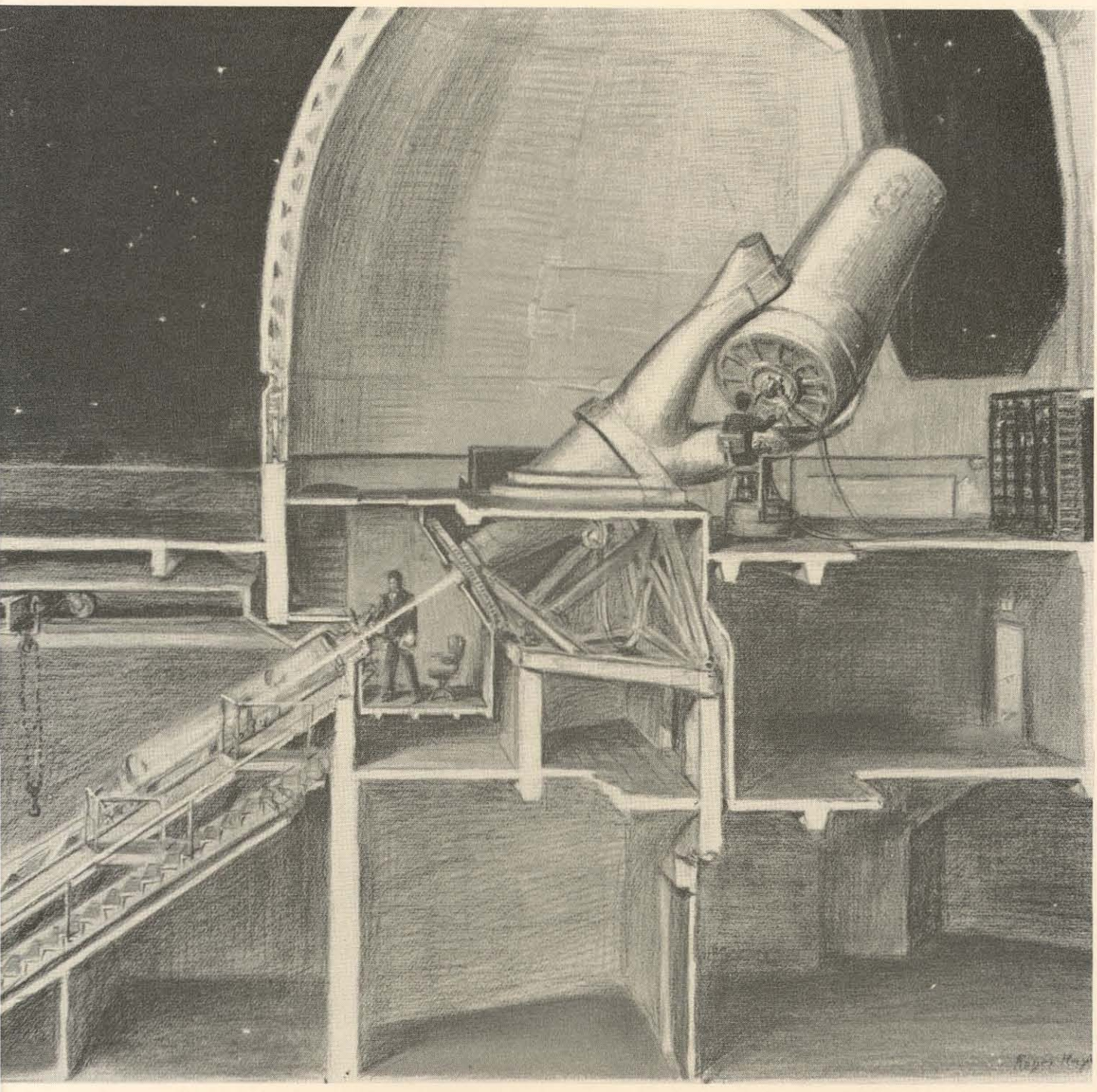
MAY 1966

# ENGINEERING AND SCIENCE



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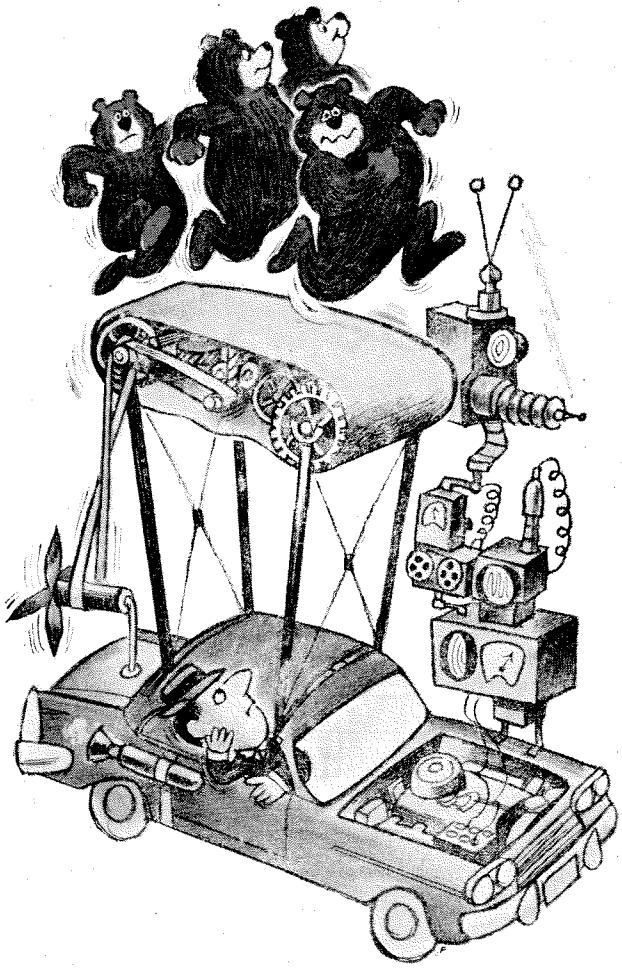
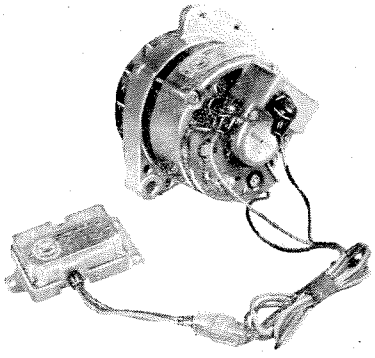


Hitch it to a herd of grizzlies . . .



. . . or feed it a Motorola alternator system*

**THE PROBLEM:** HOW DO YOU GIVE YOUR CAR BATTERY THE ENERGY OF A GRIZZLY BEAR — UPHILL, DOWNHILL, OR JUST TO GET GOING?

There was a time when engineering an alternator system was an impracticality. Most everyone in the business tried it — no one could successfully mass produce the automotive diode — the key to the system. Finally, Motorola engineers made the breakthrough — alternator systems are committing hapless generators to the museum showcase.

Today, alternator systems are designed for automotive, industrial, and marine use.

This sort of engineering sophistication is producing automotive electronic equipment to do things for the car that are impractical to accomplish mechanically.

Transistor ignition systems and electronic tachometers, hour meters for trucks and stereo tape decks, all-in-one air conditioning and heat control systems — these are a few of the projects currently in motion with Motorola automotive engineers.

The car radio? Sure. Motorola makes that too. Paul Galvin mass produced the first ones in 1929 . . . to start a little business.

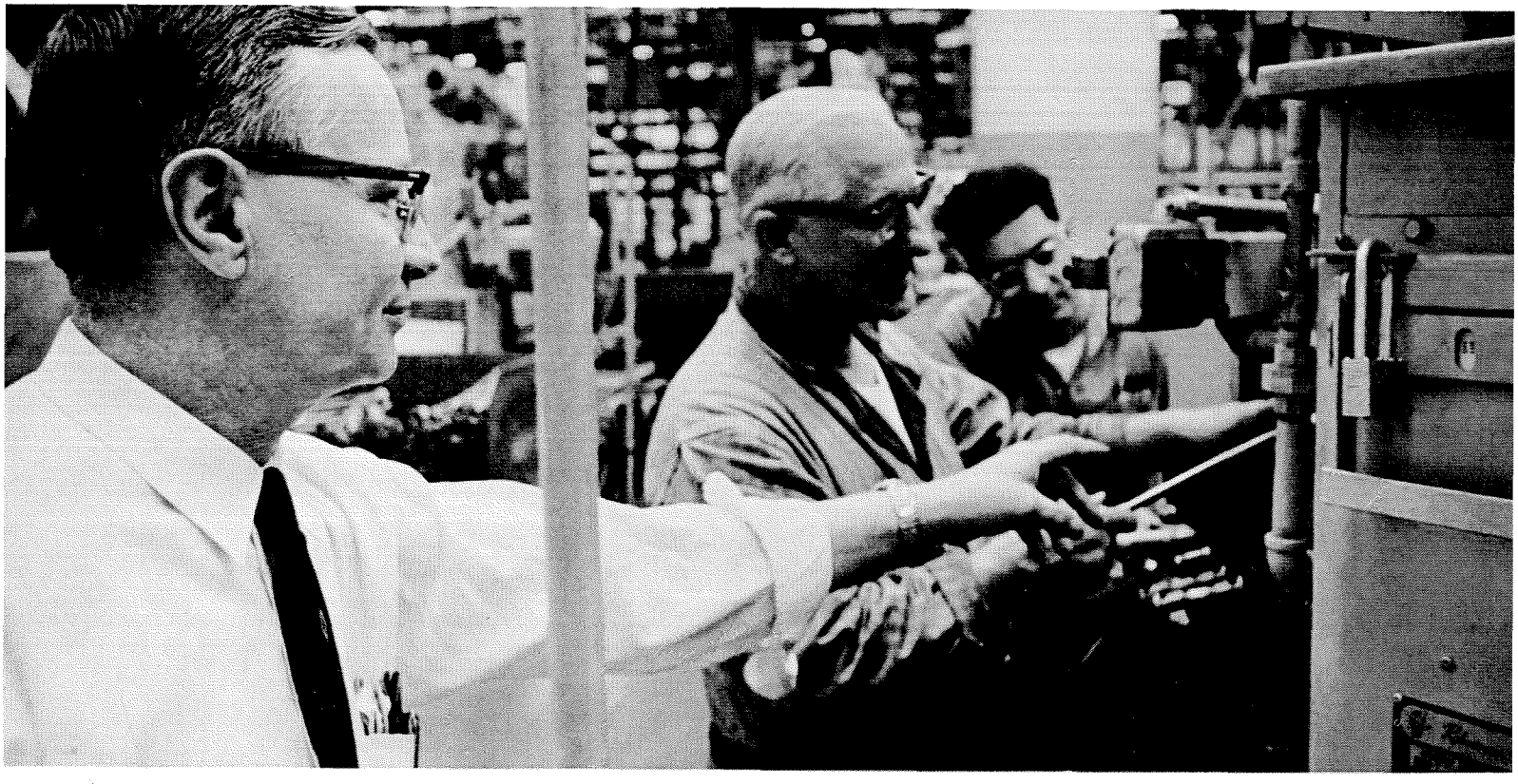
*An electronic system that maintains a consistent, reliable energy supply for the car's electrical equipment.

TRUST THIS EMSIGNIA WHEREVER YOU FIND IT

**MOTOROLA**

# The boy who wondered what made things tick...

# now keeps complex machines 'ticking' at General Motors



When Steve Slowinski was eight years old, he was lucky enough to find a broken-down alarm clock in a vacant lot near his home. He took the clock apart, and then put it back together so it worked perfectly.

In the days and years that followed, Steve considered it a personal challenge when he found anything that needed rebuilding. In high school, for example, he set up his own repair business and within a year his room was crowded with faceless clocks, dismembered watches, washing machines, toasters and other items. You name it —Steve could fix it.

After courses in mechanical arts and drafting, Steve joined the Ternstedt Division of General Motors. His first job—to fix intricate machinery when it got fouled up. Today, Steve is the Foreman of the machine repair team at this important GM Division.

Looking back, it was more than a broken alarm clock that a young boy found so many years ago. It was, in effect, a lifetime career.

We're mighty glad it worked out that way . . . for Steve Slowinski . . . and for General Motors!

GM **General Motors is People**... making better things for you

# ENGINEERING AND SCIENCE

May 1966 / Volume XXIX / Number 8



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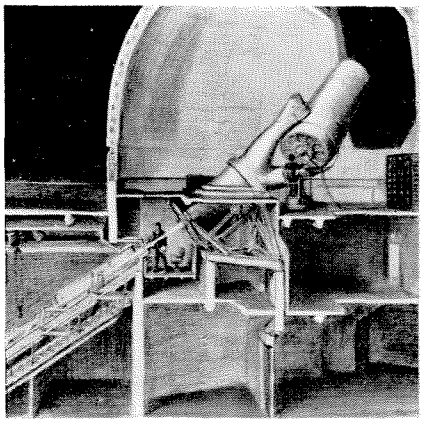

*On Our Cover*

is a preliminary artist's concept of a 60-inch photometric telescope soon to be built at Palomar Observatory. When it is finished in 1970 the Mt. Wilson and Palomar Observatories will have another instrument to help meet the increasing demands for observing time. Even more important, the new telescope will be used for research in many areas of interest in astronomy that, because of a lack of other available instruments, now have to be performed with the 100- and 200-inch telescopes. Details are given in "Palomar Gets a New Telescope" on page 9.

*James Brune,*

associate professor of geophysics, is trying to find out more about large earthquakes by studying very small ones. A report on his work, which is part of Caltech's major research program to investigate sections of the San Andreas fault, is in "Microquakes—A Tool for Understanding Destructive Earthquakes?" on page 12.

*Robert F. Christy,*

professor of theoretical physics, teamed up with a computer to develop and evaluate models of some of our more unusual stellar neighbors—pulsating stars. A report is on page 16.

# Why become an engineer at Garrett-AiResearch? You'll have to work harder and use more of your knowledge than engineers at most other companies.

If you're our kind of engineer, you have some very definite ideas about your career.

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You've worked hard to get a good education. Now you want to put it to work in the best way possible.

You will never be satisfied with run-of-the-mill assignments. You demand exciting, challenging projects.

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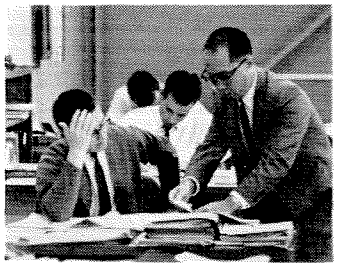

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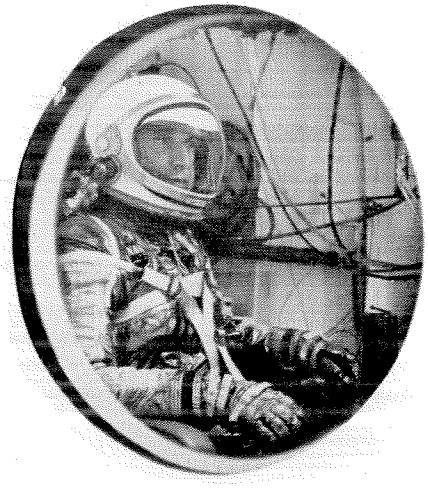

The product lines at AiResearch, Los Angeles Division, are environmental systems, flight information and controls systems, heat transfer systems, secondary power generator systems for missiles and space, electrical systems, and specialized industrial systems.

In the Phoenix Division there are gas turbines for propulsion and secondary power, valves and control systems, air turbine starters and motors, solar and nuclear power systems.

In each category AiResearch employs three kinds of engineers.

Preliminary design engineers do the analytical and theoretical work, then write proposals.

Design engineers do the layouts; turn an idea into a product.

Developmental engineers are responsible for making hardware out of concepts.

Whichever field fits you best, we can guarantee you this: you can go as far and fast as your talents can carry you. You can make as much money as any engineer in a comparable spot – *anywhere*. And of course, at AiResearch, you'll get all the plus benefits a top company offers.

Our engineering staff is smaller than comparable companies. This spells opportunity. It gives a man who wants to make a mark plenty of elbow room to expand. And while he's doing it he's working with, and learning from, some of the real pros in the field.

If the AiResearch story sounds like opportunity speaking to you – don't fail to contact AiResearch, Los Angeles, or Phoenix, or see our representative when he comes to your campus.

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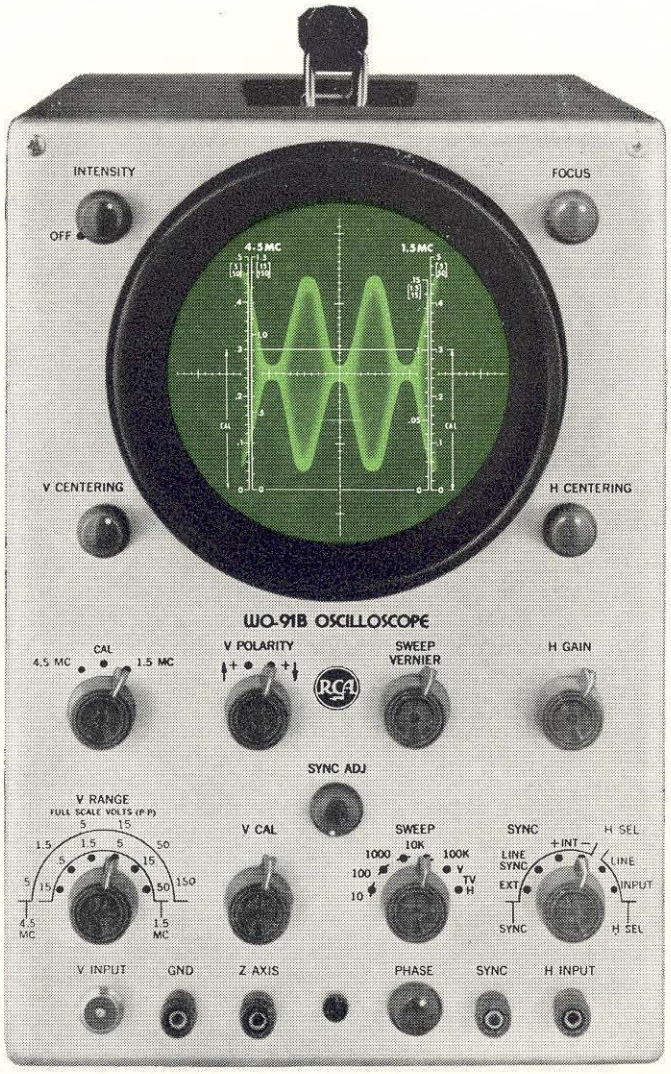


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# Letters

*San Diego, California*

EDITOR:

I am sure that a large number of the alumni who have received advanced degrees from the Institute will be interested to learn of the retirement of Mrs. Jeanne Augé, assistant to the Dean of Graduate Studies. She has made a most important contribution to the administration of the Graduate Office for a period of 30 years.

Mrs. Augé came to Caltech in 1936 as assistant to the first Dean of Graduate Studies, Richard C. Tolman. As other deans came and went, she remained as assistant to each and, until her retirement on April 1, she was the only person to have served Caltech in that capacity.

Her interest in helping to smooth the way for students has been keen. Foreign students naturally have more problems and so have benefited particularly. As a result, she has friends dotted all over the globe.

Her service to Caltech will be missed —as will her virtuosity in accompanying carols on the recorder at campus Christmas parties. Her interest in music and other intellectual activities will keep her busy during her retirement, and everyone who has known her, I am sure, wishes her well.

WILLIAM N. LACEY
*Professor of chemical engineering, emeritus and Dean of Graduate Studies, 1946-56.*

*Pasadena, California*

EDITOR:

Perhaps you would be interested in one of the many letters I received after the Caltech Glee Club's recent tour to the East Coast—this one from Charles V. Decker, Director of Music of the City of Oneida (N.Y.) Schools:

"I want to congratulate you and the Caltech Glee Club for the superior performance you recently gave here. I feel that it was one of the finest choral concerts we have ever had the privilege of hearing. It was amazing to hear such fine, trained voices in a non-music-major school. Not only was the caliber of the performance superior, but the boys were a fine group of well-mannered and courteous gentlemen. If you are ever in this area again, we would like to have you back for another concert."

OLAF M. FRODSHAM
*Caltech Director of Choral Music*

*Woodland Hills, California*

EDITOR:

In *Newsweek* I read **Cal Tech.** In JPL's publication, *LAB-ORATORY*, it was written **CIT.** In your magazine it's **Caltech.** Isn't there a standard way of referring to the Institute?

HAL WYMAN '62

*Officially it's Caltech.*

# Books

**Fluid Mechanics with Engineering Applications**

*by Robert L. Daugherty and Joseph B. Franzini*
*McGraw-Hill* ..... *$9.95*

*Reviewed by Vito A. Vanoni, professor of hydraulics.*

Robert Daugherty is professor emeritus of mechanical and hydraulic engineering at Caltech. This sixth edition of his book is co-authored by his former student, now professor of civil engineering at Stanford University. It is more than 100 pages longer than the fifth edition by Daugherty and Ingersoll. The material has been rearranged so that it is more convenient for teaching and revised to include a more rigorous and complete development of basic principles. A higher level of mathematics is used.

The book features a complete treatment of turbo machinery as do the previous editions. Daugherty's clear physical approach to the subject and his practice of including data needed to solve engineering problems have been retained.

The reader familiar with the fifth edition will recognize that much of the important material has been changed very little. The changes which do appear make the book a better one for use in the classroom, but are less important to engineers using it as a reference book.

**Thirty Years That Shook Physics: The Story of Quantum Theory**

*by George Gamow*
*Doubleday & Company* ..... *$5.95*

*Reviewed by Frederick J. Gilman, research fellow in theoretical physics*

The prolific George Gamow, physicist and writer, has now come forth with a book on the basic ideas of quantum theory and the history of their development during the first 30 years of this century. The book contains the usual lucid Gamow presentation for the educated layman of a scientific theory, in this case the theory and momentous new concepts involved in the development of quantum mechanics. In addition, the book contains personal recollections of important scientific meetings, lectures, and incidents at Niels Bohr's Institute in Copenhagen, as well as Gamow's own drawings of, and anecdotes about the men who created the quantum theory.

For the scientist already acquainted with quantum mechanics, the most interesting part of the book is to be found in the personal anecdotes, reminiscences, and pictures sprinkled through the book. Where else can one find pictures of Ehrenfest lecturing, the physicists in attendance at the 1932 Copenhagen Spring Conference, and, Niels and Mrs. Bohr roaring down a road on a motorcycle?

**The Language of Life: An Introduction to the Science of Genetics**

*by George and Muriel Beadle*
*Doubleday and Co.* ..... *$5.95*

*Reviewed by Lois Edgar**

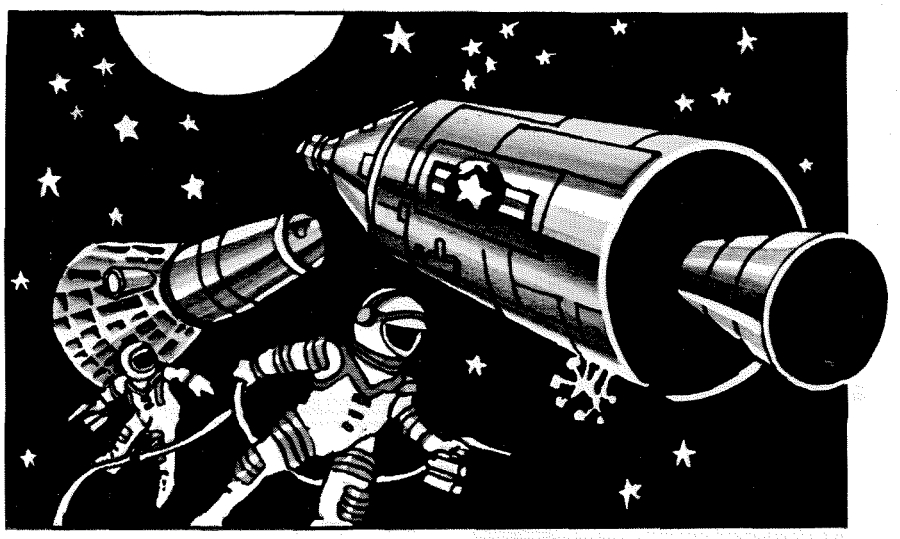
As every high school student knows today, the science of genetics has changed and expanded immensely in the past 10 or 15 years, since the discovery of DNA.

This new book on genetics for the layman, by the former chairman of Caltech's biology division, Nobel Laureate George Beadle, and his writer-wife, Muriel, is aimed at filling in for

*continued on page 28*

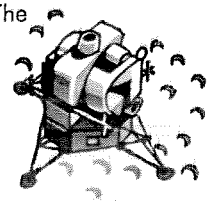
**Mrs. Edgar is the wife of Robert S. Edgar, Caltech associate professor of biology.*

# Here are 7 knotty problems facing the Air Force: can you help us solve one?

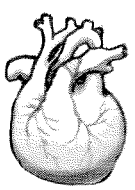


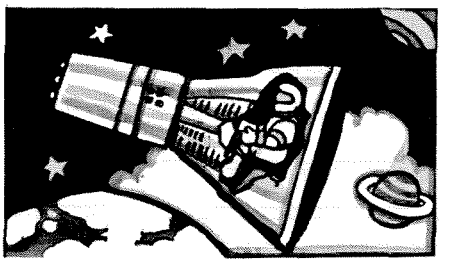
**1. Repairs in space.** If something goes wrong with a vehicle in orbit, how can it be fixed? Answers must be found, if large-scale space operations are to become a reality. For this and other assignments Air Force scientists and engineers will be called on to answer in the next few years, we need the best brains available.

**2. Lunar landing.** The exact composition of the lunar surface, as well as structural and propulsion characteristics of the space vehicle, enter into this problem. Important study remains to be done—and, as an Air Force officer, you could be the one to do it!

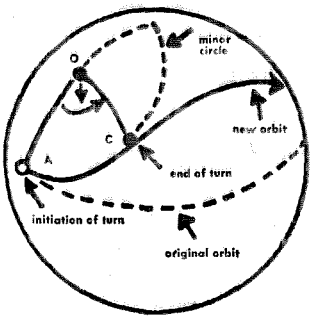


**3. Life-support biology.** The filling of metabolic needs over very extended periods of time in space is one of the most fascinating subjects that Air Force scientists are investigating. The results promise to have vital ramifications for our life on earth, as well as in outer space.



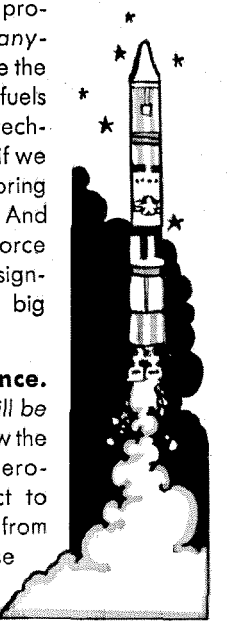


**4. Space orientation.** The orbital problems of a spacecraft, including its ability to maneuver over selected points on the earth, are of vital importance to the military utilization of space. There are plenty of assignments for young Air Force physicists in this area.




**5. Synergetic plane changing.** The ability of a spacecraft to change altitude can also be crucial to space operations. Where but in the Air Force could Sc.B.'s get the chance to work on such fascinating projects right at the start of their careers?

**6. Space propulsion.** As our space flights cover greater and greater distances, propulsion—more than anything else—will become the limiting factor. New fuels and new propulsion techniques must be found, if we are to keep on exploring the mysteries of space. And it may well be an Air Force scientist on his first assignment who makes the big breakthrough!



**7. Pilot performance.** Important tests must still be made to determine how the pilots of manned aerospacecraft will react to long periods away from the earth. Of course not every new Air Force officer becomes involved in research and development right away. But where the most exciting advances are taking place, young Air Force scientists, administrators, pilots, and engineers are on the scene.

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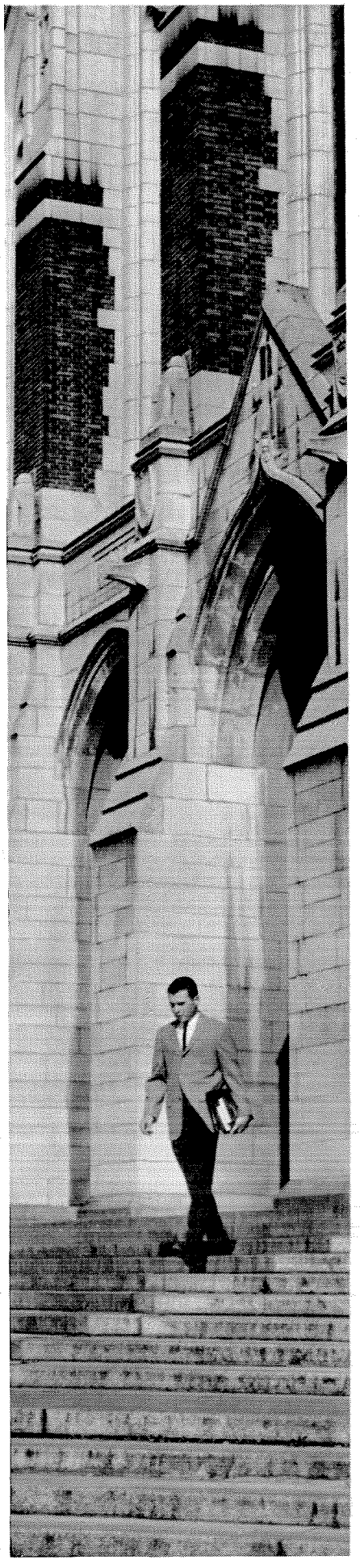
# Your career at Boeing began years ago



It started, in fact, the day you decided to become an engineer or scientist. Along the way, you've developed and learned many of the things you'll need to accomplish the challenging assignments awaiting you at Boeing.

Why Boeing? Boeing is one of the nation's leaders in aerospace. A substantial backlog of firm contracts and orders—more than $3 billion as of December 31, 1965—assures a high degree of career stability. Boeing activities range from commercial jetliners and helicopters through military programs to space flight contracts, offering a broadly diversified spectrum of long-term assignments. It's a good combination. Initiative and ability can get you to the top fast.

This year Boeing celebrates its 50th Anniversary. From a small shop in 1916, it has expanded into an aggressive, eminently successful and still growing organization, with sales over $2 billion in 1965. The power behind this remarkable growth has been a forward-striding attitude, an orientation toward the future which, over the years, has produced a steady succession of pioneering, years-ahead achievements.

It's a propitious moment, perhaps, to consider a Boeing career. For further information about career opportunities, write directly to: Mr. T. J. Johnston, The Boeing Company, P.O. Box 3707, Seattle, Washington 98124. Boeing is an equal opportunity employer.

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ENGINEERING
AND SCIENCE
*May 1966, Vol. XXIX, No. 8*

# PALOMAR GETS A NEW TELESCOPE

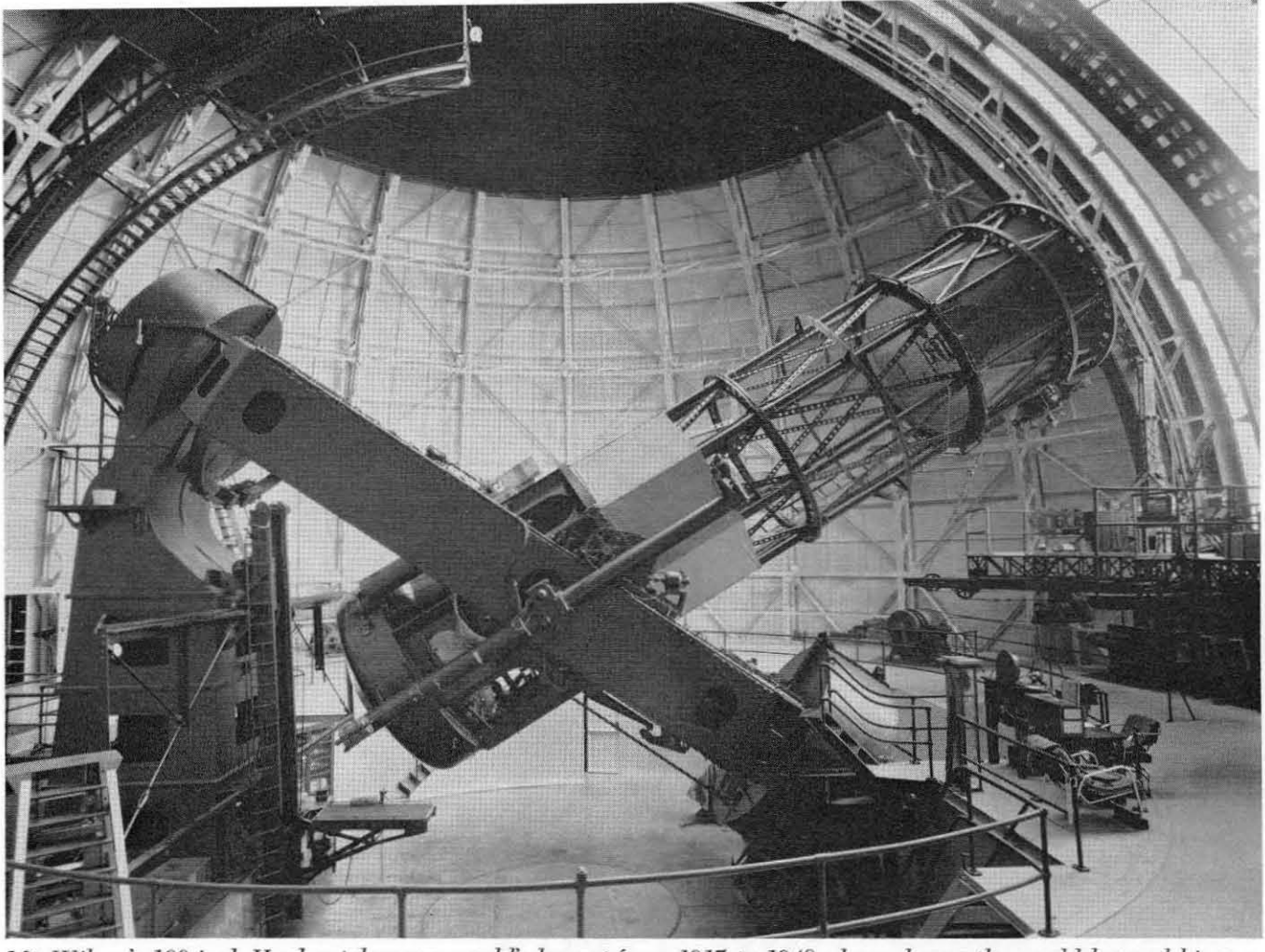
*Work is beginning on a 60-inch photometric instrument which, when completed in 1970, will permit more efficient use of the Mt. Wilson and Palomar Observatories' other telescopes*

Palomar Observatory will soon have another telescope. A 60-inch reflector of advanced design, scheduled for completion in 1970, will be the first major addition to the Mt. Wilson and Palomar Observatories since the 200-inch Hale telescope became operational in 1948. The new instrument will be a powerful, versatile addition to the Observatories' facilities. Although it is "small" compared to the giant telescopes, it will permit more efficient operation of the Observatories' four major telescopes—the 200-inch Hale and the 48-inch schmidt at Palomar, and the 100-inch Hooker and the 60-inch at Mt. Wilson.

The total cost of the new 60-inch telescope will be about $1,000,000. The National Science Foundation has made a grant of $590,000 to the Carnegie Institution of Washington, co-operator with Caltech of the Mt. Wilson and Palomar Observatories, for materials and construction of the telescope. The Oscar G. Mayer family of Madison, Wisconsin, has pledged to Caltech the funds for the observatory building. The National Aeronautics and Space Administration has given $125,000 for the preliminary design studies and for purchase of the 60-inch mirror blank that was cast by the Corning Glass Works. And additional funds will come from the Carnegie Institution ($74,000) and Caltech ($20,000). Design studies and engineering plans have been completed by Bruce Rule, chief engineer of the Observatories.

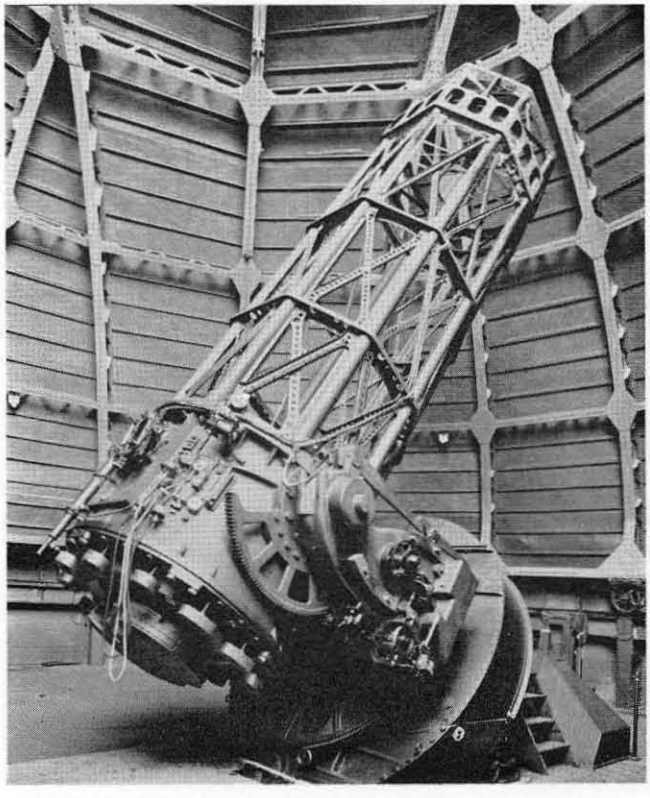
The urgent need for this telescope has been recognized for several years, and planning for it was begun in 1962. It may be regarded as an important unit in the fulfillment of the recommendations made in 1965 by the National Academy of Sciences when it considered a ten-year development program of ground-based astronomy facilities for the United States. Its report stated that of all equipment needed (which includes more than 30 new optical and radio telescopes at an estimated cost of nearly $225 million), construction of two intermediate-size (60 to 84 inches) optical instruments should have the highest priority.

The new telescope will be particularly effective for important photometric observations that do not require the light-gathering capability of the 200-inch telescope. This will free the big telescope to concentrate on observations of the very faint objects for which it was designed. The 60-inch will also get much of the direct photographic and photoelectric work now being done at Mt. Wilson. Increasing reflection of city lights in the night sky over Mt.



*Mt. Wilson's 100-inch Hooker telescope, world's largest from 1917 to 1948, showed man the world beyond his own galaxy. After 1970 it and the older 60-inch can be used mainly for bright objects and spectroscopic studies.*

*The 60-inch telescope at Mt. Wilson, in use since 1909, was the first of the Mt. Wilson and Palomar Observatories' great astronomical instruments.*

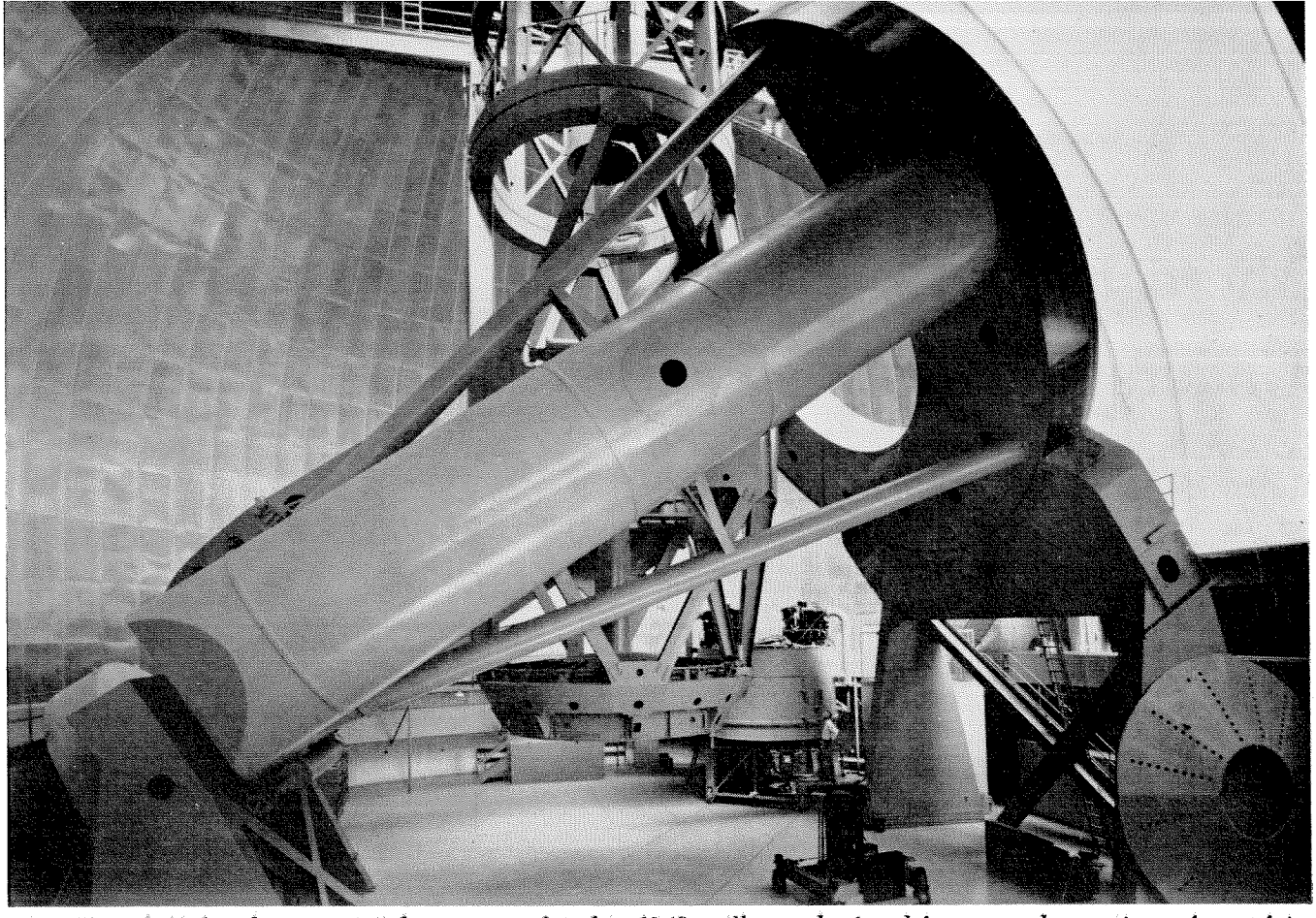


Wilson has reduced the effectiveness of the 100-inch telescope for observations of very faint sources.

After some work from Mt. Wilson is transferred to the new telescope, the Mt. Wilson instruments can be used more effectively for observing brighter objects and for conducting spectroscopic studies in which chemical composition, temperatures, and motions of objects are analyzed. Also, increased availability of the instruments there will help meet the growing need for observing time by the Observatories' staff, graduate students, and guest observers from other institutions.

The new telescope will bridge the gap between the high magnification and small field of the 200-inch and the comparatively low magnification and large field of the 48-inch schmidt. The relatively large field of the 60-inch (1¼ degrees—a little more than two moon diameters) will make it a valuable companion to the schmidt for survey work.

The telescope tube will be only about 13 feet long; the use of mirrors will extend its focal length to that of a much longer telescope. It will have a Cassegrain focus (where the image is reflected by a mirror near the top of the tube to a plane below the primary mirror) for photometry and direct photography and a coudé focus (which is independ-



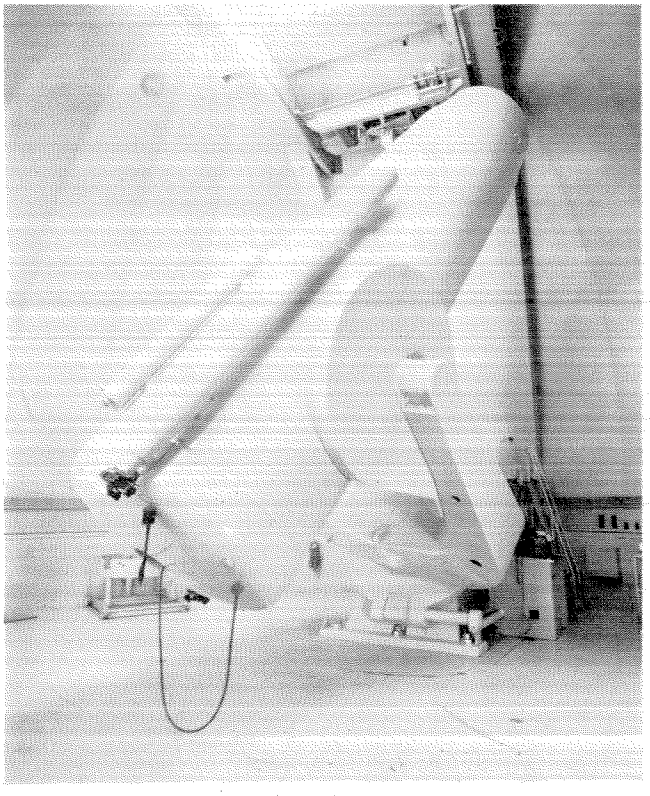
*The 200-inch Hale telescope at Palomar, completed in 1948, will soon be freed for more observations of very faint objects. The new 60-inch will take over some of the other kinds of work that the 200-inch must be used for now.*

ent of telescope orientation and is situated in a basement room) for spectrographic studies. The small size of the telescope will make it possible to move quickly from one celestial object to another, and it will also be possible to change rapidly from one focus to another. This will make it extremely useful in photometric work.

The telescope mirror blank, now in the Optical Shop at the Observatories' headquarters in Pasadena, is of fused silica, which is little affected by temperature changes. It has been edge-ground and roughly contoured. After further grinding and polishing the mirror will be coated with highly reflective aluminum, as will the smaller mirrors that direct the image to the observing foci.

The design of the three-story building and dome for the new telescope is being adapted from that of the 48-inch schmidt telescope. It will contain observing space; a basement coudé room; a combination office, library, and photographic plate assessment room; and darkrooms for developing plates. Insulated walls and an air-conditioning system will provide temperature control to safeguard sensitive equipment. The building will be named for the late Mr. Mayer, founder of the large meat packing firm that bears his name.

*Palomar's 48-inch schmidt camera, able to take high-resolution photographs with a wide field of view, acts as a scout for the 200-inch telescope.*



# Microquakes — A Tool For Understanding Destructive Earthquakes?

*Very small shocks may help determine the strain rate along a fault*

Portable seismometers originally developed at Caltech to land on the moon to detect possible moonquakes are now being used closer to home to measure extremely small earthquakes. These "microquakes" are too weak to be detected on ordinary seismometers; their magnitudes are about one-millionth that of the smallest destructive earthquakes.

James Brune, associate professor of geophysics, has been measuring microquakes as part of a major research program being conducted by Caltech geologists and geophysicists to instrument and study sections of the San Andreas fault. Associated with him on this project are Clarence Allen, professor of geology and geophysics and interim director of the Caltech Seismological Laboratory; and Frank Press, former director of the laboratory and now chairman of the department of geology and geophysics at MIT.

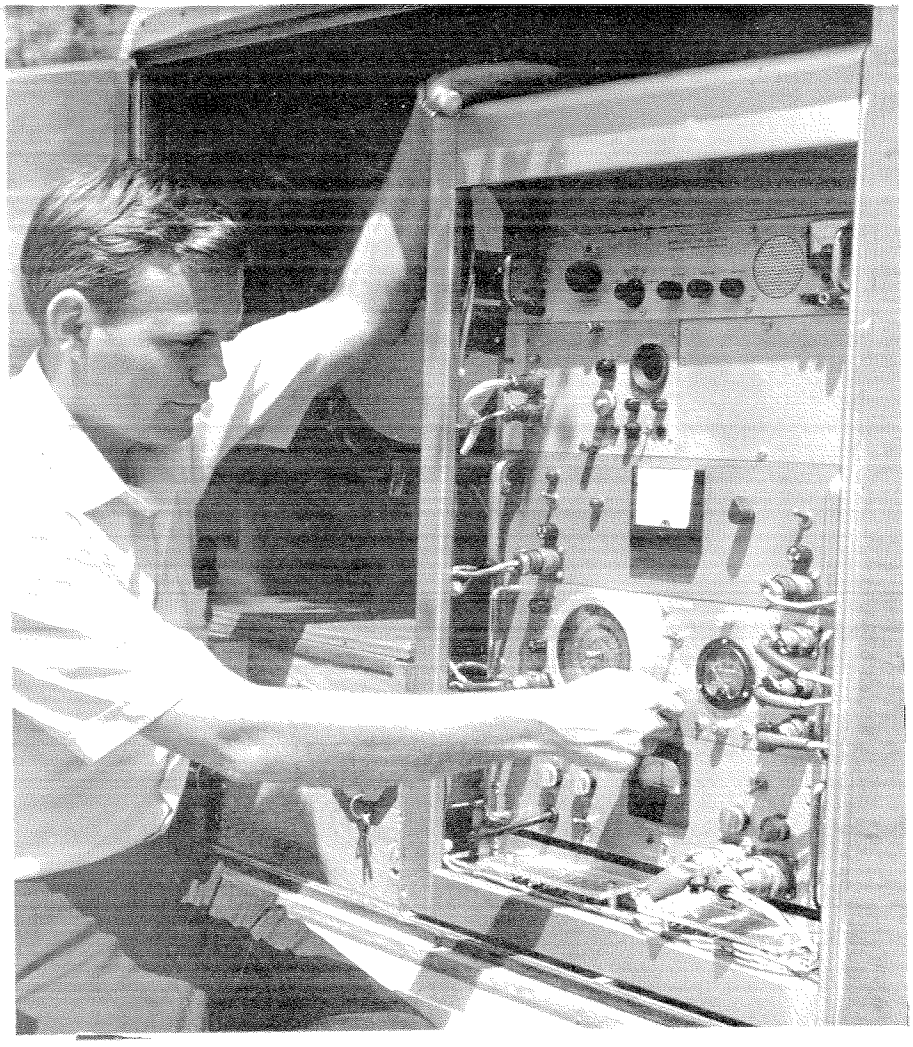
Microquakes may provide clues to the understanding of large earthquakes, and possibly even to their prediction. They will certainly reveal more about the great forces that move large land masses. Microquakes are probably caused by small movements along underground cracks near a major fault; most of them occur at depths of less than ten miles. Thus, while microquakes are concentrated near large active faults, they usually do not represent movement along the fault itself. However, on the San Andreas they do appear to be associated with "creep" along parts of the fault. The creep, in turn, is a reflection of the regional stress that is always present and which keeps the land on the west of the fault moving north, relative to the other side, at a rate of about two inches per year.

If seismologists are ever going to be able to predict earthquakes, they must first understand the relationship between stress accumulating at various sections of a fault and relief of that stress through creep and slippage. It is not now clear what role microquakes play in this give and take. However, it is unlikely that they actually can relieve any significant amount of stress. Rather, they may serve as an indication of the presence, absence, or change in stress patterns.

The San Andreas is being monitored for microquakes at selected sites between Hollister and Brawley, a distance of some 400 miles. Activity, which seems to be concentrated only in certain areas, occurs near Hollister and San Bernardino, where creeping has been observed. Unexpectedly, the 175-mile stretch between Cholame (on the fault east of Paso Robles) and Wrightwood (in the San Gabriel Mountains) is relatively quiet. Such silence along some sections of the fault could mean that the fault is "locked" so that stress is building up, or it could mean the reverse—that no strain exists.

Microquakes tend to occur in bursts and are very irregular in frequency at any one location. More than 125 a day were recorded at the south end of the Salton Sea near Brawley. On the other hand, at Lake Hughes, 40 miles north of Los Angeles, an average of only one every ten days was recorded over a period of about a year. This is contrary to what might have been expected because the Lake Hughes area is directly on the fault. The frequency of microquakes recorded there corresponds to that found in such stable areas as New Jersey.

Microquakes have been recorded on other active faults in California and Nevada, in addition to the San Andreas. Flurries of microquakes have been detected along the Elsinore and San Jacinto faults



*James Brune, associate professor of geophysics, uses trailer-mounted equipment to record the output of a portable seismometer located on the ground not far away.*

in southern California, for example. In general, any given 30-mile diameter area in southern California will have an average of one to ten microquakes a day. Of course the actual number recorded depends on the sensitivity of the instrument and the background noise in the ground. If this noise could be reduced, even more microquakes could be recorded.

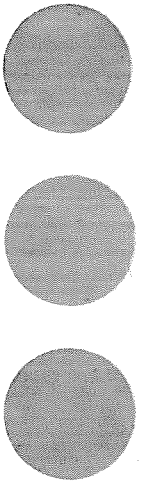
The equipment is mounted on small, two-wheeled trailers that can be towed to almost any desired location and set up quickly. The seismometers are put into the ground and linked by cable to recorders in the trailers. The equipment was built with the support of the Advanced Research Projects Agency's Project Vela. Francis Lehner, special projects engineer at Caltech's Seismological Laboratory, has supervised the development of the equipment. The over-all San Andreas research program is being sponsored by the National Science Foundation.

For maximum precision, the instruments can be set up in the form of an array of five, with one placed at each corner of a square about ten miles on a side, and with one in the middle. With the array it is possible to make an accurate determination of the origin of a microquake.

It may eventually be possible to obtain a quick seismic picture of an area by using microquakes. Perhaps there is a correlation between them and other phenomena, such as earth tides and temperature changes. Ultimately, it is hoped that microquakes will help seismologists understand the mechanisms of large earthquakes.

*Seismometers for detecting microquakes along the San Andreas fault were originally designed to be landed on the moon to detect possible moonquakes.*

# LATE NEWS for 1966 ENGINEERING GRADUATES



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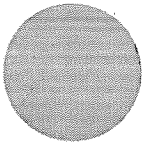

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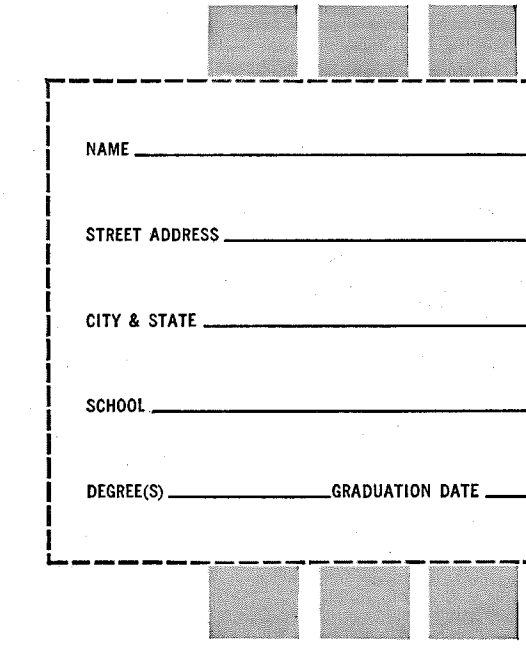

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*A Caltech physicist reveals results of a four-year computer study of*

# PULSATING STARS

*by Graham Berry*

Using a computer to imitate the behavior of the type of pulsating star that our sun is expected to evolve into, Robert F. Christy, professor of theoretical physics, has refined an important yardstick involved in measuring cosmic distances. The yardstick consists of a group of oscillating objects called RR Lyrae stars, which are sprinkled throughout our Milky Way Galaxy. He has determined that all these stars are about 50 times brighter than the sun; that they are about half as massive as the sun; and that about 30 percent of their surface layers consists of helium.

RR Lyrae are easy to distinguish from other stars because, as they pulsate, they dim and brighten in periods of a day or less. As yardsticks for cosmic distances it is vital to know their intrinsic brightness (i.e., the brightness of one of them compared with that of the sun, if both were placed side by side). Their distances are determined by comparing their apparent and intrinsic brightnesses.

RR Lyrae are slowly evolving stars, thought to have once had about the same mass as our sun, that have consumed enough of their hydrogen to swell up and become cool giants. Although now only half as massive as the sun, their diameters are about five times that of the sun. Further evolution elevates their surface temperatures to near that of the sun, causing their outer layers to become unstable. The instability is reflected in pulsations that persist for probably 10 million to 100 million years, a brief time in the life of these stars that are believed to be nearly as old as our galaxy.

To reach his results Dr. Christy has developed a new method of using a computer to simulate the behavior of stars. The method is an outgrowth of techniques that evolved at Los Alamos during World War II in calculating the design of the first atomic bomb. In the present study, he fed Caltech's IBM 7094 computer with numbers representing various masses, luminosities, surface temperatures, helium contents, and the physical properties of helium and hydrogen. He then fed to the computer the equations from applicable laws of physics. Finally, he instructed the computer to use all this information to imitate an RR Lyrae star.

The computer simulated some 100 possible models of the stars; each required about 100 million computations. The behavior of some of the models closely simulated the observed behavior of RR Lyrae stars.

It has been known that RR Lyrae stars have similar surface temperatures, ranging from 11,000° to 13,000°F. Stars of similar size, but with different temperatures, do not pulsate. Thus, it was assumed that the pulsations depended on the surface temperature.

The computer models showed that this is not completely true—pulsation also depends on the amount of helium in the surface layers. By testing models containing various amounts of helium, he determined that stars with little helium pulsated only at the lower end (11,000°F) of the temperature range, while stars very high in helium pulsated only at the higher end of the range (13,000°F).

The model containing 30 percent helium pulsated exactly within the observed range. Thus, Dr. Christy concluded that RR Lyrae stars probably contain about 30 percent helium.

The large helium content, which is considerably more than was expected, lends support to the "big bang" theory of the birth of the universe. If the surface helium content is representative of their composition at birth, these stars demonstrate that our galaxy was already rich in helium when it was very young. The helium could come from some unknown mechanism active in the early time of our galaxy, or it could come from a big bang that some scientists believe triggered the birth of our universe more than 10 billion years ago.

Dr. Christy's work is supported by the National Aeronautics and Space Administration and the Office of Naval Research.

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# *Flower Initiation*

*Experiments show there is more than one gene group in a plant that can make it bloom*

A Caltech researcher in biology has added some important new information to scientific knowledge on the genetics of flowering. Wesley O. Griesel, visiting associate in biology and professor of botany at California State College at Los Angeles, working with *Cestrum* in Caltech's Earhart Plant Laboratory, has determined that there is more than one simple inheritable system that can act in the flowering of a plant, and that any one of these systems can take over and perform independently of others under certain conditions.

It was only in this century that scientists began the study of what makes a plant bloom—what growth processes cause a plant to stop producing leaves and stem and to begin developing flowers. The first important work in flower initiation was recorded in the early 1900s by U.S. Department of Agriculture scientists who were looking for the causes of flowering in Maryland Mammoth tobacco after plants failed to bloom under the usual conditions. Their research showed that the most significant factor initiating flowering is not the size or age of the plant, as had been supposed, but the length of time the plant is exposed to light each day (the day-length or photoperiod). For example, the spinach plant, which flowers only during the long days of summer, does so because it must have lengthened periods of light to start flowering. On the other hand, zinnias, which will bloom only when exposed to shorter light periods, flower in the shortening days of fall.

The leaf plays the major role in reacting to day-length. When certain patterns of light and darkness are imposed, the leaf synthesizes a hormone which is transmitted to the bud, directing it to stop putting out leaves and begin initiating flowers.

Day-length patterns are known for many species of plants today. Caltech plant biologists have made many contributions to knowledge in this field, particularly since the climate-controlled rooms in the Earhart Laboratories became available in 1949. However, even though a tremendous amount of data has been collected on flowering, very little is known about the inheritance of the factors involved —how the information is passed from one generation to the next.

Dr. Griesel began to investigate the problems of inheritance in 1961. Using *Cestrum* (the genus which includes the familiar night-blooming jasmine, *Cestrum nocturnum*) he found that not one but a series of independent gene groups--each capable of responding to a different photoperiod—exists in a

*Pollen from one species of jasmine is carefully picked up with the tip of a fine watercolor brush to be placed on the stigma of the blossom of another species.*

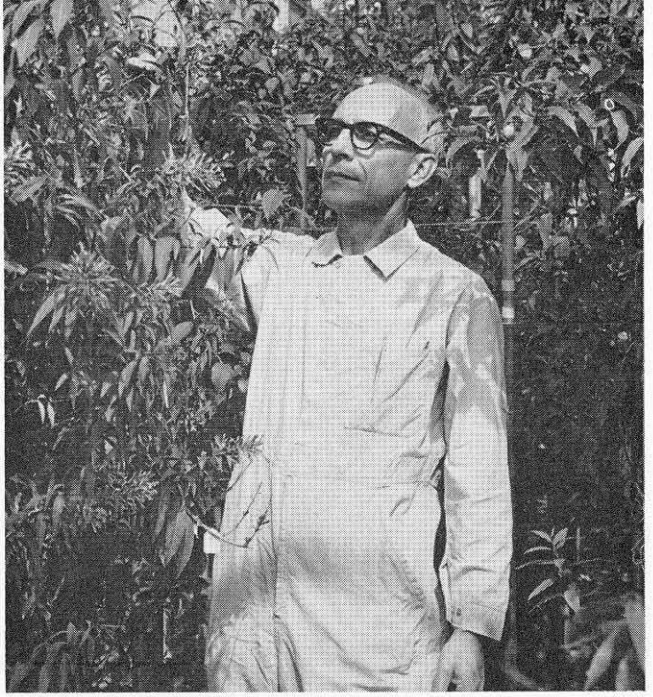
*Because of problems of incompatability between some individual plants it is often necessary to cross-pollinate as many as 100 flowers to get a single seed.*

single species. The combination of these genes, in crossbred plants, results in a blooming capability that is sensitive to different combinations of day-length.

The *Cestrum* project initially made use of two of these species. *C. nocturnum* and *C. elegans* were tested under seven basic light patterns, ranging from four hours of light to continuous light. Plants of the first and second generation and backcrosses to each parent were similarly tested. Temperatures were maintained at a constant 23° C in daylight and 19° C in darkness in all of these experiments. The conditions under which the plants began to flower were recorded. In *C. nocturnum* it was found that a single dominant gene was activated by growing the plant on 16 hours of light and then shifting it to a day of 8 hours of light (called a long-short day). A recessive gene or genes responded when it was exposed to 16 hours of light (long-day) for a long period of time. In *C. elegans* a series of independent gene groups responded to various photoperiods, the combination of which resulted in flowering on all photoperiods.

The discovery of more than one gene group capable of initiating flowers in a single plant raises several interesting questions: Is there a single hormone, or are there various hormones each capable of initiation? To what extent is the vegetative bud capable of responding to or rejecting these hormones? And, to what extent is the bud able to begin flowering independent of leaf action?

To find answers to these questions, Dr. Griesel is continuing his research, supported by a National Science Foundation grant. One aspect of his work involves a complex grafting experiment. Grafted *Cestrum* plants are placed under photoperiod and temperature conditions known to synthesize a flower-producing hormone in the leaves of one of the two grafted plants. The leaves of the receptor plant are removed. If the receptor "accepts" the hormone, it will produce blossoms.



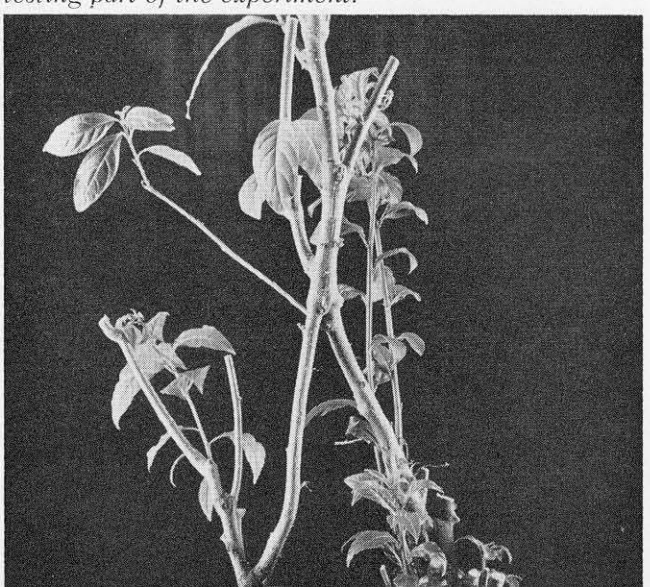
*Wesley O. Griesel, Caltech visiting associate in biology, checks each of his 2,000 plants twice weekly.*

In one experiment involving three *Cestrum* species grafted in various combinations, some puzzling results were obtained. One species received hormones through a graft union from both of the other species. However, neither of these two could induce each other to bloom. The evidence suggests that more than one hormone is present in the three species and that their buds possess the ability to accept or reject various of the substances.

If further research determines that what is true of *Cestrum* is true of other plants, agriculturalists may be able to develop food-producing plants by selective hybridization that have specific flowering patterns which will produce fruit in areas of the world where such production is not now possible because of lack of flowering.

*Research assistant Marilyn Chase prepares a Cestrum nocturnum and a Cestrum elegans for grafting by stripping a slice from each stem and binding the two wounds together with thin onionskin tape.*

*The successful result of a grafting has outgrown its binding and healed its scars; when it has sprouted four feet of growth, it will be ready for the hormone-testing part of the experiment.*



# The Month at Caltech

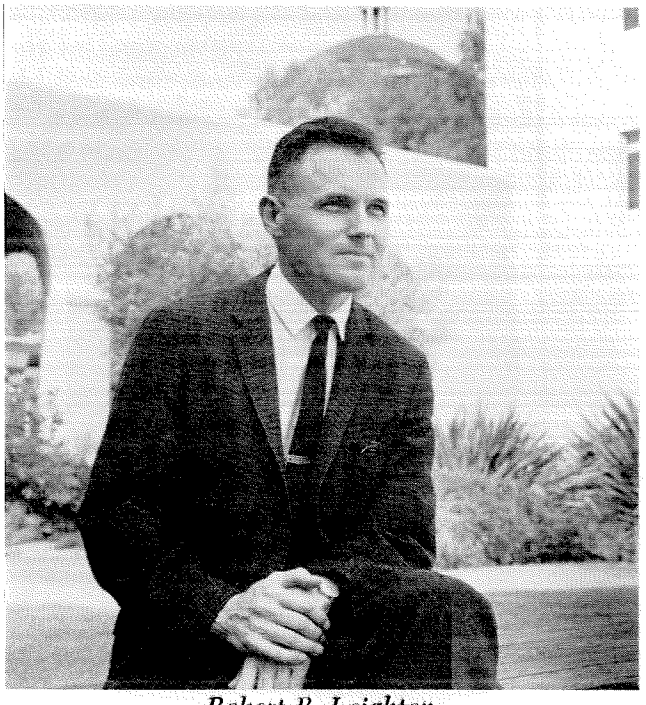
*National Academy of Sciences*

Two Caltech faculty members were elected to membership in the National Academy of Sciences at its annual meeting in Washington, D.C., last month, in recognition of their outstanding achievements in scientific research. They are Ray D. Owen, professor of biology and chairman of the division of biology, and Robert B. Leighton, professor of physics and staff member of the Mt. Wilson and Palomar Observatories. Their election brings to 30 the number of Caltech faculty now members of the Academy.

Dr. Owen, a geneticist and immunologist, has made important contributions in the fields of tissue transplantation and inherited blood groups. He came to Caltech in 1946 as a Gosney Fellow, became associate professor in 1947, full professor in 1953, and was appointed chairman of the biology division in 1961. He is also a consultant for the Oak Ridge National Laboratory in Tennessee and is a past president of the Genetics Society of America.

Dr. Owen was graduated from Carroll College in Waukesha, Wisconsin, in 1937 and received his PhD from the University of Wisconsin in 1941.

*Ray D. Owen*



*Robert B. Leighton*

Dr. Leighton has made many important contributions to the fields of physics and astronomy. He was chief investigator of the Mariner IV television experiment. He also designed, built, and put into use a 60-inch infrared telescope which is being used in a survey of the skies. Earlier he developed a camera capable of disclosing details and patterns in the sun's atmosphere.

Dr. Leighton received his BS, MS, and PhD degrees in physics from Caltech in 1941, 1944, and 1947. He joined the faculty in 1947, became assistant professor in 1949, associate professor in 1953, and professor in 1959.

*Melvin David Brockie*

Melvin Brockie, associate professor of economics, died on April 24 of a heart attack at his home in Altadena. He was 45.

Dr. Brockie came to Caltech in 1947 as an instructor in economics. In 1949 he was promoted to assistant professor and in 1953 to associate professor.

Born in Boston in 1921, Dr. Brockie received his BA, MA, and PhD degrees in economics from UCLA in 1942, 1944, and 1948, and was a member of the economics faculty there from 1943 to 1947.

He was known for his work on business cycles, investment growth, and interest theory, and was a member of the American Economic Association, a life fellow of the Royal Economic Society of England, and a member of Pi Gamma Mu and Omicron Delta Gamma honorary societies. He is survived by his wife, Jane, and three children: Pamela, Lynne, and Bruce.

### *Honors and Awards*

Don L. Anderson, associate professor of geophysics, is the fifth recipient of the James B. Macelwane Award, given by the American Geophysical Union for outstanding contributions by a young geophysicist. He is honored for his work on the structure of the earth's interior and the application of seismological knowledge to studies of the structure of the moon and planets. Frank Press, former director of the Caltech Seismological Laboratory and now chairman of the department of geology and geophysics at MIT, presented the award to Dr. Anderson in Washington, D.C., on April 20.

Jesse L. Greenstein, professor of astrophysics and staff member of the Mt. Wilson and Palomar Observatories, has been appointed by the National Aeronautics and Space Administration to a 13-man science advisory committee to help plan future space projects. The committee of distinguished astronomers, biologists, physicists, and geologists from eight universities will also advise NASA on ways for involving more scientists in space projects.

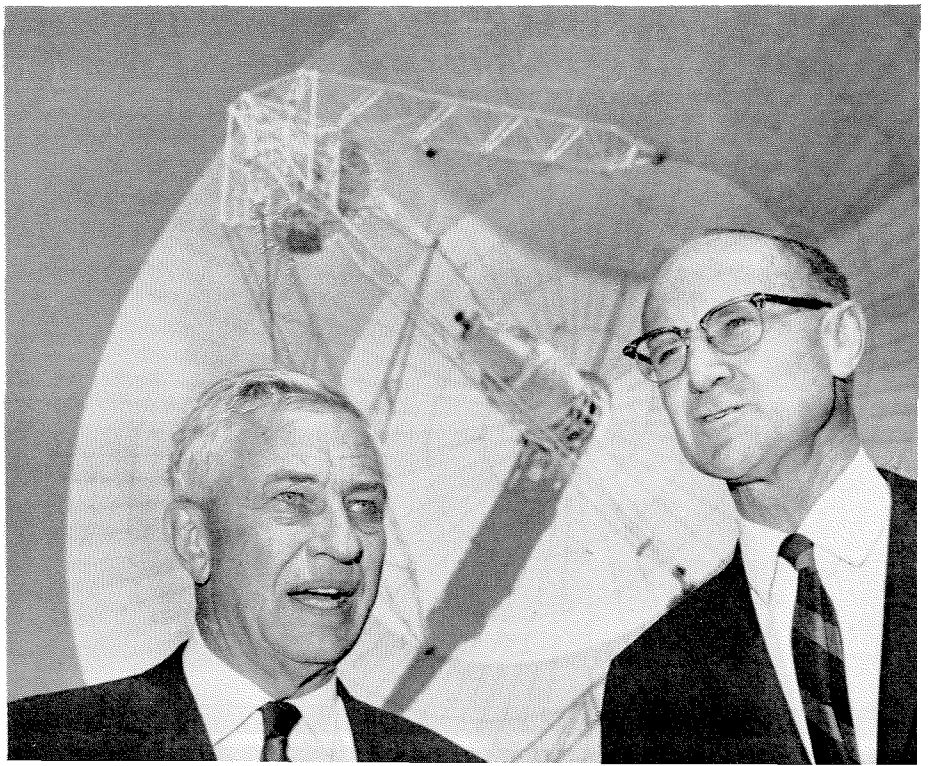
Robert A. Huttenback, associate professor of history, has been awarded a research grant by the American Council of Learned Societies and the Social Science Research Council. He will spend three months this summer in London and at Cambridge doing archival work on the history of the northern frontier of India from 1846 to 1901, with special emphasis on the development of British policy there. He is one of 23 scholars to be honored by the two organizations.

William H. Pickering, professor of electrical engineering and director of Caltech's Jet Propulsion Laboratory, received two honors last month for his contributions to space navigation—the "Commander" of the order of merit of the Italian Republic at ceremonies in Los Angeles, and the Magellanic Gold Medal of the American Philosophical Society in Philadelphia.

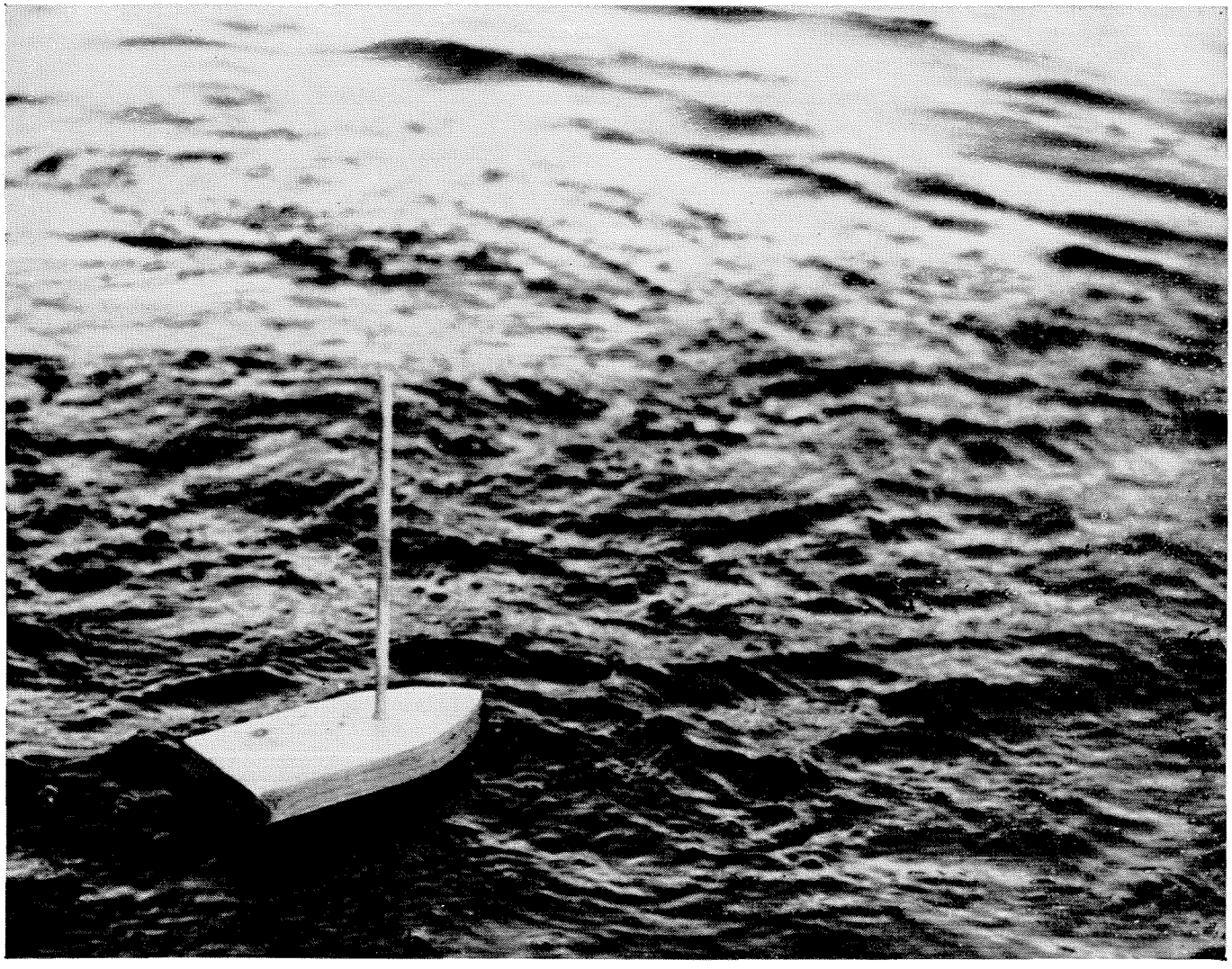
### *Goldstone Dedication*

A new tracking and communication antenna at JPL's Goldstone deep space facility was dedicated on April 29. The 210-foot diameter dish is the world's most powerful instrument for tracking spacecraft missions into deep space, with the potential to maintain contact with a spacecraft at the distance of Pluto. The antenna is now operating on a limited basis in support of spacecraft missions and other scientific experiments, and is expected to be

*continued on page 23*



*Caltech President Lee A. DuBridge and William Pickering, director of Caltech's Jet Propulsion Laboratory, at the dedication of JPL's newest and most powerful tool for its space flight programs—a 210-foot tracking and communication antenna at Goldstone in the Mojave Desert.*



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fully operational on the same basis as the other antennas in the Deep Space Network early in 1967.

*New Development*

Charles Newton, assistant to the president at Caltech, who has directed the Institute's fund-raising activities since 1948, will resign his development position on August 1 in order to resume his academic post as lecturer in English in the division of humanities and social sciences. He also will retain his assignment as assistant to Dr. DuBridge.

Succeeding Mr. Newton as head of development is H. Russell Bintzer, who comes from the Carnegie Institute of Technology in Pittsburgh, where he is vice president for development, the title he will have at Caltech.

Before joining the staff at Carnegie nine years ago Mr. Bintzer was at Washington University in St. Louis and, before that time, was coordinator and later development director at his alma mater, Drexel Institute of Technology in Philadelphia.

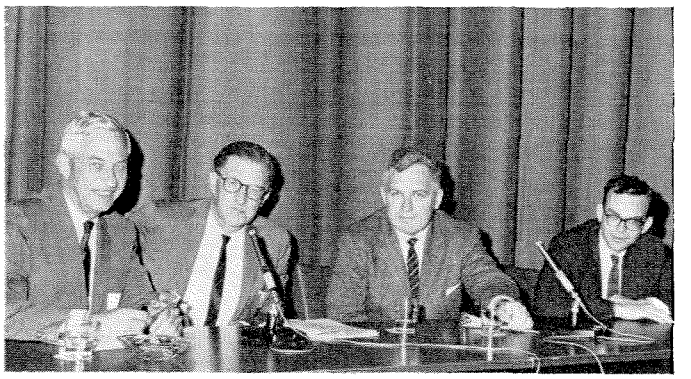
*Pass-Fail To Be Continued*

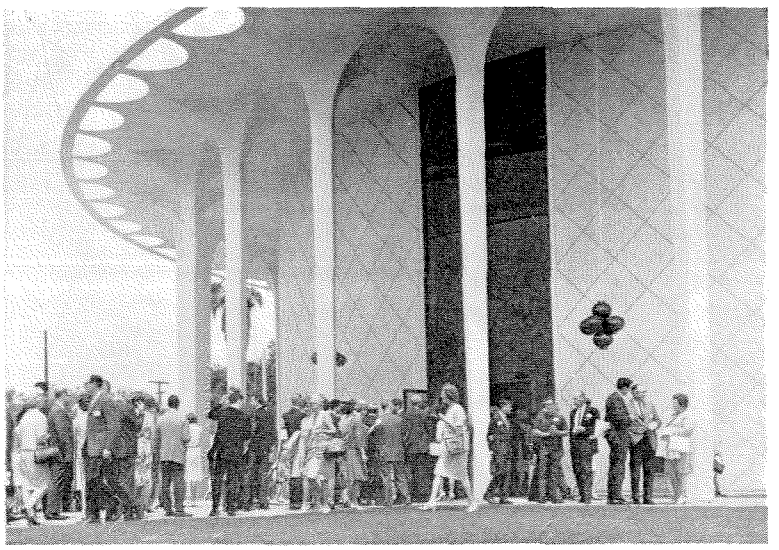
The "pass-fail" grading system for Caltech freshmen will be continued indefinitely. At the May 9 faculty meeting there was a "nearly unanimous" vote to accept the recommendation of the ad hoc committee on the freshman year—that the present system of recording pass-fail instead of letter grades become permanent policy.

The new procedure, which has been on a two-year trial basis at Caltech, has been thoroughly studied, discussed, and evaluated by faculty, students, parents, and administrators of other schools. Studies made by the ad hoc committee show that students and faculty directly involved rate the system as being partially responsible for a marked improvement in these areas: an easing of pressures in the transition from high school; an improvement in student morale; a closer association with the faculty through the new faculty advisor system; an increase in the number of freshmen engaging in honors work; and reduction of the freshman attrition rate.

## Alumni Seminar

*Nearly 1,300 alumni and guests were on campus May 7 at the 29th Annual Alumni Seminar for a day-long program of lectures and exhibits. Featured attraction was a special panel on "Air, Water, and People" with President Lee A. DuBridge; Arie J. Haagen-Smit, professor of biology; James Morgan, associate professor of environmental health engineering; and Thayer Scudder, assistant professor of anthropology. The day concluded with an evening banquet at which John A. McCone, former director of the CIA, was speaker.*





# Personals

1927

M. MAXWELL BOWER died suddenly on April 15. He was chief of the reliability and equipment engineering department of the Western Electric Company's Vandenberg Laboratory at Vandenberg AFB. He had been instrumental in the radio guidance of more than 100 space orbital vehicles from Vandenberg during the past five years. Bower joined AT&T in 1930. In 1934 he transferred to the Bell Telephone Laboratories, and for 20 years worked in engineering of carrier and coaxial transmission systems. In 1950 his work shifted to military contracts and he was involved with the Navy Project Cosmos and on the Titan I ballastic missile project. He leaves his wife, Barbara, a son, Peter, of Honolulu, and two grandchildren.

1933

JOHN S. WARFEL, who has been a vice president of Aerojet-General Corporation since 1958, has been appointed assistant plant manager-support for the firm's Von Karman Center in Azusa. Warfel, who has been with Aerojet since 1946, will continue as vice president of astrionics in addition to his new responsibilities.

JOHN R. PIERCE, MS '34, PhD '36, executive director of the research-communications sciences division of the Bell Telephone Laboratories in Murray Hill, N.J., recently made the opening address at the 1966 Convention on Aerospace and Electronic Systems in Los Angeles. Pierce joined Bell in 1936, and was appointed to his present position in 1965.

1935

CHARLES H. ELMENDORF III, MS '36, has been appointed assistant vice president in charge of engineering at the American Telephone and Telegraph Company in New York. He has most recently been director of the Merrimack Valley Laboratory and associate executive director of the transmission division of Bell Telephone Laboratories in North Andover, Mass. Elmendorf began with the Bell System in 1936.

1946

LEO W. MULLANE, MS, AE '47, has been elected chairman of the board of directors of the three-year-old Aerojet Delft Corporation of New York. He is also a group vice president of the Aerojet-General Corporation, which is one of the two owners of the new corporation.

1947

ROBERT M. ILFELD, MS, who is with the Quick Plastics Company in Jackson, Mich., has been awarded a 1966-67 Alfred P. Sloan Fellowship for a year of management education at MIT, beginning June 1. Fellowships are given annually to outstanding young business and government executives in the U.S. and abroad. Ilfeld is one of 45 recipients of the fellowships this year.

L. EDWARD KLEIN, MS, recently appointed assistant general manager of the Monsanto Company's international division in St. Louis, Mo., has been granted a leave of absence to attend a management course at Stanford University this summer. Klein, who has been with Monsanto since 1947, is one of eight company men to be chosen for their program of development of key personnel. Klein was assistant general manager of the organic chemicals division, until his new appointment, effective May 1.

1948

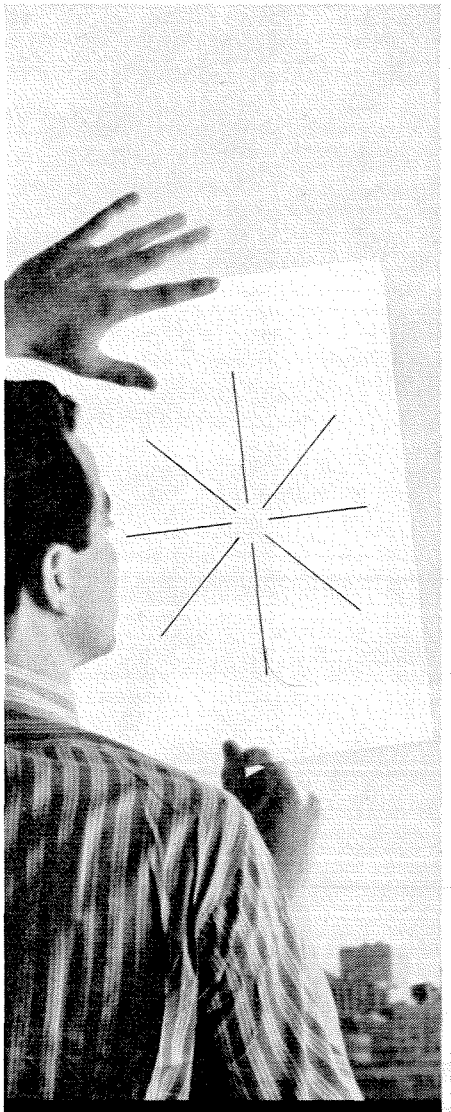
ROBERT M. PEDRAGLIA, MS '55, who is with Douglas Aircraft Company, Inc., of Santa Monica, is one of 45 recipients of an Alfred P. Sloan Fellowship for a year's study in management at MIT, leading to a master of science degree, beginning June 1. The awardees are chosen annually from among executives nominated by their organizations for the special training.

DOUGLAS C. STRAIN, president of Electro Scientific Industries, was recently appointed to the executive committee of the board of directors of the Scientific Apparatus Makers Association and was installed as chairman of the industrial instrument section of SAMA. He sends news about Electro and his family: "Several of us from Caltech formed ESI in 1953. LAWRIE ROCKWOOD '43 is executive vice president and plant manager; MERLE MORGAN, PhD '54, is our research director; and BOB PAILTHORP '59, is one of our project engineers . . . My own family numbers two boys and a girl . . . Jim is taking architecture at the University of Oregon; my daughter is an education major at Pacific University in Forest Grove; and my youngest, in high school, wants to be an archaeologist. Not an EE in the bunch."

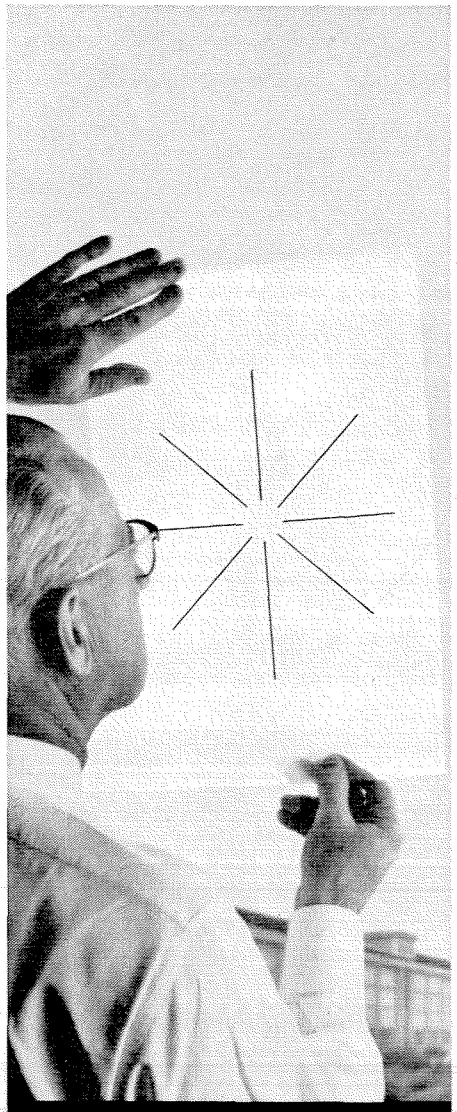
1949

WARREN P. WATERS has been appointed to the new position of manager of

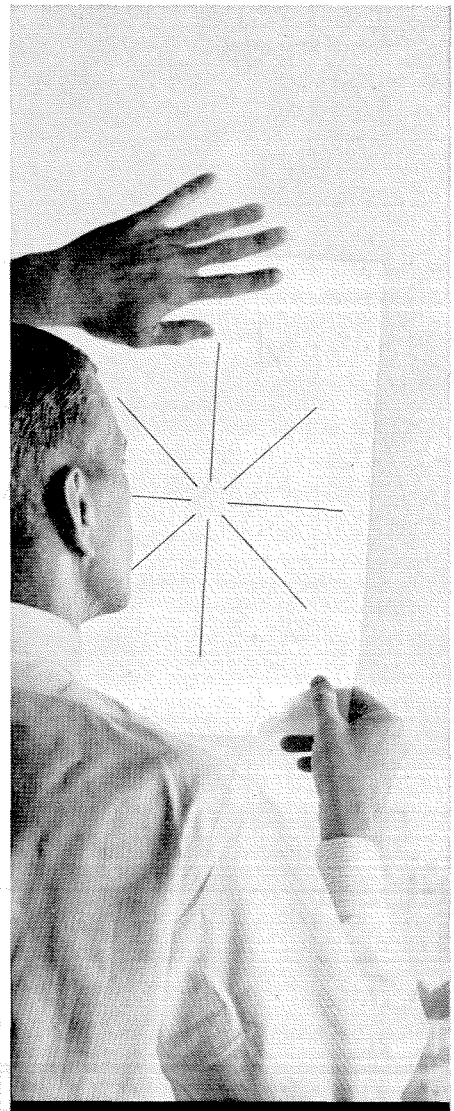
*continued on page 26*



STUDENTS...



PROFESSORS...



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# Personals . . . *continued*

the Hughes Aircraft Company's solid state research center in Newport Beach, Calif. He is returning to Hughes after four years as manager of the advanced device development branch of Texas Instruments' semiconductor research and development laboratory. Waters first joined Hughes in 1952, and was head of the advanced development department of the semiconductor division in Culver City when he left in 1962 to join TI.

GEORGE E. SOLOMON, MS, PhD '53, has recently been appointed director of a new organizational unit — systems laboratories — of TRW Systems of Redondo Beach, Calif.

RICHARD D. DeLAUER, AE, PhD '53, is the new general manager of the system engineering and integration division of TRW Systems.

### 1954

EDWARD J. GAUSS has been named to head the University of Alaska Computer Center in College, Alaska. He reports that the entire center is housed in a sealed area, with no outside walls, in order to maintain humidity control in the "incredibly" low dewpoint during Arctic winters.

### 1959

WALTER S. BAER, a physicist at the Bell Telephone Laboratories in Murray Hill, N.J., is one of 18 people chosen to be White House Fellows for 1966-67. They were selected from among 3,000 applicants nominated by their employers. Baer will be assigned for a year, beginning in September, to the office of a top government official in Washington, D.C. The White House Fellow program, initiated last year for the purpose of giving young people (between 23 and 35 years of age) a chance to test their power of leadership in positions of responsibility in government, is financed by the government and the Carnegie Corporation.

### 1961

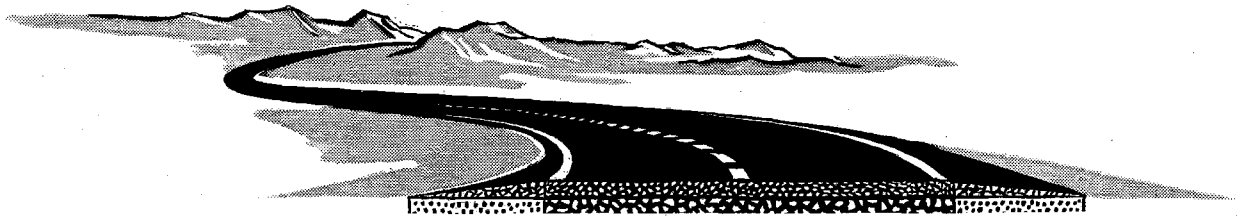
J. ERIC NORDLANDER, PhD, is an assistant professor of chemistry at Western Reserve University in Cleveland, Ohio. He writes that he was married last October to Ruth M. Hallett of Cleveland.

### 1963

NED C. WEBB, PhD, is a research chemist with the Procter and Gamble Company in Cincinnati, Ohio, and this past year taught a graduate course in structural inorganic chemistry at Xavier University there. He and his wife, Edith, have a son, Timothy, 5, and a daughter, Kalinde, 5½ months.

# RESEARCH OPPORTUNITIES IN HIGHWAY ENGINEERING

## The Asphalt Institute Suggests Projects in 5 Vital Areas



**Phenomenal advances in roadbuilding techniques during the past decade have made it clear that continued highway research is a must.**

Here are five important areas of highway design and construction that America's roadbuilders need to know more about.

If you or your department are planning research studies, you can make important contributions to highway technology through projects in one or more of these areas:

### 1 Rational Thickness Design and Materials Evaluation.

Much remains to be done in the refinement of thickness design concepts for asphalt pavement structures. Research is required in areas of asphalt rheology, behavior mechanisms of individual and combined layers of the pavement structure, stage construction and pavement strengthening by Asphalt overlays.

Traffic evaluation, essential for thickness design, requires the development of improved procedures for utilizing loadometer and other traffic data. These new procedures will more adequately permit conversion of mixed traffic loads into terms of 18,000-lb. single-axle loads as required by design guides of the American Association of State Highway Officials, The Asphalt Institute and others. Also needed are better methods for predicting future traffic volumes and characteristics.

### 2 Materials Specifications and Construction Quality-Control.

Needed are more scientific methods of writing specifications, particularly for determining rejection and acceptance criteria. Also urgently needed are speedier methods for quality control tests at construction sites, such as improved air- or water-permeability procedures for controlling pavement density.

### 3 Drainage of Pavement Structures.

Better and more positive methods are needed in this area. Suggested are experiments with two-layer systems and investigations of differing roadbed cross sections.

### 4 Compaction of Pavements, Traditional Lifts and Thicker Lifts.

Rolling procedures, compaction equipment and compaction testing-methods for traditional thin lifts of asphalt pavements need further study. The recent use of much thicker lifts in asphalt pavement construction suggests the need for new studies to develop and refine techniques of compaction to obtain the densities desired.

### 5 Conservation and Beneficiation of Aggregates.

In light of greatly increased road and street construction, in which high-grade materials are being used in abundance, the conservation of aggregates has become a pressing requirement. A study of the use of Asphalt in membrane form to envelop low-quality base courses and soils would be helpful. Other procedures utilizing Asphalt also could be studied.

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those who were educated before this new burst of knowledge reached the textbooks—"people whose study of biology culminated, ten or more years ago, with the dissection of a frog."

"If George could explain genetics in terms simple enough for Muriel to grasp, *anybody* could understand it" was the theory behind the Beadles' collaboration. However, they do not oversimplify in the sense of leaving out important parts of the over-all picture. They have written in a chatty, readable style, adding many delightful anecdotes, and avoiding scientific terminology as much as possible.

The first few chapters of the book describe nucleic acids and then present the highlights in the evolution of life: current ideas as to its origin; its evolution from simple nucleotides through genes to multicellular and higher organisms; and so down to man, where a cultural evolution becomes superimposed upon biological evolution.

As might be expected of a biochemical geneticist, much of the latter part of the book deals with DNA, RNA, the cracking of the genetic code, and how it functions. Yet there is a delightful treatment of "classical genetics" from Mendel on, full of personalities and anecdotes, which forms the basis for understanding the more recent work.

The Beadles also consider the impact of this new knowledge on modern man, and, in a chapter titled "Some Unanswered Questions," they discuss some still-mysterious aspects of biology—differentiation, the cause of cancer, the functioning of the brain—and then move on to philosophical implications of the new view of evolution and its conflict with the concept of God.

The final chapter, "A Look into the Future," considers the possibility of man directing his own evolution; the increasing load of genetic defects in the world's population; the increments added to this by manmade factors such as weapons testing and medical x-rays, and the moral questions these raise; the genetics of race; and the problem of differentially expanding population.

These clearly raised questions and the range of possible answers discussed make clear how important it is that the layman understand genetics, and extend the scope of an already interesting book.



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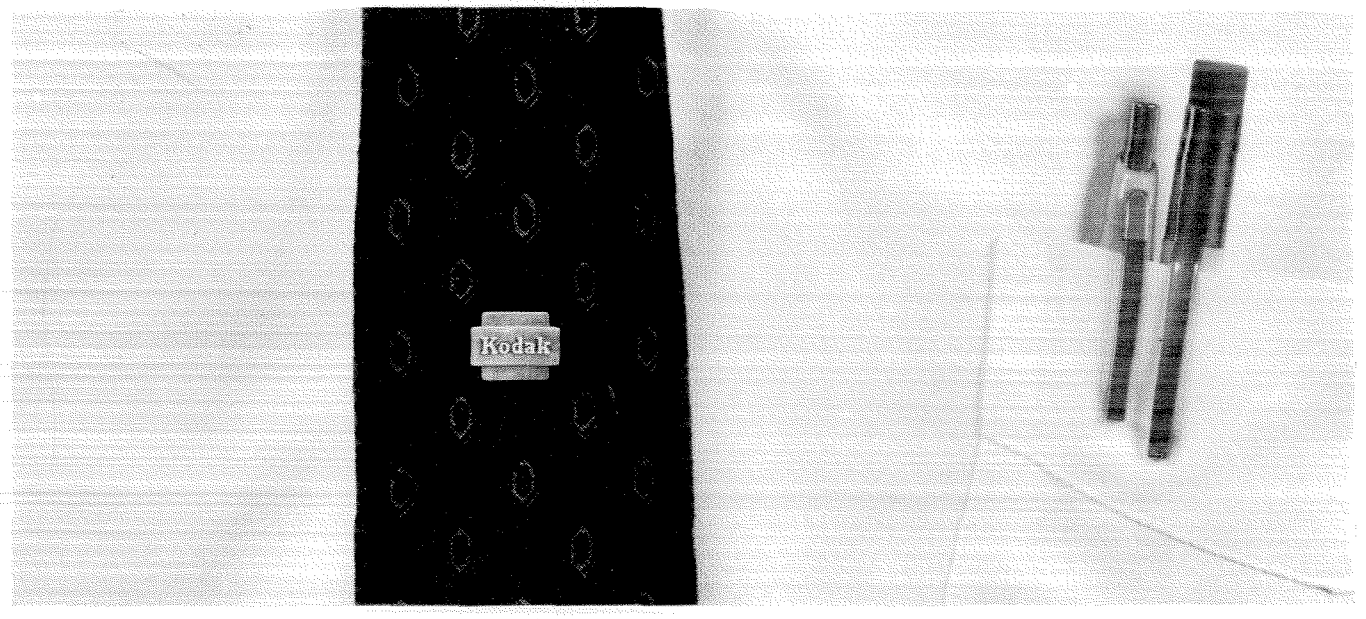


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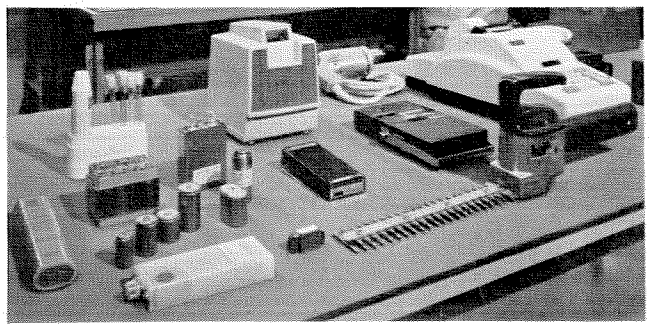

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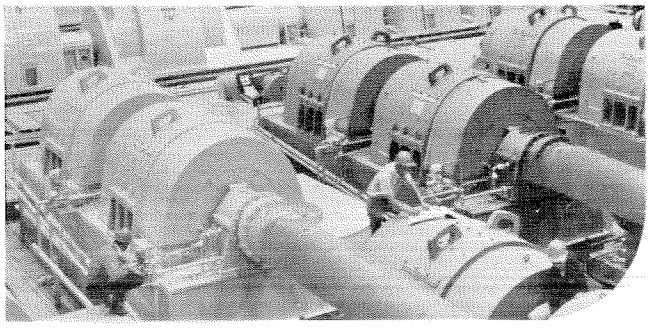

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