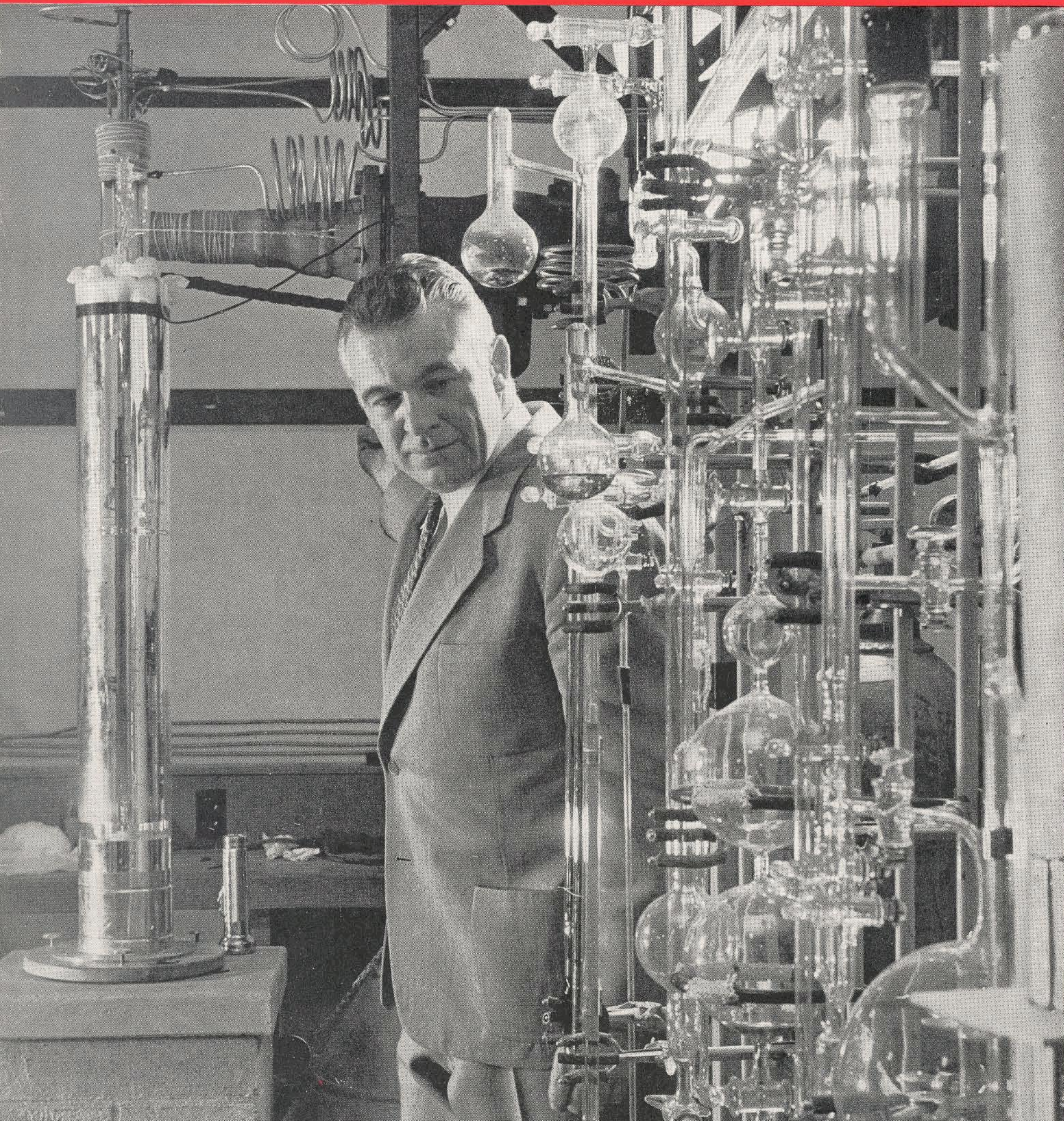
ENGINEERING | AND | SCIENCE

MAY/1958



The coldest spot in the world . . . page 18

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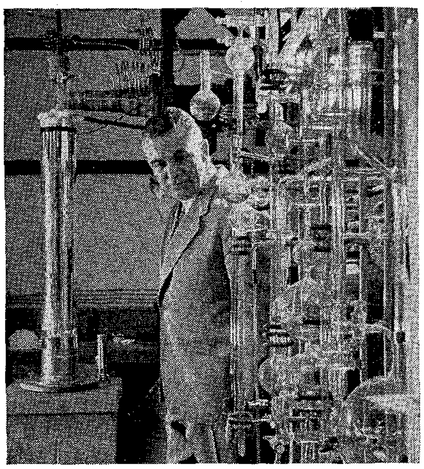
HOMECOMING

ENGINEERING AND SCIENCE

IN THIS ISSUE



ON THE COVER—John R. Pellam, Caltech professor of physics, and the spectacular glass structure he uses to condense helium 3 for his low-temperature research. Helium is forced by mercury through the glass bulbs to the silver dewar at the left. By pressure, and a temperature of 1.° K., the helium is condensed into about 1 cc. of fluid. Only one small drop of this may be the actual rare isotope, helium 3, which is now being used for studies of absolute zero.

For more about low-temperature physics, see page 18.

H. ROWAN GAITHER, whose Alumni Seminar speech, "Science and the National Welfare," appears on page 9 of this issue, is chairman of the board of the Ford Foundation, and the Rand Corporation. He is also chairman of the science resources panel of President Eisenhower's Science Advisory Committee, whose still-secret "Gaither Report" stirred up considerable excitement in the press recently.

PICTURE CREDITS

Cover	Richard Hartt
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Books

Modern Science and the Nature of Life
by William S. Beck
Harcourt, Brace and Co., N.Y. $5.75

The Dawn of Life
by J. H. Rush
Hanover House, N.Y. $4.50

Reviewed by George W. Beadle
Chairman of the Biology Division

These are exciting days in the biology laboratory. Viruses are disemboweled and reassembled in ways that promise to reveal the innermost molecular secrets of these simplest of known living systems. The structure of the protein molecule and the sequences of its amino acid building blocks are yielding to the patience and persistence of chemists. The detailed structure of deoxyribonucleic acid (DNA) is understood in ways that promise to tell us how this carrier of genetic information is reproduced at each cell division with almost unbelievable precision. And we are close to an understanding of the manner in which this gene material undergoes mutation—the basis of all organic evolution—and the mechanism by which the information coded within it is used in the synthesis of the thousands of kinds of protein molecules of which we are so largely built.

Biochemists seem on the verge of a complete synthesis of nucleic acid of the type that could have been the beginning of organic evolution on earth. If man succeeds in making such a primitive "living" molecule in a test tube—living because it can both reproduce and evolve—it will no longer seem miraculous. The mystery of life is rapidly being replaced by understanding—the deep and rewarding understanding that is the goal of all science.

Many of these breakthroughs in biology have been made by chemists and physicists who have responded to the challenge of the problems of biology.

With Sputniks, Explorers and Vanguards, public interest in science in general has been raised to a high pitch, even though the orbiting satellites are not themselves science but are rather spectacular technological applications of science.

We are barraged with information and misinformation about fallout from tests of nuclear weapons and its mutation-producing properties. The man in the street argues with the doctor about whether that recommended X-ray examination or treatment will make monsters of his children. The ninth-grade member of the Science Club asks: "What is the difference between DNA and RNA?"

It is good that the urge to know about science in general and biology in particular has grown to such proportions, for more and more the decisions that affect the future of our free and democratic society involve science and its applications.

The two books reviewed here should go a long way toward satisfying the non-specialist's thirst for knowledge about the new biology, and for an understanding of its proper place in the science that has become such an important part of man's culture.

William Beck's delightfully written book is the more general of the two. It describes science as science, and examines it from a sound and informative philosophical point of view.

In the author's own words: "This book is being written in the belief that science and scientific methods are the best means available to us for solving the problems of our cultural crisis. Science is, beyond question, the outstanding feature of modern civilization. Our world is, to an increasing extent, dominated, if not by pure science itself, then by the conceptions of the public at large and its leaders concerning the nature of science. More and more, this idea of science, misunderstood through it is, has gained in influence, and, as its status has changed, great new problems have arisen, many of which have yet even to be identified as problems by the majority of people.

"It can be argued, I think (and I intend to argue), that much of humanity's present difficulty stems from the paradoxically strained relations between science and the other areas of knowledge, and from the surpassing paradoxes within science itself, the very ingredients which make it such a frustrating and delightful mistress to its practitioners.

"These paradoxes are an important cause of the present crisis; they are its consequences and one of its best examples. For the essence of science is paradox and, in trying to explain science, this is one of the main points I hope to get across.

"To the mid-twentieth-century citizen, science is an almost grotesquely ambivalent phenomenon: it is at the same time highly systematic in its approach to the real world, yet it is never complete and never reaches final conclusions. It is the model of certainty in its methodology and logic, yet its driving force is deliberate doubt, and its results are probable, never certain. It requires of its workers absolute discipline, yet it is the fountainhead of exciting new ideas and new ways of thought. Though it may be local in origin, its conclusions are universal. For its creators it is a supreme adventure of the spirit, while at the same time it is the sole basis of endless reams of myth and superstition. It is the healer and builder and the propagator of untold suffering and death. Is it any wonder that science, the strong, the promising, the unforeseeable, the anarchical force in our modern world, should be the cause of acute anxiety?"

Beck goes on to discuss such topics as the nature of science, how biology became a science, what is certainty, the cell as a unit of life, how life evolves, the nature of life, the technique of discovery, genes, viruses, the origin of life, the problem of cancer and the nature of mind. All these

CREATIVITY

and PRODUCIBILITY

Basic research has been described as "a search for knowledge, unfettered by production demands." At Avco, we realize that fundamental new ideas cannot be programmed in advance to fit the needs of even the highest priority schedule. There will always be room here for this kind of basic creative work.

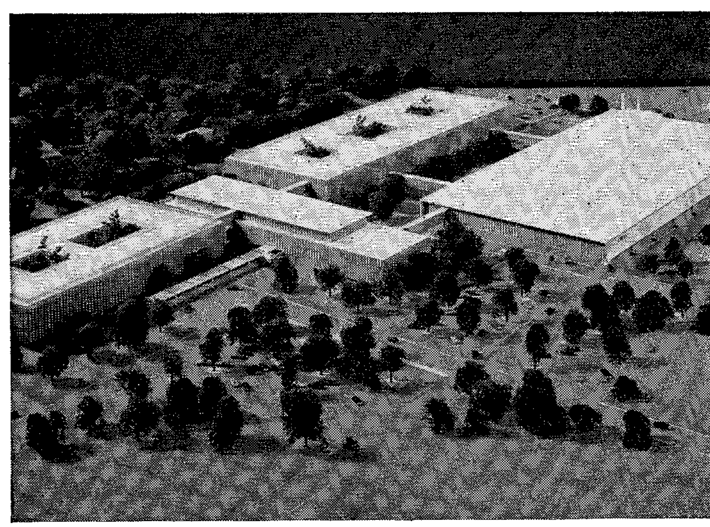
Yet, as an industrial research operation, we want to realize the material benefits that have historically resulted from scientific breakthroughs. Economic common sense and national security require an industrial research structure that can transform the idea in a scientist's brain into workable, useful hardware.

We see nothing inconsistent in the pursuit of new products simultaneously with the pursuit of new ideas—and doing both under the same roof. Rather, we feel that the continuous feedback resulting from close association of basic research people, applied scientists and engineers, test engineers and product engineers does as much for creativity as for producibility. And America's future depends upon a good supply of both.

Robert D. Grange

Robert D. Grange,
Manager, Prototype Development Department

Robert D. Grange



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.

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.

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things he does with wit, skill and a refreshing literary style.

Rush concerns himself mainly with living systems. His is a more nearly straightforward presentation of the subject matter of modern biology. The thread of continuity is evolution, inorganic and organic, from the primordial earth to the present.

More and more we are coming to see that evolution is a continuous process from the hydrogen of the primitive universe, through elements, inorganic molecules, complex carbon compounds, simple virus-like systems, and on to man himself.

At first thought this concept may seem crudely and revoltingly materialistic. It seems to leave no room for a Creator. But when one asks the question, "Does it require less faith in a universe so designed as to be capable of giving rise to man by an orderly process of evolution than it does to accept the creation of man in his present state?" one sees that modern science has in no way changed the problem of what lies beyond the knowable.

Dawn of life

Rush, a physicist, tells us in his preface how he became interested in biology and what he attempts to accomplish in his book:

"Sometime between the formation of the earth and the advent of man, the first tentative organic systems crossed the uncertain boundary line from the non-living world to that of the living. The origin of life is a uniquely appealing mystery. It is something that unqestionably happened, an event in the finite past. Yet the idea of a world without life, and the manner by which life came into it, both challenge the imagination to the utmost. I developed an active interest in the subject out of my professional work in physics and astronomy. No one, I believe, can be concerned with the throng of planets and stars and galaxies that fill the depths of space without wondering whether other worlds than ours—Mars, perhaps, or Venus, or the unknown planetary families attending other stars—are peopled by life and even intelligence. This preoccupation leads one immediately to wonder about the adaptability of life to radically different environments, and to make some educated guesses as to the conditions that prevail on other planets. It is but a step from such thoughts to the more fundamental question of the origin of life, on earth or elsewhere.

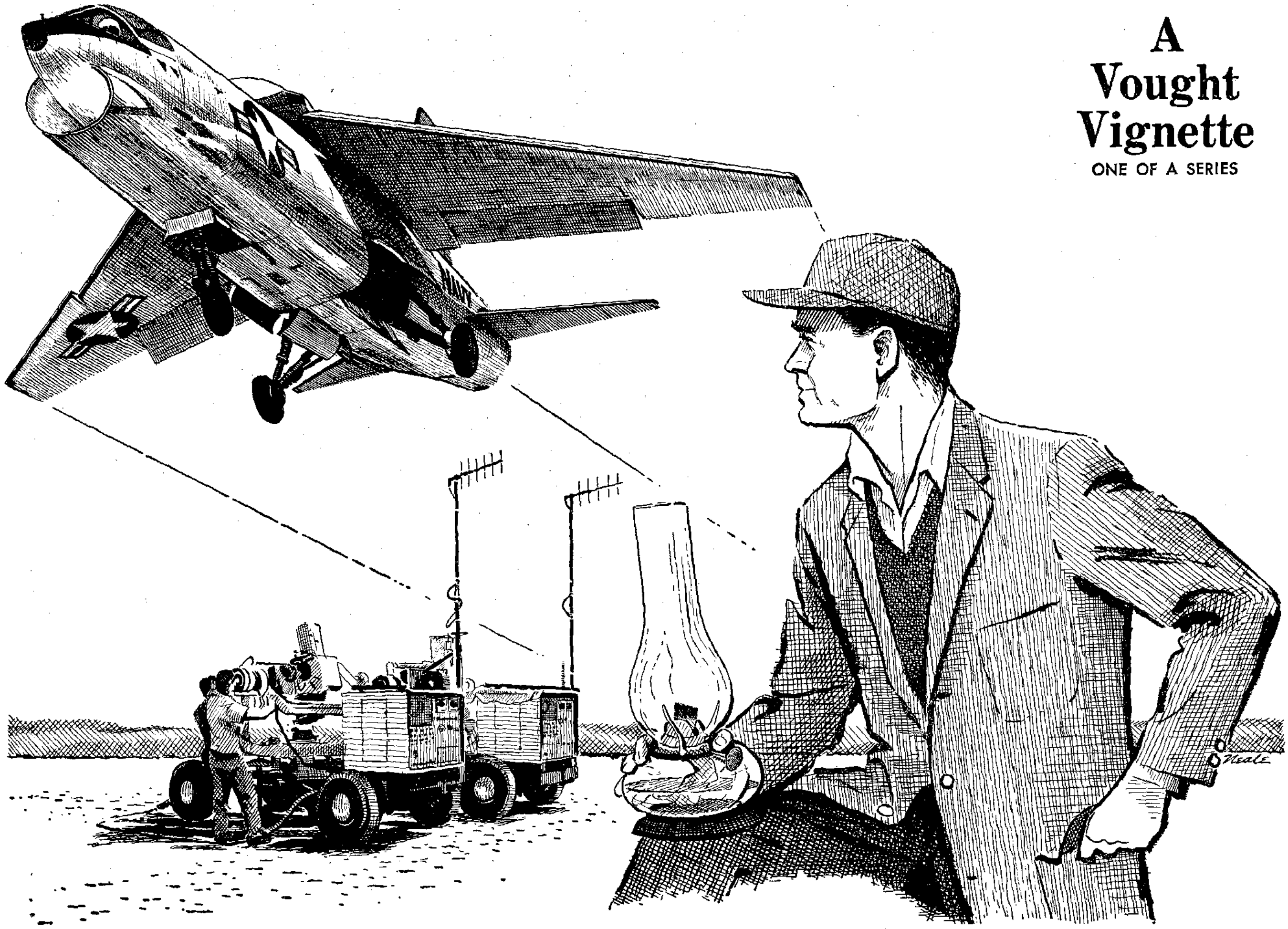
Showing the way

"This book is not intended to give an answer to the riddle of life's origin, but to point a direction. The principle of rational inquiry, of reasoning logically from experience, has served us well. Its range of application broadens as science consolidates its gains. Yet we have only very recently learned enough of astronomy and physics, of the earth's history, of chemistry and biology, to be able to bring the origin of life out of the realm of pure conjecture. The detailed ideas and interpretations set forth in this book undoubtedly will be drastically modified as our understanding grows; but I do not believe that the direction in which they lead our thinking will be changed. That direction is expressed in the conviction that life is a natural phenomenon in the same sense that the phenomena of inanimate matter are natural, and that life will develop out of non-living material wherever suitable conditions prevail for a sufficient time."

The book includes a discussion of the ever-fascinating possibility of life on other solar planets and elsewhere in the universe. It concludes with a chapter on the emergence of mind, that remarkable product of evolution that has made it possible for man to add cumulative cultural inheritance, including science, to the blind biological inheritance of his evolutionary forbears.

I know of no easier or more enjoyable way to learn about the new biology than to read these two books.

A
Vought
Vignette
ONE OF A SERIES



Soot Solved This Problem

One thing Richard (Rick) MacDonnell could say for flight test instrumentation — it had variety. Here he was, in line of duty, hunting a coal oil lamp on the Mojave Desert.

Looking back, Rick saw that the whole Crusader instrumentation program had been a series of shifting scenes. He'd started by talking to different specialists, finding out the kinds of flight information they wanted. He learned a lot about heats, loads, amplitudes and flutter. These were the things Rick's instrumentation would have to detect.

Designing and building the system took him in another direction. There was the airborne equipment — up to 12 miles of wiring and 600 pounds of black boxes for a single demonstration aircraft. Each sub-system was environment-tested, breadboarded, checked out and packaged to fit key corners of the Crusader structure.

Taking shape at the same time was a mobile ground station — another project with which Rick was associated. It brought flight test telemetering and data processing closer to automation than they'd ever been before. At Vought's Mojave Desert test base, Rick's equipment clicked. It speeded preparation for the Crusader's dramatic operational debut — the Thompson Trophy-winning speed run.

There was just one hitch — a National Aeronautical Association rule which would limit altitude deviation to 328 feet during the Trophy dash. A Bureau of Standards barograph would ride with the pilot, its stylus etching out exact altitude on a smoked cylinder. Fair enough — but Vought's desert crew didn't have a workable way to blacken duplicate cylinders for practice. And precise warm-up flights were essential.

That's why Rick went hunting for a coal oil lamp. He found one in the store of a desert outfitter. Back on the base, the lamp was lighted and the wick turned up. It "sooted" the purpose perfectly.

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N. Boyle

Science and the National Welfare

Our survival depends on our ability to act decisively —— and now

by H. Rowan Gaither

It is now just six months since the human race propelled some exciting hardware, and then man's best friend, into outer space. I do not have to remind anyone here that the first successful adventurers into this new age of outer space were not Americans, as we hoped would be the case, but Russians.

Americans have shared outer space with the Russians for only a part of this time. And for that success, delayed though it was by decisions of a non-scientific and non-technical nature, the American people must thank the men of Caltech's Jet Propulsion Laboratory. From the date the job finally was authorized by Washington until the first American earth satellite shot up, and out, and into orbit took only 12 weeks. This is nothing if not remarkable.

Nevertheless, we cannot ignore the fact that the date history will attach to the opening of the age of outer space will be a date written in Cyrillic characters. This is not a belated, dubious, or cynical claim like those we became familiar with several years back—when Russia was telling the world and itself that practically every technical and scientific advance known to man was Russian in origin. This claim on the original penetration of outer space is real—and we cannot afford the luxury of derisive laughter.

From all the confusion that ensued in the wake of Russia's first Sputnik, one might almost think our scientific and technological impulse had ground to an unhappy halt and that the only thing left to wait for was the end itself. One might even conclude from the furor that no one in the scientific community had engaged in responsible thinking about any of our most critical needs.

I think it is fair to point out that some of the loudest critics of the scientific community in recent years may very well have drowned out what the scientists were trying to tell us.

I come neither as a critic nor as a scientist. I should like to talk with you about science and the national welfare in the language of one who is himself not a man of science or technology. I would not be so presumptuous as to try to tell you how your job should be done. But in all conscience I can talk with you in terms of what the job ahead is, as I see it.

My premise is simple. Science and the national welfare are linked insolubly.

This is as true for the Russians as it is for ourselves. It is necessary to understand—as now indeed we do—that science and technology are not a monopoly of the free nations.

We face real needs and hard choices. So let us first of all do away with the soft words.

I am convinced of three interrelated propositions:

First, that our national welfare—and to us that means spiritual and political freedom as well as mere physical survival—depends to a preponderant and unmeasurable degree upon the future course of American science and technology.

Second, that American science and technology, which once our people thought to be unquestionably unsurpassed, *has not yet attained the strength and viability necessary to guarantee our welfare and survival in a prolonged period of international crisis.*

Third, the American people and their representatives in government must understand the extent to which their progress and security depend upon science and technology—and must understand what large tasks await us all in this connection. As of this moment, this understanding still has not been fully awakened.

There is evidence that whatever awareness has developed under the impact of recent events may already be receding in the light of our own successful orbiting of satellites. We must guard zealously against any return to complacency. The responsibility for this rests on each of us—on our men of government, on our men of education, our men of industry, on the citizens at large and even on the institutions which already are most responsive to the needs.

America must view its strengths and weaknesses in the

"Science and the National Welfare" has been adapted from a talk given by Mr. Gaither at Caltech's 21st annual Alumni Seminar on April 12. Mr. Gaither is chairman of the trustees of the Ford Foundation.

time perspective of the remaining years of the 20th century, in the social perspective of what we want America to be, in the politico-military perspective of the external threats to our values and principles, and in the humanitarian perspective of our acknowledged responsibilities to mankind everywhere.

In this total perspective, the relative strength of the United States is not adequate to these historic responsibilities.

I will not, however, be a prophet of gloom. There is time to repair this situation and to build our relative strength—*if we act decisively and act now.* The United States is the world's most powerful nation today. If we act now it will remain the most powerful nation in the future.

Let us look forward a few years—to 1975. This is only as far into the future as we already have come from Pearl Harbor; and we know what vast changes have affected mankind in that short span of years.

Let us, for purposes of our discussion, make several assumptions. Let us assume, first, that there will be no general nuclear war during these next two decades. We must base this on the further assumption that our nation will maintain a military capacity for retaliation that will stay the hand of any would-be aggressor.

Let us assume also that the principal communist powers, the Soviet Union and Red China, will remain politically intact and stable.

And let us assume that the political destiny of the newly independent and largely underdeveloped nations of Africa and Asia will largely be determined during these two critical decades.

The communist world

Based on these assumptions, the communist world as we define it today will present in the 1970's the following picture:

It will have a subjugated population of upwards of $1\frac{1}{4}$ billion people;

It will command, as it does today, one-third of the world's land mass;

It will have weapons and weapons systems capable of delivering catastrophic destruction in a matter of minutes to any nation of the world, and a general military capability of engaging in conventional wars in Europe, Asia, the Middle East and Africa;

And the Soviet Union, perhaps alone, will have reached a gross national product at least equal to that of the United States, with all the implications inherent in that for their military expenditures and for their ceaseless economic and political offensives in the non-communist world.

Forecasting the future comparative growths of the U.S. and the U.S.S.R. is, within certain limits, necessarily speculative. There is conservative economic opinion that the likely future rate of Soviet industrial growth will be significantly higher than ours, that the interval for which we will remain the biggest industrial power is 15 to 30 years. But the "cross-over" point in either gross national product or in industrial output is not as meaningful as the fact that today the Soviet Union, with an industrial base roughly two-fifths of ours, maintains a thoroughly modernized and menacing military establishment and prosecutes an increasing program of foreign economic subversion and infiltration.

Russia is currently graduating 500 engineers per billion dollars of GNP while we are graduating about 60. What this portends for the future relative rate at which technological creativity is injected into the Russian economy and military technology, and for the scientific manpower serving the communists' military purposes and economic offensives, is arguable in degree but ominous in total.

These are some of the blunt and awesome facts that come clear as we look at the future in perspective.

We dare not comfort ourselves with hollow hopes.

Key to the future

Our total relative strength is the key to the future. This strength at any given moment is a compound of many factors—populations, economic forces, scientific achievement, military capability, industrial progress, educational commitments. Communism's strength relative to the free world is based on the same factors.

The communist world and the free world are two dynamic systems *at work, moving at different rates of* speed, taking different turns, and driving ultimately toward ideological goals which are diametrically opposed.

If we are to plan with any degree of hard realism, we must expect the Russians not only will maintain but actually will increase their rate of forward industrial and economic development. And let us not underestimate the potential power of Red China. It is on this basis that I must conclude that our relative strength is ebbing.

There are those who will argue that my assumptions put the communist position in the most optimistic light possible and, by contrast, our position in a pessimistic light. I fervently hope that, in this, history will prove I am in gross error. But I will contend, with all the emphasis at my command, that these assumptions are warranted—indeed compelled—by any objective appraisal and that we cannot lose if we make them and act accordingly.

We will have maintained a constant military readiness to suppress with strength the possibility of nuclear disaster at home and throughout the free world. We will have cut wasteful fat from our economic and social frame and hardened our ideological muscle. Our society will have had the incalculable benefit of research, education and expansion from which so much of our future economic and democratic strength will derive. We will be fully prepared for almost any eventuality of the decades ahead. If time ultimately proves my assumption of communist strength to be grossly overestimated, then the United States and all mankind will be the beneficiary on every count of our expanded effort.

H. G. Wells said that "human history becomes more and more a race between education and catastrophe." We are intimately involved in this race. Science, of course, is but one part of education's total job—important in the extreme, but only one part.

Education must produce enlightened human beings determined to preserve fundamental values and principles. It must produce an informed citizenry able to accept responsibility and to make democratic processes fully effective even in a protracted period of great stress. It must produce political leaders for the management of government, and judicial leaders to uphold the supremacy of law and reason. It must produce leaders for all sectors of our society who place foremost our freedoms and economic strengths, and scholars, scientists and teachers adequate in number and competence to meet the ever-growing demands already confronting our heavily committed educational resources.

The role of education in the decades ahead being as all-encompassing as it is, why do I equate to such a large degree our national welfare with science?

I see three major reasons.

The power to destroy

The first is the inescapable if burdensome call for military technology of the highest order. The nature of Russian and American weapons development is such that when intercontinental missiles with nuclear warheads are operational, the United States and Russia will possess the power to destroy each other.

The second major reason that I equate our national welfare and science is that the security of the United States and the free world depends upon the ability of our nation and our allies to maintain economic strength and viability. We know the counterpull of economic weakness and debility. A strong economy is basic to national welfare—and nothing feeds and invigorates the economy more than science and technology.

The third major reason for equating the national welfare and science is that it is imperative for the industrialized nations of the free world to assist the less-developed nations of the free world in their Herculean task of achieving better standards of living for their peoples and the foundations for economic development with democratic principles. The ultimate course of civilization and freedom may depend on whether they succeed or fail in attaining these goals.

That our communist competitors know their destiny too turns largely on science and technology is abundantly clear. From the very outset of their communist regimes, both the Soviet Union and Red China have made industrialization overriding national objectives. In the pursuit of this, extraordinary emphasis has been put on science and technology in the school systems of those countries.

What then can be done to bolster our scientific and technological strength?

First and foremost, education in science and technology must be improved at all levels.

Our objective must be to produce men and women who are both superbly trained in science and technology and broadly educated. And we need men and women in the humanities and social sciences who are educated in the physical and natural sciences and technology as well. We cannot settle for less.

We must subject ourselves to a searching self-scrutiny as to curriculum content and techniques. We must hold the best science teachers in their honored and vital profession and increase their numbers and competence.

Improving education

The upcoming generation of students must be better prepared for the rigors of advanced study. We must guard against the preoccupation of the day and remind ourselves that boys and girls in our high schools today will be the new scientists and engineers in the most critical period in our history. Not only must they be assured of the best education we can devise, but also they must not be denied that education for economic reasons. We must get on with the task of improving education today—even though we do not find all the solutions for many years to come.

In this connection, those institutions which even now carry the special burden of leadership, institutions like your own California Institute of Technology, the Massachusetts Institute of Technology, and others, have an urgent and weighty responsibility to our national welfare.

In addition, these great institutions must now take on a strong, new role—education of the general public about the role of science and technology as an integral part of our whole social fabric.

Never before has it been so important that there be public understanding of science as a part of our culture and of the essential nature of science to our security and our progress.

Without such widespread understanding there cannot develop the support which is desperately needed.

The classical role of institutions such as those I have named has embraced both education and research. Now additional stress must be put on the improvement of research.

The research function has been augmented, particularly in periods of national peril, to provide scientific assistance to government. This responsibility has been built into the very structure of these institutions, and will remain there, I think, forever—even as such institutions have provided ever-increasing scientific and technological assistance to industry. Both government and industry must now bear in mind the intimate relationship between the establishment of scientific principle and application of that principle, and the order in which these occur.

Pure science, in any field, demands an atmosphere of freedom to seek the truth, wherever it leads. Where we lack the knowledge or the insight to see its ultimate application, if any, then we must have faith. The understanding will come later. Even those who underrate basic research must acknowledge in pragmatic terms, if they insist on direct application, that basic research does pay off. It always has.

We dare not overlook, however, the importance of applying the results of our basic research.

The Russians have demonstrated, particularly in weapons technology, great speed and efficiency in telescoping the time interval between discovery and operational use. In the modern world the fastest transition time may carry with it the decisive margin of power.

Aside from the important military aspects, the days and years ahead dictate that scientific knowledge and techniques be brought to bear on all our problems—and that this be accomplished without injury to education as a whole or to basic research.

One important way to pursue this goal is for the academic scientist, the governmental scientist and the industrial scientist to meet on common ground. Such a meeting ground is the technological institute. *The technological institutes must accept this willingly and in doing so must have the full understanding and support of their trustees, staff and alumni.*

All of this is fundamental to the vastly increased understanding which is so necessary if science and technology are to flourish as they must in the interests of our national vigor. And all of this, admittedly, is quite an order. *How do you go about it?* One part of the answer is in terms of dollars.

Uncommitted dollars

Government has dollars, but generally wants specific answers to specific problems for its dollars.

Industry has dollars, and for its dollars generally asks something of the same.

Foundations have dollars, but all the funds available to foundation philanthropy in the United States, however large they may seem, can only serve to point up the needs, to help others seek experimental courses of action, and to challenge still others to share the burden.

Yet the very nature of our problems of science and national welfare transcend any immediate need of any potential participant—government, industry, alumni or whatever.

The easiest money to get is for applied research — where results are often predictable, if not, in fact, specified in advance. This, however, is not general-support money. Yet the ability of institutions to handle applied research rises or falls in direct relation to the soundness of the overall academic structure.

The kind of general financial support that I speak of is imperative in building the overall strength of our institutions of learning. This kind of money—the so-called free or uncommitted money—is unfortunately the hardest of all to get. It also is the most important.

This free money is free only in the sense that it has no strings attached—no *quid pro quo*, no C.O.D. tag for specific research, however important or meritorious. But it is part of the cost of society's welfare. It is, if you will, an investment in our own faith in freedom's future.

What better purpose awaits our commitment to this faith?

There is particular pertinence for this commitment, in the form of vastly increased support to such institutions as Caltech.

With greater public awareness and knowledge of the role of science and technology, which you yourselves promote, there will come more enlightened governmental policies at all levels that will make federal and state funds more acceptable in the future than many people think they are today.

Science and technology are, as I have said, but a part of the total educational structure with which we must be concerned. In our concern for science we must not lose sight of the essential roles of the liberal arts colleges. From them, again in pragmatic terms, we get most of the men and women who continue on into science.

The scientist's responsibility

The scientific community and all associated with it have a particular responsibility here to the entire educational enterprise—not as scientists or as educators, not as industrialists or as military experts. The responsibility is on each individual as a citizen.

Let me make clear: the scientific community does not hold a monopoly on responsibility for shaping the future; but it does carry a large and inescapable share of that burden.

This responsibility includes specifically the right—the need—to participate in affairs of the community at large.

Saying this, I must also say that as free citizens of a free society, to whose strength their work contributes immeasurably, men of science must accept too the responsibility for any misjudgments they may make. I am speaking at once for the scientist's freedom in the public arena to be as right, or as wrong, as any other free citizen—without damage to his scientific integrity. In matters of science, a scientist is judged by his scientific peers. In all other matters, the scientist will be judged by all men.

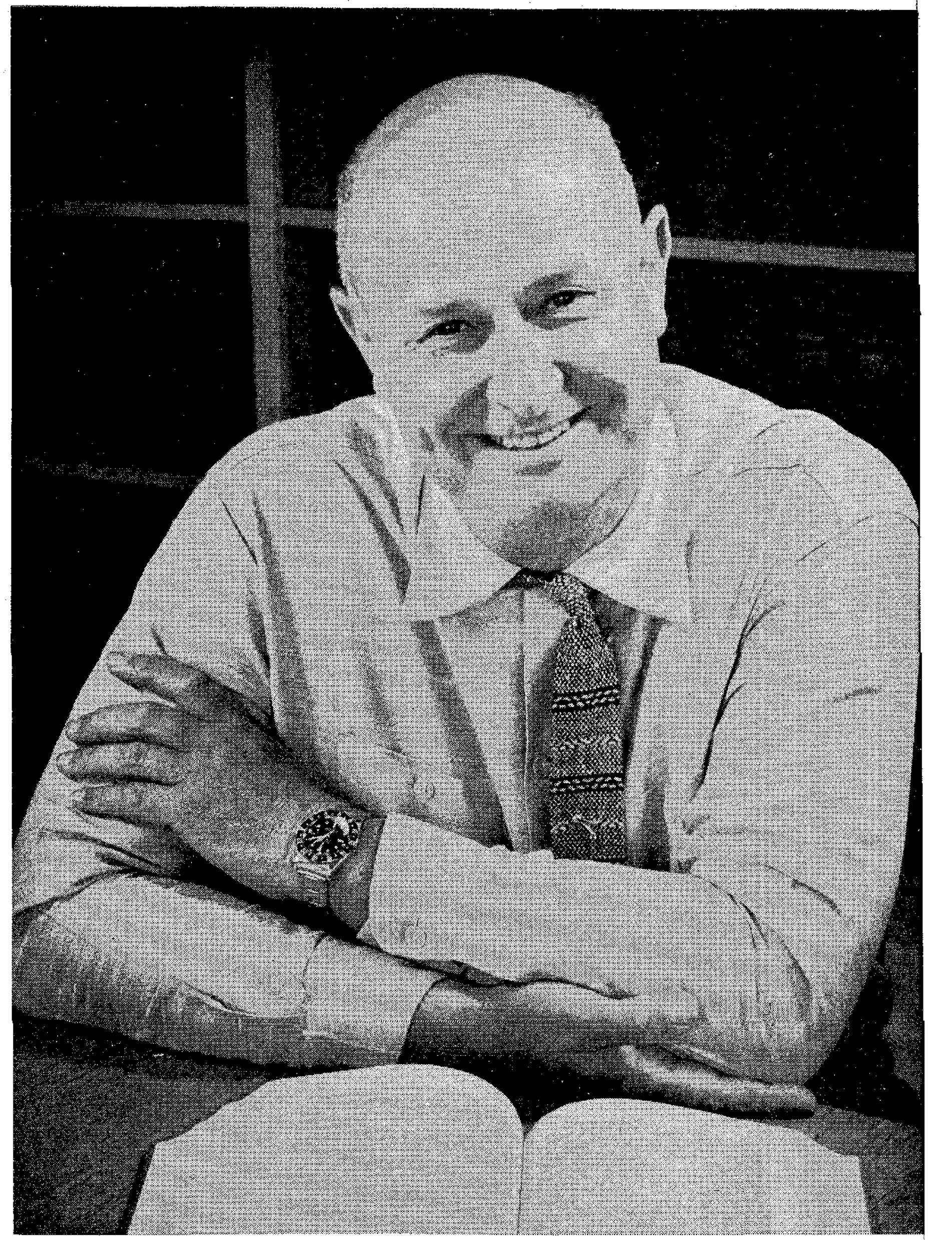
This goes both ways. It reinforces my plea that an increased public understanding of the true role of science and technology is fundamental.

While I have discussed the needs for strengthening science and engineering in the face of a prolonged peril, I must make emphatically clear one additional and significant point: I would hold to these very same arguments even in the absence of such a peril!

Realistically, of course, the peril *is* present. We *are* in a period of accelerating change and of prolonged threat. We live in a time when the decisions we make, or fail to make, can affect the freedom of men for all time.

The torch of the national welfare and national survival are very largely in the hands of science. And science needs the massive support of every intelligent citizen to do its job.

The Month at Caltech



Gordon A. Alles

Two new buildings

Two of the sixteen buildings which (along with increased faculty salaries) are the goal of Caltech's $16,100,000 Development Program have now been assured by recent gifts to the Institute.

A gift of $350,000 from Gordon A. Alles of Pasadena means that a major addition to the facilities of the Biology Division can now be built. And a gift of $335,000 from P. G. Winnett of Los Angeles will provide the Institute with the first student activities center it has ever had.

Dr. Alles' gift will finance in large part a five-story building that is needed for rapidly expanding research and teaching in virology, biochemistry, biophysics, immunology and psychobiology. The new building, forming a link between the present Kerckhoff and Church laboratories, will be located near the northwest corner of the campus, and will be known as The Gordon A. Alles Laboratory for Molecular Biology.

The total cost of the building is estimated at $900,000, of which $391,500 has been pledged by the U.S. Public Health Service.

Mr. Winnett's gift will finance a two-story building that will contain offices for student publications, meeting rooms for the student governing body, headquarters for the student YMCA and headquarters for Throop Club. The building will also contain a new campus bookstore, a student shop, a game room and a lounge.

The student union will be located near San Pasqual Street, on the site of the present campus coffee shop, and is to be known as The Winnett Center. Detailed plans are now being worked out by a faculty-student committee, in consultation with architects, but construction cannot begin for about two years—after new student houses and a new cafeteria have been built.

Dr. Gordon A. Alles, chemist and pharmacologist, received his BS (1922), MS (1924), and PhD (1926) degrees from Caltech.

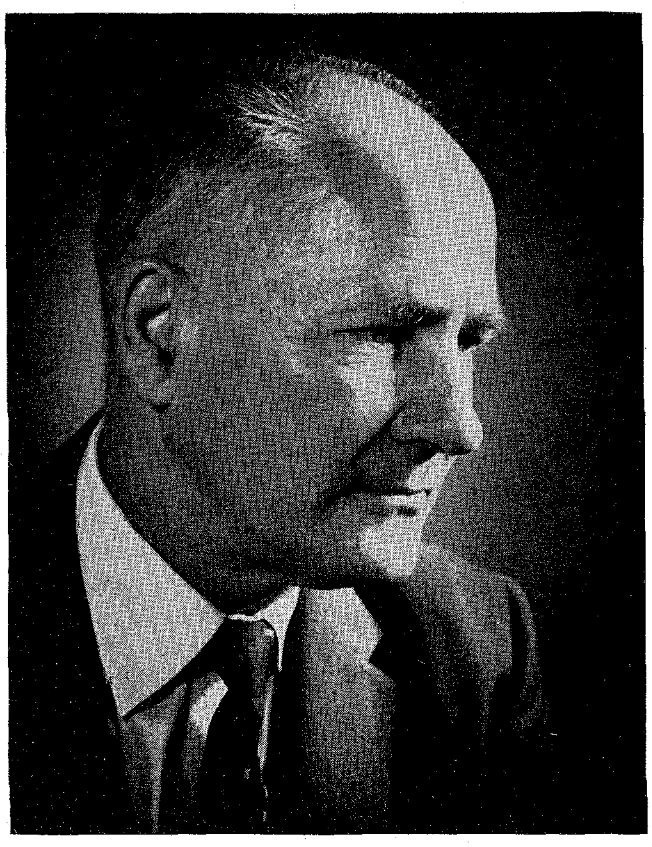
His major interest has been in natural and synthetic drug chemicals, with particular regard to the relations between their molecular structures and their biologic actions. He did early research on the isolation and properties of insulin, and has specialized in the study of the "sympathomimetic" drugs. In 1928, he discovered the physiological properties of benzedrine and contributed to its development as a drug. This drug and dexedrine, which was developed from the discovery, have had world-wide medical use as general brain stimulants.

Dr. Alles has been a research associate in biology at Caltech since 1939. Since 1931 he has been a lecturer in pharmacology at the University of California Medical School in San Francisco, and since 1951 he has been Professor in Residence of pharmacology at UCLA. From 1934 to 1951 he was consultant for Smith, Kline & French Laboratories.

Mr. Winnett, who has been a member of Caltech's board of trustees since 1939, is a native of Winnipeg, Canada, where he was born in 1881. He went directly from school into merchandising and was one of the founders of Bullock's Inc., in 1906. He was president of the corporation from 1933 to 1950 and has since been chairman of the board. He is president of the Bullock Foundation, the Winnett Foundation and the Santa Anita Charity Foundation. He is a trustee of the Letts Foundation and an honorary trustee of Claremont Men's College. He holds an honorary LLD from Occidental College.

Mr. Winnett has led an active civic life, having served as chairman of the Los Angeles Area War Chest during the war years and later as chairman of the Community Welfare Federation. He was the organizer and first chairman of the Citizens' Transportation Committee which conducted the original survey for the Los Angeles Freeway System.

In addition to his gift for the student activities center, Mr. Winnett has also recently given Caltech $75,000 for its expanding program of research in radio astronomy.



George W. Beadle, chairman of Caltech's Biology Division and winner of the 1958 Albert Einstein Commemorative Award in the field of science.

Einstein Awards

George W. Beadle, chairman of Caltech's Biology Division has just received the 1958 Albert Einstein Commemorative Award in the field of science. The award was presented to him at the third annual Einstein Commemorative dinner on May 4 at the Waldorf-Astoria Hotel in New York.

These awards, presented by the Albert Einstein College of Medicine of Yeshiva University in New York, were inaugurated on the first anniversary of Einstein's death to lend recognition to outstanding achievement in the fields of Science, Medicine, Citizenship, the Humanities and the Arts. Each award carries a cash prize of $1,000 and a commemorative medallion.

Other award winners this year include Selman Waksman, director of the Institute of Microbiology at Rutgers University (Medicine); Marion Folsom, secretary of the U.S. Department of Health, Education and Welfare (Citizenship); Archibald MacLeish, Boylston Professor at Harvard University (Humanities); and Marian Anderson, the singer (Arts).

Guggenheim Fellowships

Four staff members from Caltech and its Jet Propulsion Laboratory have been awarded Guggenheim Fellowships for the coming year: Dr. Robert Finn, associate professor of mathematics; Dr. Yuan Cheng Fung, associate professor of aeronautics; Dr. John Laufer, JPL research specialist; and Dr. Guido Munch, associate professor of astronomy and staff member of the Mount Wilson and Palomar Observatories.

Dr. Finn will use the grant to continue his studies of non-linear partial differential equations at the Technical University in Berlin. Starting in November, he will also be a guest lecturer there for six months. A graduate of Rensselaer Polytechnic Institute, he got his PhD from Syracuse University in 1951, and came to Caltech in 1956.

Dr Fung, an aerodynamicist, will be investigating the thermodynamics of irreversible processes at Gottingen, Germany, and at Delft University in Holland. After receiving his MS degree from National Central University in Chungking, China, in 1943 he came to Caltech and received his PhD here in 1948. He joined the staff the same year.

Dr. Laufer is interested in measuring characteristics of air turbulence, such as the decay of turbulent shear flow. Though he will travel to many aeronautics laboratories in Italy, his headquarters will be at the Polytechnic Institute of Turin. A mechanical engineering graduate of Louisiana State University, he came to Caltech in 1942, received his MS here in 1943 and his PhD in 1948. He has been at JPL for the past six years.

Dr. Munch plans to study the theoretical aspects of the motion of interstellar matter in our galaxy, the Milky Way, at the Max Planck Institute for Physics in Gottingen. Having been interested in theoretical astrophysics and mathematics for several years, his investigations will be concerned with the origin of interstellar gas and its relation to magnetic fields within the galaxy. After receiving his BS in 1938 and MS in 1944 from the Universidad Nacional Autonoma de Mexico, he came to the United States and got his PhD at the University of Chicago in 1947. He has been a member of the Caltech staff since 1951.

NAS member

Frank Press, professor of geophysics at Caltech and director of the Institute's Seismological Laboratory has just been elected a member of the National Academy of Sciences—one of the highest scientific honors in the nation.

Election to the Academy is in recognition of outstanding achievement in scientific research, and membership is limited to 500 American citizens and 50 foreign associates. The election of Dr. Press brings the number of Caltech staff members in the Academy to 31.

Frank Press's research contributions cover a wide range of subjects in geology, geophysics and seismology —including microseisms (the continuous ground unrest of the earth's surface); the geologic structure of the ocean floor, derived from artificially-produced waves; the behavior of waves in floating Arctic ice sheets; the crustal structure of the earth based on earthquake-wave propagation; and the generation of sound waves in the atmosphere by earthquakes.

A native of New York City, Frank Press was graduated from the College of the City of New York in 1944. He received his MS in 1946 and his PhD in 1949 from Columbia University, where he taught from 1945 to 1955. In addition to teaching, he was employed on research contracts with the U.S. Navy and Air Force, served on the scientific staff of numerous oceanographic expeditions, and, on a tour of duty for UNESCO, set up a system of seismological stations in Israel.

He was an associate professor of geophysics at Columbia and a member of the research staff of the university's Lamont Geological Observatory when he left to come to Caltech in 1955. He has been head of the Seismological Laboratory here since the retirement of Dr. Beno Gutenberg in 1957.

Frank Press, Caltech professor of geophysics and director of the Institute's Seismological Laboratory, is a new member of the National Academy of Sciences.

Dr. Press is currently a member of the Continental Committee of the International Geophysical Year, which is in charge of overall planning of all IGY research projects on this continent. He is also a member of the IGY's Technical Panel on Glaciology, of the Seismology and Gravity Panel and of the Polar Research Committee.

New electrostatic generator

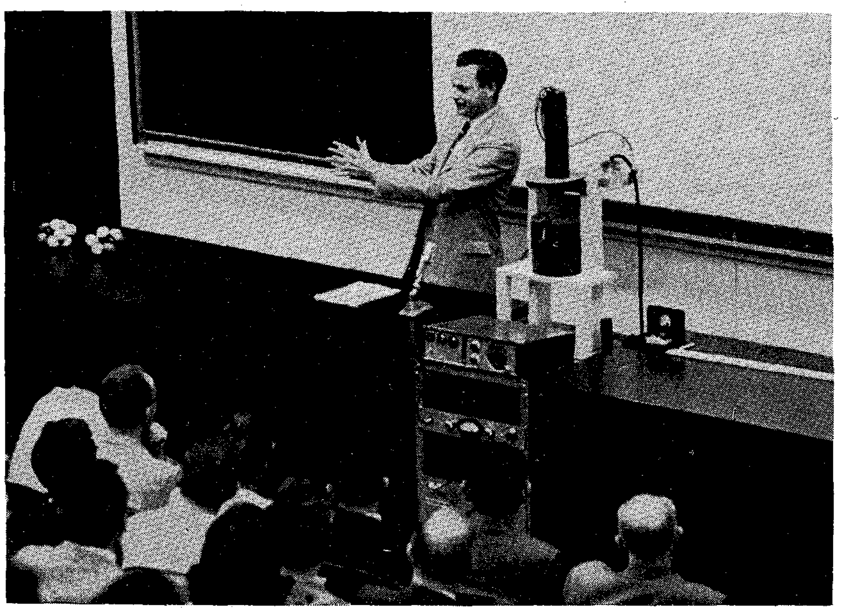
The delivery date is about two years away, but Caltech's Division of Physics, Mathematics and Astronomy is drawing up plans now to house a big new 100,000,000-volt electrostatic generator.

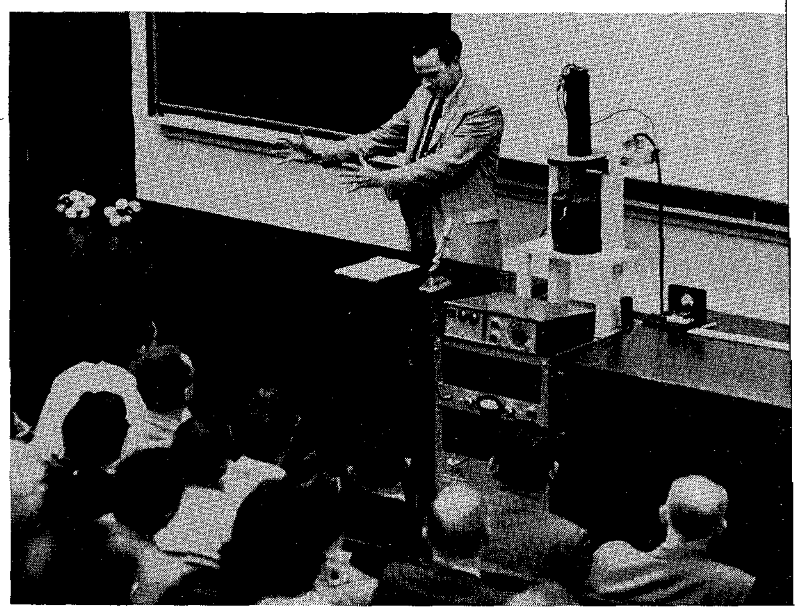
The Office of Naval Research has agreed to supply the $1,000,000 generator itself, but Caltech will have to build a large room, with thick concrete walls and other heavy shielding, in which to house it.

The machine will be located in the basement of the proposed Mathematics and Physics building on the campus, adjacent to the Kellogg Radiation Laboratory. This building now houses the High-Voltage Laboratory, but, as part of the Caltech Development Program, the interior will be completely altered to provide quarters for mathematics and physics research.

The Institute already has three electrostatic generators housed in the Kellogg Laboratory. They have served to investigate the thermonuclear fusion reaction of light nuclei such as those of hydrogen and helium, which are energy sources in stars. The new 10-mev machine will make it possible to study heavier atomic nuclei and fusion processes.

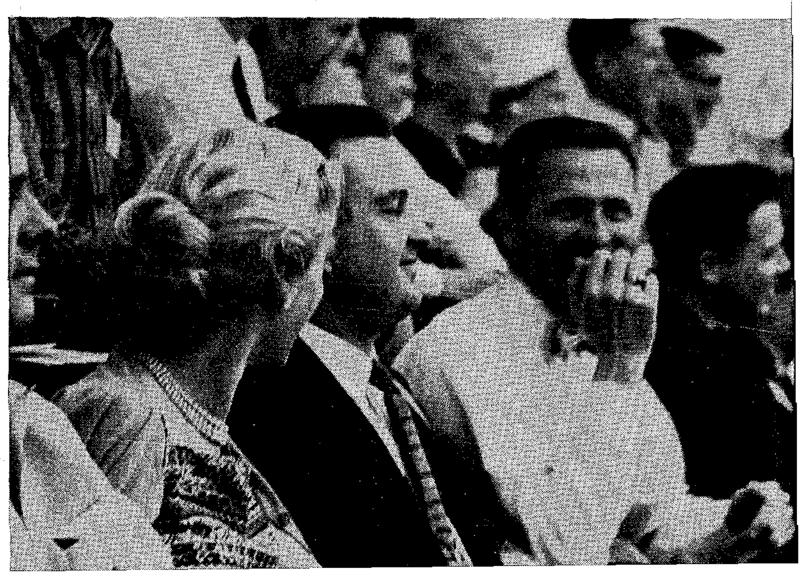
Alumni Seminar Day





"The question is—if something is built exactly like a mirror reflection—in reverse—will it work the same? That is, are the laws of physics the same when we reflect all the equipment to make a mirror image?"

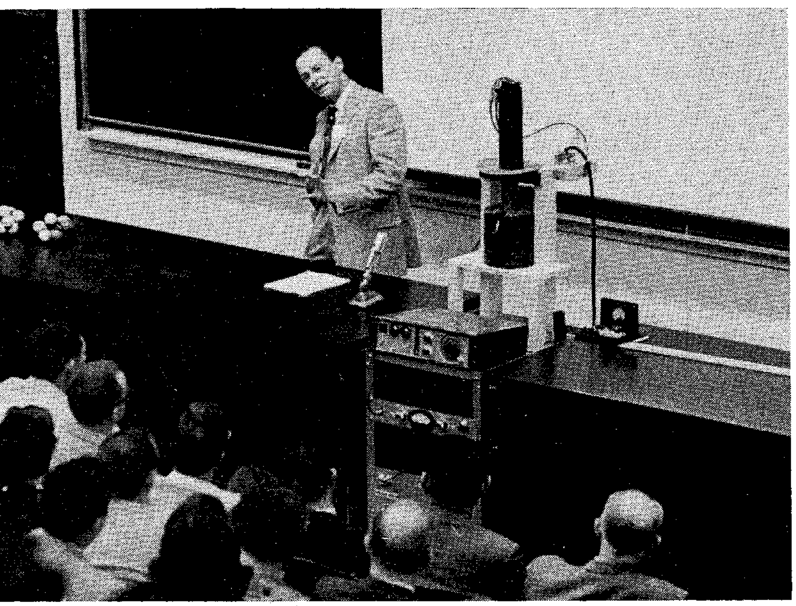
"Say we telephone some being on another planet and tell him how to build a model man. If he is made out of the same gunk as we are, then he builds the model with the heart on the left side—but if he is made of anti-matter, he'll put the heart on the right."



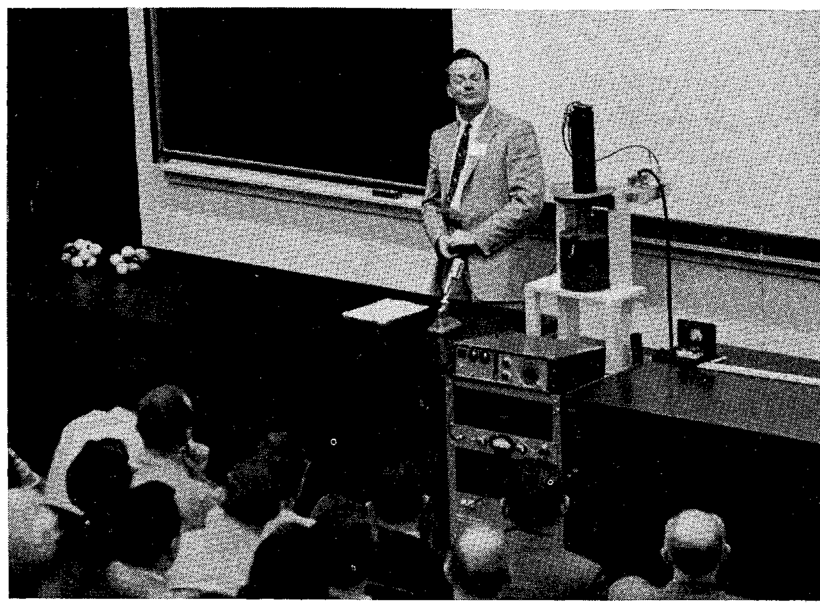
A record total of 1185 alumni, wives and guests came to the campus for the 21st annual Alumni Seminar on April 12—almost double the attendance of previous years.

Nine lectures on subjects ranging from physics to philosophy were featured on the morning program. (If the audience shown below is any indication, the program was an unqualified success. They're listening to Richard P. Feynman, professor of physics, talk about the non-conservation of parity.) In the afternoon, the visitors had a choice of 18 exhibits and demonstrations (including the last scheduled appearance of the high volts demonstration, the spectacular electrical display that has been one of Caltech's best shows for the past 35 years.

H. Rowan Gaither, chairman of the board of trustees of the Ford Foundation, was the main speaker at the evening banquet. His talk, "Science and the National Welfare," is on page 9 of this issue.



"Then we find a way to go and visit this guy and get a chance to meet his model man. If this model starts to shake hands with his right hand—go ahead and shake."



"But if he holds out his left hand—look out. You'll annihilate each other!"

The Coldest Spot in the World

It's in a vacuum tube in the low-temperature physics laboratory

by Jane Werner Watson

"The Coldest Spot in the World" has been taken from a forthcoming book, The World of Science, *by Jane Watson. The book, which is written for junior high and high school students, tells about current research in all the various fields of science.*

Most of the research projects described in The World of Science *are now going on at Caltech. Even the idea for the book came from Caltech—from Earnest Watson, in fact, dean of the faculty, who felt strongly that younger students needed, and would welcome, a greater understanding of science. Since Mrs. Watson is a skilled writer of books for young people,* The World of Science *was the natural result.*

The World of Science, *a Golden Book by Jane Werner Watson, copyright 1958 by Simon & Schuster, Inc., and Artists and Writers Press, Inc., will be published in the fall.*

What is the coldest spot in the world?

Near the North Pole? No, in its polar ice pack temperatures go down only to about —81°F. (the record for North America). Siberia's record cold was —90°F.

The South Pole? The lowest temperature reported thus far from the South Pole is —89°F.

But in a low-temperature physics laboratory in the middle of a well-protected vacuum tube or thermos bottle, the temperature may go down to —459.5°F. or even lower.

—459.6°F. is absolute zero. It is the coldest possible temperature. On the special scale used in scientific work, it is 0°K. (for Kelvin).

The helium in that thermos bottle in the physics laboratory is not at absolute zero. But it is not far from it. It is perhaps 0.01° away. At this temperature even one of the lightest, freest gases in the world has turned—if we could see it inside its silvered container—to a bubbling liquid, then stopped even bubbling and turned smooth as jelly.

This is the coldest spot in the world.

You know that atoms and molecules are always in motion. In gases they move most freely. For there they are not held together in any shape. In liquids they still slide around easily. And even in a solid—a piece of wood, for example—if you could see the molecules and atoms you would find them vibrating slightly in place.

You know that most kinds of matter can be turned from solid to liquid to gas. Let us take iron and water as two examples. Water as a solid is ice; as a liquid it is water; as gas it is water vapor. As ice, it is rather cold; its molecules move slowly. When ice warms up, its molecules move faster; at the melting point they break loose from their solid form and flow like water. As water warms up, its molecules move faster still. At the boiling point they break loose from the liquid form and leap up into the air. They can move fast enough and exert enough force to push the cover up from a pan.

So it is with iron. The molecules in solid iron ore are more tightly bound than in ice. Iron must be heated to a much higher temperature than water before it melts, before its molecules get to moving fast enough to break loose from their solid form and flow as a liquid. And liquid iron must be heated very hot indeed—specifically, it must be heated to 3032°K.—before it turns to a gas.

We see then that heat is connected with the motion of molecules. In fact, the energy in this motion of molecules is heat. When you touch a hot stove, what you feel as heat is partly the result of the rapidly vibrating molecules striking at your finger.

Cold is the lessening of that motion. And absolute zero is the point at which, practically speaking, all the motion of molecules would cease. There would be practically no energy, no heat, no motion. That is the state our low temperature physicist is trying to approach in his experiments with liquid helium.

We have said that it takes a lot of heat—or energy—to get iron molecules moving fast enough to break loose from their solid state and turn to liquid. This is mostly because the forces of attraction holding the iron molecules in place are very strong.

Water melts from its solid state of ice at a much lower temperature because its molecules are not so strongly bound. It takes less heat or energy to get them moving fast enough to break away from the solid state.

Air is the gas with which we are most familiar. Its molecules dart around freely as a gas until they are cooled down to about 85°K. or —300°F.

At 85°K. or colder, air molecules are so slowed down that they form a liquid. Moreover, this liquid air can be separated into liquid oxygen (1/5) and liquid nitrogen (4/5).

Several uses have been found in industry for liquid oxygen. You know that oxygen is necessary to keep any fire burning. Liquid oxygen is used to speed up the burning of fuel in long-range rockets and jet airplanes. It is also used in the manufacture of steel, to speed up the burning of fuels there.

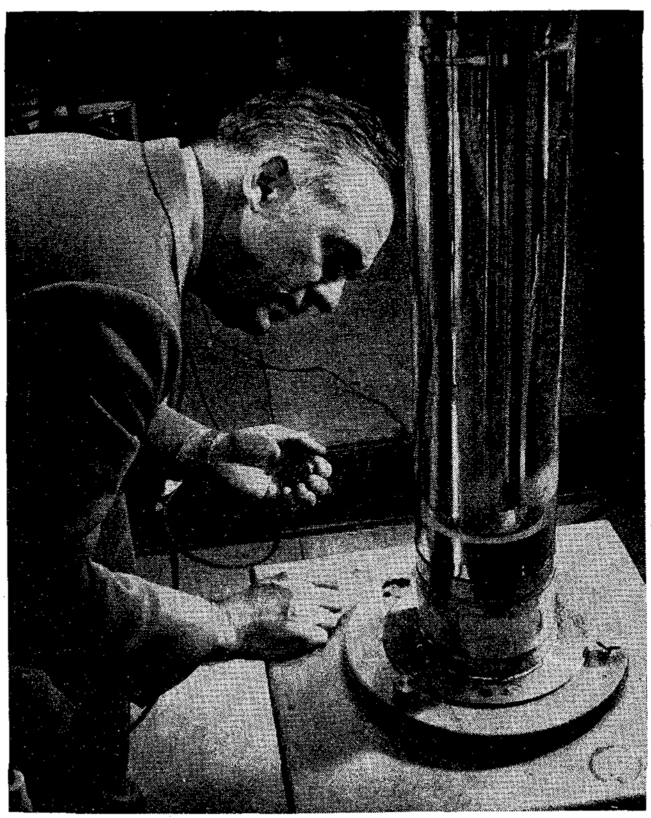
Liquid oxygen has enough industrial uses so that it is shipped by tank-carloads. And scientists are busy looking for new uses for the liquid nitrogen which is left over in the separation. One possible use is a liquid nitrogen bath (at —320°F.) for steel, which can then be rolled to extreme hardness.

But there are gases even better than oxygen and nitrogen for low-temperature work. There is hydrogen, which does not slow down into a liquid until 20.38°K. It does not slow down into a solid, or freeze, until it reaches 14.04°K. Unfortunately hydrogen is too explosive for safe industrial use.

Then there is helium. Although it is not as light as hydrogen, its molecules need even less heat or energy to keep moving freely as a gas. They do not slow down into a liquid until 4.22°K. In fact, there is a light isotope of helium, He^3, which does not liquefy until 3.20°K.

That is the lowest natural boiling point for any liquid. It is the reason low-temperature physicists use helium when they are trying to get as close as possible to absolute zero.

How do you go about cooling helium down almost to absolute zero? You use every method of cooling you can think of.



John R. Pellam, Caltech professor of physics, is timing the cooling of liquid helium in this dewar. Submerged within the liquid helium is a small glass vial of condensed helium and helium 3, the rare light isotope which will not liquefy until nearly absolute zero temperature.

Restaurants and physicists

How do restaurants keep certain foods ice-cold while they serve them? They set the dishes containing the foods in bowls of ice. Physicists use this method, too.

They may surround the tank of helium gas with liquid nitrogen at about 77°K. to start the cooling process. They also compress the helium into a small space. The work of doing this heats it up, of course, but the heat is absorbed in the packing of liquid nitrogen. When the helium is allowed to expand again, it cools down still more.

Physicists also use already-cooled helium to help them cool more. On the way to the cooling box, the gas is piped through coils of tubing. Coming up through other coils is helium which has already been cooled. The two sets of coils are wrapped together. So the already-cooled helium helps cool the incoming gas. That brings the temperature down some more.

Heat is energy, we have said. You know one way to use up energy—doing work. So the physicists make the helium do work. Inside the cooling machine is a small engine. There are two cylinders with pistons in them. The pressure of the helium gas pushes up the pistons. That means the gas is doing work. It is using energy. It loses heat in the process.

You know that in a steam engine water is heated until it turns to steam, and the pressure of this steam pushes up the piston in a cylinder. Doing this work cools the steam so that it turns back into water and more fuel has to be burned to heat it to steam again. In the same way, doing the work in this engine cools the helium a bit more.

Of course a steam engine has to have lubricating oil to keep the piston from sticking. For years men thought it would be impossible to run an engine with helium or cooled air because it would be working at such low temperatures that any lubricating oil would freeze solid. How could they keep the pistons from sticking? In these engines, a thin film of the gas itself provides the lubrication!

Next, some of the helium is allowed to expand through a small nozzle leading into another container. In this expansion, some of the small amount of heat still remaining in the gas is used to separate the atoms. This "work" against the natural force of the atoms' attraction for each other cools the helium so that it turns to liquid. Its temperature is now 4.2°K.

Keeping cool

What do you use to keep lemonade cool for a picnic? You use a thermos bottle. That is what the physicists use for their liquid helium, too. But what a thermos bottle!

Outside are two layers of silvered glass with a vacuum between. Next comes a layer of liquid nitrogen, itself very cold. Again, inside this, is a double layer of glass with another vacuum between the two glass walls. And finally comes the liquid helium.

This sounds like real protection. But there are still difficulties. One is that the vacuum must be pumped out repeatedly, because helium can leak even through pyrex glass walls!

For the final chilling steps, the liquid helium is pumped through vacuum-protected tubes into a dewar vacuum tube waiting in a special laboratory.

Then a sample of a certain material called a paramagnetic salt is suspended inside a tube of rarefied helium gas in the middle of the liquid helium.

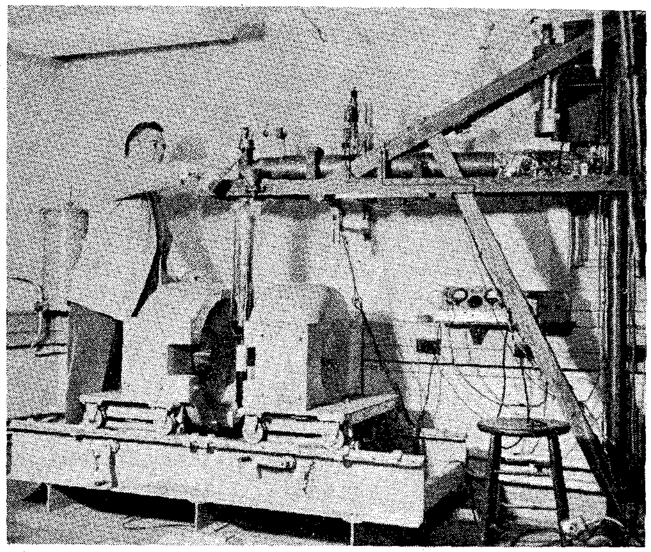
When all is ready, the physicist swings the tube around to an electromagnet (as shown in the picture at the top of the page), whose two sections roll shut around the tube. The time has come for the last steps down toward absolute zero.

The paramagnetic salt has a special quality. When a magnetic field is applied to it—when the big electromagnet is turned on—its molecules line up magnetically like tiny iron filings near a bar magnet.

We have said that it was the disorderly motion of molecules, called thermal chaos, which causes heat. Now, this magnetic lining-up of molecules is just the opposite of disorder or chaos. So what it does is force heat out of the salt.

The heat flows from the salt into the rarefied helium gas around it. This gas carries the heat out to the surrounding liquid helium. Now, to prevent the heat from flowing back in again by the same route, this gas must be pumped out by a vacuum pump. At these extremely low temperatures, atoms move very slowly indeed. So it may take as much as 20 minutes to complete the pumping out.

Then the magnetic field is removed. The lined-up salt molecules can turn in all directions again. This movement takes some energy, and therefore uses up some heat, which cools the salt as a whole.



This powerful electromagnet helps to produce temperatures close to absolute zero. Liquid nitrogen, a cooling agent, is being poured into a dewar which surrounds a container of liquid helium. When the silver dewar is swung into position, the two heavy iron sections of the electromagnet are rolled shut and the cooling procedure begins.

Down goes the temperature of the salt in the half second it takes to turn off the current, down to perhaps 0.001°K.

By now the glass of the tube is at such low temperature that it does not conduct heat well. So, even if room temperature heat should strike the outside surface, it would have a hard time flowing all the way in. Inside the vacuum protection, it will take seven or eight hours for the precious salts to warm up even to .01°K.

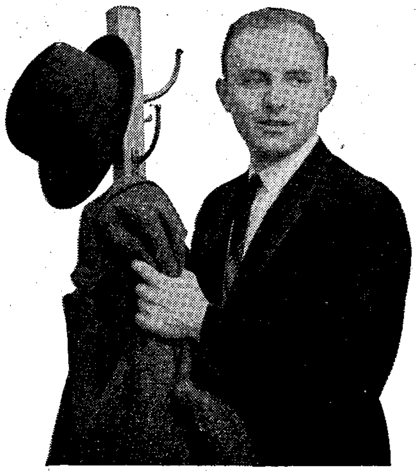
No excitement

"Why try to approach absolute zero?" people used to ask low-temperature physicists. "When you get there, everything will be motionless as death. There will be no excitement."

The scientists themselves did not know just what they would find down near 0°K. But they kept working toward it. And just a few years after they first managed to liquefy helium (which had been done in 1908) they made a surprising discovery which has not lost its excitement in 50 years.

This discovery was superconductivity. You know that some substances are better conductors of electricity than others. Wood is no good at all. Among metals, lead is not very good. Tin is fairly good. And copper is very good. Now it was discovered that, at very low temperatures, certain metals, including lead and tin, become superconductors.

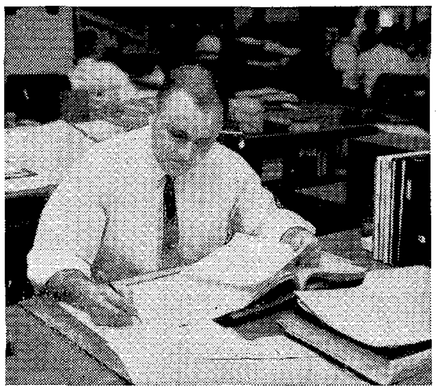
This is how the experiment works. The physicist takes a small ring of lead and places it in a container planned



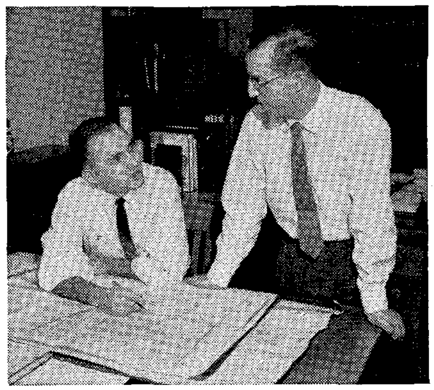
KEITH LYNN, B.S.E.E., PURDUE, '52, INVITES YOU TO

"Spend a day with me at work"

"I'm an Equipment Engineer for Illinois Bell Telephone Company in Chicago. Speaking personally, I find Bell Telephone engineering darned interesting and very rewarding. But judge for yourself."

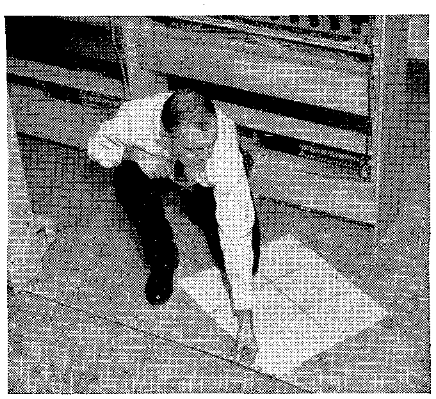


"**8:30 a.m.** We start at my desk. I'm studying recommendations for additional dial facilities at the central office in suburban Glenview. This is the beginning of a new engineering assignment for me."

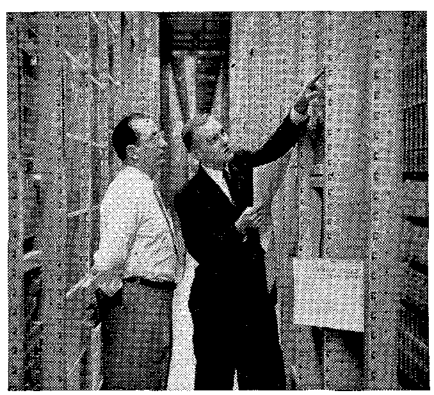


"**10:20 a.m.** I discuss a proposed layout for the additional central office equipment with Supervising Engineer Sam P. Abate. Since I'll want to see the installation area this afternoon, I order a car."

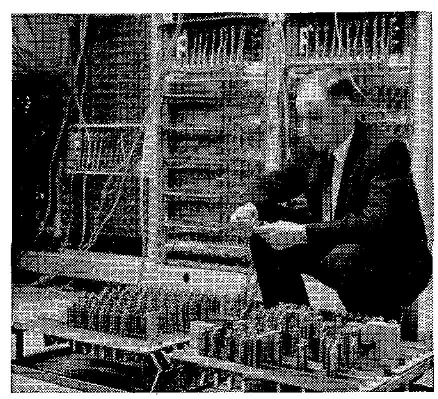
"**11:00 a.m.** At an interdepartmental conference I help plan procedures for another job I'm working on. Working with other departments broadens your experience and know-how tremendously."



"**2:00 p.m.** After lunch I drive out to the Glenview office. Here, in the frame room, I'm checking floor space required by the proposed equipment. The way our business is growing, every square foot counts."



"**3:10 p.m.** Then I drive to the office at nearby Skokie where a recent assignment of mine is in its final stages. Here I'm suggesting a modification to the Western Electric installation foreman."

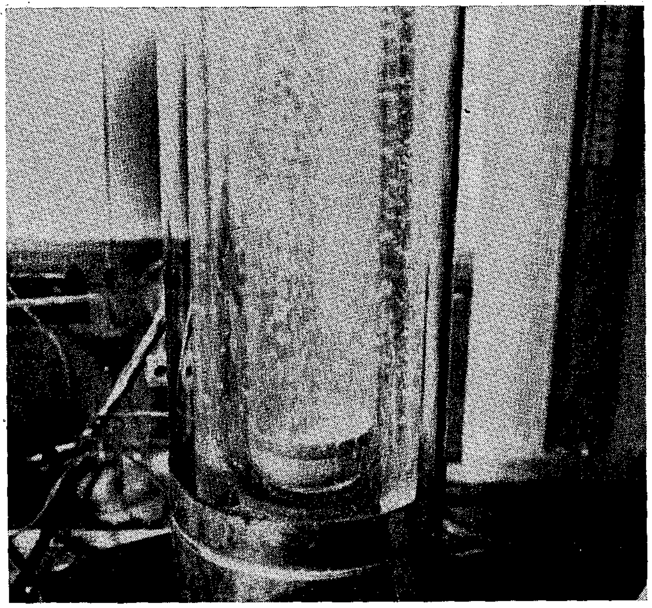


"**3:30 p.m.** Before starting back to Chicago, I examine a piece of Out Sender equipment being removed from the Skokie office. This unit might fit in just fine at another office. I'll look into it."

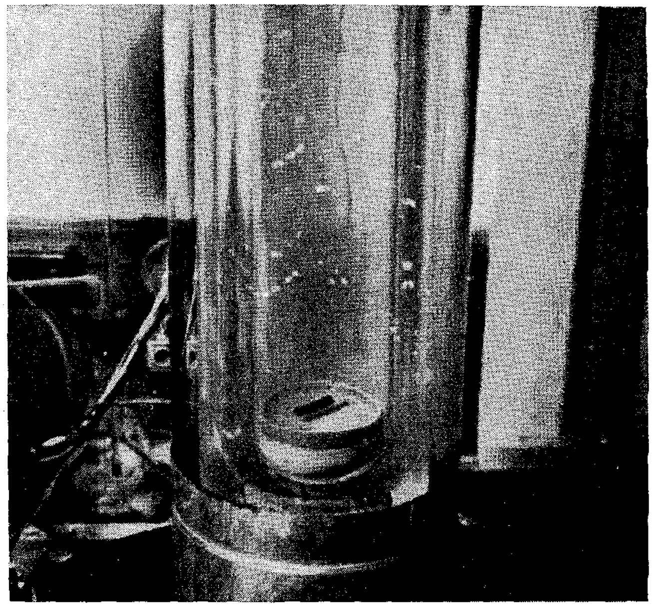
"Well, *that was today. Tomorrow will be different.* As you can see, I take a job from the beginning and follow it through. Often I have a lot of jobs in various stages at the same time. I think most engineers would agree, that keeps work interesting."

Keith Lynn is one of many young engineers who are finding rewarding careers in the Bell Telephone Companies. Find out about opportunities for *you.* Talk with the Bell interviewer when he visits your campus. And read the Bell Telephone booklet on file in your Placement Office.

BELL TELEPHONE COMPANIES



In this experiment a small magnet is dropped into a container filled with liquid helium. As long as the temperature is kept below 7.2° K., the magnet will float instead of dropping to the bottom. The magnet can hardly be seen in this picture because, at 3° K., the helium is still boiling violently.



In this phase of the experiment the liquid helium has been cooled to just a couple of degrees above absolute zero. The boiling has ceased and the liquid is smooth as jelly—in fact, it is the most quiescent substance known. The floating magnet can now be plainly seen through the clear windows in the silvered sides of the dewar.

for liquid helium. Around the thermos bottle he places a coil of wire through which a steady d-c electric current is set running. The starting up of this current sets up a temporary current in the lead ring. But it almost immediately dies out, because of resistance in the lead.

Now liquid helium is poured into the container, around the lead. The lead cools to an extremely low temperature, of course. As it falls below 7.2°K., the lead becomes a superconductor. Again, changing the current in the coil outside induces a current in the lead ring as before. But with a difference. Now the current in the outer coil of wire can be turned off. But the current thus induced in the lead ring will run on and on, presumably forever, as long as the lead is kept so extremely cold. For there is no resistance to electricity in the lead to slow down and stop the current, so close to absolute zero.

The physicist holds up a compass close to the thermos bottle or vacuum tube. And the magnetic field set up by that current in the lead ring is strong enough to attract the compass needle!

Next he lowers a small lead plate to the bottom of another container of liquid helium. Then he lets down a small magnet into the helium. You would expect it to fall to the bottom too. But it does not.

What happens? The magnet sets up a mirror image of itself in the lead plate. Since like poles of a magnet repel each other, the mirror image repels the magnet. And just enough electric current is generated in the lead plate to balance the power of the magnet and hold it suspended above the lead. It would remain thus suspended forever if the temperature could be kept permanently below 7.2°K.

Why is this "mirror image" set up? Why is there no resistance to electricity at these very low temperatures? Why does the current seem to run on forever like a perpetual motion machine?

These are questions no one has been able to answer in 50 years. Perhaps the answer is hidden in the perpetual motion within atoms. For electrons, you know, whirl forever around their nuclei with no loss of energy. You may be the one to find the answers to these and other questions in electricity and magnetism, if you make low-temperature physics your field.

A more recent surprise in low-temperature physics is what happens to helium itself. At 4.2°K. it settles into a liquid, boiling with small, lively bubbles. The vapor which keeps forming at the top is drawn off through a vacuum line. And the temperature keeps going down.

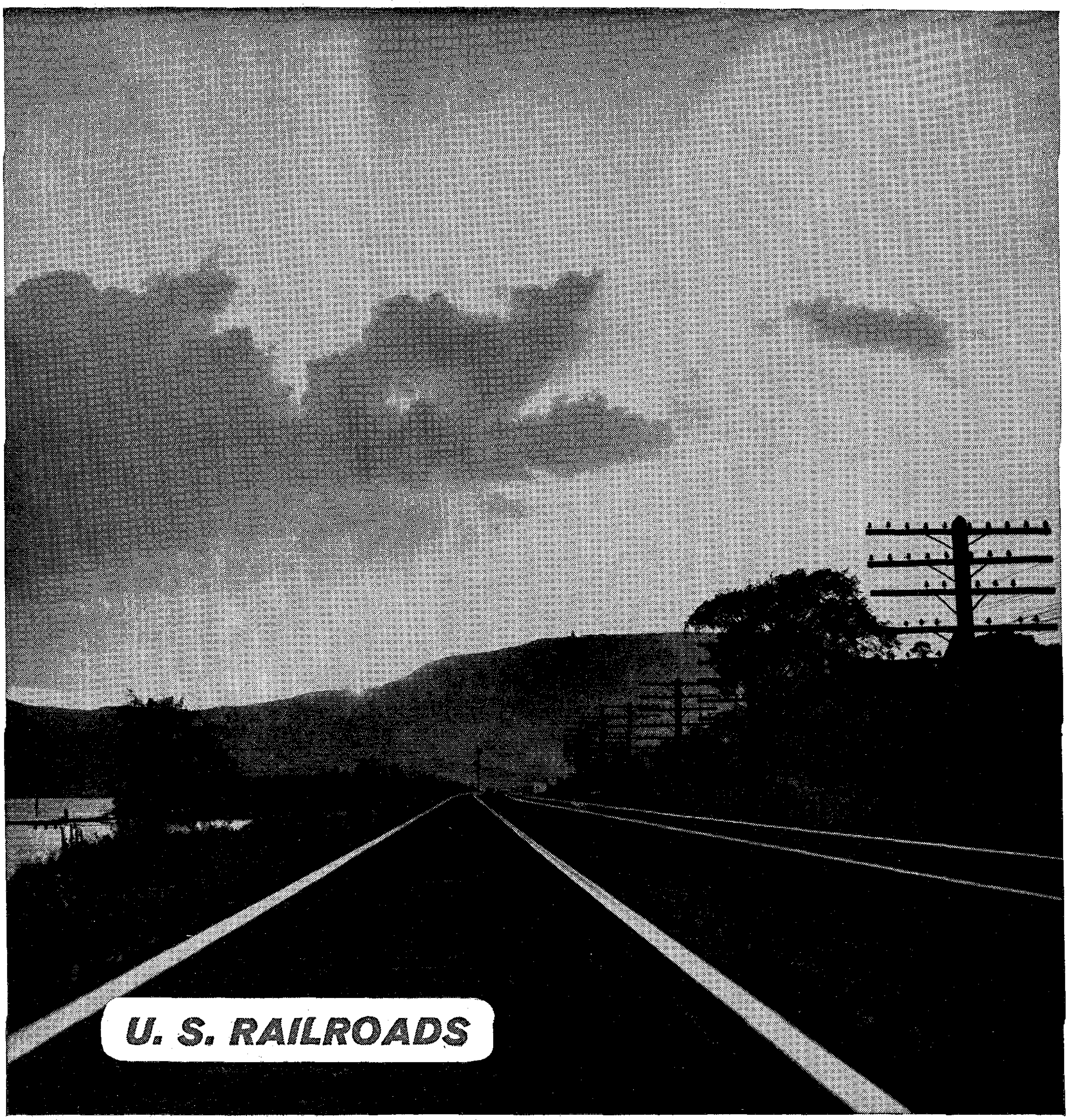
At 2.19°K. the boiling stops. The liquid is smooth as jelly, as you can see through the small clear windows in the silvered sides of the Dewar jar.

Has the helium frozen into a solid state comparable to ice? No. There is a solid state of helium, but it has so far been reached only under a combination of low temperature and very high pressure.

It is still liquid, but some of it has a new form. It is called a superfluid. And it has been given the name helium II.

Why is it called a superfluid? Because it can do things other liquids or fluids cannot do. Most liquids do not flow perfectly freely. There is a certain amount of resistance, or friction, which we call viscosity. But helium II flows with perfect ease through the tiniest openings.

continued on page 26


U. S. RAILROADS

Chemistry stands at the threshold of a new age of discovery

It has been said that more significant scientific advances have taken place in the last fifty years than in all the centuries that have gone before. One fact is indisputably clear. The use of applied science in American industry today is progressing at a rate so fantastic it staggers the imagination of the boldest visionary!

This is particularly evident in the vast, highly diversified field of industrial chemistry. Here, products, materials and processes that were unknown a few years ago are in wholesale use today. The accomplishments of chemical research are being felt in every area of human endeavor. The prospect of further advancement in the immediate future appears limited only by man's imagination and his desire for improvement.

Our society stands at the threshold of a new age of discovery that offers an infinitely better way of life as its reward. A host of courageous, creative industrial chemists will help lead the way.

. . . and you, too, can help shape the future

See for yourself. This interesting, informative booklet, "Opportunities for College Trained People with The Dow Chemical Company" can help you make an all-important decision about your future. Write our Director of College Relations for the booklet and the date a Dow representative will visit your campus.

THE DOW CHEMICAL COMPANY, MIDLAND, MICH. DOW

Water seeks its own level within one container. But helium II does more. If you lower an empty tube into helium II, the helium will creep up the sides of the tube and fill it to the level of the liquid outside.

Lift the tube containing some helium II and hold it above the level of the rest of the helium II, and the liquid in the tube climbs out and down to join the rest.

Perhaps strangest of all, there is the mysterious phenomenon called "second sound."

Helium II is a perfect conductor of heat. We would scarcely be inclined to think of heat at a temperature equal to —459°F. But there is a very small amount of heat or motion of molecules left in the liquid helium. If a very small bit of additional heat is applied, we can observe its movements through the superfluid. And a strange sort of movement it is!

In most materials—from air to a rod of gold—heat moves slowly, spreading out gradually by what we call diffusion. But in helium II heat travels in sharp little pulses, very much like sound waves. In fact, this method of heat movement is called "second sound."

Back in the nineteenth century, when scientists were just finding out about sound waves, it was discovered that these waves could turn aside a hanging disk of metal called a Rayleigh Disc.

When low-temperature physicists started finding out about "second sound" in helium II, one of them recalled this old-time experiment and dangled a tiny Rayleigh Disc in liquid helium. Sure enough, it turned as the "second sound" waves of heat struck it.

Of course these waves of "second sound" cannot be heard. They cannot be picked up with microphones. Since they are really temperature waves, special receivers have had to be made to receive them. These are tiny plates of carbon with a small constant current of electricity flowing through them. The colder they are, the less well they conduct electricity. The warmer they are, the better. One of these receivers is placed in the liquid helium. The current changes ever so slightly each time a "heat wave" strikes it and warms it a bit. And these changes in voltage can be amplified enough for a physicist to record.

These experiments with "second sound," or thermal waves, are very delicate. As we have seen, it is a slow and difficult process to make the liquid helium needed just to start the experiments. And what will they prove? What use can be made of the knowledge?

There is a saying among scientists to answer questions like this. "What good is a new-born baby?" they ask. In other words, "Give us time. Who can say what our experiments may lead to? Only time and testing will tell."

Personals

1922

Howard G. Vesper has just been elected president of the Standard Oil Company of California, Western Operations, Inc. For the past several years, he has been a vice president and director, with marketing as his primary responsibility. The company is the largest operating subsidiary of the Standard Oil Company of California and includes all of the company's activities in the seven western states, Alaska, and the Pacific Islands.

1924

Earl S. Hayman, owner of the Earl S. Hayman Company in Glendale, died of pneumonia on March 20. Earl worked in sound engineering for 18 years at Paramount Pictures and during the war he owned and operated an aircraft accessory firm while still with Paramount. He established his own office in real estate and insurance in 1945.

1926

Allen L. Laws writes that he's still division manager for the Southern California Edison Company in Los Angeles. Last year he was appointed a trustee of the San Marino City Library, and he is also on the executive committee of the San Marino Community Council.

1927

W. Layton Stanton, PhD '31, has been transferred to Denver, Colorado, to serve as manager of the Rocky Mountain Division of the Union Oil Company. He had been working as a geological coordinator for the company's Canada & Rocky Mountain Division in Los Angeles.

1932

John A. Leermakers, PhD, assistant director of the Kodak Research Laboratories in New York, was the main speaker at the Tenth Annual Management Conference of the Cornell University Graduate School of Business and Public Administration in Ithaca, N.Y., last month.

1933

Robert L. Suggs, MS, writes (from New Orleans) that he is now president of four companies — Petroleum Helicopters, Inc.; Offshore Navigation, Inc.; International Offshore Navigation, Inc.; and Offshore Raydist, Inc.

Maurice F. Hasler, PhD, president and director of research of the Applied Research Laboratories in Glendale, California, received the $1,000 Beckman Award in chemical instrumentation at the 133rd national meeting of the American Chemical Society in San Francisco last month. The prize, sponsored by Beckman Instruments, Inc., in Fullerton, was awarded to Maurice for his leadership in the introduction of devices to investigate compounds by specific measurements of such properties as light intensity, radiant energy and color.

Gregory K. Hartmann, technical director of the U.S. Naval Ordnance Laboratory at Silver Spring, Md., received the Defense Department's Distinguished Civilian Service Award from Defense Secretary McElroy last month. The award was given for his leadership as a scientist-executive. He has guided the work of the Naval Ordnance Laboratory since 1955, after serving four years as associate director for research.

Although most of the work of the Laboratory cannot be made known because of security restrictions, one of the recent accomplishments under Gregory's direction was the development and perfection of the new BETTY weapon, an atomic depth bomb for use against modern enemy sub-

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Personals . . . *continued*

marines. The NOL also has a large and vital part in the current POLARIS project—the intermediate-range missile with nuclear capability that U.S. atomic-powered submarines will soon be able to launch while lying submerged off enemy shores.

The Hartmanns live in Garret Park, Md., with their four children.

1937

Martin H. Webster, who has his own law practice in Los Angeles, has just been appointed chairman of the tax committee of the Los Angeles Bar Association. Martin, who specializes in tax and business law, writes: "I can make no promise of tax reductions as a result of this post, but you can be sure that I, and the 45 tax attorneys who serve on the committee with me, will work very hard for tax reforms." Martin and his wife live in Brentwood and have two children—Felicea, 9, and Larry, 7.

1940

Warren H. Vetter is now chief engineer of the Southwest Welding and Mfg. Company in Alhambra, California.

Miller Quarles, Jr., '41, writes that he (with his wife and three daughters) changed his address from San Antonio, Texas, to Paris, France, last month. He is now a consulting geophysicist for the recently-formed international firm of Companie Reynolds de Geophysique. "My wife awaited 20 years for this chance to use the five years of French she took at Occidental," Miller says, "and she thinks it took a long time for me to show that she could marry a geologist and see the world."

1942

Boyd T. Marshall, MS '43, writes that "after living in Pasadena since graduation, I moved the family to Arcadia about two years ago. We now have a family of three girls and one boy—ages four to twelve. Last year I was elected vice president of the Waste King Corporation in L.A."

1943

Earle R. Atkins, Jr., is now a section leader at the Union Oil Company's Research Center in Brea, California.

1944

William T. Collings, MS '47, has announced the formation of a consulting engineering firm in Milwaukee. The new firm's name is Collings-Vranich and Associates. Bill was formerly with the engineering firm of Klug and Smith in Milwaukee.

Fred Behrens writes a short note on events as far back as 1946. "Since then, I have acquired a wife and three sons—Jim, John and David. We've just expanded, modernized and redecorated our home in Arcadia.

"I left Pillsbury Mills, Inc., after nine

continued on page 34

Engineers • Scientists • Mathematicians . . .

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Extensive laboratory facilities at Palo Alto and Sunnyvale, near Stanford University, provide an atmosphere to satisfy the most inquisitive scientific mind, yet pique the desire for further knowledge and achievement. Both locations are less than an hour's drive from San Francisco.

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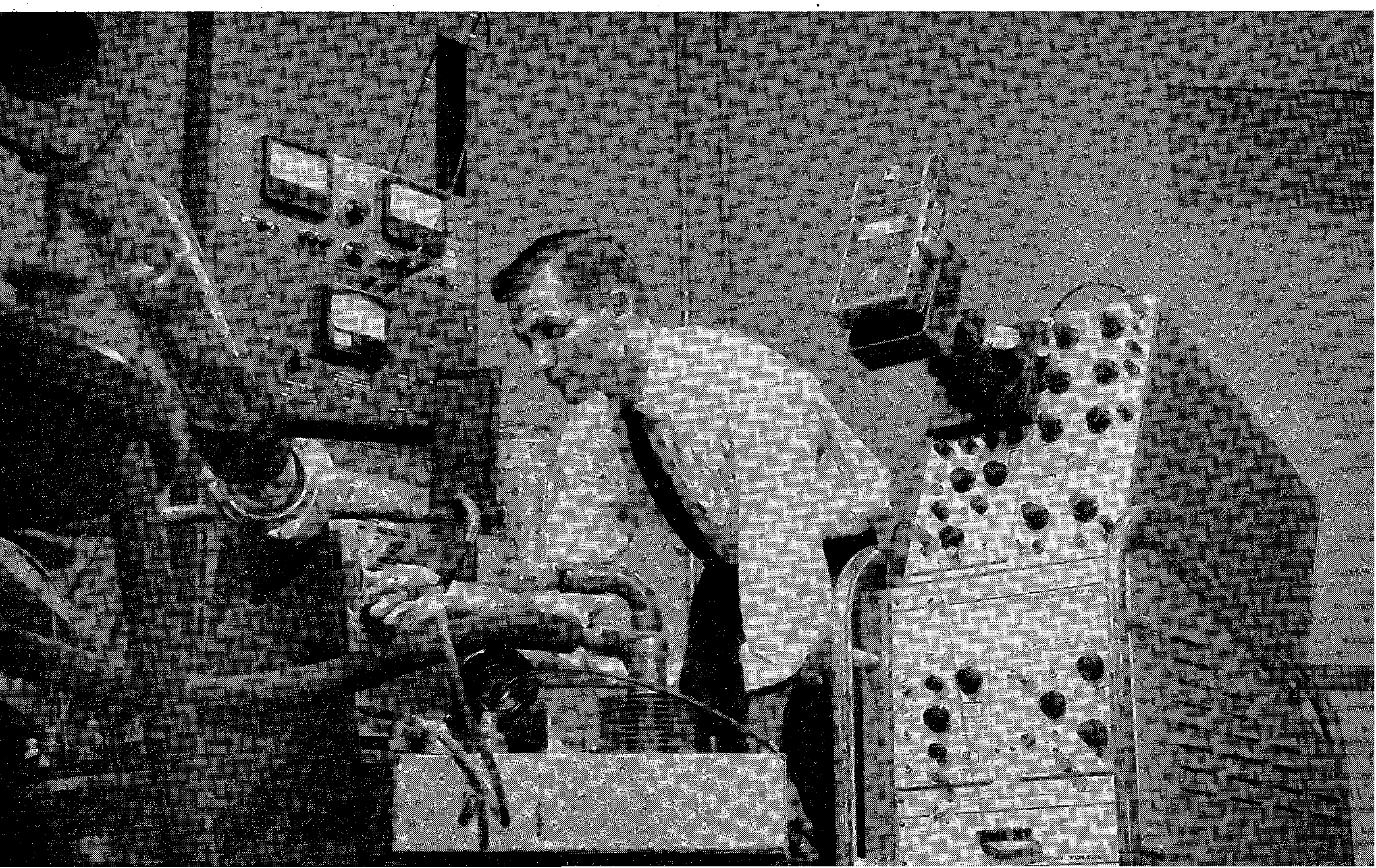
Advanced Study Program physics student J. T. Naff charges up the condenser of a high velocity shock tube preparatory to firing. Naff, a graduate of Louisiana Polytechnic Institute, is working on his Master's Degree at the University of California, while employed at Lockheed's Palo Alto Research and Development Laboratory.



ANNUAL ALUMNI PICNIC

Saturday, June 28, 1958—Knott's Berry Farm

The date set for the Annual Alumni Picnic is Saturday, June 28, 1958 and it will be held this year at Knott's Berry Farm, Buena Park, California.

Come and bring the children—and your friends and their children!

Common meeting place—"The Arena" in Ghost Town.

Box lunches complete with beverage can be purchased and eaten in "The Arena."

or

Bring your own lunch and eat in "The Arena." Ample seating in the shade available.

Announcements, with details, will be in the mails early in June.

SAVE THIS DATE

Charles F. Forester, '49
Chairman, Picnic Committee

ANNUAL ALUMNI BANQUET

Wednesday, June 11, 1958
Rodger Young Auditorium

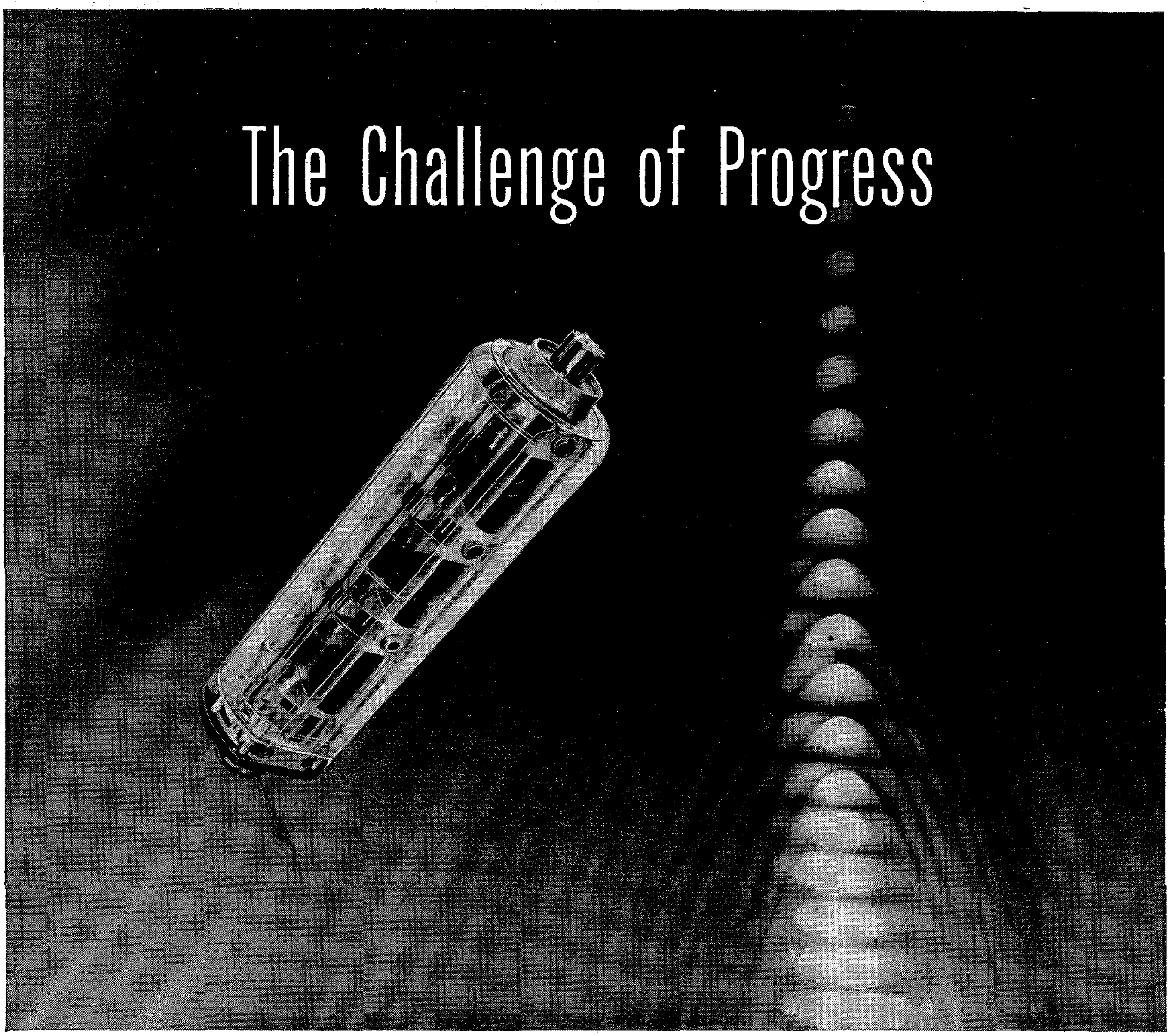
The Caltech Alumni Association will hold its annual dinner and meeting on Wednesday, June 11, 1958 at the Rodger Young Auditorium, 936 West Washington Blvd., Los Angeles, California.

Dr. Simon Ramo, '36, President of Space Unit Division, Ramo-Wooldridge Corporation, will be the principal speaker and his subject ("Space and Electronics—Which Will Dominate the Century?") is timely.

Dr. Lee A. DuBridge will give his annual report to the alumni on Institute affairs.

The reunion of Classes of 1903, 1913, 1918 (April and September), 1923, 1928, 1933, 1938, 1943, 1948, and 1953 will be held on the same evening. All alumni are cordially invited to attend. Please get your reservation into the Alumni Office by June 6th.

Barton B. Beek, '44
Chairman, Banquet Committee



Recently AiResearch engineers were called upon to develop an accessory power motor for aircraft and missiles which would operate at +1000°F.... a temperature area where present-day hydraulic and electrical devices fail.

Their answer was this cam piston air motor, pictured above in a specially built transparent shell. Operating on hot air or gas, its efficiency actually increases as temperatures rise.

This problem and its solution are typical of many encountered at AiResearch in aircraft, missile, nuclear and electronic fields. Specifically, you'll find them in system electronics; computers and flight instruments; gas turbine engines and turbine motors; cryogenic and nuclear systems; pneumatic valves; servo control units and air motors; industrial turbochargers; air conditioning and pressurization; and heat transfer.

Upon your employment, in addition to direct assignments, a 9-month orientation program is available to aid you in selecting your field of interest. This permits you to survey the project, laboratory and administrative aspects of engineering at Garrett. Also, with company financial assistance, you can continue your education at outstanding universities located nearby.

Project work is conducted by small groups where individual effort is more quickly recognized and opportunities for learning and advancement are enhanced.

• ***For full information write to Mr. G. D. Bradley.***

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1945

James B. Green, formerly midwest district manager for the Jeffrey Mfg. Company, is now manager of the Fort Worth (Texas) Steel and Machinery Company's engineering sales division. The Greens have four children—a daughter and three sons.

1946

Carl Richardson, MS, works as a materials coordinator at C. F. Braun & Company in Alhambra. He has two daughters, Emogene and Kay.

Ali Bulent Cambel, MS, chairman of the department of mechanical engineering and head of the gas dynamics program at Northwestern University, is co-author of a new textbook, *Gas Dynamics*, published by the McGraw-Hill Book Company.

1948

James Wendel, PhD, writes from Ann Arbor: "I've been associate professor of mathematics at the University of Michigan since the fall of 1955—and we have five children now. *Donald A. Darling*, PhD'57, and *Jack E. McLaughlin*, PhD '50, are both here, too."

1949

Radoy W. Heggland writes that he moved to New Orleans from Roswell, New Mexico, two years ago. He is assistant division geologist with the Continental Oil Company. The Hegglands have a six-year-old daughter, Sherry.

William C. A. Woods is now a nuclear engineer with the Ralph M. Parsons Company in Los Angeles and is living in Monrovia. Until last summer, Bill worked for the AEC in Washington.

Burton B. Rutkin MS '50, is now working as an engineer at the Shell Development Company's Emeryville, California, Research Center.

1951

William E. Eilau is a project engineer for the Sandberg-Serrell Corporation in Pasadena. Currently in charge of the design of a hypersonic wind tunnel for one of the local aircraft companies, Bill has been with Sandberg-Serrell for the past five years. The Eilaus have three children—Ronnie, Patty and Barbara.

John R. Fee is now director, secretary and assistant chief engineer for James M. Montgomery, consulting engineer—a Pasadena corporation specializing in hydraulics, water supply, water treatment, and sanitation engineering.

1954

Neal Huntley, MS '55, writes: "Since returning to Procter & Gamble from the Army last July, we have bought a home in Anaheim and now have a baby son, Christopher Neal. I am a chemical engineer for synthetic products at P&G's Long Beach plant. Other recent graduates here are *Dick Hodges*, '54, *Bill Chambers*, '55, *Arne Kalm*, '56, and, in June, Don Stocking, '58 and *Larry Berry*, '58, will join us. *Phil Conley*, '56, just left for two years at the Army Chemical Center, and *Terry Thomas*, '53, MS '56, has been transferred to the Kansas City plant."

Quayton R. Stottlemyer, MS, is now working in the research division of Du Pont's photo products department at the Parlin, New Jersey, laboratory. He received his PhD in physical chemistry from Penn State this year.

Mark Cher received his PhD from Harvard University last month.

Charlton Dunn, III, is working with the applied mechanics group at the Rocketdyne division at North American Aviation in Los Alamos.

1955

Oreste W. Lombardi is now chief chemist for the Columbia Southern Chemical Corporation in Bartlett, California.

Alfred M. Goldman, MS '56, writes that he was released from active duty at the Air Research and Development Command headquarters in Baltimore last December and is now an aeronautical engineer in the aerodynamics department of the Hughes Aircraft Company in Culver City.

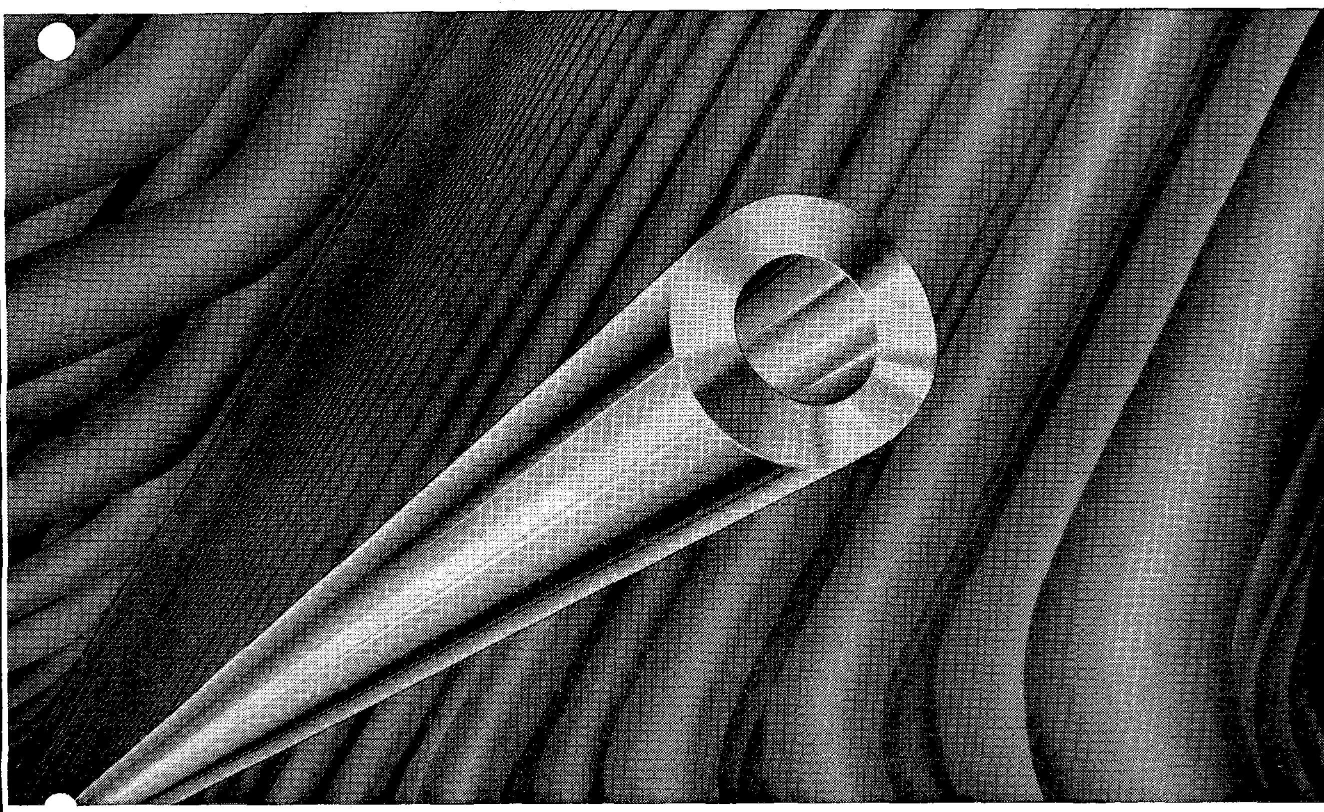
Robert L. Metzenberg, Jr., PhD, research associate in physiological chemistry at the University of Wisconsin Medical School, has been appointed a Scholar in Medical Science by the John and Mary R. Markle Foundation of New York. Bob is one of 25 appointees who will share in $750,000 which has been appropriated toward their support to the schools where they will teach and do research.

Thomas H. Bergeman received his Master of Arts degree from Harvard University last month.

1957

Michael Bleicher is studying for his MS at Tulare University, and also teaching freshman calculus. The Bleichers are enjoying New Orleans—finding it "a fascinating, cosmopolitan and very rainy city."

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



The hole that couldn't be made will be 20 miles long

THE Philadelphia Electric Company set out to build a revolutionary new power plant that would squeeze more energy out of fuel than ever before. This meant harnessing the highest combination of pressure and steam temperature ever achieved in a central station—5,000 psi. and 1,200° F.

The boiler superheater tubes that carry this steel will glow red hot 24 hours a day, year in, year out. If made from the alloy steels customarily used, the tube walls would have to be so thick that no mill could pierce it. So thick that heat transfer losses would be ruinous to boiler efficiency. A super alloy steel was needed, but no one had ever succeeded in piercing such steel into tubes without developing internal flaws.

Combustion Engineering Co., designers and builders of the boiler, gave the problem to Timken Company metallurgists. The problem was to make the steel with all the alloys in just the right balance to produce piercing quality steel.

Thru metallurgical research, they achieved the proper balance of alloy elements that made it possible to pierce 20 miles of seamless superheater tubes of the size shown above. It's another example of how Timken Company metallurgists solve tough steel problems.

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For information about fine steel, send for "The Story of Timken Alloy Steel Quality". And for help in planning your future, write for "BETTER-ness and Your Career at the Timken Company". Just drop a card to The Timken Roller Bearing Company, Canton 6, Ohio.

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CALTECH CALENDAR

Athletic Schedule

TENNIS

May 17
UC, Riverside at Riverside

May 23
Conference Tournament at Pomona-Claremont

May 24
Conference Tournament at Pomona-Claremont

BASEBALL

May 17
Occidental at Caltech

GOLF

May 16
Occidental at Caltech

May 23
All-Conference Tournament at Los Serranos

Alumni Events

June 11 Annual Meeting
Rodger Young Auditorium

June 28 Annual Picnic
Knott's Berry Farm

San Francisco Chapter
June 7 Family Picnic
Lake Temescal Park, Oakland

Friday Evening Demonstration Lectures

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

May 16
Radiation and Its Effect on the Heredity of Animals—
by Dr. Edward Lewis

May 23
The Use of Multipurpose Food to Ameliorate Protein Malnutrition in Asia—
by Dr. Henry Borsook

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