of Hamburg, and is now at the Labatoire de Physique of the Ecole Normale Superieure of the University of Paris. Rolf is in a group working in low-energy nuclear research under Professor Hans Halbau. At the end of his year there, he will return to the Westinghouse Lab.

1950

Dean A. Rains, MS '51, PhD '54, is now working with the rocket propulsion group

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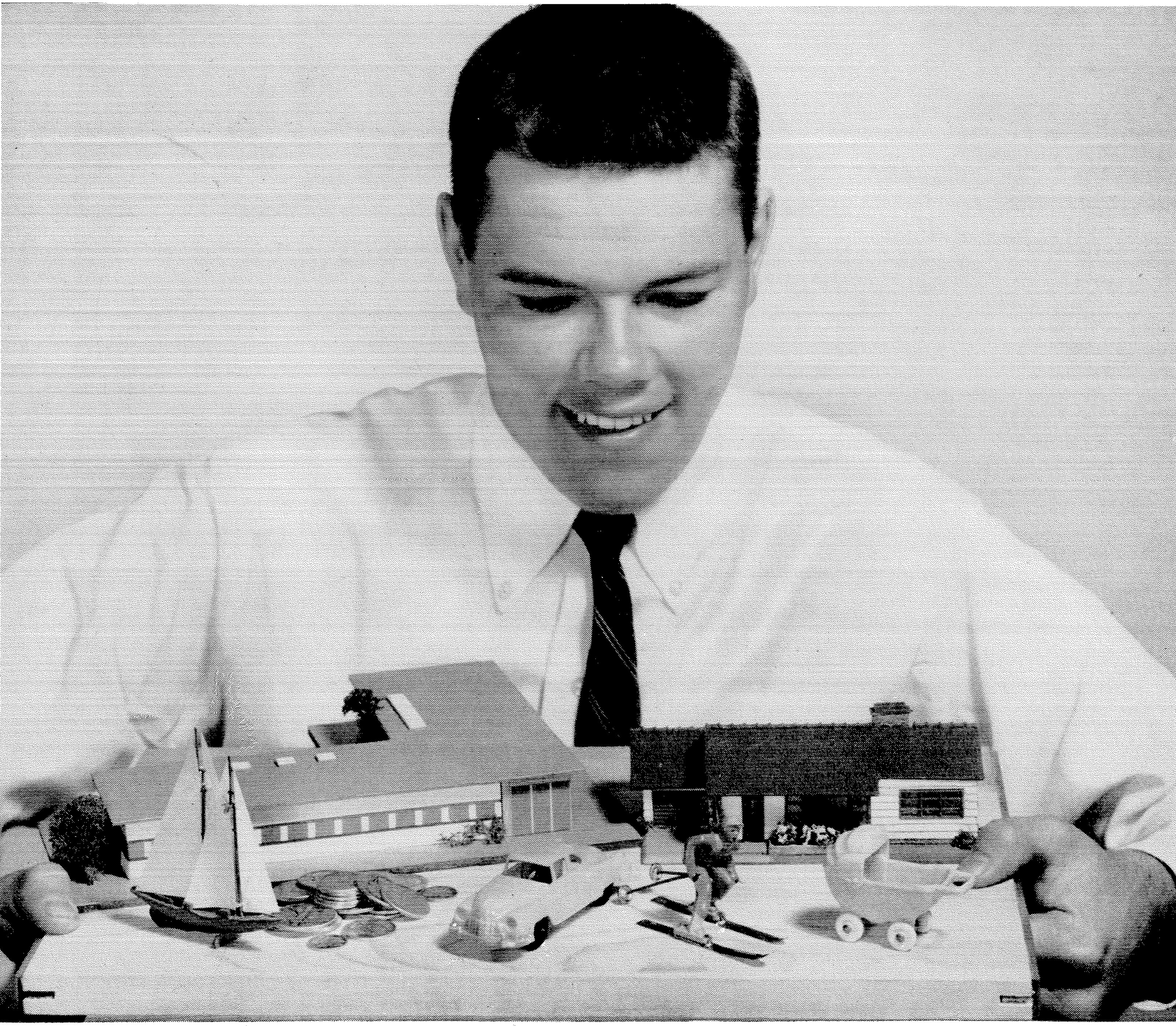
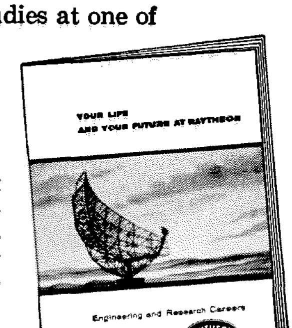
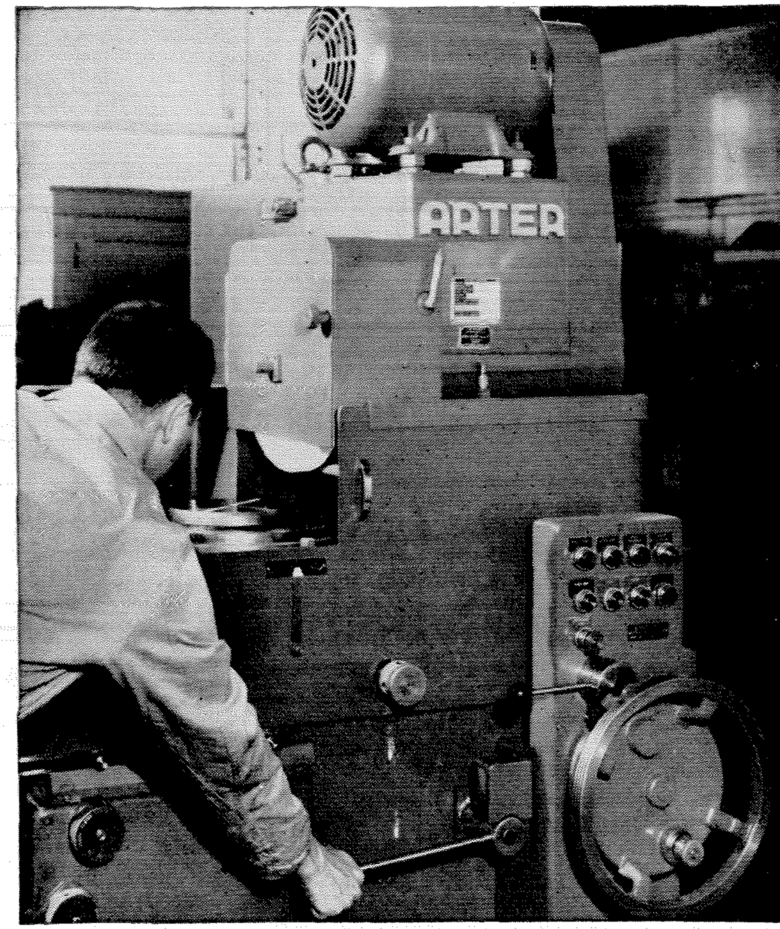




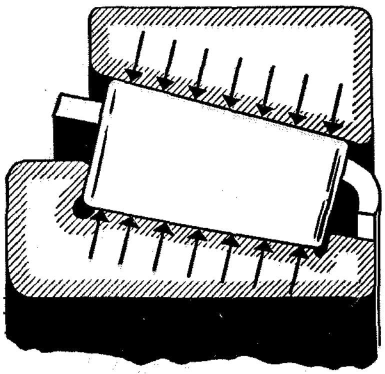
YOUR LIFE AND YOUR FUTURE AT RAYTHEON
Engineering and Research Careers

Tear out this page for **YOUR BEARING NOTEBOOK...**

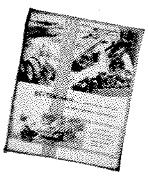
How to get higher spindle accuracy, cut costs too



The engineers who designed this new surface grinder had to be sure of the highest spindle accuracy in order to get the smooth spindle operation required for extreme precision work. To hold the work and wheel spindles rigid, maintain highest accuracy, the engineers specified Timken® "00" tapered roller bearings. Timken "00" bearings make possible the closest machining tolerances ever achieved. Run-out is held to 75 millionths of an inch. And they gave the manufacturer greater capacity in less space, cut manufacturing costs ⅓ over earlier spindles used.

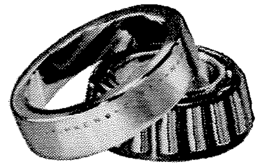


How Timken bearings hold shafts rigid to maintain accuracy—The full line contact between Timken bearing rollers and races gives shafts rigid support over a wide area. Shaft deflection is minimized. And the tapered design of Timken bearings permits them to be set up with the most desirable amount of end play or preload that gives the best performance.



Want to learn more about job opportunities? Timken bearings help make better machines. Better machines enrich our lives, give us more spare time. It's what the Timken Company calls Better-ness. Want to help create Better-ness? If so—write for your free copy of: "BETTER-ness and your career at the Timken Company". The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN TAPERED ROLLER BEARINGS



TRADE-MARK REG. U. S. PAT. OFF.

NOT JUST A BALL NOT JUST A ROLLER THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION in the guided missile research division of the Ramo-Wooldridge Corporation in Los Angeles. The Rains' fourth child, Brian, was born on November 6. Their other children are Diane, 6, Bruce, 5, and Darryl, 1.

1952

Donald E. Stewart, MS '53, who received his degree last month from the Stanford Graduate School of Business, is being married this month to Carolyn Fox of South Pasadena.

John A. Carlson, MS, PhD '55, chief of the recently-formed engineering analysis department at the Teletype Corporation in Chicago, announced the birth of a second son, Jeffrey, last April 11. Their first son, John, Jr., is two years old. The Carlsons are living in Park Ridge, Illinois.

Robert S. Davis, MS, is now director of engineering development at the Scientific Design Company in New York City.

1953

Robert Gillingham, mechanical engineering designer at Northrop Aircraft in Los Angeles, has a son, James Robert, born on October 29.

James LaTourrette, who receives his PhD from Harvard next month, will stay at Harvard for the academic year as a research fellow. He has been appointed "Lecturer on Physics" for the spring term. The LaTourette family, which includes a daughter, Mary Beth, born last October 18, is looking forward to spending next year at the University of Bonn, Germany, on an NSF postdoctoral fellowship.

Peter L. Goldacre, PhD, writes from Canberra City, Australia, that he has been appointed senior research officer (biochemist) in the division of plant industry of the Commonwealth Scientific and Industrial Research Organization.

"My wife and I," writes Peter, "look back with some affection on our two years in Pasadena as a most exciting and profitable experience in our lives, and we treasure the many warm friendships begun at Caltech. We now have two children—a daughter, Lesley Ann, 4, and a son, Philip, 2. We have acquired a block of land at Merimbula, some 150 miles away on the coast, where we are in the process of building a weekender."

Carl A. Anderson, Jr., control chemist at the Stauffer Chemical Company in Vernon, California, now has a daughter, Teresa, born on December 1.

1955

Frank Wallace, experimental engineer at the Pratt & Whitney Corporation in Manchester, Connecticut, announces the birth of a son, Stephen, on December 8.

1956

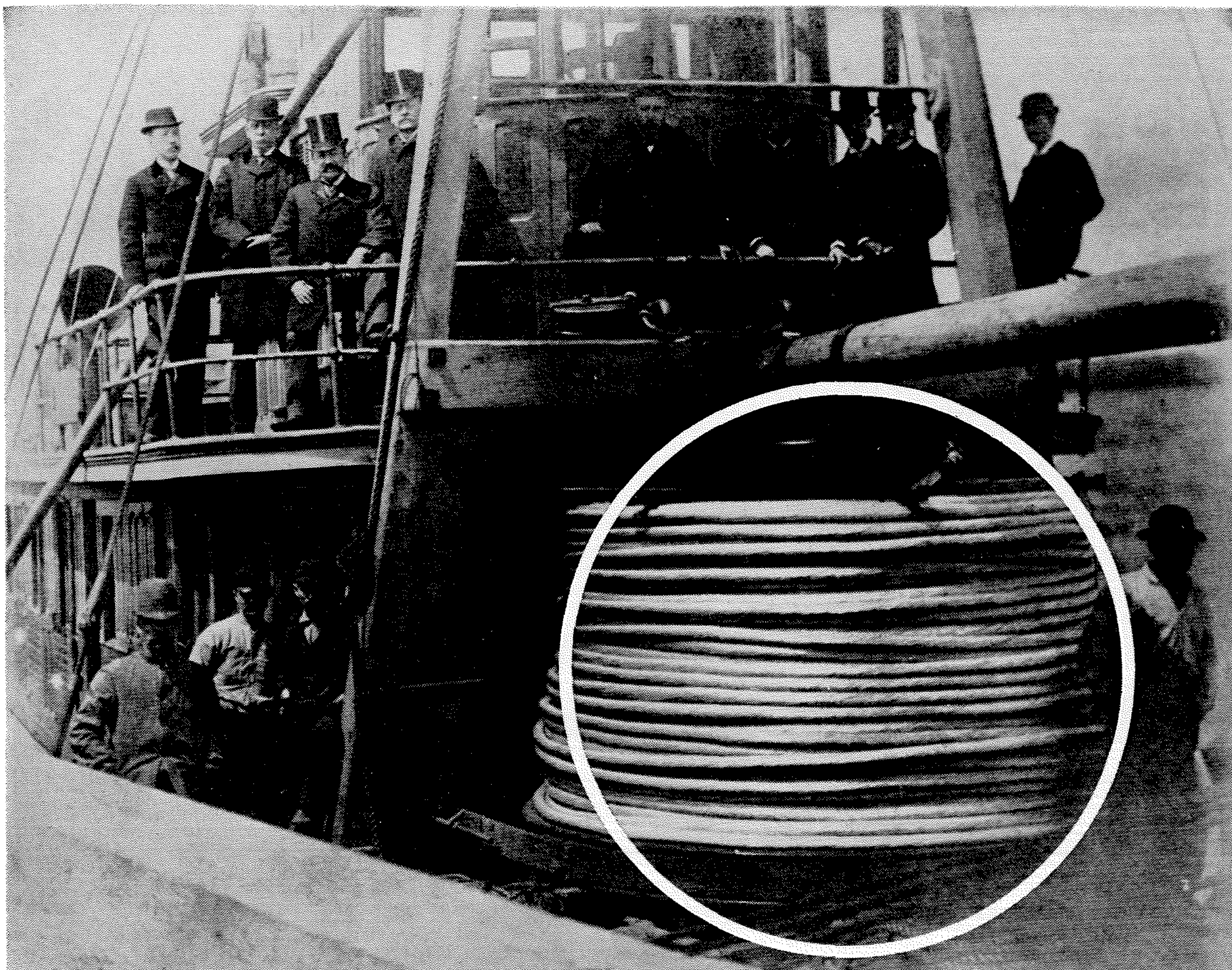
Jeremy F. Crocker is now stationed at the Aero Medical Laboratory at Wright Patterson Air Force Base in Dayton, Ohio. He was married last August to Ann Sears of Corte Madera, California, at Hamilton Air Force Base.

Lee R. Gallagher, MS, graduate student in physics at Caltech, was married on December 6 to Astrid Jansa, daughter of the former Czechoslovakian minister to Colombia, South America, in Tustin, California.

John E. Young is one of the 19 second-year students at the Harvard Law School who have been elected to membership in the Student Legislative Research Bureau. The Bureau assists members of Congress, state legislators, attorneys general, faculty members, and civic organizations in drafting legislation to be presented to federal, state, and local legislative bodies. Members are chosen from students of high scholastic standing.

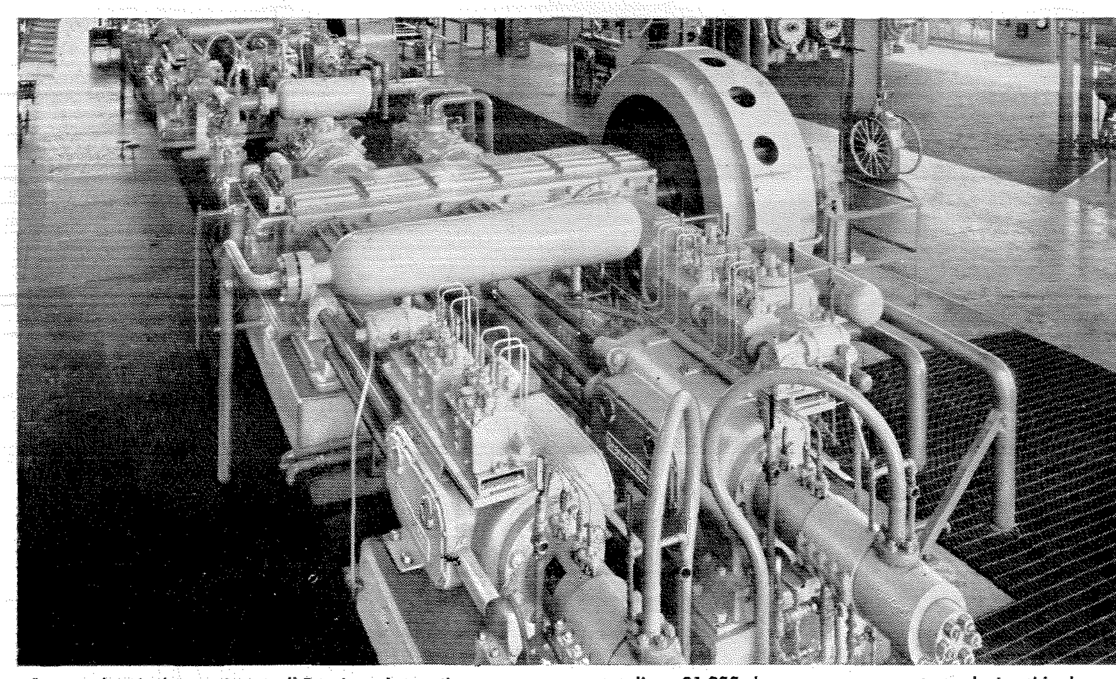
1957

Gordon R. Wicker, MS, is now a chemical engineer in the experimental plants department of the Shell Development Company's Emeryville, California, research center.



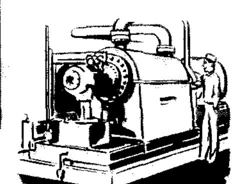
YOUR ENGINEERING CAREER

with INGERSOLL-RAND

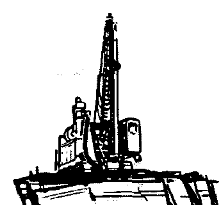


Seven electric-driven Ingersoll-Rand reciprocating compressors totaling 21,900 horsepower are at work in this large ammonia synthesis plant. The units in the foreground compress mixed gases to more than 12,000 pounds per square inch.

also means
LEADERSHIP
in

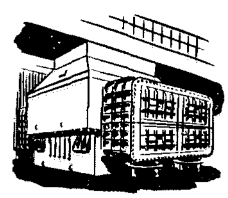


Centrifugal Pumps

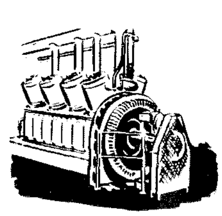


Rock Drills

Air & Electric Tools



Steam Condensers



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Here's What Compressor Engineering at Ingersoll-Rand can mean to you...

TODAY, air power is one of the industry's most vital requirements. Compressed air and gases are the "breath of life" to chemical and process industries, refineries, power plants, steel mills, manufacturing plants, mines and all types of construction jobs. Hence, compressor and blower engineering offers an exciting and ever-expanding field of challenging opportunities that are virtually industry-wide.

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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

VARSITY BASKETBALL

January 18
Caltech at LaVerne

January 21
Caltech at Nazarenes

January 25
Caltech at Redlands

January 28
LA State at Caltech

February 1
Redlands at Caltech

February 7
Caltech at Whittier

February 8
Caltech at LA State

February 11
Caltech at Occidental

FRIDAY EVENING DEMONSTRATION LECTURES

Lecture Hall, 201 Bridge, 7:30 P.M.

January 17
A New Method for Exploring the Depths of Oceans
Dr. Harrison Brown

January 24
Desalting the Pacific
Dr. Jack E. McKee

January 31
The Temperatures of Past Epochs
Dr. Samuel Epstein

February 7
Earthquakes
Dr. Hugo Benioff

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U. S. Navy Electronics Laboratory

One of a series*

Interview with General Electric's Earl G. Abbott Manager—Sales Training

Advancement in a Large Company: How it Works

Where do you find better advancement opportunities—in a large company or a small one? To help you, the college student, resolve that problem, Mr. Abbott answers the following questions concerning advancement opportunities in engineering, manufacturing and technical marketing at General Electric.

Q. In a large Company such as General Electric, how can you assure that every man deserving of recognition will get it? Don't some capable people become lost?

A. No, they don't. And it's because of the way G.E. has been organized. By decentralizing into more than a hundred smaller operating departments, we've been able to pinpoint both authority and responsibility. Our products are engineered, manufactured and marketed by many departments comparable to small companies. Since each is completely responsible for its success and profitability, each individual within the department has a defined share of that responsibility. Therefore, outstanding performance is readily recognized.

Q. If that's the case, are opportunities for advancement limited to openings within the department?

A. Not at all. That's one of the advantages of our decentralized organization. It creates small operations that individuals can "get their arms around", and still reserves and enhances the inherent advantages of a large company. Widely diverse opportunities and promotions are available on a Company-wide basis.

Q. But how does a department find the best man, Company-wide?

A. We've developed personnel registers to assure that the best qualified men for the job are not overlooked. The registers contain complete appraisals of professional employees. They enable a manager to make a thorough and objective search of the entire General Electric Company and come up with the man best qualified for the job.

Q. How do advancement opportunities for technical graduates stack-up with those of other graduates?

A. Very well. General Electric is recognized as a Company with outstanding technical skills and facilities. One out of every thirteen employees is a scientist or engineer. And approximately 50 per cent of our Department General Managers have technical backgrounds.

Q. How about speed of advancement? Is G.E. a "young man's Company"?

A. Definitely. A majority of all supervisors, managers and outstanding individual contributors working in the engineering function are below the age of forty. We believe that a job should be one for which you are qualified, but above all it should be one that challenges your ability. As you master one job we feel that consideration should be given to moving you to a position of greater responsibility. This is working, for in the professional field, one out of four of our people are in positions of greater responsibility today than they were a year ago.

Q. Some men want to remain in a specialized technical job rather than go into managerial work. How does this affect their advancement?

A. At G.E. there are many paths which lead to higher positions of recognition and prestige. Every man is essentially free to select the course which best fits both his abilities and interests. Furthermore, he may modify that course if his interests change as his career progresses. Along any of these paths he may advance within the Company to very high levels of recognition and salary.

Q. What aids to advancement does General Electric provide?

A. We believe that it's just sound business policy to provide a stimulating climate for personal development. As the individual develops, through his own efforts, the Company benefits from his contributions. General Electric has done much to provide the right kind of opportunity for its employees. Outstanding college graduates are given graduate study aid through the G-E Honors Program and Tuition Refund Program. Technical graduates entering the Engineering, Manufacturing, or Technical Marketing Programs start with on-the-job training and related study as preparation for more responsible positions. Throughout their G-E careers they receive frequent appraisals as a guide for self development. Company-conducted courses are offered again at all levels of the organization. These help professionals gain the increasingly higher levels of education demanded by the complexities of modern business. Our goal is to see every man advance to the full limits of his capabilities.

If you have other questions or want information on our programs for technical graduates, write to E. G. Abbott, Section 959-9, General Electric Co., Schenectady 5, N. Y.

***LOOK FOR other interviews discussing: • Qualities We Look For in Young Engineers • Personal Development • Salary.**

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