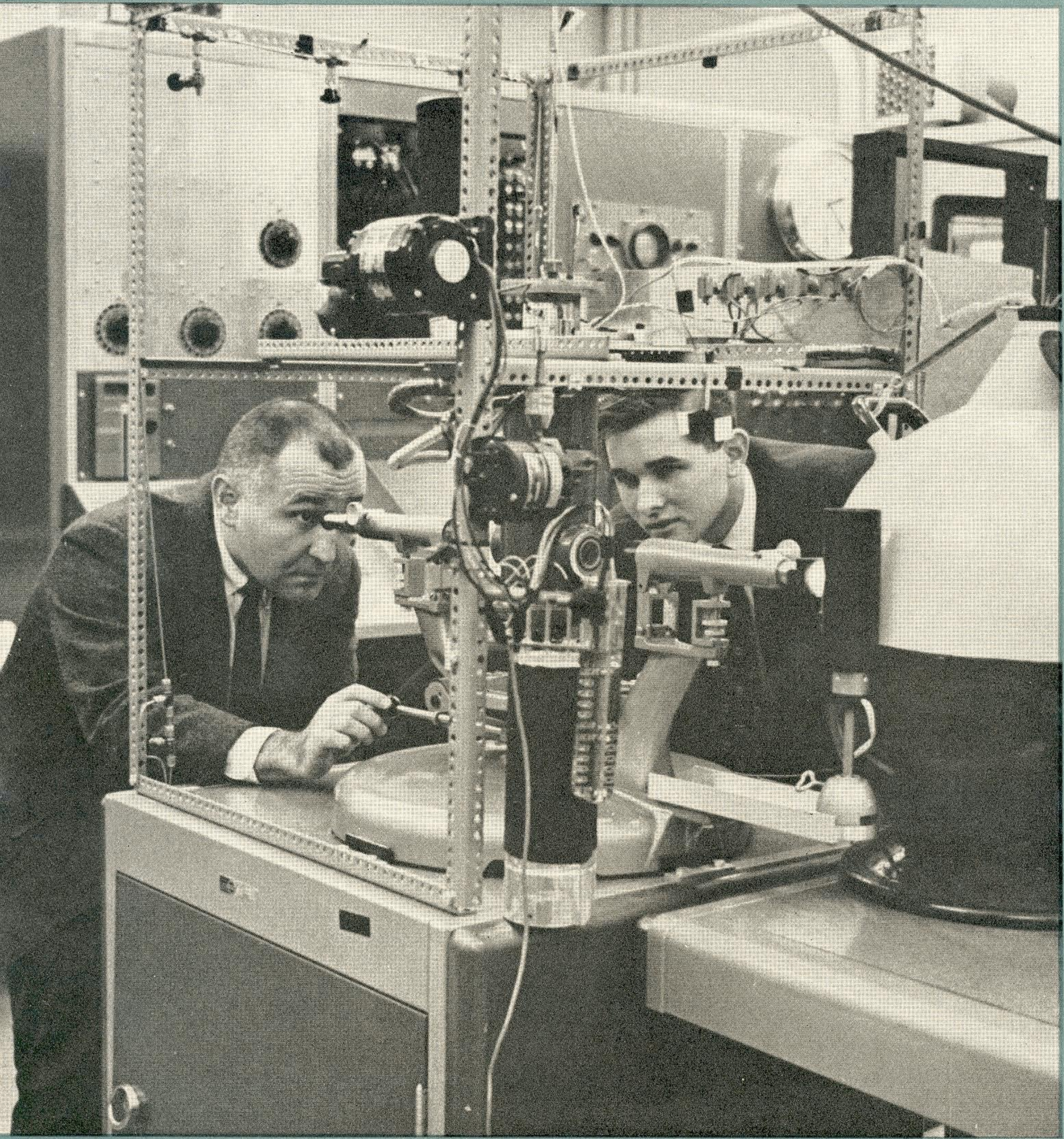
# ENGINEERING | AND | SCIENCE

January 1962



Inert gases . . . page 14

Published at the California Institute of Technology


If it isn't fun, don't do it!
There are those who will tell you that the world beyond the academic walls is (a) highly competitive, (b) full of opportunity, and (c) above all, serious business. Although we are keenly aware of the serious implications of the advanced propulsion work we're doing, at UTC we take a somewhat different view.
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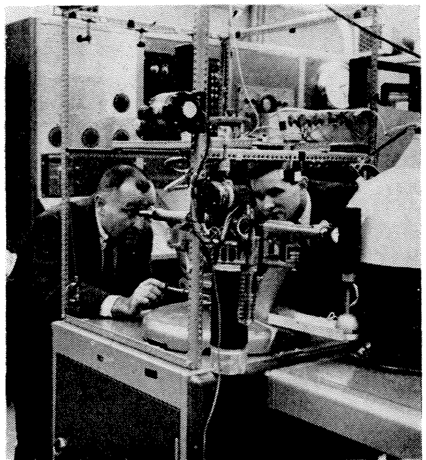

*On Our Cover*

–C. J. Pings, associate professor of chemical engineering at Caltech, and research fellow Brian L. Smith. Here, in the Spalding Laboratory of Engineering, Pings and Smith are determining the optical properties of liquid argon, one of the inert gases.

Although inert gases were discovered nearly 70 years ago, only in recent years have they been recognized as valuable materials in research. At Caltech, today, the inert gases are being studied in the divisions of chemistry, engineering, geology, and physics—as Dr. Smith relates in his article, "Inert Gases—Ideal Atoms for Research," on page 14. Brian Smith is from England, where he received his PhD at Queen Mary College at London University in 1960.

*Podophthalmus vigil*

is the name of a crab with three brains, and astigmatic periscope eyes on long stalks, who is assisting scientists toward a better understanding of the central nervous system. C. A. G. Wiersma, professor of biology at Caltech, started research with the crab last summer at the University of Hawaii's Waikiki Marine Laboratory. On page 28, Graham Berry, assistant director of the Caltech News Bureau, tells about this research on "The Cooperative Crab."

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Cover, 16, 19 (top), 22-24, 28–
James McClanahan
17, 18, 19 (bottom)—Brian L. Smith

*JANUARY 1962    VOLUME XXV    NUMBER 4*





Published monthly, October through June, at the California Institute of Technology, 1201 East California St., Pasadena, Calif. Annual subscription $4.50 domestic, $5.50 foreign, single copies 50 cents. Second class postage paid at Pasadena, California.  Manuscripts and all other editorial correspondence should be addressed to: The Editor, *Engineering and Science*, California Institute of Technology. 

# Books

## *On Growth and Form*

*by Sir D'Arcy Thompson*

*Abridged edition, edited by John Tyler Bonner*

*Cambridge University Press . . $5.95*

*Reviewed by Hendrik J. Ketellapper, research fellow in biology*

*On Growth and Form* is one of the classics of biology. The first edition, published in 1917, caused quite a commotion among the comparative anatomists of that time. The author called his opus "an easy introduction to the study of organic form by methods which are the commonplaces of physical sciences." D'Arcy Thompson looked for immediate physical causes for the explanation of growth and form, to the extent of being one-sided. However, he opened the modern era where the application of physical and mathematical principles to biological problems does not raise any eyebrows.

The reader may be disappointed because D'Arcy Thompson was no experimenter, nor did he suggest experiments. Therefore, no immediate causes are definitely established. The book has greatly influenced biology, however.

The author's fame rests on the first edition. The second edition of 1942 was too unwieldy and the examples obscured the issues. Since our present generation is scared by books of 1116 pages, John Tyler Bonner has done biologists a service by editing the book down to a manageable 346 pages containing all the essentials of D'Arcy Thompson's ideas in his own words.

## *Notes on Molecular Orbital Calculations*

*by John D. Roberts*

*W. A. Benjamin, Inc. . . . $4.95*

*Reviewed by John H. Richards, associate professor of organic chemistry.*

In his third slim volume in as many years John Roberts, Caltech professor of chemistry, sets out to make intelligible the complex world of molecular orbital theory. The book is intended for those persons interested in becoming familiar with a technique (LCAO molecular orbital theory) for predicting and correlating the behavior of conjugated organic molecules. The calculations required in the application of this theory are simple and, considering the approximations involved, the results are astonishingly useful and in many cases of fairly precise quantitative significance.

These *Notes on Molecular Orbital Calculations* admirably accomplish their purpose. Concepts which have hitherto been available only in relatively abstruse papers in the original literature are presented in this volume with great clarity. There are frequent exercises interspersed throughout the text which lead the active student gently (usually!) to a feel for the molecular orbital technique just discussed. Though neither a detailed nor an advanced monograph, this book does contain brief descriptions of the more elegant MO methods and sufficient leading references so that the interested student may easily find his way into the more sophisticated literature.

Besides being a learn-it-yourself text, this book has a real do-it-yourself flavor: written by Roberts, art work (including dust jacket design) by Roberts, and published by W. A. Benjamin, Inc., a company of which Roberts is a co-organizer and director. The only book of its kind presently available, these notes will make available to a large body of organic chemists a theoretical tool which in the past they have too little used or too superficially understood.

**ALUMNI BOOKS**

## *Handbook of Transistor Circuit Design*

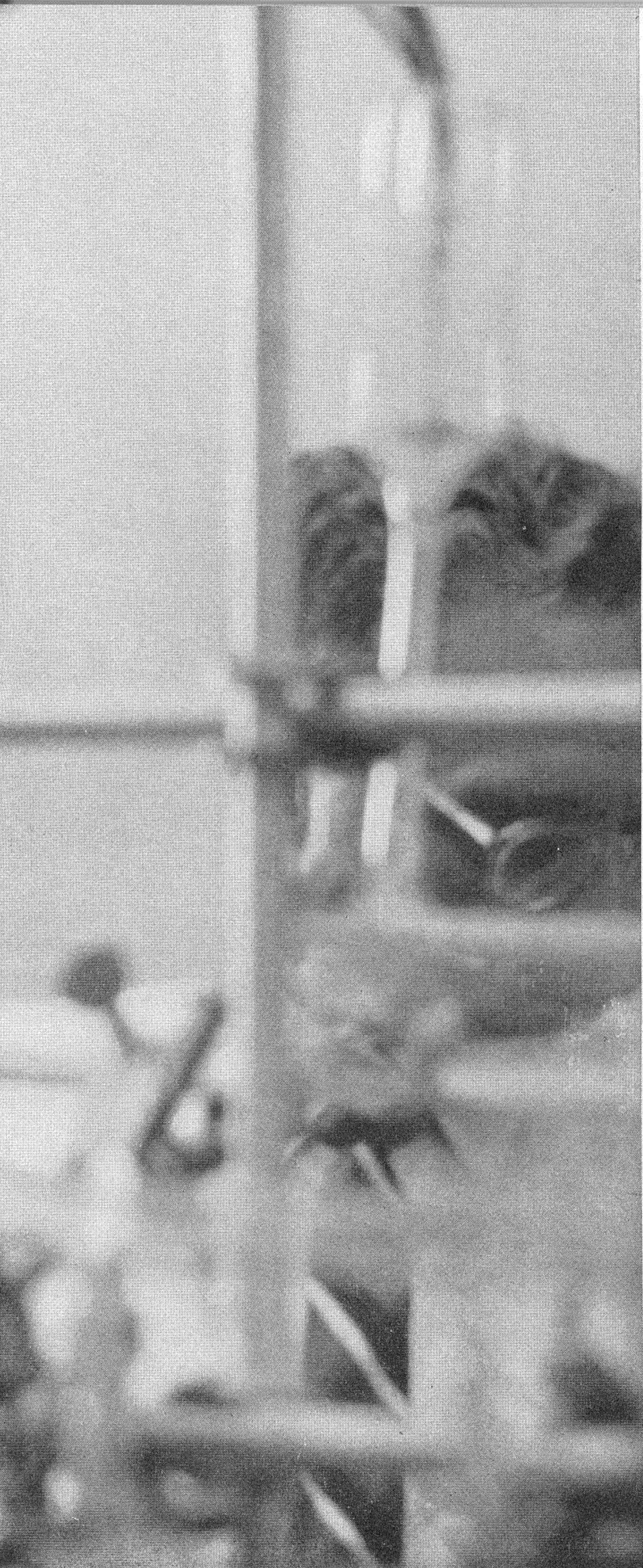
*by Keats A. Pullen, Jr. '39*

*Prentice-Hall . . . . . $4.95*

## *Computer Programming Handbook: Guide for Beginners*

*by Robert Nathan, Ph.D. '56, and Elizabeth Hanes*

*Prentice-Hall . . . . . . $6.75*



Edward M. Davis, Jr. (B.S.E.E., Carnegie Tech '55; M.S., Cal Tech '56; Ph.D., Stanford '58) is directing micro-electronic device development at IBM's Poughkeepsie, New York Laboratories.

# DR. DAVIS AND MICRO-DEVICES

When Dr. Edward M. Davis was working for his bachelor's degree, miniaturization was a novelty. Today, with the transistor and the printed circuit commonplace, micro-miniaturization is one of the newest challenges in electronics. Ed Davis is helping to meet that challenge.

Today's computer operations take only millionths of a second; tomorrow's may accelerate to billionths. In a billionth of a second, however, even light can travel only about a foot, and the physical size of an electronic circuit may slow its operation critically. The answer is in micro-electronics where complete circuits are packaged on minuscule substrates, and each transistor may occupy less than a thousandth of a square inch.

Since early in 1961, Ed Davis has been in charge of an IBM engineering project exploring the parameters of advanced micro-devices. His work may very well help establish the technology of future computers. Equally important, he and his colleagues are already gathering significant knowledge in the advanced study of solid state electronics.

A basic approach is encouraged at IBM. Whether in research, development, manufacturing, or programming, the IBM scientist and engineer are encouraged to go to the heart of the problem. The IBM representative interviewing on your campus will be glad to discuss with you the opportunities in any one of these fields. All applicants will receive consideration for employment without regard to race, creed, color or national origin. Your placement office can make an appointment, or you may write, outlining your background and interests, to:

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# Letters

Los Angeles, California

Sirs:

Caltech Peak is now the official name of a lofty High Sierra mountain, according to a decision taken by the Board on Geographic Names of the Department of the Interior at its December 14 meeting in Washington, D. C. The mountain, 13,832 feet high and previously unnamed, is located near the John Muir Trail almost on the boundary between Sequoia and Kings Canyon National Parks and near Mt. Whitney, about 200 miles north of Los Angeles.

The new name is the result of an idea and a weekend climbing trip by Jim Eder ('65), Dick Jali ('55) and Ted Matthes ('55) who decided there should be a mountain named after Tech, especially since University Peak (University of California), Mt. Stanford (Stanford University), and Trojan Peak (University of Southern California) are other California mountains named after California universities. The peak chosen was selected because it was prominent, unnamed, and near the other peaks mentioned above.

The three Techmen made the third recorded ascent of the chosen peak on 25 June 1961. They left the roadhead in the Owens Valley near the town of Independence on Saturday 24 June and hiked over Shepherd Pass (12,124 feet) into the upper reaches of the Kern River Canyon. On Sunday 25 June a long hike around Diamond Mesa and up a beautiful lake-filled valley brought them to their peak, which was q u i c k l y and eagerly climbed. An awesome view of great mountain peaks and wilderness was had from the summit, where an enlarged cairn was built and a simple summit register established.

After the climb it was a matter of letterwriting. The name Caltech Peak was simultaneously proposed to the Board on Geographic Names of the Department of the Interior and to the Superintendent of Sequoia-Kings Canyon National Parks. Copies of the Los Angeles *Times* supplement on Caltech (supplied by *E & S*) were also sent to both parties for their information. After careful deliberations the name was approved for Federal usage by the Board and will be published in Decision List 6103.

The climb is long and arduous (about 26 miles round trip and over a high pass) but is not technically difficult and is rather pleasant.

Richard M. Jali '55

Erwinna, Pennsylvania

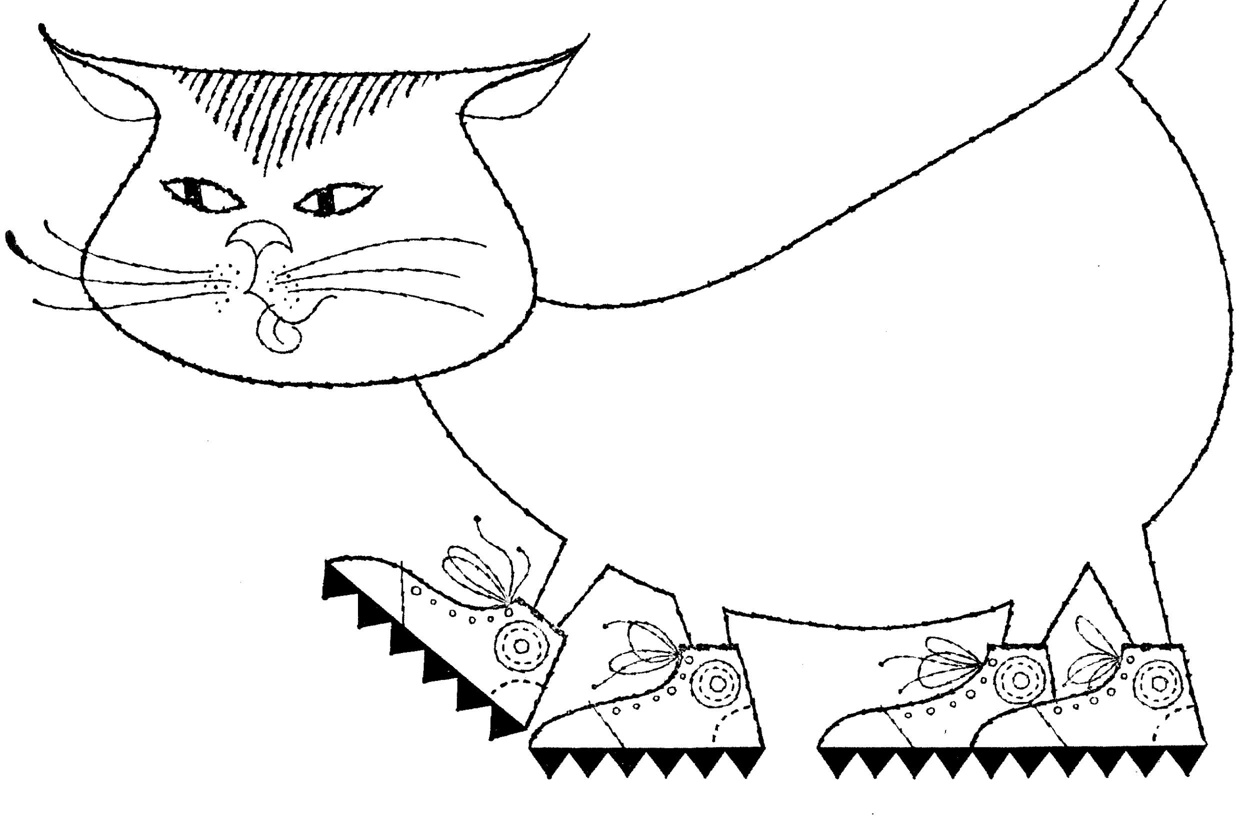
*From Robert Lawler, a former student at Caltech, comes this tribute to Hunter Mead, professor of philosophy and psychology, who died on July 2, 1961.*

## HUNTER MEAD TAUGHT ME

That I might find in works and lives of men
Absurdity, high tragedy and pen
  a truer line of praise than that the head
Could shape from dreams reworked and shown again.

"Art can be seen as tapestry. Align
"Experience. Select and weave. Refine
  "And order life and death. The form," said Mead
"Survives the truth. Since colors fade, design."

"With irony and reverence your life,
"Though short, can be allright. Use piety rife
  "With ribaldry," he stuttered, and is dead.
I celebrate the way he wore his life.



ENGINEERING AND SCIENCE
*January 1962, Volume XXV, No. 4*

# THE NEED FOR DETECTION

## *Some comments on our negotiations with the Russians on nuclear testing.*

*by Robert F. Bacher*

Our present negotiations with the Soviets on nuclear testing really started almost three and a half years ago. In the spring of 1958, President Eisenhower, after consulting with Prime Minister Macmillan, proposed to Chairman Khrushchev that a conference be called to discuss the technical problems which would be encountered in monitoring a nuclear test ban. After an extended exchange of letters, arrangements were made for East-West talks to start July 1 in Geneva.

The Western group consisted of representatives from the United States, Britain, Canada, and France; the Soviets brought representatives from Czechoslovakia, Poland, and Rumania. It was not clear, just before the talks were scheduled to start, whether the Soviet group would appear at all. The conference did start as scheduled, but with a most inauspicious introduction, since the Soviets wanted a guarantee that the technical discussions would be followed automatically by political agreement for a test ban. The United States and other western nations were completely unwilling to go ahead on this assumption. However, after some rather strained meetings, the conference did get down to the problems of detection and inspection.

The detection of nuclear explosions had been studied by both East and West. Work on the detection of atmospheric tests had been going on for many years in the United States and had been successful in detecting the first Soviet test in 1949. This test was verified by the collection of nuclear debris from high in the atmosphere. In the succeeding years, these and other methods had been developed and improved, and by 1958 it was possible to detect relatively small atmospheric tests by their electromagnetic effects or their pressure pulses, as well as by the collection and analysis of the nuclear debris which was formed.

A few days ago I saw some equipment which had detected the air-pressure pulse from the large Soviet explosion on October 30, 1961, on three successive transits around the earth—the first one being off scale on the most insensitive setting. This equipment was located inside a college laboratory, and it was no larger – and considerably less complicated – than a portable television set.

Our knowledge of underground explosions was very

*"The Need for Detection" has been adapted from a talk given by Dr. Bacher at a colloquium on Detection of Underground Nuclear Explosions held at Caltech on December 14 and 15, 1961. Dr. Bacher, provost of the California Institute of Technology, served as a member of the original U. S. scientific team at the Geneva test ban conference in 1958.*

*About 200 scientists and government administrators from Canada, England, France, and the United States attended this Caltech colloquium, which was sponsored by the Institute's Office of Industrial Associates. Arthur H. Dean, chairman of the U. S. delegation to the Conference on the Discontinuance of Nuclear Weapons Tests, and U. S. Representative to the 16th session of the General Assembly of the United Nations, was originally scheduled to address the colloquium, but "public business of the highest importance" prevented him from attending the meeting.*

*"Despite the present unhappy status of the negotiations in Geneva," said Ambassador Dean in a message to the colloquium, "I am absolutely convinced that achieving a nuclear test ban treaty will continue to be one of the principal objectives of United States foreign policy . . . If I may be allowed to strike the keynote of the colloquium in absentia, I would say that constructive optimism should be the order of the day."*

*"It has been argued that the last three years of political negotiations on a test ban—which culminated last August with the breaking off of these talks, and the start of a Soviet test series which ran to around 50 tests and 120 megatons of nuclear explosions—have made it clear that nothing will be achieved in this area of negotiations, and that efforts on the improvement of detection are a waste of time. I must say that I find it impossible to accept this view."*

fragmentary in 1958 and was based on observations of a single underground explosion, the Ranier test. The results of this test were difficult to understand and there were sizable differences in the seismic records produced at various stations nearly equidistant from the explosion. The relation of this test to natural seismic disturbances, both as to the nature of the record received and as to the magnitude of earthquake to which it corresponded, was known only roughly.

## *Technical and political problems overlap*

Our preparations during May and June of 1958, for the conference scheduled for July, showed that talks which would involve complicated technical problems raised many difficulties new to political negotiations. This Geneva conference was to be technical in nature and political problems were to be deferred until later negotiations, if these were desired by both sides. Nevertheless, technical and political problems often overlapped. For example, worldwide coverage for a nuclear detection network cannot be achieved if major land areas are excluded. Clearly, the participation of Communist China would be required for a successful system, whether or not this was politically easy. The same could be said about Africa and Australia.

This much was clear and had been recognized publicly by Secretary Dulles. But there were many other ways, not so obvious, in which technical problems became involved in political problems. Our government was not well prepared to handle problems of this sort, and somewhat similar difficulties arose in the East-West conference on the prevention of surprise attack held later in 1958 in Geneva.

During the 1961 session of Congress, the United States Arms Control and Disarmament Agency was established to prepare for United States participation in international negotiations in arms control, as well as to foster necessary research and to prepare for participation in such control systems as may become part of United States arms control and disarmament activities. The director of this agency is Mr. William C. Foster, former Deputy Secretary of Defense, who has had extensive experience in this subject. The establishment of this agency is a major advance.

Our preparations for the talks in 1958 naturally led to the consideration of the detection of small nuclear explosions as well as large ones. Small nuclear devices are considered to be useful for certain military operations, and in addition are important in the development of larger-yield weapons. For explosions in the atmosphere or in the oceans it is possible to detect even rather small explosions quite effectively. For small underground nuclear explosions the problems are much more difficult. The most difficult problem of all is to distinguish a suspected underground explosion, detected by the seismic disturbance it causes, from the rather large number of small seismic disturbances which occur naturally. In preparing our position it was suggested that we might set a threshold and not try to limit nuclear explosions below some particular yield. This raised a great many non-technical problems and this procedure was not followed, even though it might have simplified the technical difficulties.

## *Differences of opinion*

As far as we know, the Soviets had not carried out any underground tests prior to the 1958 conference. After the talks got under way there were wide differences of opinion as to how the seismic signal from a nuclear explosion decreases with distance. The differences between seismic signals from a nuclear blast and those caused by an earthquake also gave rise to heated discussions. No data were brought forward except those from the Ranier test, and most of the discussions had to depend on general seismic information, and on information available about natural disturbances. The frequency of earthquakes in various parts of the world, which is important if natural phenomena are difficult to distinguish from nuclear explosions, was also known only very roughly.

The really sensitive question, of course, was—and still is—inspection. Could a nuclear detection network function so well that the explosion of a nuclear weapon could be established beyond all reasonable doubt by technical means alone, so that inspection would not be necessary? For underground explosions there seemed to be very little chance that this could be done. The best one could do would be to provide grounds for suspecting that a nuclear explosion had occurred at some location, and that a careful inspection of the region would be necessary in order to arrive at a definitive answer.

Since the Soviets were most reluctant about inspections of their territory, and later, in the political discussions, tried to limit drastically the number of inspections which would be allowed, the criteria for determining that there were sufficient grounds for suspecting that a nuclear explosion had occurred came in for detailed examination. For the underground explosions, the principal difficulty was lack of experimental information. Furthermore, it was clear that a much greater effort would be needed to improve the means of detecting underground explosions and natural disturbances as well. In the last three years a great effort has been focused on this area under the Vela Project, a government research program devoted to improvement in the technique for the detection of nuclear explosions.

## *The need for detection*

But what about the need for detection? A better understanding of seismic disturbances, and better means for the detection of these effects, and for nuclear explosions as well, may be sorely needed if we are to have a nuclear test ban. But the chances for such a ban in the immediate future do not look very good today. It has been argued that the last three years of political negotiations on a test ban—which culminated last August with the breaking off of these talks, and the start of a Soviet test series which ran to around 50 tests and 120 megatons of nuclear explosions—have made it clear that nothing will be achieved in this area of negotiations, and that efforts on the improvement of detection are a waste of time I must say that I find it impossible to accept this view. Although the events of the past few months are certainly most discouraging, it is hard to believe that in time the Soviets will not come to the conclusion that both they and we will benefit by a limitation in the arms escalation that is now going on. In particular, we would both benefit by a limitation in the spread of really powerful weapons and delivery systems to nations not now possessing them. The Soviets have given indications that they are sensitive to this view.

This is precisely the position that has been taken by our government, in the proposals which President Kennedy made to the United Nations in September, 1961, for an extensive program aimed at general and complete disarmament. While the international climate today does not seem to be very favorable for these proposals, nevertheless they do appear to be sound objectives. It is difficult to see how our national security—and, indeed, that of the Soviets, too—can fail to be diminished by the spread of the most modern and most powerful weapons.

The proposals made by our government in the United Nations provide for the establishment of an International Disarmament Organization. Under this organization, there would be provision for arms limitation and disarmament in a series of stages. The first stage provides for the reduction of armed forces and the so-called conventional armaments, as well as for steps to contain and reduce the nuclear threat, and to reduce strategic nuclear weapons delivery systems. There would be provisions to promote the peaceful use of outer space, a subject on which a little progress has just recently been made, and provisions to reduce the risks of war by accident, miscalculation, and surprise attack. Later stages would provide for further steps in all these areas, and for the establishment of a United Nations Peace Force.

## *Reducing the nuclear threat*

The provisions to contain and reduce the nuclear threat start with the effective prohibition of nuclear tests by all states that had not already so agreed. The proposals go on to a cessation of the production of fissionable material for use in weapons and provision for the transfer of material produced in the past to non-weapons purposes. Provision is made that the states owning nuclear weapons will not transfer them to any nation not owning them; nor will these latter states be allowed to manufacture or develop them. These are tremendous steps that are proposed, but they are only the first of the steps required.

For the very first step, the effective prohibition of nuclear testing requires careful monitoring and also inspection. Monitoring and inspection are central to *any* agreement for effective arms limitation and control. Unilateral actions which do not provide for these combined functions are not very meaningful, as we have recently seen. But if monitoring and inspection are to be important in the future, we need to understand them and we must be prepared to use them where they are required.

The limitation of nuclear tests is almost certain to be a requirement for any agreement in the whole area of arms limitation and control. Our present proposals make it one of the earliest steps. If such a step is to be successful, it is most important that we improve our methods of detection and identification of underground nuclear tests, and that we understand what can be detected and what can not be detected. Success will depend heavily on the accomplishments of those who are attending this conference, so you have great opportunities and great responsibilities.

# INERT GASES —

## *Ideal Atoms for Research*

*by Brian L. Smith*

Argon, neon, helium, krypton, xenon, and radon sound like characters from the Old Testament of the Bible. They are actually members of the "inert gas" group of chemical elements, small amounts of which exist in every breath of air we take.

The inert gases were brought to light less than 70 years ago. Their discovery caused a considerable stir in scientific circles because their existence upset the ideas then current concerning the composition of the atmosphere, and the periodic classification of the elements. Once these difficulties had been settled, however, scientists soon lost interest in the inert gases. Only in recent years have they been recognized as valuable materials for research, and at Caltech, today, they are being studied in the divisions of chemistry, engineering, geology, and physics.

Argon was the first of the inert gases to be discovered. Shortly before the turn of the century, Lord Rayleigh, an English physicist, set out to redetermine the densities of the principal gases then known to scientists. The measurements were considered to be routine and Rayleigh did not anticipate that the investigation would lead to any startling results. Still less did he suspect that the work would lead to the discovery of a new element, for which he and his colleague, Sir William Ramsey, would be awarded Nobel Prizes.

*Inert Gases in the Atmosphere*

| | |
|---|---|
| Argon | 1 part in 107 |
| Neon | 1 part in 55,000 |
| Helium | 1 part in 200,000 |
| Krypton | 1 part in 1,000,000 |
| Xenon | 1 part in 12,000,000 |
| Radon | 1 part in $10^{21}$ |

The results of Rayleigh's experiments were consistent, except for nitrogen. Atmospheric nitrogen was found to be slightly more dense than nitrogen produced chemically. At this stage Rayleigh was joined in his researches by Ramsey, and the two men investigated the discrepancy. They found that the difference was due to the presence in atmospheric nitrogen of about one per cent of an unknown element, which they named argon (Greek—non-active) because of its apparent inertness. In 1895, Rayleigh and Ramsey announced their discovery to a meeting of the Royal Society in London.

Their news was greeted with a certain amount of scepticism. At that time it was commonly supposed that air consisted of nitrogen, oxygen, carbon dioxide, and water vapor. Scientists had forgotten the work carried out by the chemist, Henry Cavendish, more than a century earlier. Cavendish had experimented to see whether "phlogisticated" air (nitrogen) was homogeneous or a mixture of different gases. He had found a small bubble of gas—presumably mainly argon—for which he could not account, but had concluded his investigation with the comment, ". . . if there be any part of the phlogisticated air of our atmosphere which differs from the rest, we may safely conclude that it is not more than 1/120 part of the whole."

Another upsetting factor which made scientists unprepared to accept the existence of argon was that it did not fit into the periodic table. The properties of argon were such that it did not correspond to any of the elements which scientists predicted would be brought to light because of the gaps left in the table.

The controversy was ended with the subsequent discovery of helium, neon, and the other inert gases. It was then realized that these gases formed an entirely new group in the periodic table — elements which were characterized by complete chemical inactivity.

Apart from radon, which is radioactive, and helium, which exhibits unusual properties at low temperatures, the inert gases had little obvious appeal as materials for research. In recent years, however, there has been a revival of interest in these substances because of the realization that they closely correspond to simple theoretical models, and are therefore useful in the development of molecular theory.

One of the most ambitious programs in which physicists and chemists are now engaged is the development of the molecular theory of the physical properties of matter. Their aim is to describe the macroscopic or "real-life" properties of gases, liquids, and solids, in terms of molecular behavior. In general, this is an impossible task because of the complicated mathematics involved; but for certain substances, of which the inert gases are outstanding examples, enough simplifying assumptions may be made for the development of such a theory to be possible.

For example, when calculating a macroscopic property, one should, in principle, consider the contributions made to the property by each of the molecules. It is, in other words, a "many-body" problem involving all n of the molecules, where n is probably about $10^{22}$. This, of course, takes a long time to compute! Fortunately, the problem can be simplified somewhat for the inert gases.

The forces which act between inert gas molecules, and which bind them together in the liquid and solid states, are short-range and effective only over a distance of a few molecular diameters. They are also expressible in simple algebraic terms.

The net force acting on any one molecule can therefore be accurately estimated by considering interactions with its nearer neighbors only. Molecules further away than a few molecular diameters will make no contribution. The net force operating on the representative molecule can be expressed as a "two-body" force, acting between the molecule on one hand and its neighbors on the other.

The bulk property is then obtained by adding up these effects for all the molecules which are present, assuming that the net forces acting on them are the same as for the representative molecule.

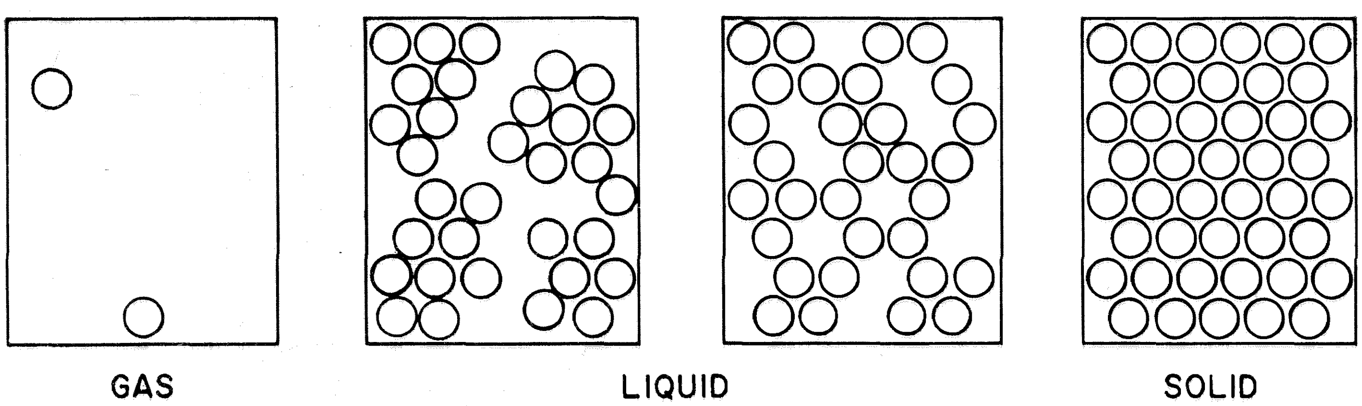
This type of calculation is relatively easy for the inert gases because the effect of "free" electrons does not have to be taken into consideration. The atoms are characterized by full and stable electron shells, and this is what gives them their inert properties. They are in fact like the miniature "ping-pong balls" often used in scientific theories—easy to handle mathematically because they are spherically symmetrical in their interactions.

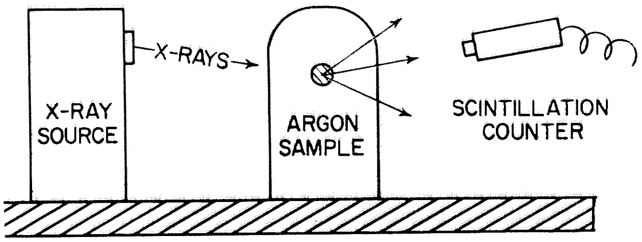
The inert gases, with the exception of helium, are readily liquefied and solidified by normal low temperature methods. They may therefore be studied as gases, liquids, or solids. At Caltech, for example, I am assisting C. J. Pings, associate professor of chemical engineering, in an investigation of the distribution of molecules in dense fluids, using argon.

This has been a puzzle for a long time. In a gas at low pressure, the molecules are distributed completely at random. In a solid, the molecules are usually fixed in some type of crystal lattice. The molecules in a dense gas or a liquid, however, have neither the complete "chaos" of a low pressure gas nor the "order" characteristic of a solid. The structure of these fluids is intermediary, and at present not known. A number of suggestions have been put forward as possible molecular distributions in a liquid, but more evidence is required before one of these "models" is established as correct.

We use x-rays to investigate the structure of liquid argon. A narrow beam of monochromatic x-rays impinges on a sample of argon, contained in a cylindrical beryllium tube and maintained at a constant temperature and pressure. The x-rays are scattered both by the argon sample and the beryllium tube. Some of the x-rays are absorbed and others deflected

*Distribution of Molecules in a Gas, Liquid, and Solid*






*In Caltech's chemical engineering laboratories, an x-ray diffractometer is used to investigate the structure of liquid argon.*

at various angles. Of those that are absorbed, a certain percentage are re-emitted, but with a longer wavelength. The emergent beam forms a diffraction pattern which is detected and recorded either by means of photographic film or an electronic counter.

In the present work, we use a scintillation counter to measure the intensity of the diffracted beam. The counter is able to rotate about the axis of the specimen. It can, therefore, be used to measure the intenity of the x-rays which are scattered at different angles.

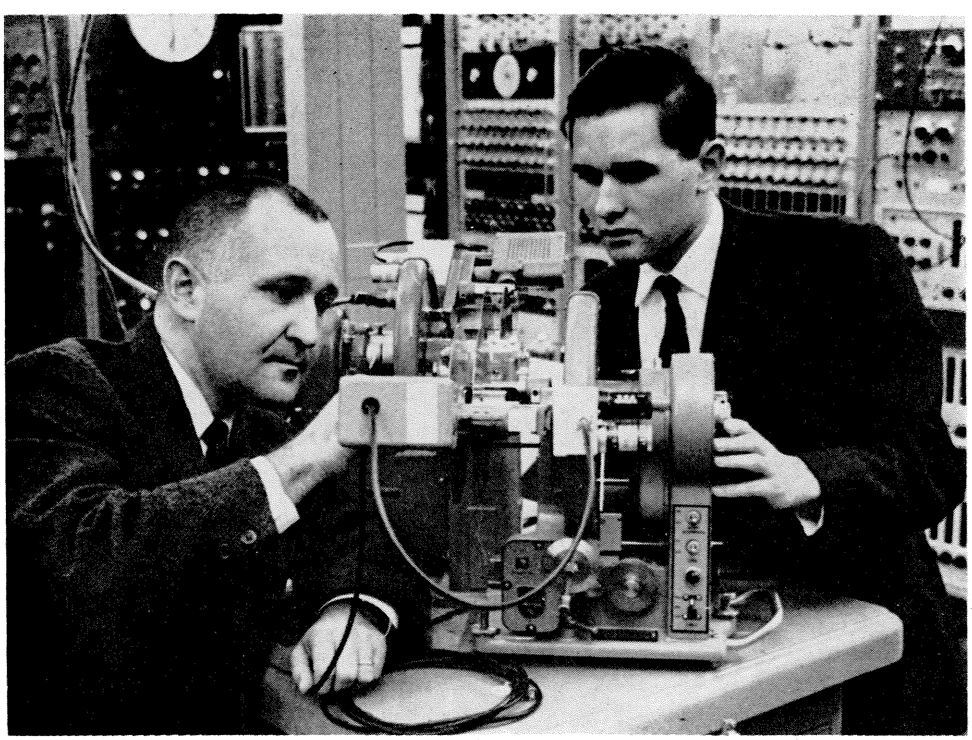
From these measurements, a quantity known as the "radial distribution function" is calculated. This is a mathematical function which represents the average configuration of molecules at the particular temperature and pressure at which the experiment was performed. Hence, the radial distribution function, although a most useful concept from a theoretical point of view, does not give the positions of individual molecules. Thus, x-ray diffraction cannot be used directly to confirm or refute a model for the liquid state.

However, properties such as the pressure and energy content can be estimated from the radial distribution function. These data can then be compared with the results of theoretical computations based on the various models which have been suggested. The comparison should indicate which of these is correct.

The radial distribution function for molecules in liquid argon has been determined before. However, the results of earlier work are not sufficiently accurate or extensive for a definite conclusion to be reached with regard to its molecular structure. The recent development of high precision counters and techniques for handling diffraction data now allows radial distribution functions to be determined with a greater accuracy than was previously possible. Whereas in crystallographic work intensity measurement is only of secondary importance, with x-ray diffraction in liquids accurate determination of intensity is essential.

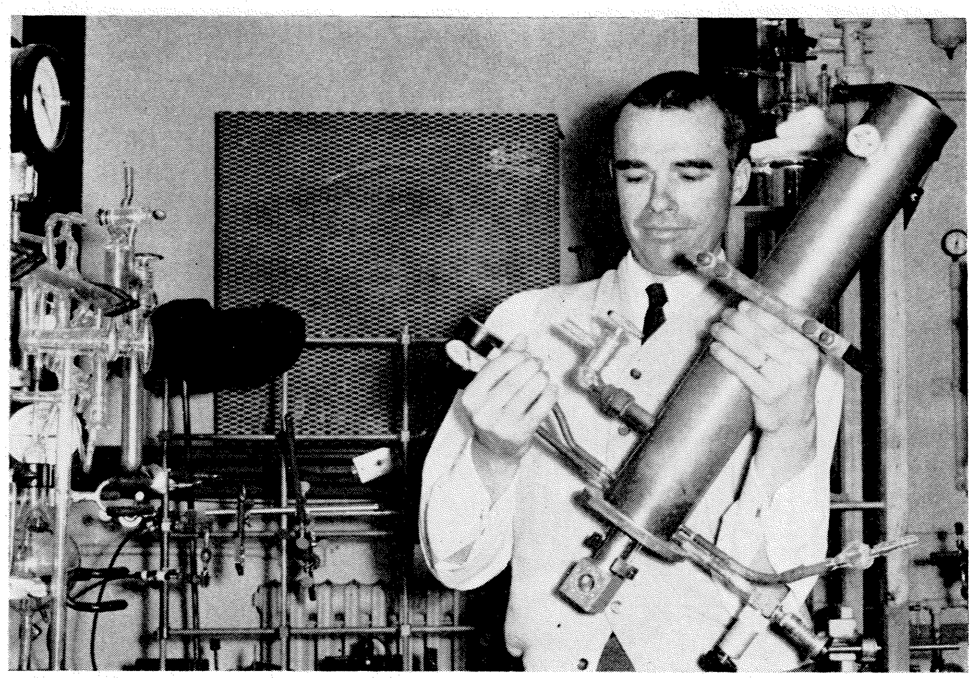
One pertinent question which has arisen from the work is—how monochromatic do x-rays have to be in order for them to correspond to the single wavelength relations used in diffraction theory? To a certain extent the practical answer is a compromise. The x-rays must obviously have a finite band width in order for the determination to be experimentally possible. What is not evident, however, is how wide a wavelength band can be tolerated without the diffraction pattern becoming smeared. This problem is being examined as an auxiliary investigation.

Another project which is in progress in the chemical engineering department is a study of the optical properties of the inert gases. In this study, Dr. Pings and I are measuring the refractive index of fluid argon over a wide range of temperature and pressure to provide experimental data for comparison with theoretically predicted values. The method should be



*C. J. Pings, associate professor of chemical engineering, and Brian L. Smith, research fellow, estimate the molecular distribution of liquid argon with the x-ray diffractometer, then compare the results with theoretically predicted values.*

*An absorption cell containing xenon is used in the study of molecular spectra by G. Wilse Robinson, professor of chemistry.*



familiar to anyone who has taken a freshman laboratory course in physics. Inside a cryostat, the argon sample is condensed in the form of a prism. The refractive index is measured by means of an optical spectrometer.

Refractive index measurements are useful because they can be used to calculate the "polarizability" of a molecule, which is the distortion produced in the molecule due to the presence of its neighbors. The polarizability is directly related to the radial distribution function. Hence, refractive index measurements can give useful information regarding the molecular distribution in a liquid and provide a valuable check on x-ray diffraction data.

Robert M. Mazo, assistant professor of physical chemistry, is currently engaged in theoretical work on the liquefied inert gases, examining recent theories and checking their logical consistency by means of a series of calculations.

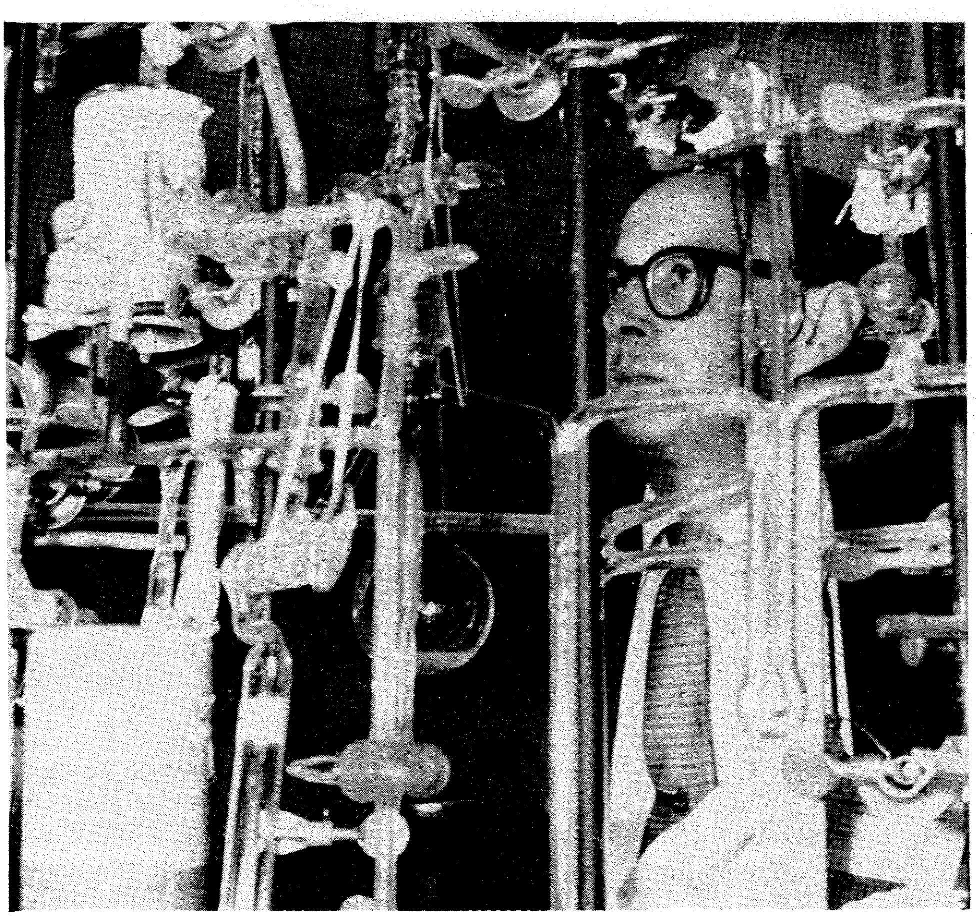
G. Wilse Robinson, professor of physical chemistry, is interested in the condensed inert gases, but from an entirely different standpoint. Liquid argon, krypton, and xenon are good solvents for many substances. They are also transparent to radiation ranging from the ultraviolet to the infra-red, and including the visible region. Hence, by dissolving a small amount of a substance such as mercury in, say, liquid xenon, the absorption spectrum may be studied. The effect of the environment of xenon molecules on the spectra can be estimated either theoretically by calculating the interaction, or experimentally by varying the density and noting the differences in the spectra produced by the changing intermolecular distances.

The results of one of these experiments has thrown some light on the problem of molecular distribution in a liquid. Dr. Robinson noted that one of two components of the spectrum, observed for mercury atoms dissolved in liquid xenon, corresponded almost exactly in position with the spectral line recorded for mercury in solid xenon. Similar results have been observed for a number of other simple solvents. This indicates that there is a tendency for "clusters" to form in these liquids, with intermolecular distances and local density very similar to that found in the solid. The second component in the liquid phase spectrum is tentatively identified as arising from mercury atoms adjacent to vacancies in the liquid structure.

Another technique employed by Dr. Robinson to obtain molecular spectra consists of freezing one of the inert gases in such a way that molecules of the substance under study are trapped in the crystal lattice. Diatomic carbon frozen in a solid xenon lattice is particularly interesting because it is an experimental example of a quantum mechanical harmonic oscillator in a small box.

The inert gases are also of interest to the chemical biologist. For example, xenon is found to be an almost perfect anesthetic agent—in spite of its chemical inertness. This has been a puzzle for some time, but is understandable in the light of a recent theory of anesthesia. Originally proposed by Linus Pauling, professor of chemistry at Caltech, the theory is now being investigated by John F. Catchpool, research fellow in chemistry. Dr. Pauling suggests that anesthetics cause unconsciousness by reacting with the water in the brain to form microcrystalline hydrates. The effect of these crystals is to reduce the electrical conductivity and, hence, the activity of the brain. The only known chemical property of xenon is that of forming a crystalline hydrate—a fact which is most significant in the light of Pauling's theory of anesthesia, as it could account for the effectiveness of xenon as an anesthetic agent.

G. J. Wasserburg, associate professor of geology, is



*G. J. Wasserburg, associate professor of geology, uses isotopes of argon and xenon to determine the age at which a mineral crystallized.*

interested in the inert gases as they occur in nature. For example, the $A^{40}$ isotope of argon is produced by the radioactive decay of the potassium isotope $K^{40}$, and may be used to determine the age at which a mineral crystallized. This method has been used to date meteorites. The amounts of $A^{40}$ and $K^{40}$ measured in some stony meteorites showed that these objects have existed for about 4.4 billion years. Helium, argon, and xenon have cast some light on the nature and origin of natural gas accumulations.

Even in an engineering field such as jet propulsion, the inert gases are proving to be useful materials for research. R. G. Jahn, assistant professor of jet propulsion at Caltech, uses a 21-foot-long tube of argon to study the ionization of gases by shock waves. The wave is made to travel through the tube at speeds ranging from seven to ten times the velocity of sound. The passage of the wave raises the temperature for an instant to 5000° C—high enough to initiate measurable ionization in the argon. The rate at which the argon approaches its equilibrium ionization level is measured by its absorption and reflection of a probing microwave beam.

Studies of this nature are valuable because conditions in the shock tube are similar to those found in jet propulsion devices. The knowledge gained by performing experiments with simple substances such as argon may lead to a better understanding of the basic mechanisms which occur in these devices and thus result in improved designs.

Argon, krypton, and xenon have normal physical properties. Helium, however, falls into a category of its own. Helium gas condenses at about 4° Kelvin to form a colorless liquid. If this is cooled, at about 2° Kelvin it undergoes a "second order" phase change to form another type of helium, known as liquid helium II.

Further cooling will not produce solid helium, however. Helium has a high "zero-point vibrational energy," which is sufficient to prevent the light helium molecules from forming a crystal lattice. Even if it were possible to lower the temperature to 0° Kelvin, a pressure of 25 atmospheres would be required to overcome the vibrational energy sufficiently for solid helium to be formed.

Liquid helium II demonstrates many unusual properties. It is sometimes referred to as a "quantum" fluid because much of its behavior is understandable only in the light of quantum theory.

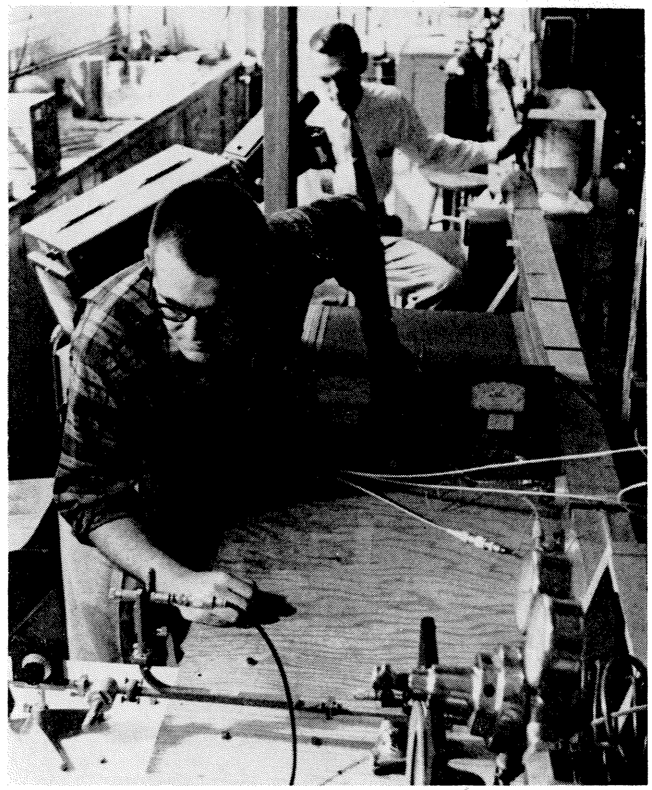
To explain the properties of helium II, physicists have proposed what is known as the "two-fluid" theory. On the basis of this theory, liquid helium is supposed to consist of two fluids, one a "normal" fluid and the other a "superfluid." These both occupy the same space, but nevertheless operate independently of one another.

The normal fluid is responsible for the properties of liquid helium II which are usually associated with liquids—for example, viscosity and heat content. The superfluid, on the other hand, has no viscosity or even entropy. It does, of course, still possess its zero-point energy. As the temperature of liquid helium drops toward absolute zero, the relative amount of the superfluid increases and that of the normal fluid decreases. At 0° Kelvin, only superfluid would remain and helium would then be a "perfect" fluid.

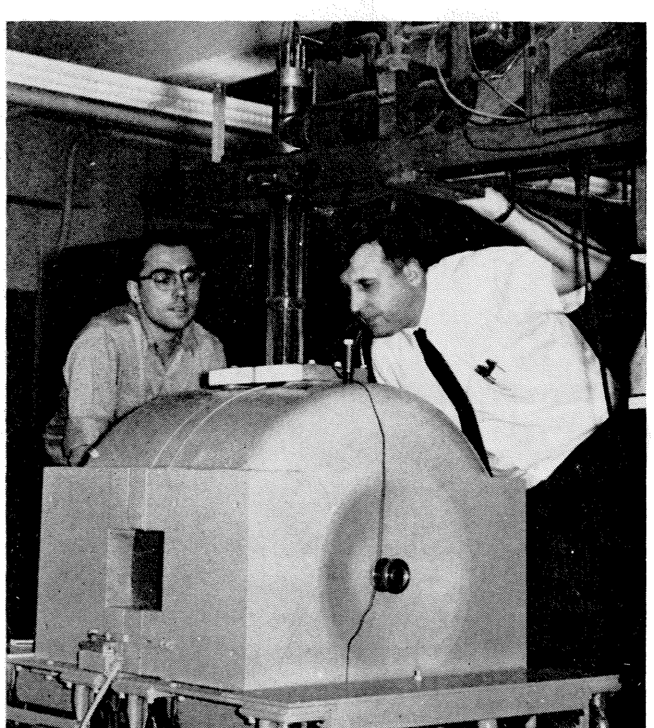
At Caltech, John Pellam, professor of physics, has carried out experiments designed to test the two-fluid theory. One of these involves a concept known as the "second-sound" method of heat propagation. In a normal substance heat transfer by conduction is "smeared out" as it travels through the material. According to the second-sound theory, however, a heat pulse will travel through superfluid helium without losing its thermal profile and will advance according to a wave type of propagation.

There are, of course, definite properties associated with waves. Before the second-sound theory was accepted, these characteristics had to be demonstrated for second-sound thermal waves. Dr. Pellam, in conjunction with John Mercereau, assistant professor of physics, devised an experiment in which a diffraction pattern was produced by a number of thermal sources placed equal distances apart. Several orders of thermal intensity maxima were observed at angles to the thermal grating similar to those observed when x-rays are diffracted by a crystal. This wave-like behavior presented striking evidence in favor of the second-sound theory.

Arising from the superfluidity of helium II, a novel device known as the "superfluid wind tunnel" has been invented by Dr. Pellam to test the basic principles of hydrodynamics. According to theory, bodies of arbitrary shape exposed to the flow of a perfect fluid will not experience "lift" or net force, but only a torque. By utilizing the so-called "thermomechanical effect," the superfluid in helium II is made to flow past the model of a wing assembly while the normal fluid remains stationary. The results of this experiment confirm the theoretical predictions. Within certain limits of superfluid velocity no "lift" is observed on the wing assembly.



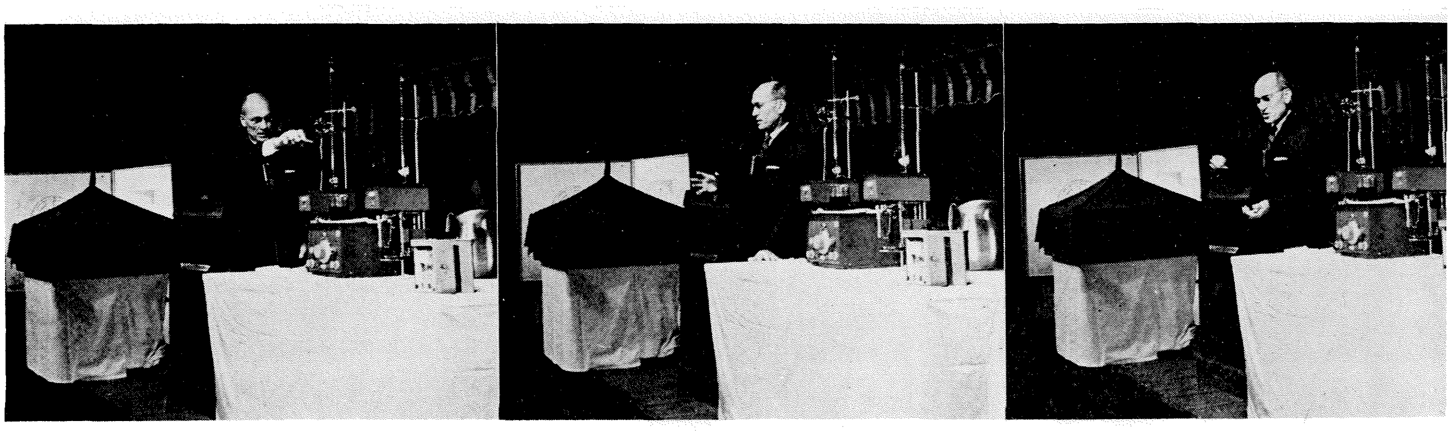
*Kenneth Harwell, graduate assistant in aeronautics, and R. G. Jahn, associate professor of jet propulsion, use a 21-foot-long tube of argon to study the ionization of gases by shock waves. Conditions in the shock tube at high pressures are similar to those found in jet propulsion devices.*



*In Caltech's low temperature laboratory, Harris Notarys, graduate student, and Donald B. Lawson, cryogenic engineer, use liquid helium and an electromagnet to produce temperatures close to absolute zero.*

An experiment performed by Dr. Pellam some years ago is particularly interesting because it provides a link with the historical past. A thermal "Rayleigh disc" was used to measure the torque produced by second-sound waves in liquid helium II. This device works on the same principle as the disc which was invented by Lord Rayleigh before the turn of the century, and which was employed by him for refined acoustical measurements.

It is appropriate that Rayleigh's name is still heard in the laboratory in connection with the inert gases, because he is the man who started the ball rolling with the discovery of argon. Seventy years ago the inert gases were unknown; now, at Caltech and elsewhere, they are firmly established as valuable materials for research.



# The Month at Caltech

## *AUFS*

On January 8, Edward A. Bayne arrived on campus for a two-week stay, to report to students, faculty, and friends of the Institute on current conditions in Iran, Israel, and Italy. On January 22, Kal H. Silvert will be here to report on Latin America. Charles Gallagher comes on February 5 to discuss North Africa and Algeria. And on February 19, Reuben Frodin arrives to report on Nigeria and West Africa.

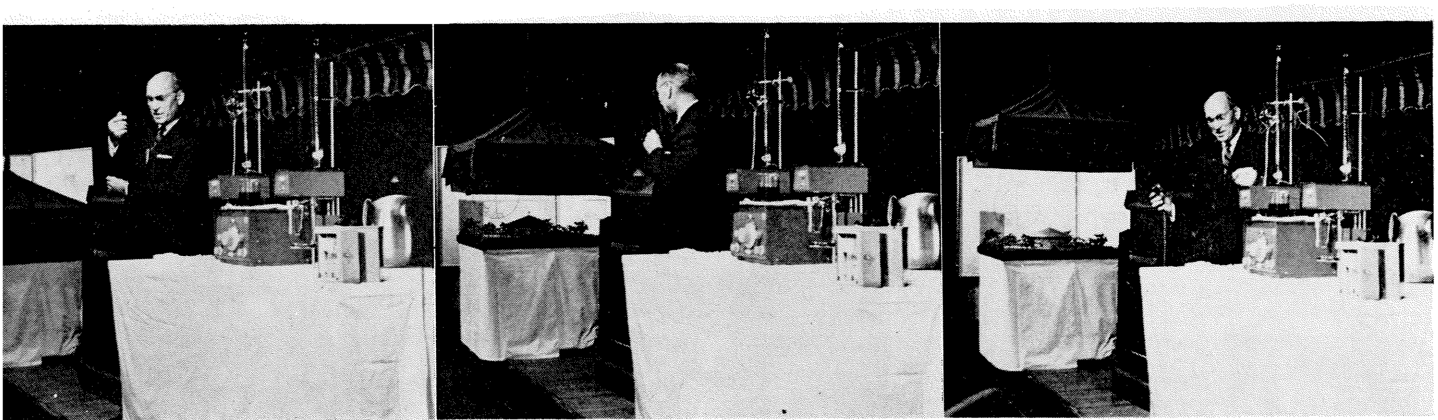
All four men are representatives of the American Universities Field Staff, the organization set up in 1951 by Caltech and seven other educational institutions in this country to send qualified young men out as their correspondents in foreign areas. In addition to sending back regular reports to the sponsoring colleges and universities, each of these men returns home every two years to visit the campus of each of the sponsoring institutions and to report in person on political, social, and economic conditions in the area he is studying.

*Edward A. Bayne*

## *Earthquake Engineer*

Donald E. Hudson, professor of mechanical engineering, has returned to the Institute after two months in South America as a member of a six-man UNESCO scientific team. The engineers and scientists visited Columbia, Ecuador, Bolivia, Argentina, and Chile as one of three seismological teams UNESCO is sending to the earthquake regions of the world to determine what can be done to prevent temblors from causing damage and to promote the study of seismology.

The South American team found that there was a



## BECKMAN AUDITORIUM

*Highlight of the ground-breaking ceremony for Caltech's new Arnold O. Beckman Auditorium on January 8 was the demonstration by Dr. Beckman which is shown above.*

*A chemical reaction involving lemon juice and potassium hydroxide was electromechanically performed in a beaker by an automatic titrator, which Dr. Beckman's firm developed. The reaction activated an electrical circuit. The circuit raised a curtain that displayed a model of the auditorium, and also started the motor of a bulldozer, which broke the ground.*

*The new auditorium will be located on South Michigan Avenue north of San Pasqual Street.*

*Dr. Beckman is president of Beckman Instruments, Inc., of Fullerton, Calif., and is a member of the Caltech board of trustees. At the right, with President DuBridge, he examines the auditorium model.*

great need to include earthquake-resistant regulations in building codes in this area. Very few cities in the earthquake regions of South America have such regulations today. Because of available building materials, larger structures are built of reinforced concrete while smaller buildings are usually brick or adobe. The UNESCO team is recommending that studies be made to learn whether adobe and brick houses can be built so they can better withstand earthquake shocks—perhaps by substituting lighter roofs for those made of heavy tile, and by providing better means of tying the structures together. The team is also recommending that all nations have disaster plans for relief measures in case of earthquakes, and that nations establish facilities quickly to warn the public of natural catastrophes such as typhoons and volcanic activity.

As the earthquake engineering specialist on the UNESCO team, Dr. Hudson studied building regulations, materials and methods, and talked to building officials and officials of cities and universities. He found that engineers and seismologists were well-trained and were much interested in problems of earthquake resistant construction.

### *New Executive Director*

Arthur Howard Warner is the new executive director of the California Institute of Technology's Industrial Associates. He succeeds Chester M. McCloskey, who has resigned to work in private industry. Dr. McCloskey will serve as a consultant for the Industrial Associates and will retain his Caltech position as senior research fellow in chemistry.

The Industrial Associates is a group of more than 40 corporations that give Caltech financial support. The Institute, in turn, provides them with visiting lecturers, technical reports, and information on the progress of its research programs.

Dr. Warner comes to Caltech from Aerospace Cor-


KARMAN LABORATORY

*At the formal dedication of the Institute's new Karman Laboratory of Fluid Mechanics and Jet Propulsion on December 11, 1961, Dr. Theodore von Karman, professor of aeronautics, emeritus, (center) tours the building named for him, with President DuBridge. At the right are Clark Millikan, director of Caltech's Graduate Aeronautical Laboratories, and Dan A. Kimball, president of Aerojet-General, whose $450,000 gift made the Karman Laboratory possible.*

poration, after having established that firm's Atlantic Missile Range Office at Cape Canaveral.

Born in McComb, Ohio, Warner was graduated from the University of Colorado and received his PhD in physics from Caltech in 1927. For 28 years he was on the UCLA physics faculty.

During World War II Dr. Warner worked on radar, first at the Massachusetts Institute of Technology and then in Europe. He received the U.S. Legion of Merit and Order of the British Empire for his radar work.

From 1946 to 1950 he headed aviation and underwater ordnance as well as the test department of the U.S. Naval Ordnance Test Station at China Lake, Calif.; and underwater test work at NOTS in Pasadena. In 1951 he was made technical director at Cape Canaveral, directing the planning, procurement, and installation of instruments, communications, and supporting facilities.

## *Crossroads*

"Science Crossroads," a half-hour television show starting on February 3, will feature two Caltech scientists—Jesse L. Greenstein, professor of astrophysics; and Norman H. Horowitz, professor of biology.

The program will run for 16 weeks, at 8 a.m. on Saturdays over Channel 4, KRCA. It is sponsored by the Los Angeles City Schools, and is designed for high school science teachers, who will receive credit for following the series.

Jesse Greenstein will discuss "A Biography of the Elements" on February 3, 10, 17, and 24. Norman Horowitz will talk on "Modern Genetics" on March 3, 10, 17, and 24. The remaining lectures in the series will be given by Dr. Joseph F. Ross of the UCLA School of Medicine ("Radiation Biology") and Jay M. Savage, associate professor of biology at USC ("Life in the Sea").

## *Faculty Changes*

Rudolf L. Mössbauer, co-winner of the 1961 Nobel Prize in Physics (*E&S*—November 1961), has been promoted from senior research fellow to professor of physics.

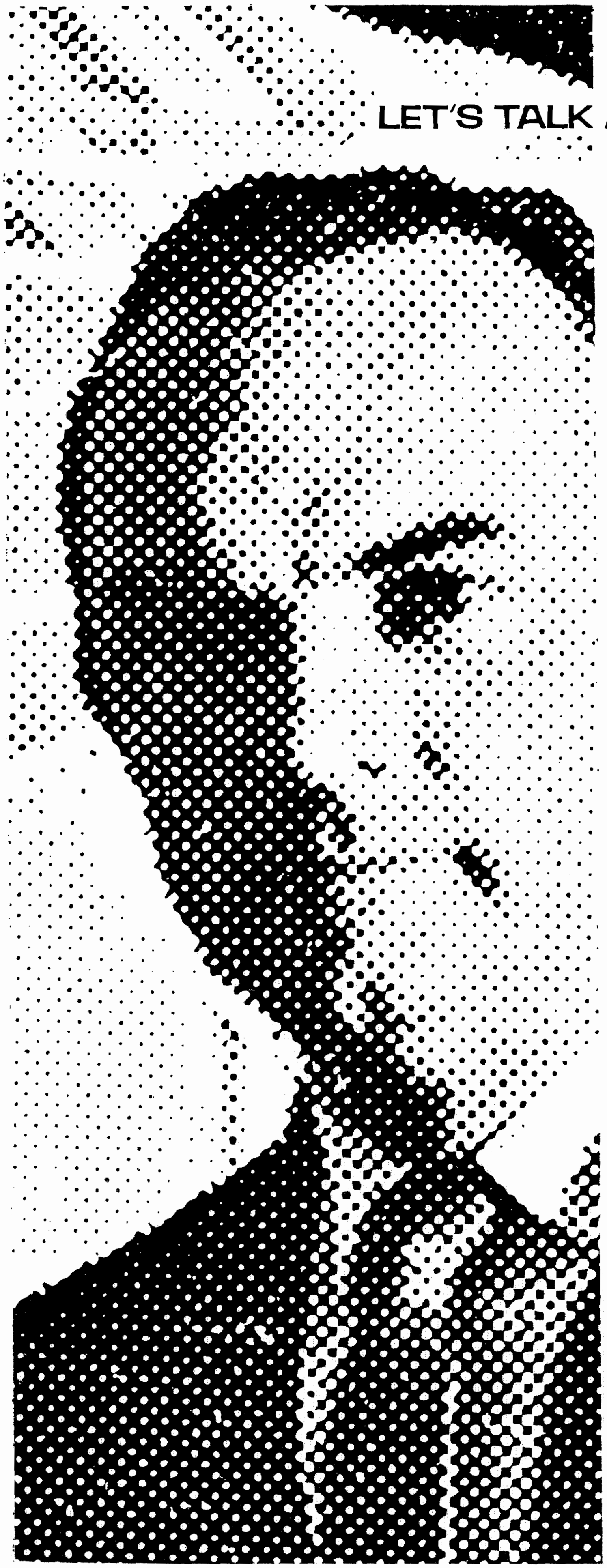
Carl D. Anderson, professor of physics, has been named acting chairman of the division of physics, mathematics and astronomy. He will serve until October 1962, while chairman Robert F. Bacher is on leave.

# THE BELL TELEPHONE COMPANIES SALUTE: BILL PIGOTT

Six years ago Bill Pigott graduated from college with an engineering degree. Today he is responsible for the performance of 12 microwave relay stations, numerous communications cables, and other equipment. He also supervises the work of some sixty transmission specialists.

Bill Pigott of Pacific Northwest Bell Telephone Company, and the other young engineers like him in Bell Telephone Companies throughout the country, help bring the finest communications service in the world to the homes and businesses of a growing America.

**BELL TELEPHONE COMPANIES**



# The Cooperative Crab

*by Graham Berry*

A cooperative crab, with three brains and astigmatic periscope eyes on long stalks, is making major contributions at Caltech toward a better understanding of the central nervous system.

Dr. C. A. G. Wiersma, professor of biology, started research with the crab last summer at the University of Hawaii's Waikiki Marine Laboratory, with Dr. Talbot H. Waterman, professor of comparative physiology at Yale University; and Dr. Brian M. H. Bush, visiting post-doctoral fellow from Cambridge University, England. The study is supported by the National Science Foundation and the National Institutes of Health.

The unusual way in which this crab, *Podophthalmus vigil*, is built, plus the comparative simplicity of its nerve structure, make it invaluable for the investigation of the central nervous system. A native of Hawaiian waters, the crab is only about six or seven inches wide and three or four inches long. Its eyes are set on top of exoskeletal stalks about two inches long. For protection, the antenna-like stalks may be folded back into an indentation in the shell. A small brain is located directly behind each eye. These little brains are computers. Nerve trunks enclosed in the exoskeletal stalks link each "optic brain" with each other and with the larger central brain under the main body shield, or carapace.

## *How the brains work*

The two small brains evaluate the data from the eyes and then pass the evaluated information on to the central brain and to each other. It may be that they are able to bring almost instantaneously into action muscles that are used in running or evasive action.

Of great advantage to biologists is the fact that the optic nerve of this crab contains only about one or two thousand individual nerve fibers, or interneurons —compared with about one million fibers on the human optic nerve. Because most animals of similar complexity have a great many more such optic fibers, the task of learning from them about the central nervous system is much more formidable.

The reason the crab's optic nerve contains comparatively few individual interneurons is that the information received by the eye does not go directly to the larger central brain for evaluation, but travels a very short distance to the so-called optic brain. Here, many steps in the evaluation of the information are carried out. Afterwards, the impulses are sent on to the central brain and to the other eye. Since the optic brain has analyzed the incoming optic signals to a large extent, the evaluated data can be carried by many fewer nerve fibers.

There is at least one biological advantage in having a special brain directly back of each eye—as all crustaceans with good vision have. To get detailed information from the eye to the brain many nerve fibers are required and therefore they must be thin. The thinness offers resistance to the electrical nerve impulses, slowing them down. As a result, the information reaches the brain only after a considerable delay. With a brain near the eye, the many impulses from the eye need travel only a short distance before they reach the optic brain for evaluation. From there to the central brain, or to other parts of the nervous system, fewer evaluated impulses are sent over larger fibers, enabling the impulses to travel much faster.

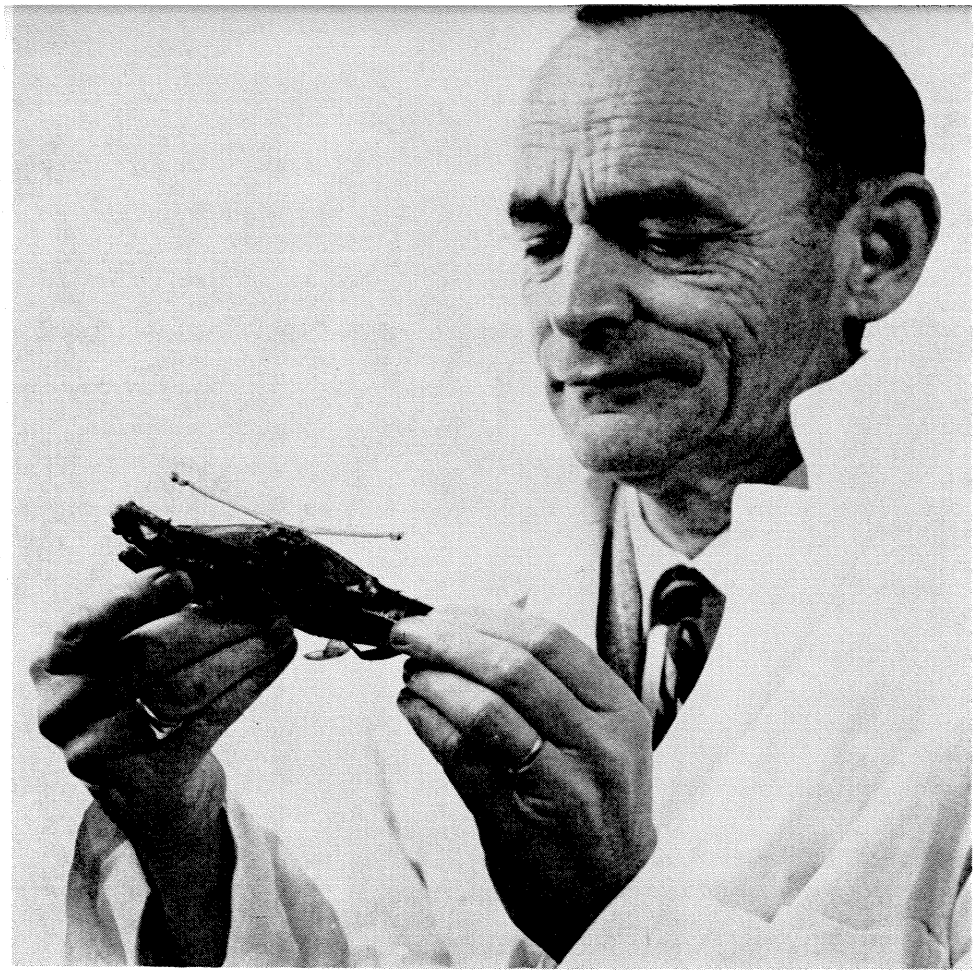
## *The way to do it*

"If you want eyes to be located at a considerable distance from the brain," says Dr. Wiersma, "this is the way to do it." Even so, having one's eyes on the end of long stalks is a rather precarious business, although it can be handy when the crab wants to rest under the mud and still see what's going on.

Because of its shape, the eye must be very astigmatic. Being on the end of a stalk, it has a tremendous range of vision and can see just about everything in its vicinity.

It is the optic nerve of the crab, available as it is in a comparatively long, exoskeletal, insulated sheath, that Dr. Wiersma uses in his research. With delicate and precise techniques which he has developed in years of work on the nervous system of the crayfish, he removes a small segment of the exoskeleton from the eye stalk, exposing the optic nerve trunk. Observing through a binocular microscope, he taps individual nerve fibers with micro-electrodes and records electric nerve impulses that have been stimulated by placing and by moving objects in front of the eye.

These nerve impulses are "waves" of electrical disturbance that move swiftly down the nerve path. The impulses all have about one-tenth volt of energy and



*Dr. C. A. G. Wiersma, Caltech professor of biology, and Podophthalmus vigil.*

the impulses occur at the rate of 5 to 200 per second. This is the language by which nerves talk. The effect at the receiving end is proportional to the number of impulses.

Dr. Wiersma and his colleagues have discovered three different kinds of optic nerve fibers, or interneurons that react to moving objects. He believes there are several more kinds, some responding to stationary objects. Each of the three "movement fibers" carries a different kind of electrical response to eye stimulation.

One type of interneuron fires (carries electrical nerve impulses) when an object is moved rapidly past the eye. A second kind of interneuron fires only when an object is moved with average speed past the eye. And the third type fires only when an object moves slowly past the eye. These interneurons will fire bursts of impulses only when the kind of eye stimulation is specific to them; otherwise they give only a few scattered impulses which are of little importance to the brain.

Strangely, interneurons of types 1 and 3 will not fire such bursts again for perhaps a minute after the first stimulation, unless the stimulating movement passes the eye in a different direction than the first time.

As for the second kind of interneuron, which apparently is not affected by the same type of inhibition, but continues to fire bursts of impulses as long as objects are moved at medium speeds past the eye, this may give rise to what is called an optic kinetic reflex in which the crab can turn its eyes or even its whole body to follow another animal in its vicinity.

All three kinds of signals are generally independent of the amount of background light, the biologists have found. This is understandable because the crab must be able to react very similarly whether he is in bright or dimly-lit surroundings.

In one series of experiments it was noted that if the eye observes a small object, certain interneurons will fire, but if a larger object then is moved into the place of the smaller one, this interneuron doesn't fire. Apparently the interneuron that has observed the small object now is inhibited by nearby optic fibers.

Does the human optic nervous system operate the way the crab's does? Dr. Wiersma believes it may, pointing out that there is no evidence to the contrary. As with the crab, impulses from the eyes of higher animals probably reach nerve centers along the way to the brain where similar types of preliminary evaluating are carried out, so that different aspects of the visual surroundings are thrown into different nerve channels.

Dr. Wiersma plans to continue to work with the crab, with the idea that a better understanding of its simpler central nervous system will shed light on the operation of the central nervous system of more complex creatures, such as humans.

*High Voltage Engineering Corporation . . .*

# "CHARGED PARTICLES"

## Nuclear Radiations and Materials Evaluation

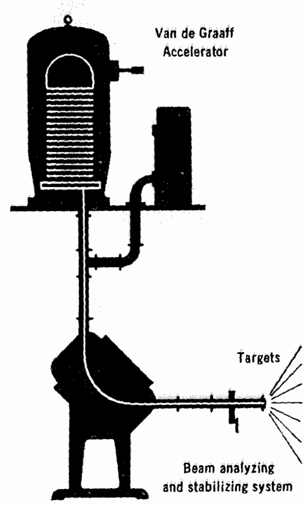
Chemists and metallurgists have been quick to adopt experimental techniques first used for fundamental nuclear physics research. Today, they are exploiting the characteristics of intense ion beams and neutron fluxes for applied research, engineering and analysis. Already, important results have been obtained using nuclear radiations for trace analysis, wear studies, semiconductor modification and similar applications where interactions of positive ions or neutrons create desired, predictable and measurable effects.

Although a number of positive-ion accelerators have been installed specifically for this kind of developmental work, we believe that the use of particle beams for *materials evaluation* is just getting started, and that many programs are dormant because of the cost and skill-requirement of owning and operating an accelerator facility.

## Ion Beams and Neutrons for Hire

We think we have an answer to this problem for those who wish to explore activation analysis or research involving accelerated positive ions or neutrons. Here in Burlington, we have a fully-equipped and expertly-staffed *Positive Ion Service Facility*, employing a 2-Mev Van de Graaff accelerator and neutron source as the central research instrument. *Both the facility and the assistance of the staff are now available for independent research and analyses by outside organizations on a rental or contract basis.*

The Van de Graaff is our Model AN-2000. It offers 0.3 to 2.0 Mev hydrogen or deuterium ion beams with currents up to 100 microamperes in continuous or pulsed operation. A 90° mass analyzing magnet and feedback system stabilizes the voltage. A large fraction of the accelerated ion beam is emitted with a homogeneity within 1 part per 1000 for monoenergetic neutron experiments.




The facility is fully instrumented, including a 200-channel pulse height analyzer for scintillation spectrometry and decay-scheme studies, a remotely-operated sample changer, and neutron moderator.

You may want to use the facility to carry out specific analyses . . . or investigate the feasibility of a certain technique . . . or solve a knotty materials-evaluation problem. Other research possibilities are: *particle interactions; neutron-induced reactions; production of short-lived isotopes; instrument calibration; environmental research; radiation damage and shielding parameters; solid state surface studies; radiobiology.*

Users plan and evaluate all work. We provide an operator. If it bothers you to carry out what may be proprietary development programs in somebody else's house, have no fear. If the use of accelerators is encouraged, we are content. You may draw the shades tightly on any techniques used, and, of course, the results are strictly your own business. If, however, you would like to take advantage of some knowledge we have, a staff physicist is on hand to help.

If the requirement is perfectly straightforward, such as routine analysis, ship us the sample, and we'll do the work. We will supply cost estimates for any program contemplated on a project or continuous use basis. For more information, write for our Bulletin N-1.

| Reaction | Neutron Energy (Mev) | Neutron Yield (n/sec) |
|---|---|---|
| D-D | 1.5-6* | $5 \times 10^9$ |
| D-Be | 0.6-5† | $4 \times 10^{10}$ |
| D-T | 14-15* | $5 \times 10^8$ |

*monergic †polyergic

**Neutron Yield From 2-Mev Van de Graaff**

Of course, if the rentee gets carried away with the possibilities of this work and wants to buy an accelerator, that's all right. Van de Graaffs are available from 0.4 to 4 Mev, producing up to 400 microamperes of current for monoenergetic neutron production. For really high neutron fluxes, the microwave linear accelerator excels. We can recommend a package of suitable instrumentation and would be glad to give counsel on installation and shielding.

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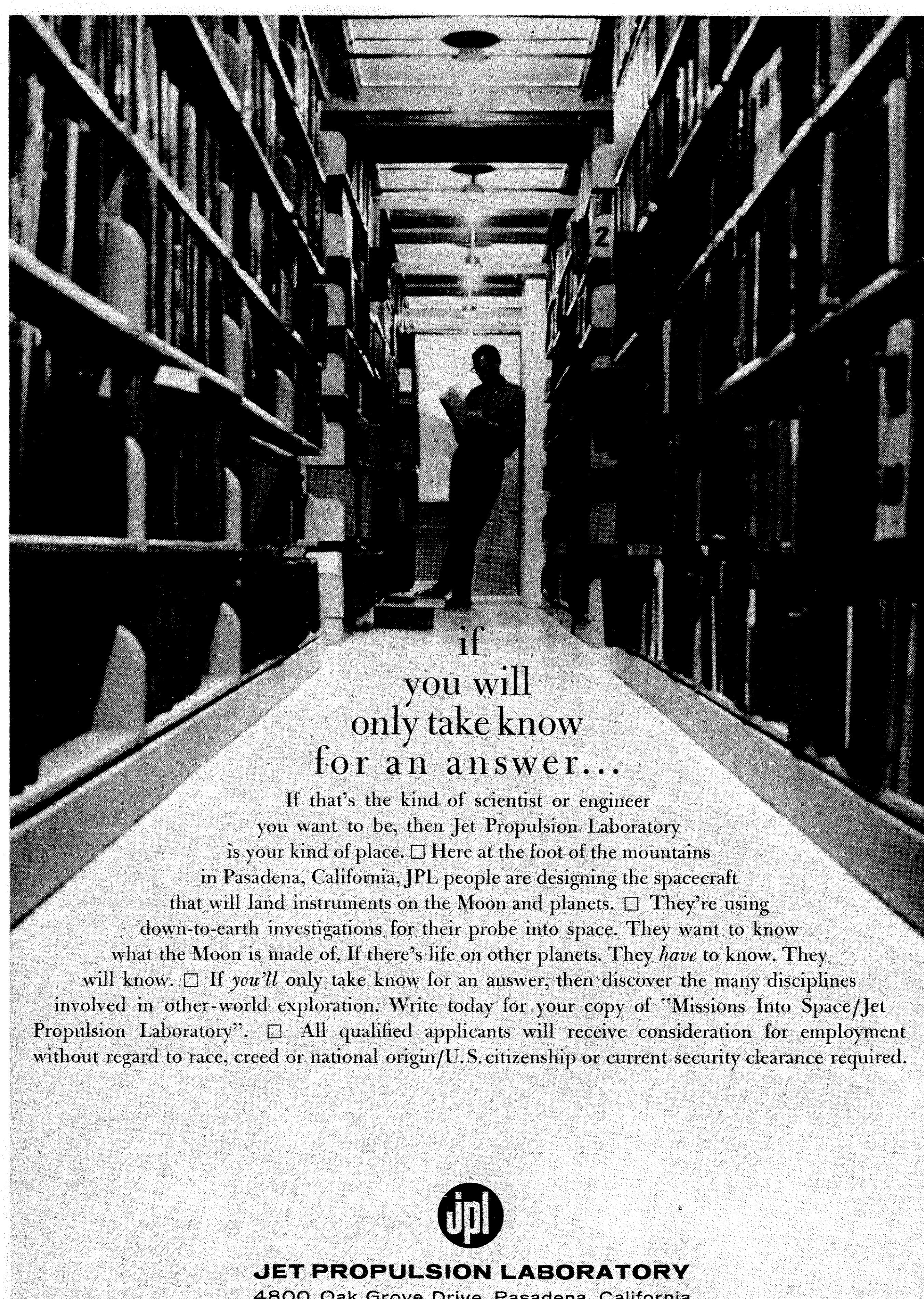
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for an answer...
If that's the kind of scientist or engineer you want to be, then Jet Propulsion Laboratory is your kind of place. □ Here at the foot of the mountains in Pasadena, California, JPL people are designing the spacecraft that will land instruments on the Moon and planets. □ They're using down-to-earth investigations for their probe into space. They want to know what the Moon is made of. If there's life on other planets. They *have* to know. They will know. □ If *you'll* only take know for an answer, then discover the many disciplines involved in other-world exploration. Write today for your copy of "Missions Into Space/Jet Propulsion Laboratory". □ All qualified applicants will receive consideration for employment without regard to race, creed or national origin/U.S. citizenship or current security clearance required.
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# Personals

### *1919*

*M. Reginald Coles,* supervising engineer of the ground support services of AiResearch Manufacturing Co., died of a heart attack on October 11, 1961. He had been with the company for the past six years. Mr. Coles is survived by his wife, a son and daughter, and five grandchildren.

### *1925*

*Samuel L. Diack, M.D.*, was selected as "Citizen of the Year" by the Portland (Ore.) Board of Realtors in December. Sam has been active in many community affairs and was the guiding force in the establishment of the Oregon Museum of Science and Industry. Last September he was named as the Oregon State Medical Society's "Doctor-Citizen of the Year." Portland's Women in Journalism presented him with a plaque last spring for "outstanding service to the state," and described him as the "stubbornest, most persistent, most engaging beggar in Oregon."

### *1926*

*Charles H. Bidwell* has spent the last ten years on leave from the Bell Telephone Laboratories to work at the Sandia Corporation in Albuquerque, N.M. He is in charge of the Systems Analysis Division, which is mostly concerned with electronic counter-measures but also with counter-measures involving atomic weapons as well. "We've got a married daughter," Charlie writes, "and a grandaughter. Our son is just entering the University of New Mexico. I'm still playing in *minor* tennis tournaments as a 'Senior Veteran,' at the qualifying age of 46, which age I've retained for many years."

### *1927*

*John H. Maxson,* MS '28, PhD '31, president of the Aerial Exploration Company in Denver, Colorado, has prepared a geologic map of the Bright Angel Quadrangle in Grand Canyon National Park, just published by the Grand Canyon Natural History Association.

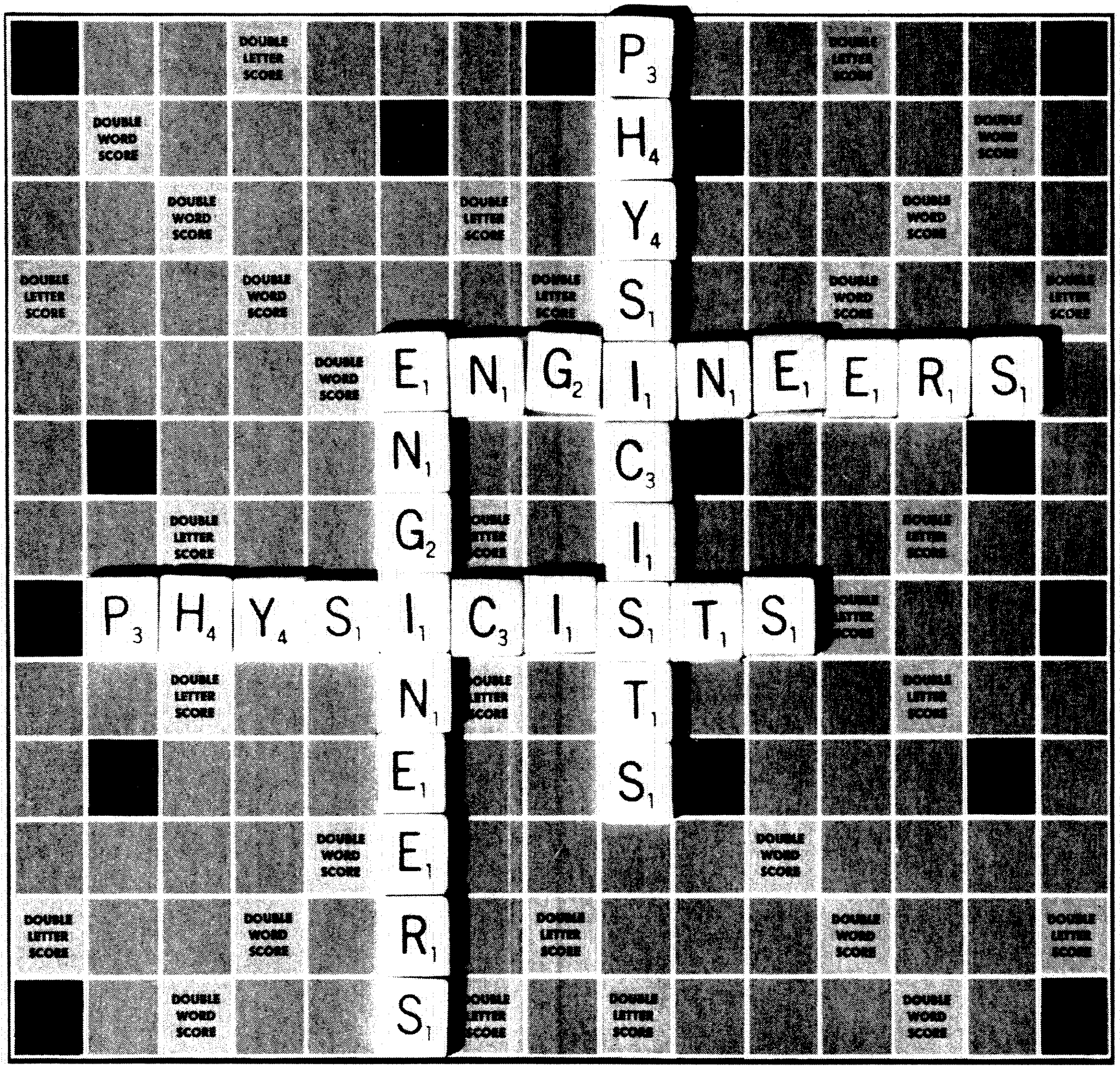
### *1931*

*Sho-Chow Woo,* PhD, is director of the Institute of Physical Chemistry at Academia Sinica in Peiping, China.

### *1932*

*Kenneth H. Swart,* MS '33, is now executive vice president and general manager of Smith Industries International, Inc., in Compton, Calif. He was formerly president of the Smith Tool Co., a division of Smith Industries.

*continued on page 34*


PHYSICISTS
ENGINEERS
ENGINEERS
PHYSICISTS

*1937*

*John L. Sullwold* has been appointed manager of the Elliott Company's Los Angeles district. John joined Elliott's parent company, the Carrier Corporation, in 1949.

*1938*

*Armand F. DuFresne* has been elected president and board chairman of Du Pa Co., Inc., in Arcadia. He succeeds the late *Franklin Page, Jr.*, PhD '50, who died on Nov. 16. Armand was formerly materiel manager of the A & C Instrument Division of Consolidated Electrodynamics Corporation.

*1939*

*Calvin A. Gongwer*, MS, is now manager of the new Oceanics Division of the Aerojet-General Corporation. The former anti-submarine warfare division has been split into two independent units—the Oceanics and the Torpedo divisions. Cal has been with Aerojet since 1945, and his inventiveness has led to the development of the powerful Alclo solid propellant, the Hydrocket and other water-jet propulsion systems for surface craft. He was also a co-inventor of the Minisub—a two-man, free-flooded submarine.

Cal was newly appointed vice president of the Global Marine Exploration Company — a firm newly engaged in deep sea drilling and other oceanography research programs. He and his family live in Glendora, Calif.

*1940*

*Lt. Col. William W. Stone, Jr.*, MS '41, is now director of the Operations Research Group at the Army Chemical Center in Maryland.

*Robert B. Young,* vice president of Aerojet's Liquid Rocket Plant in Sacramento, recently received the American Rocket Society's Propulsion Award, for his outstanding work in liquid rockets and his leadership in the development of engines for the Air Force Titan I and Titan II missiles.

*1943*

*Klaus Mampell*, PhD, is now retired and living in Beatenberg, Switzerland.

*Patrick S. Chase,* MS '46, AE '50, is now president of Servonic Instruments, Inc., in Costa Mesa. He has been executive vice president and general manager of the firm for the last five years.

*1946*

*Lt. Col. Harry L. Gephart,* MS, retired from the U.S. Air Force on May 31 after 27 years of service. He is now assistant professor of mechanical engineering at New Mexico State University and is teaching aerodynamics and a new course in astronautics.

*Donald B. Hicks* has been transferred from the main office of the Kaiser Steel Corporation in Oakland to Fresno, where he will act as resident sales representative. He has been with the company since 1953.

*1949*

*Aaron N. Fletcher,* aeronautical fuels research chemist at NOTS in China Lake, writes that he received his PhD last year from UCLA, and that the Fletchers have a new addition to the family—Denise, born in December. Their other children are Clixie, 9; Roberta, 7; Delora, 5; and Ronald, 1.

*Arthur E. Bryson, Jr.*, MS, PhD '51, is now Gordon McKay professor of mechanical engineering at Harvard Uni-

*continued on page 36*


# PUT THE ATOM TO WORK

● This is just the kind of challenge Allison scientists and engineers like to "get their teeth into."

With major research and engineering effort focused on the field of nuclear energy conversion, Allison has several nuclear projects currently in progress, including;

An exceptionally mobile, lightweight, compact reactor which can produce from 2,000 to 3,000 kilowatts . . .

A nuclear rocket engine to launch large payloads into earth orbit, propulsion for manned space vehicles . . .

A nuclear powered thermally Regenerative Fuel Cell to light small cities, power magnetohydrodynamic devices, submarines and space platforms . . .

We expect these programs now in the research phase to have broad applications in the power and propulsion systems of the next generation.

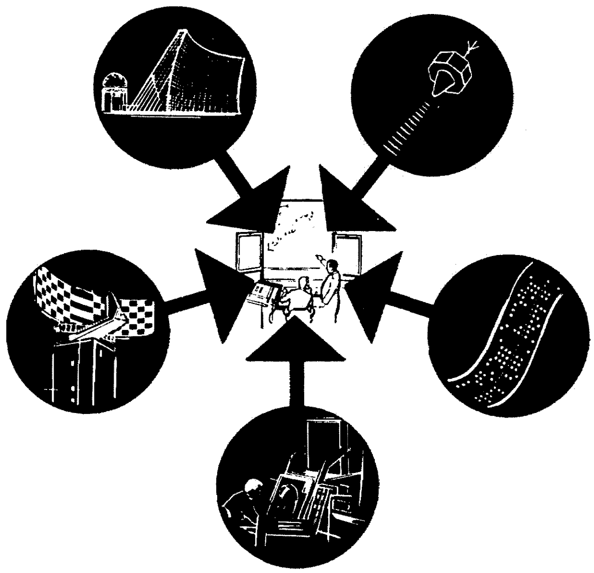
To this end, our atomic scientists and engineers draw upon such extensive, modern facilities as physical chemistry, solid-state physics, radio-isotope, infra-red, fluid dynamics, rocket propulsion and metallurgical laboratories; a vacuum chamber which simulates pressures at altitudes in excess of 200 miles; a liquid metal loop; analog and digital computers, and numerous other research tools. These efforts and facilities are further backed-up by every resource General Motors possesses.

As nuclear technology advances, Allison will continue probing new forms of energy conversion in the search for improved forms of propulsion and power.

In short, we take all energy sources to be our starting point, as reflected in our guiding theme:

*Energy Conversion is Our Business*

ALLISON DIVISION GENERAL MOTORS CORPORATION





## Personals . . . *continued*

versity in the division of engineering and applied physics. He is currently working on problems in high temperature gas dynamics and optimization problems in flight mechanics and automatic control. He is also a consultant for the Raytheon Company's missile and space division in Bedford, Mass.

*Samuel N. Domenico*, MS, has been appointed division geophysicist at Pan American Petroleum Corporation's gulf coast division in Houston. He was formerly consulting geophysicist at Pan American's Canadian division.

*M. Kent Wilson, PhD,* chairman of the department of chemistry and professor of chemistry at Tufts University, has been elected chairman of the Northeastern Section of the American Chemical Society for 1962.

### *1950*

*John P. Moffat, Jr.,* is now manager of product development for the transducer division of the Consolidated Electrodynamics Corporation. He was formerly chief engineer of CEC's electromechanical instrument division.

*Adam F. Schuch,* PhD, member of the staff of the Los Alamos Scientific Laboratory, also acts as an alternate group leader in cryogenics. "My time is divided in about 3 ways," writes Adam, "into administration, research, and engineering on the Rover rocket program. This summer I was appointed to the Cryogenic Engineering Conference Committee for the 1961-64 term."

### *1951*

*John M. Bozajian,* MS, writes that he "was recently promoted to assistant manager of the engineering mechanics and preliminary design departments of the space systems division at Hughes Aircraft in Culver City. My principal assignment is the technical management of thermal control, structures and touchdown landing system development for the NASA-JPL Surveyor (lunar softlanding) spacecraft.

"Other current activities include periodic professional engagements as a jazz musician. We now have three boys in the family."

### *1952*

*Gerald D. Fasman,* PhD, formerly assistant head of biophysical chemistry at the Children's Cancer Research Foundation in Boston, and research associate at the Harvard Medical School, has been appointed assistant professor of biochemistry in the graduate department of biochemistry at Brandeis University in Waltham, Mass. He is also now the father of three sons.

*continued on page 38*

# Raytheon offers Graduate study opportunities at Harvard and M.I.T.


## Raytheon offers current openings in:

RADAR
INFRARED
MISSILE SYSTEMS
COMMUNICATIONS & DATA PROCESSING
MICROWAVE ELECTRONICS
SOLID STATE
SONAR
ELECTRON TUBE TECHNOLOGY

As the major horizons in electronics are explored and extended, Raytheon offers an increasing number of challenging projects for scientists and engineers. In order to accommodate this heavy investment in research and development, Raytheon is committed as never before to comprehensive programs for developing its technical staff. The new Advanced Study Program is one of these.

This program is available to a selected group of outstanding scientists and engineers. It enables present and prospective Raytheon staff members, who are accepted for graduate study at Harvard and M.I.T., to pursue at Raytheon's expense part-time study toward a master's and/or doctor's degree in electrical engineering, physics or applied mathematics. You too may be able to qualify for the Advanced Study Program.

For detailed information, visit your placement director, obtain the brochure, "Raytheon's Advanced Study Program," and arrange an on-campus interview. Or you may write directly to Mr. G. C. Clifford, Coordinator of College Relations, Raytheon Company, Gore Bldg., Watertown, Massachusetts.

RAYTHEON

*An Equal Opportunity Employer*

*Donald K. Tautz*, MS '53, engineer at Tau-Sons Research in Englewood, Colorado, was married to Eva Aldrich in Denver on December 17.

### *1954*

*James N. Pinkerton*, who worked in the operations research group at Arthur D. Little, Inc., in Cambridge, Mass., died last October 30 of self-inflicted poisoning. He had received his PhD from Harvard in June 1961. Jim leaves his wife and a son, James, Jr.

### *1955*

*Samuel J. Sims*, geologist with the Bethlehem Steel Corporation in Republique du Gabon, Africa, was married there to Myrna Diel on July 5. They were the first white couple to be married in that French territory.

### *1956*

*Robert C. Kausen* is now a member of the research and development staff of Arthur D. Little, Inc., in Cambridge, Mass. He is working on product development in the field of plastics. In 1956, after a short period of work with the Union Carbide Corporation, Bob entered the U.S. Army and spent three years in Berlin, Germany. Bob and his wife have a son, born last April.

*Paul Shlichta*, PhD, is senior research engineer in the solid state physics department at Caltech's Jet Propulsion Laboratory He is now conducting basic research on metal whiskers.

*Paul O. Lindfors*, MS '57, section chief of the Air Force Flight Test Center's Aerospace Data Systems Branch at Edwards Air Force Base in California, recently supervised the conversion of an ineffectual, four-year-old digital data processing system into a speedy, accurate one that's saving $450,000 on its first job. The system is believed to be the only one expressly designed for rocket engine and aircraft flight testing.

Paul put in three years as an Air Force Lieutenant at Edwards, then stayed on there as a civilian engineer. He is the father of three children.

### *1958*

*Robert E. Schenter*, graduate student at the University of Colorado, announces the birth of his first child, Gregory, on June 30, 1961.

### *1961*

*Douglas Shakel* is a trainee in the Undergraduate Navigator Training Program of the U.S. Air Force at James Connally AFB in Texas. He expects to get his wings next July. He writes that *Charles J. Siegel* '61 is at Williams Air Force Base near Phoenix learning to be a pilot. *Thomas Bjorklund* '60 is finishing a master's degree in geology at the University of Texas, where his advisor is *William R. Muehlberger* '49, MS '49, PhD '54, associate professor of geology. *John Lohman* '61 is a graduate student in psychology at the University of Michigan. *Seymour Rapaport* '57, is a medical student at Moffitt Hospital at the University of California at Berkeley.

*Peter Lippman*, now a physicist at the Applied Physics Corporation in Monrovia, writes that he was married on December 24, 1961.

*Lt. Warren L. Simmons*, MS, is now with the physics division at the Research Directorate of the Air Force Special Weapons Center at Kirtland Air Force Base in Albuquerque, N.M. Warren captured the Albuquerque city crown in golf last summer. He has also written a 25-page bulletin, *Operations Research*, which has been published by Caltech's Industrial Relations Center.

## ALUMNI WINTER DINNER MEETING

February 6, 1962

Speaker: Victor Vacquier
Research geophysicist in charge of geomagnetic research at the Scripps Institution of Oceanography at the University of California at La Jolla. Mr. Vacquier was Distinguished Lecturer for the Society of Exploration Geophysicists in 1956, and was awarded the Weatherill Medal by the Franklin Institute in 1960 for the development of the airborne magnetometer.

Topic: "Probing Earth's Underwater Frontier."
A discussion of recent findings at Scripps concerning the structure of the ocean floor, and their contribution to our understanding of the internal construction of the earth.

Cocktails at 6:30, Dinner at 7:15

Rodger Young Auditorium
936 West Washington Boulevard
Los Angeles

## ALUMNI DIRECTORY SUPPLEMENT

A supplement to the 1960 Alumni Directory is now ready for distribution. This supplement lists only the names and addresses of those who received degrees in June, 1961. Copies of the supplement will be sent automatically to Association members who received degrees in 1961. Other Association members may secure copies by filling in the form below and sending it to the Alumni Office.

- - - - - - - - - - - - - - - - - - - -

Please send the 1961 Supplement to the 1960 Alumni Directory to:

Name..........................................

Address..........................................

City..............................State..............

# STERNMEYER RALLIES!!

In his room at the Scenic Vu Sanitarium, George Sternmeyer, California Institute of Technology alumnus, regained consciousness today.

Three doctors, all psychiatric specialists, and a platoon of nurses have been working around the clock since Sternmeyer's mental collapse last month in the offices of a fellow alumnus.

Mr. Sternmeyer's wife was at his side when he first opened his eyes at 10:34 a.m. Pacific Standard Time. "He looked at me," said Mrs. Sternmeyer "and then said, 'I give, he gives, you give. We give, they give, you give.' Then he went back to sleep," she added.

Mrs. Sternmeyer, while naturally alarmed and somewhat upset, has faith in her husband's complete recovery. She indicated that "he began acting rather strangely" some three months ago "about the time the Caltech (California Institute of Techology) Alumni Fund began its solicitations.

The Alumni Fund purpose, *Engineering and Science* learned earlier, is the enlargement of the Institute's endowment. Endowment interest has been providing a diminishing percentage of the funds used by the school for campus expenditures. According to Mrs. Sternmeyer, alumni gifts to the Fund will not only increase the endowment principal but will also emphasize the necessity for additional "live" gifts to this important segment of the school's income.

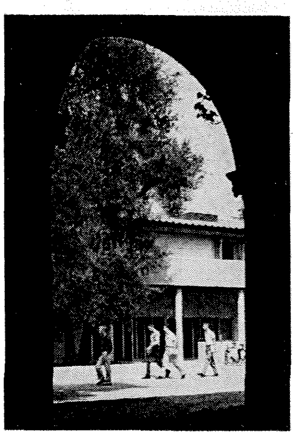
Dr. Al K. Hall, chief psychiatrist at Scenic Vu, indicated later in the day that Sternmeyer's condition was definitely "better." "He is now conjugating the verb *participate*" said Dr. Hall, "and I believe he is on the road to recovery although it will be a long, hard, uphill climb. I am of the opinion that news of Alumni Fund progress, providing it is good news, might well help him to regain some semblance of normalcy," added Dr. Hall.

A telephone call to Alumni headquarters revealed that some 1,000 Caltech alumni have contributed about $35,000.

When informed of this news Dr. Hall agreed that it was a cheering report and further indicated that he thought Sternmeyer would make rapid progress as soon as he could be made to understand the information.

"I feel sure," said Dr. Hall, "that Sternmeyer will be out of his strait jacket by early February at the latest."

# CALTECH CALENDAR



## ALUMNI EVENTS

| | |
|---|---|
| February 6 | Winter Dinner Meeting |
| March 24 | Annual Dinner Dance |
| May 19 | Annual Alumni Seminar |

## ATHLETIC SCHEDULE

### BASKETBALL

January 19
Claremont-H. Mudd at Claremont

January 23
Azusa College at Caltech

January 27
Redlands at Caltech

January 30
Occidental at Caltech

February 2
La Verne at La Verne

February 6
Whittier at Caltech

February 9
Redlands at Redlands

## FRIDAY EVENING DEMONSTRATION LECTURES

*Lecture Hall, 201 Bridge, 7:30 p.m.*

January 19
Around the Galaxy in 200 Million Years
—Maarten Schmidt

January 26
Background of Our Foreign Aid Program
—Robert W. Oliver

February 2
Magnetism in Modern Electronics —Thin Magnetic Films
—Floyd B. Humphrey

## ALUMNI AREA MEETINGS

**BOSTON**

Dinner Meeting, Friday, January 26, 1962—6:30 P.M. at the Wursthaus, 11 Prospect St., Cambridge, Mass. Speaker, Wesley L. Hershey, Executive Secretary, Caltech YMCA.

Chairman: Alan L. Helgesson, '55—6 Blanchard Road, Cambridge, Mass. IVanhoe 4-1503.

**CHICAGO**

Dinner Meeting, Monday, January 22, 1962—6:30 P.M. at the Library Room of the Furniture Club, 666 North Lakeshore Drive, Chicago, Illinois. Speaker, Dr. Lee A. DuBridge, President, California Institute of Technology.

Chairman: Laurence H. Nobles, '49—Dept. of Geology, Northwestern University, Evanston, Illinois—SUmmit 7-4500.

**NEW YORK**

Dinner Meeting, Wednesday, January 24, 1962—Speaker, Wesley L. Hershey, Executive Secretary, Caltech YMCA.

Dinner Meeting, Monday, February 19, 1962—Speaker, Dr. Lee A. DuBridge, President, California Institute of Technology.

Both Meetings at the Columbia University Club, West 43rd St., (just off Fifth Ave.) New York City, Cocktails — 6:00 P.M. Dinner—7:00 P.M.

Chairman: Victor Wouk, Electronic Energy Conversion Corp., 342 Madison Ave., New York—YUkon 6-3173.

**ST. LOUIS**

Dinner Meeting, Tuesday, January 30, 1962—6:30 P.M. at the University Club, 3607 Washington Blvd. (at Grand Ave.), St. Louis, Missouri. Speaker, William L. Holladay, '24, Vice-President, Caltech Alumni Association.

Chairman: Albert E. Lombard, Jr., '28, McDonnell Aircraft Corp., P.O. Box 516, St. Louis 66, Missouri—PErshing 1-2121.

## CALTECH VARSITY GAME SCORES

### SOCCER

| | | | | |
|---|---|---|---|---|
| November 29 | Redlands | 1 | Caltech | 4 |
| December 2 | Pomona | 3 | Caltech | 2 |

### BASKETBALL

| | | | | |
|---|---|---|---|---|
| December 1 | Azusa College | 65 | Caltech | 54 |
| December 2 | L.A. Pacific | 52 | Caltech | 58 |
| December 5 | Upland College | 59 | Caltech | 65 |
| December 15 | Naval Training Center | 54 | Caltech | 41 |
| December 16 | Cal Western | 74 | Caltech | 55 |

## ALUMNI ASSOCIATION OFFICERS

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**VICE-PRESIDENT**
William L. Holladay, '24

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John R. Fee, '51

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Wiliam H. Saylor, '32
Peter V. H. Serrell, '36
William H. Simons, '49
Charles P. Strickland, '43

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**Vice-President** — Edwin P. Schlinger '52, Scott-Buttner Electric Co., Inc. Mountain View
**Secretary-Treasurer** — Dallas L. Peck '51, U. S. Geological Survey Menlo Park

The location of the informal weekly alumni luncheon, which is held on Thursdays at 11:45, has been changed to the 13th floor of the Engineers Club, 206 Sansome Street, San Francisco; Mr. H. Farrar, EX 9-5277, can be contacted for reservations on Thursday mornings.

**CHICAGO CHAPTER**

**President** — Laurence H. Nobles, '49, Department of Geology, Northwestern University, Evanston, Illinois
**Vice-President** — Philip E. Smith, '39, Eastman Kodak Company, 1712 Prairie Ave. Chicago, Illinois

**SACRAMENTO CHAPTER**

**President** — George Langsner, '31, Division of Highways, State of California
**Vice-President** — G. Donald Meixner, Jr., '46, Dept. of Water Resources, State of California
**Secretary-Treasurer** — John Ritter, '35, Division of Highways, State of California

Meetings: University Club, 1319 "K" Street
Luncheon first Friday of each month
Visiting alumni cordially invited—no reservation

**SAN DIEGO CHAPTER**

**Chairman** — Maurice B. Ross, '24, 3040 Udal Street
**Secretary** — Frank J. Dore, '45, Astronautics Div., Convair
**Program Chairman** — Herman S. Englander, '39, U. S. Navy Electronics Laboratory

# Kodak beyond the snapshot...

(random notes)

## One use for an artificial duck

On Sunday evening, September 24th, a new associate of ours named Walt Disney broadcast from 168 TV stations a film called "Mathmagicland." It featured an artificial duck he owns named Donald. The film illustrated the mathematical unity of nature and man, while the duck quacked in order to reassure 20,000,000 viewers that there is no harm in such a discussion.

Lots of kids who were too young for it will be ready next fall. Movies can teach conic sections as easily as pie-throwing. Movie-makers with lesser resources than Disney can also teach laudably. What bothers the classroom teacher about 16mm movies is how to get the one she wants when she wants it instead of seven weeks later. Nobody is to blame. The can of film has too many classes to visit, but relief is on the way.

Enter the *Kodak Sound 8 Projector.* It projects 8mm movies with commentary from a magnetic stripe on the film.

The greatly reduced cost and bulk of 8mm film and equipment got home movies off the ground. The improvement of sharpness and color in the 8mm Kodachrome II Film introduced last year is making movies really soar as entertainment in the home. In the schoolroom 8mm sound movies can be expected to simulate the effect of the paperback on the book business. The teacher will be able to handle a teaching film more like a weekly magazine and less like a shipment of gold bullion.

## A sharp eye for infrared

The decision to announce *f/1 Irtran-2 Aspheric Lenses* has been reached in struggle against inhibitions. In the photographic trade we are habituated to a longer silence before the first blast of the trumpets. Infrared technology hates to wait, however.

These lenses transmit usefully from $2\mu$ to $14\mu$. Three focal lengths, 1-inch, 2-inch and 3-inch, are offered off the shelf. At *f/1*, we seem to have done well at providing high collecting-power for energy without undue sacrifice of sharpness. Sharpness was the goal. For all the lenses, the minimum circle of confusion *computes* at less than .001″ for any wavelength from $4.25\mu$ to $10\mu$. Note italics.

In the $2\mu$-$3\mu$ region, the sharpness does not compute to be as good as farther out in the infrared. Yet we have customers who use the lenses there and are happy with confusion-circle minima as large as .008″.

In comparison with reflective optics hitherto used, Irtran-2 aspheres offer compactness and a wider field that doesn't even show appreciable deterioration as far as 2° off axis. You do give up the perfect achromatism of mirrors.

These remarks can be interpreted as a blatant offer here and now to sell these lenses for cash. (Address inquiries to Eastman Kodak Co., Special Products Division, Rochester 4, N.Y.) Irtran-2 material resists water and common organic solvents. It retains infrared transparency at high temperature.

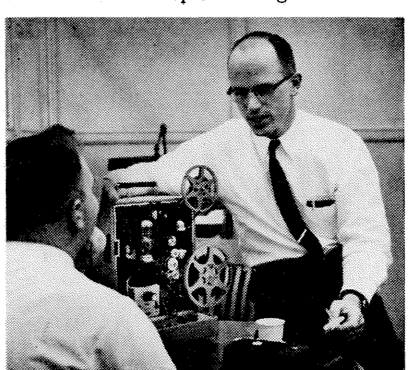
## The carboxamide way to solvation

The joy that philosophers once felt in considering an irresistible force acting against an immovable object is as nothing to the joy of the peddler who carries in his pack both an inorganic substance that resists common organic solvents *(see left)* and a solvent which dissolves inorganic substances which common solvents fail to dissolve.

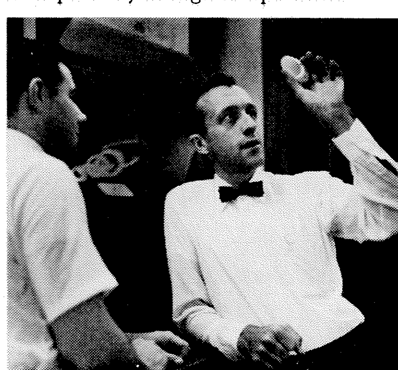
\$2.75 buys from Distillation Products Industries (a division of ours), Rochester 3, N. Y. 5 grams of *N,N-Dimethylbenzamide.* This comes as white crystals that melt at 42°C. It is a new member of a class of compounds of uncanny solvent power for high polymers, organometallics, and inorganics.

Solvation virtually demands the liquid state. Solubility also usually rises with temperature. Without the trouble and peril of high-pressure tactics, N,N-dimethylbenzamide can be maintained as a much hotter liquid than its cousins. It doesn't boil until 272°C, as compared with 152°C for N,N-dimethylformamide and 165°C for N,N-dimethylacetamide. Judged from some of the 17 other N-substituted carboxamides to be found among some 3900 Eastman Organic Chemicals we sell for research, it is probably a swell solvent. (Whether it dissolves Irtran-2 material, nobody yet cares.)

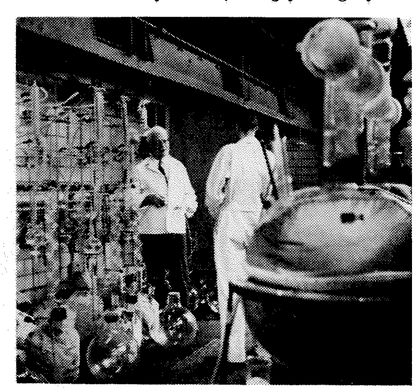
**Note:** Whether you work for us or not, photography in some form will probably have a part in your work as years go on. Now or later, feel free to ask for Kodak literature or help on anything photographic.



COST-CUTTING NEEDS GOOD PEOPLE



INFRARED OPTICS NEEDS GOOD PEOPLE



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