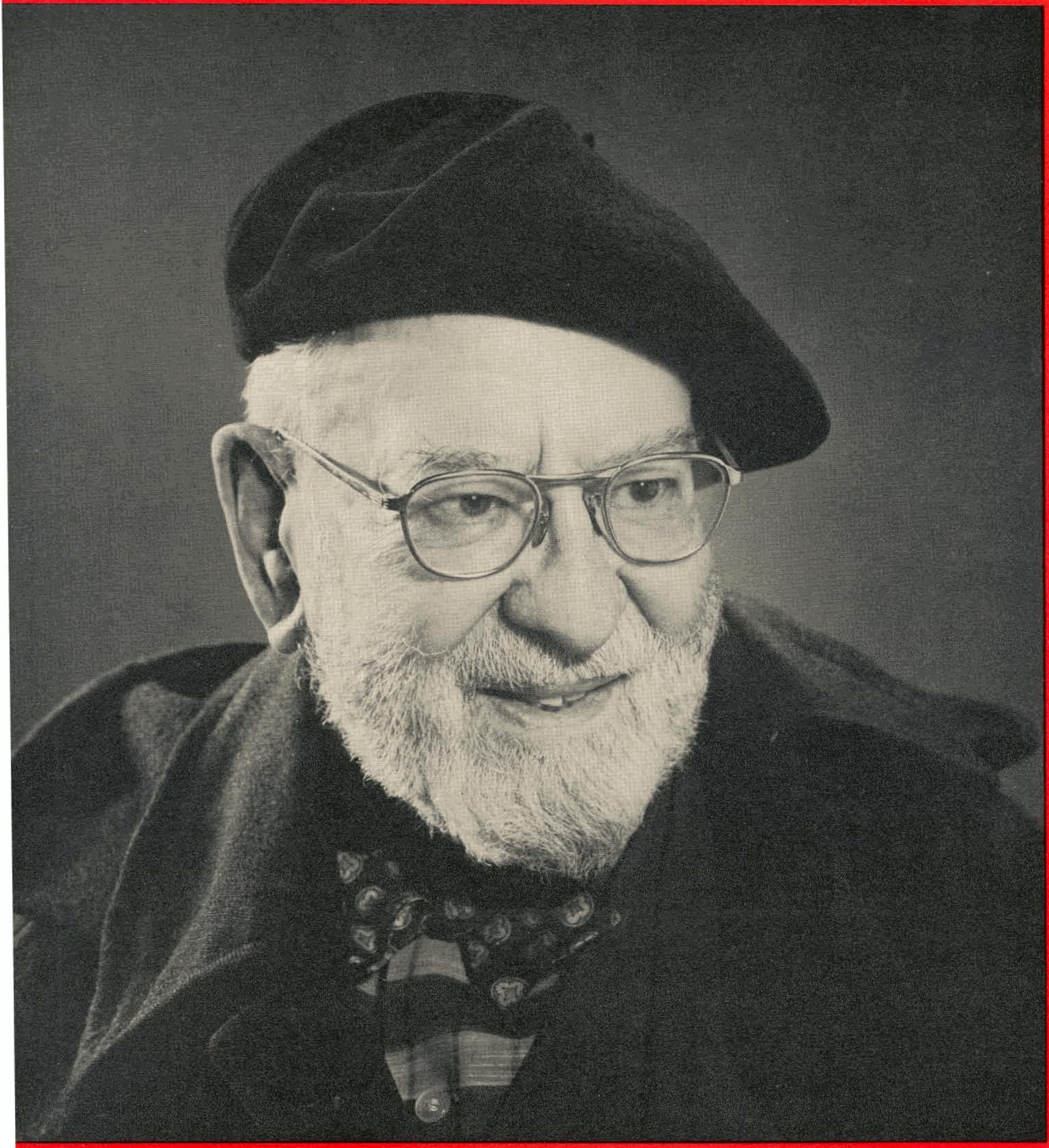
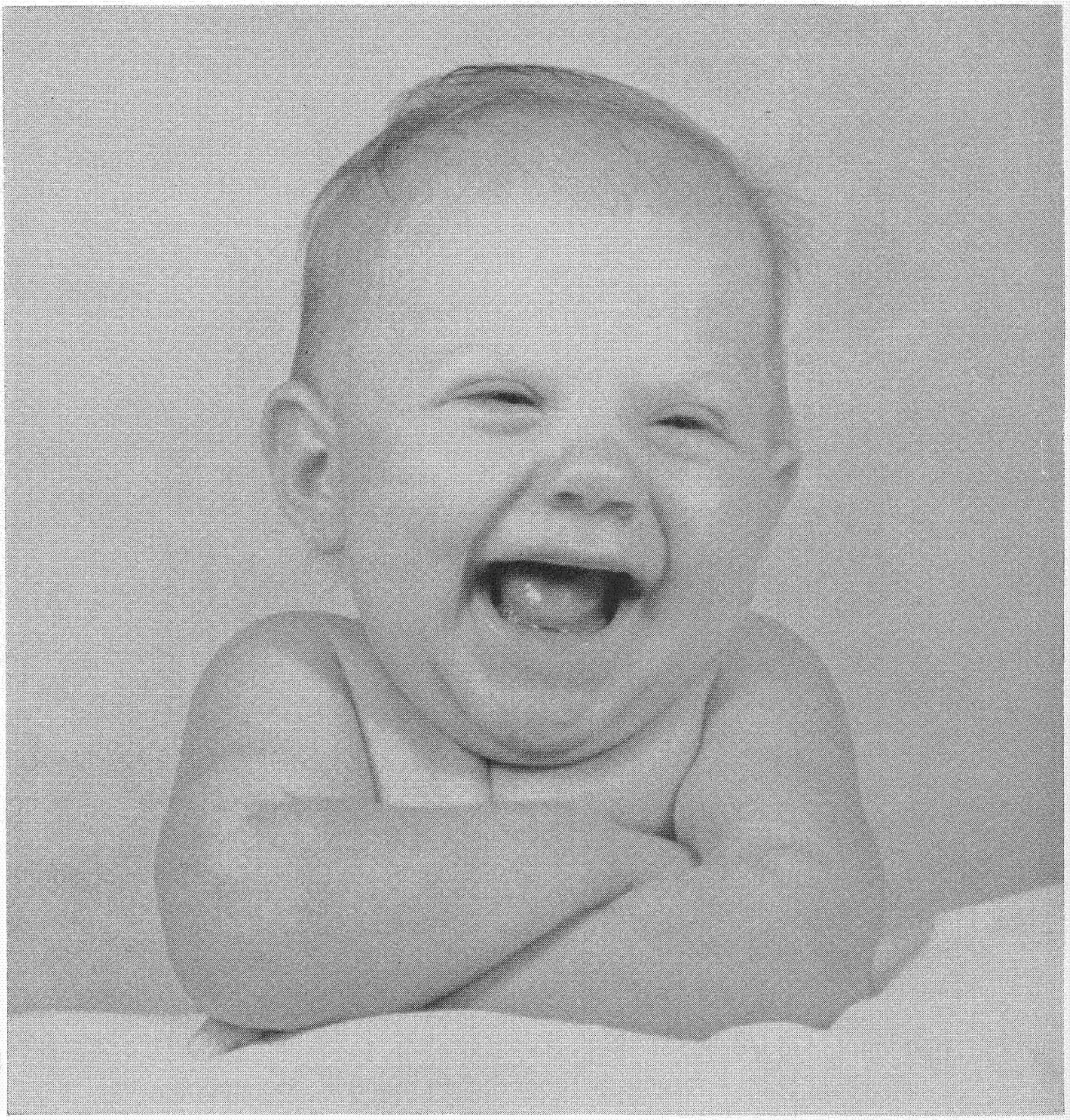
ENGINEERING | AND | SCIENCE

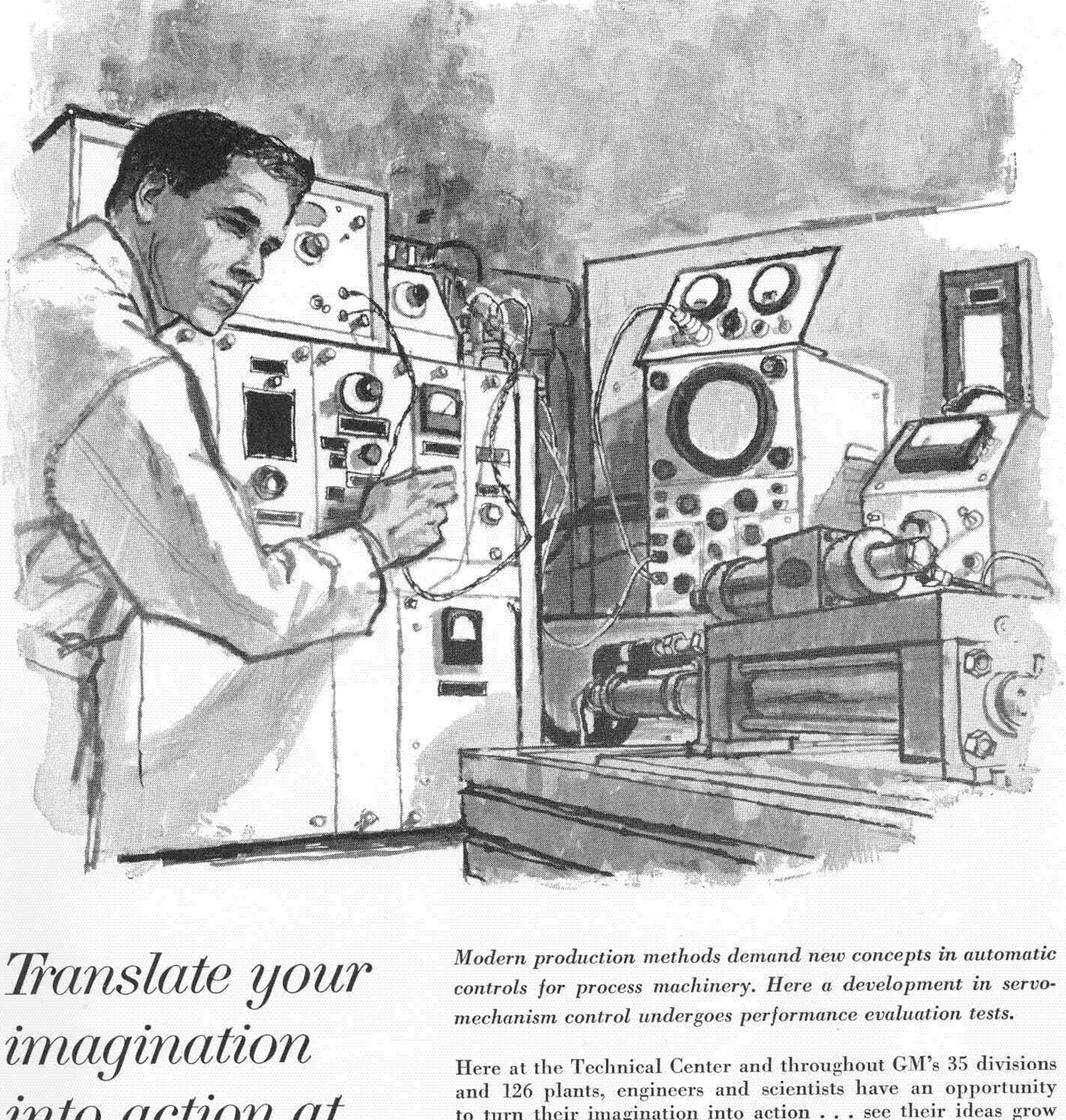
May 1959



Faculty Portraits . . . page 14

Published at the California Institute of Technology





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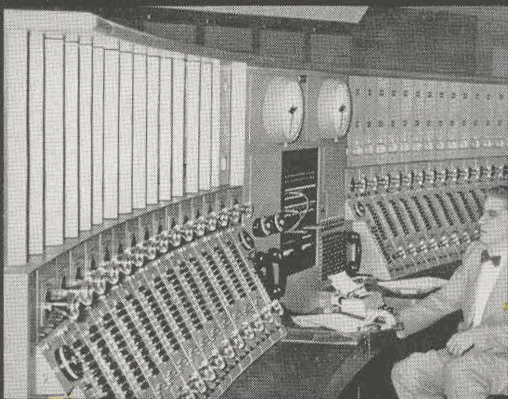

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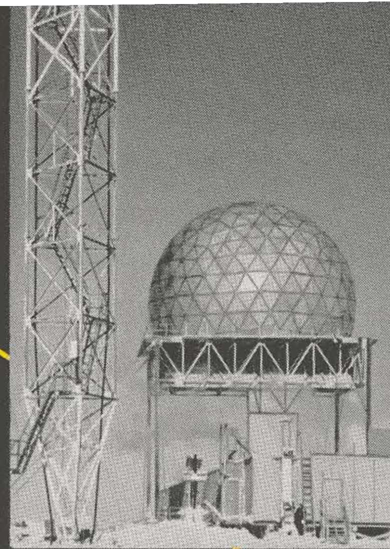

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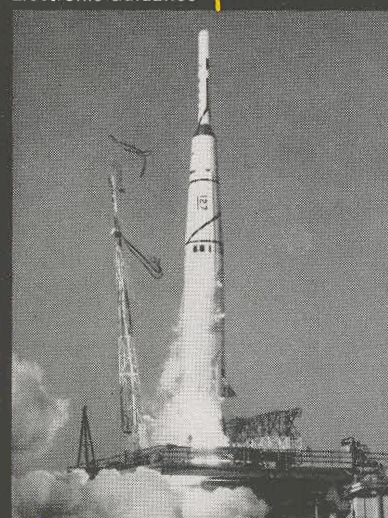

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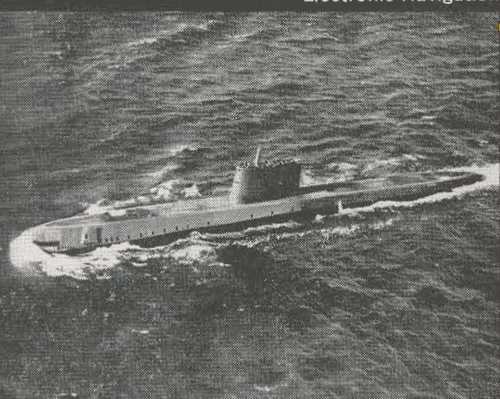

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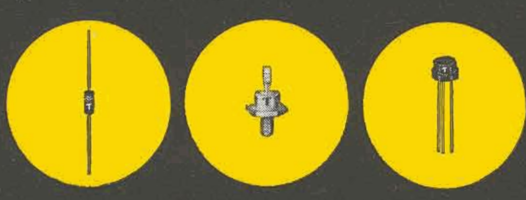

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ENGINEERING AND SCIENCE

On Our Cover

is a portrait of Paul S. Epstein, professor emeritus of theoretical physics at Caltech. For 38 years he has been a colorful figure on campus, and his cover portrait serves to introduce the sixth in a series of faculty portraits by Tom and Muriel Harvey on page 14.

Ronald Scott,

who wrote "Building from the Ground Down" on page 20, is assistant professor of civil engineering at Caltech. A native of Perth, Scotland, he is a graduate of Glasgow University. He received his MS in 1953 and his PhD in 1955 from the Massachusetts Institute of Technology. A recent addition to the Caltech faculty, he is currently teaching and doing research in soil mechanics.

James A. Lockhart,

a biologist, brings a fresh approach to the problems of space exploration. In "The Care and Feeding of Spacemen" on page 11, he tackles the subject of how man in space would feed himself. His article stems from a popular talk he gave at the 1959 Alumni Seminar on April 12. Since then, Dr. Lockhart's interest in space research has reached the point where he has constructed a working model of a space ship complete with algae farm. It's shown — and described — in his article on page 11.

Picture Credits:

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12 — Graphic Arts
14-19 — Harvey
26-28 — Graphic Arts

MAY 1959 VOLUME XXII NUMBER 8

STAFF

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Editor and Business Manager........Edward Hutchings, Jr.
Editorial Assistant........Gerda Chambers
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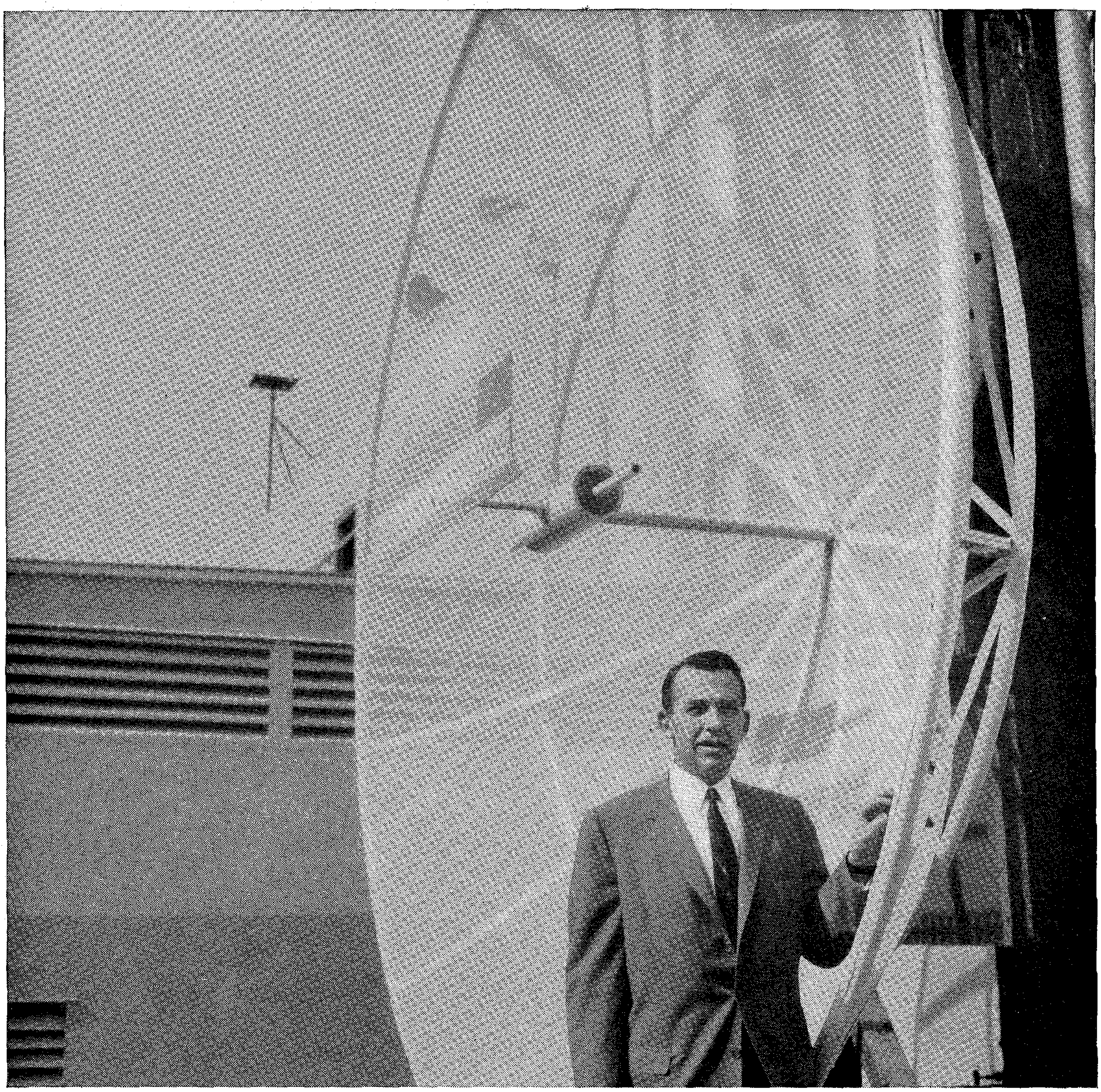
Published monthly, October through June, at the California Institute of Technology, 1201 East California St., Pasadena, Calif., for the undergraduates, graduate students and alumni of the Institute. Annual subscription $4.50 domestic, $5.50 foreign, single copies 50 cents. Entered as second class matter at the Post Office at Pasadena, California, on September 6, 1939, under act of March 3, 1879. Manuscripts and all other editorial correspondence should be addressed to: The Editor, *Engineering and Science,* California Institute of Technology,



Books

Principles of Modern Physics

by Robert B. Leighton
McGraw-Hill Book Company . . $12.50

Reviewed by Vincent Z. Peterson
Assistant professor of physics

Many texts on atomic and nuclear physics have been written since World War II, each attempting to include the latest significant developments along with the "classical" topics of atomic physics such as natural radioactivity, x-rays, and atomic spectroscopy. The spectacular nature of the early experimental discoveries made by Becquerel, Roentgen, J. J. Thomson, and Rutherford, and the revolutionary ideas of Einstein, Bohr, Planck, and Schroedinger make very interesting reading, as do the more recent discoveries in artificial transmutation of elements, elementary particle physics, cosmic rays, and stellar reactions. But too many books have been written as mere compendiums of assorted facts or historical accounts of celebrated experiments, without clearly stressing the interaction and significance of the discoveries. Even the better texts were destined to have a rather short "half-life," as new discoveries outmoded tables of elementary particles before they were printed, long cherished "laws" were found to have exceptions, and involved explanations of seemingly complex phenomena suddenly became clear in the light of a new theory.

The most successful textbooks covering "modern physics" on an undergraduate level have developed the important ideas through discussion of experiments, usually following the historical pattern. The experimental evidence is arrayed before the theoretical interpretation is developed. An outstanding text using this approach is the *Introduction to Modern Physics* by Richtmyer, Kennard and T. Lauritsen (Caltech professor of physics), last revised in 1955 (fifth edition).

The present text by Robert B. Leighton, associate professor of physics at Caltech, adopts a new approach —"expository and analytical, rather than historical and discursive." This is to say that the exposition of principles is at the forefront, and the chronology of events and detailed description of experiments are compressed to yield only the essential conclusions. (For example, the photoelectric effect, which receives a full chapter of experimental discussion in the usual "historical" approach, is compactly discussed in two pages of the chapter on quantum mechanics.) This approach permits a logical order of presentation of the principles, and allows sufficient space to treat some problems which are considerably more advanced than normally encountered in undergraduate texts.

The mathematical sophistication in this text is on a rather high level, particularly in subjects where significant advantages accrue to a more compact notation. One example is the use of 4-vector notation in the opening chapter on relativity. The treatment is rigorous, and the numerous problems are carefully designed to develop an intimate knowledge of the quantitative theory and to provide experience with the numerical magnitudes of atomic and nuclear quantities.

These two features — an analytical approach, and full utilization of a Caltech physics major's mathematical background — may make the book rough going for a student without some prior exposure to a more elementary course in atomic and nuclear physics. For those who already have a qualitative feeling for these phenomena, however, Leighton's approach is a significant transition to a deeper understanding of the fundamental theories of atomic and subatomic phenomena. The excellent figures, many of them original, help visualize difficult results of the theory.

The chapters on "Particles," and "Modern Physics in Nature" reflect Leighton's interests in elementary particles and cosmic rays, and are remarkably up-to-date. Mesons, hyperons and the "strangeness" theory of Gell-Mann are included; even the non-conservation of parity managed to beat the publisher's deadline!

It seems clear that the "analytical and expository approach," in the hands of a versatile experimental physicist has been successfully employed in *Principles of Modern Physics*.

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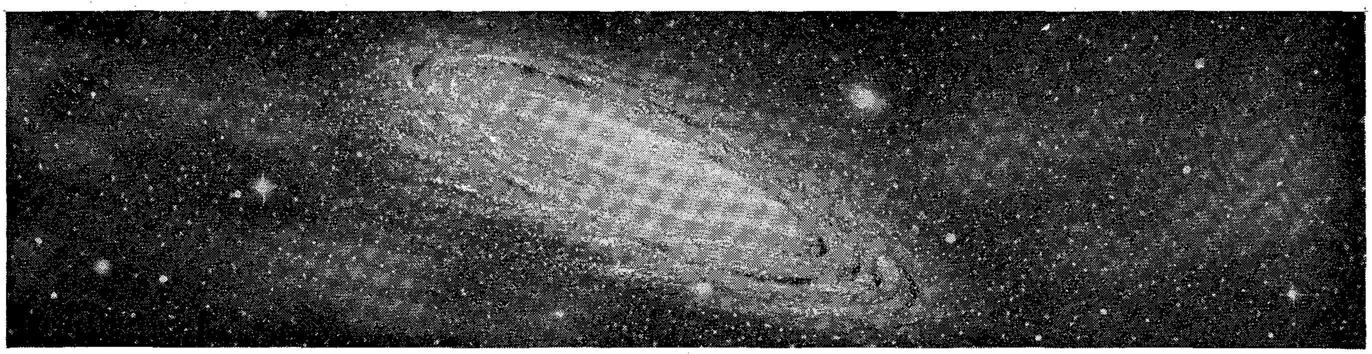

FROM SPACE EXPLORATION TO ANTISUBMARINE WARFARE ... THEY OFFER BROAD OPPORTUNITIES TO COLLEGE GRADUATES

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In this area, breakthroughs already have been scored in antenna design, in structural design for re-entry heat, and in controls and hydraulics.

CHANCE VOUGHT AIRCRAFT
DALLAS, TEXAS

The Care and Feeding of Spacemen

by James A. Lockhart
Research fellow in biology

Travel in the vast distances of outer space will require journeys lasting for many years. Even exploration of our distant planets will probably involve a matter of years (reminiscent of the early explorations of our globe). A low-energy, long-burning ion propulsion system may be one of the most efficient and effective for space travel, at least in certain cases. Such a system might take perhaps 90 days to acquire sufficient momentum to escape from the earth's gravitational field after being placed in orbit by conventional propulsion. Certainly, long travel times will require providing food and oxygen in prodigious quantities. Manned satellite platforms and manned stations on the moon and nearby planets also will require large amounts of food and oxygen.

For flights of short duration it will be most economical, of course, to carry along prepared food, but when it is necessary to remain out of contact with the earth for long periods of time it will undoubtedly be essential to grow it on the vehicle.

On a space vehicle or on a lunar or planetary station we must be prepared to establish what amounts to a balanced terrarium. This consists of a system (shown at the right) in which no matter is gained or lost. Only energy, in the form of radiant (light) energy from the sun, is added, and only heat is given off. The animal portion of the system will, of course, consist of man. The plant, or synthetic, portion of the system would appear to be best satisfied by the use of algae.

The principle thing an adult must get from his diet is energy. The energy is gained through the oxidation of carbohydrates in food with molecular oxygen from the air, yielding carbon dioxide which is then expelled back into the atmosphere. The protein intake is balanced by the output of degraded nitrogen products and this is true of the various other dietary requirements, including vitamins and minerals as well.

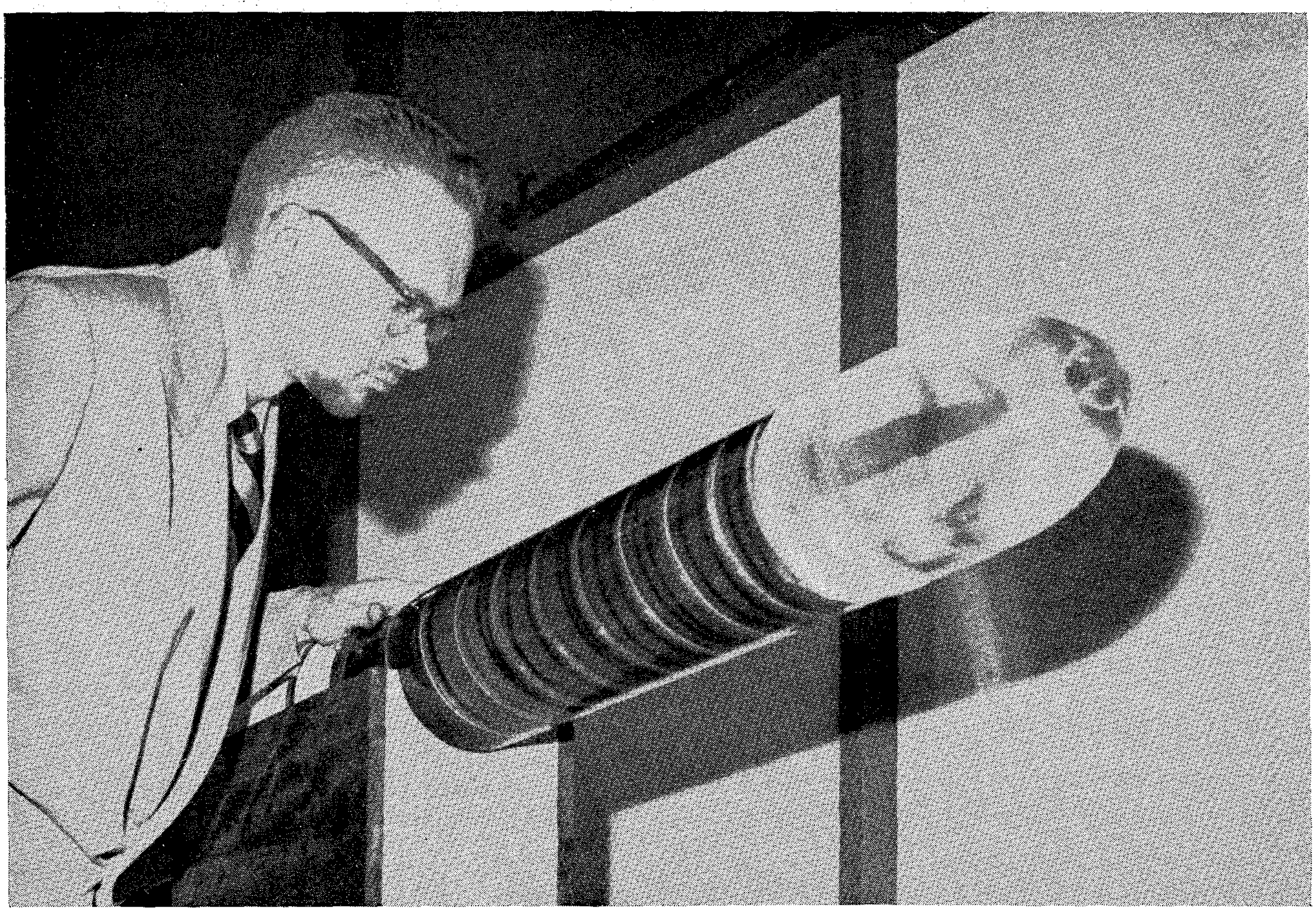
Plants, in turn, patiently utilize solar radiant energy to again reduce the carbon dioxide produced by man. In addition to carbon dioxide, the plants require only a cozy, comfortable place to work and an occasional boost by mineral nutrients.

There appears to be little doubt that the plant chosen will be one or more species of unicellular algae. While algae are not, by their nature, any more efficient than land plants, they do possess properties which make them readily adaptable to uses such as this. The algae grow in a liquid system where automatic fertilization and harvesting would be easy. They consume a minimum of space and may be readily handled even in a zero gravity field.

This balanced system would consist of a series of clear plastic greenhouses surrounding the vehicle, through which the algae are pumped while carrying on their photosynthesis. Inside the greenhouse cham-

A BALANCED BIOLOGICAL SYSTEM

Man:	Carbohydrate + oxygen	Carbon dioxide + metabolic energy
Plants:	Carbon dioxide + radiant energy	Carbohydrate + oxygen
Net Balanced System	Radiant energy	metabolic energy



James A. Lockhart, research fellow in biology, and a model of his space ship for gracious living. The dark bands which surround the vehicle are plastic greenhouses where algae are grown to provide food and oxygen.

bers will be small tubes, permeable to oxygen and carbon dioxide (but impermeable to water) to provide a supply of raw materials to the algae in the form of carbon dioxide and to draw off the waste gas (oxygen). Monitors would periodically test the cultures for an adequate supply of the essential nutrients and inject any found lacking. When an algae culture approaches an optimum concentration it would be pumped to a continuous-flow centrifuge where it would be collected and processed to an edible form.

Algae have an additional advantage. They can be made to produce a preponderance of carbohydrates, protein, or fats, depending on the cultural conditions. The nutritional components, then, may be modified at will to satisfy the requirements and desires of the crew. Furthermore, the whole plant is edible. It would be unnecessary to discard large amounts of inedible roots and stems as we do with most higher plants.

The critical question then becomes how much surface area would be required per person in such a steady-state system. The necessary information is already available to calculate the approximate area required. About 3,000 calories are required for an average man per day, including a necessity for at least 2 ounces of protein. Just 2.2 pounds of algae contain the equivalent of this daily requirement, with a large excess of protein.

We can, at present, grow algae on a small scale with a productivity of about 3 ounces per square yard per day and it is quite reasonable to assume that such yields will be possible on the scale needed for space vehicles. At a rate of 3 ounces per square yard per day, it would require 12 square yards of illuminated surface per person. It is also quite possible that the productivity of the algae may be increased by about a factor of two or even more in the future. This would be very important since radiant energy decreases markedly (as the square of the distance) as we move farther from the sun. The ratio of greenhouses to men will define how much farther from the sun we can venture with any given photosynthetic efficiency.

It will probably be necessary to design different types of vehicles to explore and travel in different regions of the planetary system. For travel to Mars and other planets nearer the sun a relatively smaller area of greenhouses will be required, while the problems of radiation and over-heating will be severe. When traveling further away from the sun the greenhouses will have to be large, perhaps unfolding after they escape from the earth's atmosphere to intercept more of the relatively low-intensity radiation. Greater provision will presumably have to be made for heating and less for cooling the vehicle. The techniques of agriculture will also have to be modified, to make maximum use of all the radiation which can be intercepted. If highly efficient energy-generating systems (nuclear-powered) are available it might be feasible to provide artificial illumination for photosynthesis instead of relying on the sun, and thus extend the potential range of the vehicles indefinitely into space, beyond our solar system.

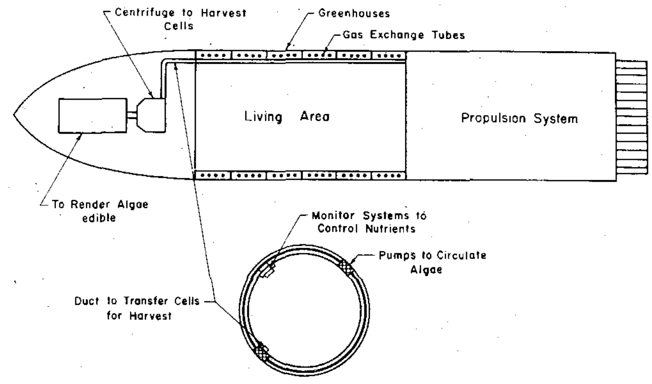
Vehicles may be designed specifically for "colonization" of the moon or one of the planets. Again, a greenhouse shell would probably surround the vehicle. In this case it would be designed so that it could be unwrapped after landing, and laid out in a sunny spot for operation. The living-quarters section could be equipped with crawler tracks for surface movement, and would return periodically to the greenhouse for food and oxygen. Whether individuals would be able to leave the pressurized cabin would depend upon the pressure equipment available. In any case, the people would be almost completely dependent on the greenhouse installation.

Algae absorb much more energy than they can utilize for photosynthesis. The rest of the energy is converted into heat, which must be dissipated to maintain a desirable temperature. The only way to get rid of this heat is to reradiate it in the form of infrared waves, just as the sun does.

Since the earth is successful in maintaining a temperature optimum for living creatures by reradiation, our vehicle should have little trouble at about this same distance from the sun. However, it must be recalled that the atmosphere of the earth prevents much of the sun's energy from reaching the surface, especially the ultraviolet and infrared. It may be expected that a desirable temperature equilibrium would be achieved somewhat further from the sun than is the earth.

For the "greenhouse," it will be necessary to use some material that is transparent to visible radiation but which absorbs or reflects almost all of the ultraviolet. Ultraviolet radiation markedly inhibits the growth and metabolism of plants. The infrared radiation, on the other hand, might be useful. It might be possible to incorporate into our system some mechanism which could control the amount of infrared penetrating the greenhouse. This would make it possible to help control the temperature without the expenditure of significant energy.

On a vehicle, the only method for dissipation of heat would be to pump some of the heat to one part of the vehicle where it would be released into space. On the surface of a planetary or lunar body the heat might be useful at "night," when the temperatures may be expected to fall drastically. Any extra heat here could probably be dissipated underground or by radiation from the dark side of the planet or moon.



How an algae farm would operate on a space ship. Such a farm could supply all of the passengers' food requirements, and also replenish vital oxygen to the air in the ship.

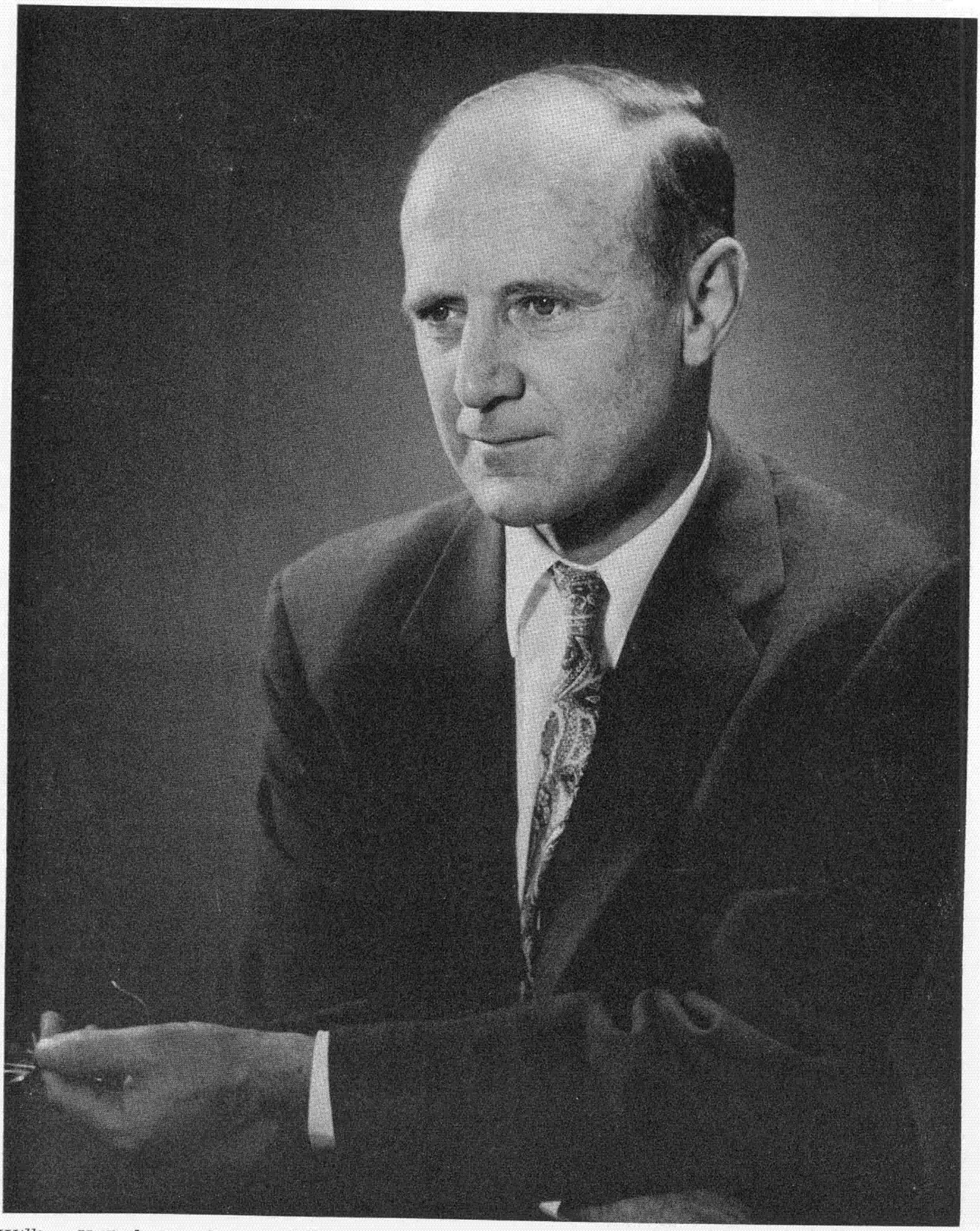
Algae, like other plants, have a very narrow temperature range within which they photosynthesize at a maximum rate (about 10-20°F.). We can breed varieties which have different optimum temperatures but the range generally remains narrow. Similarly, the extreme temperatures within which these plants can even remain alive is relatively narrow, although broader than the photosynthetic optimum) from about 32 to 120°F.). Our temperature control problems, then, are rather critical. The temperature controls themselves must, of course, be left in the hands of appropriate engineers. However, as a biologist, there may be some contribution which I can make even here. This is in terms of the protection of the plants from temperature stresses.

It has only recently become known that we can, in certain cases, make plants more resistant to temperature stresses simply by an appropriate chemical treatment. The common flowering plant, Cosmos, will grow at nearly maximum rate at very low temperatures if it is treated with vitamin B_1. Similarly, the wild flower, Arabidopsis, will be protected from high temperatures by treatment with the chemical called choline. Peas may be partially protected from high temperatures by treatment with the hormone gibberellic acid. This suggests that these plants are injured by chemical stresses principally through some effect of temperature on a single biochemical process. So, by learning and providing the appropriate chemical treatments, we can make our plants less demanding of critical temperature controls than they would otherwise be. Work on this problem is now being carried out here at Caltech.

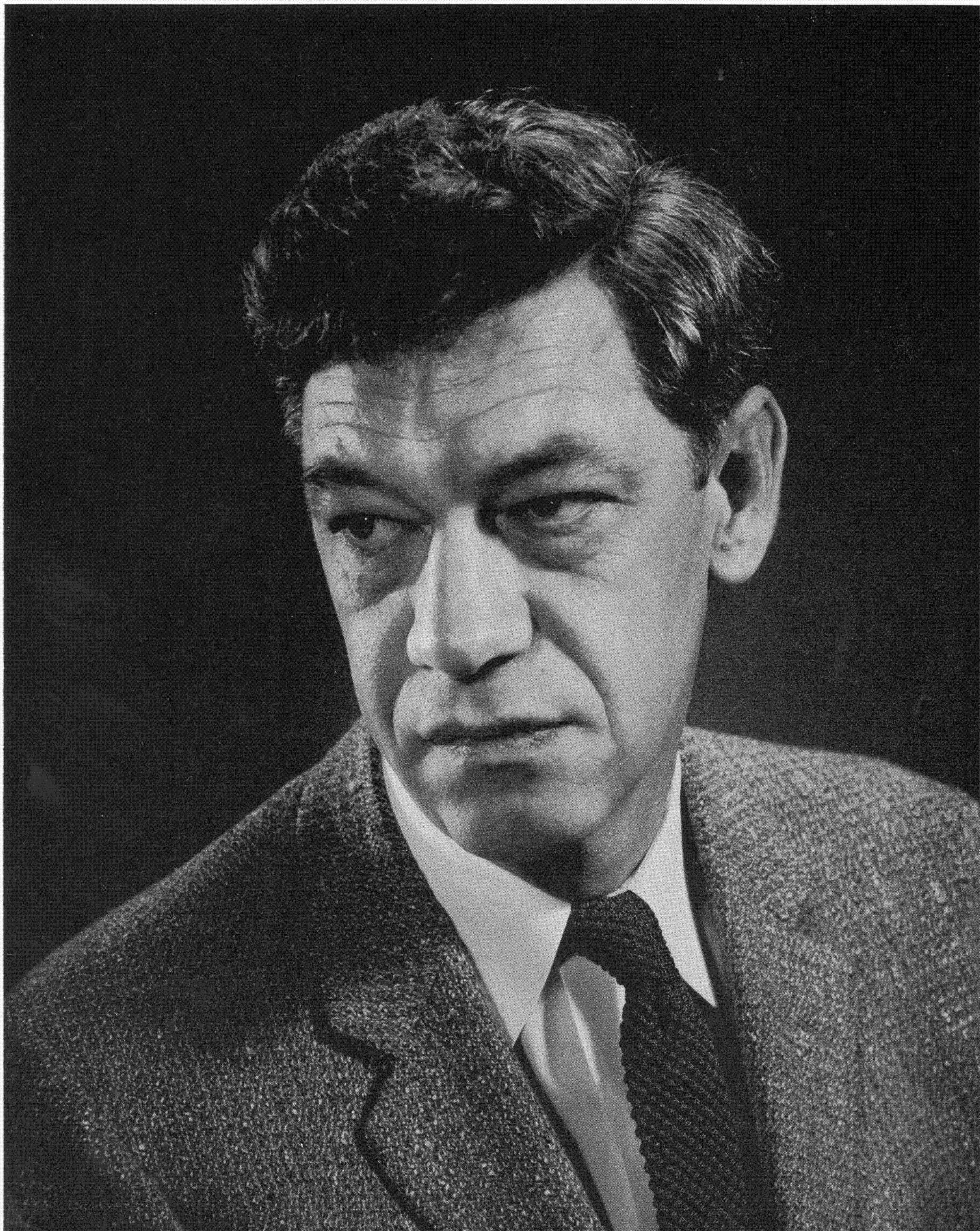
When extended, manned space flights are contemplated it will be necessary for the planners and designers to take into consideration the requirements of the algae who will almost certainly be among the important passengers. And we can now be assured that the algae will be ready whenever they are called upon to promote the exploration of our corner of the universe.

VI. A Portfolio of Faculty Portraits

by Harvey



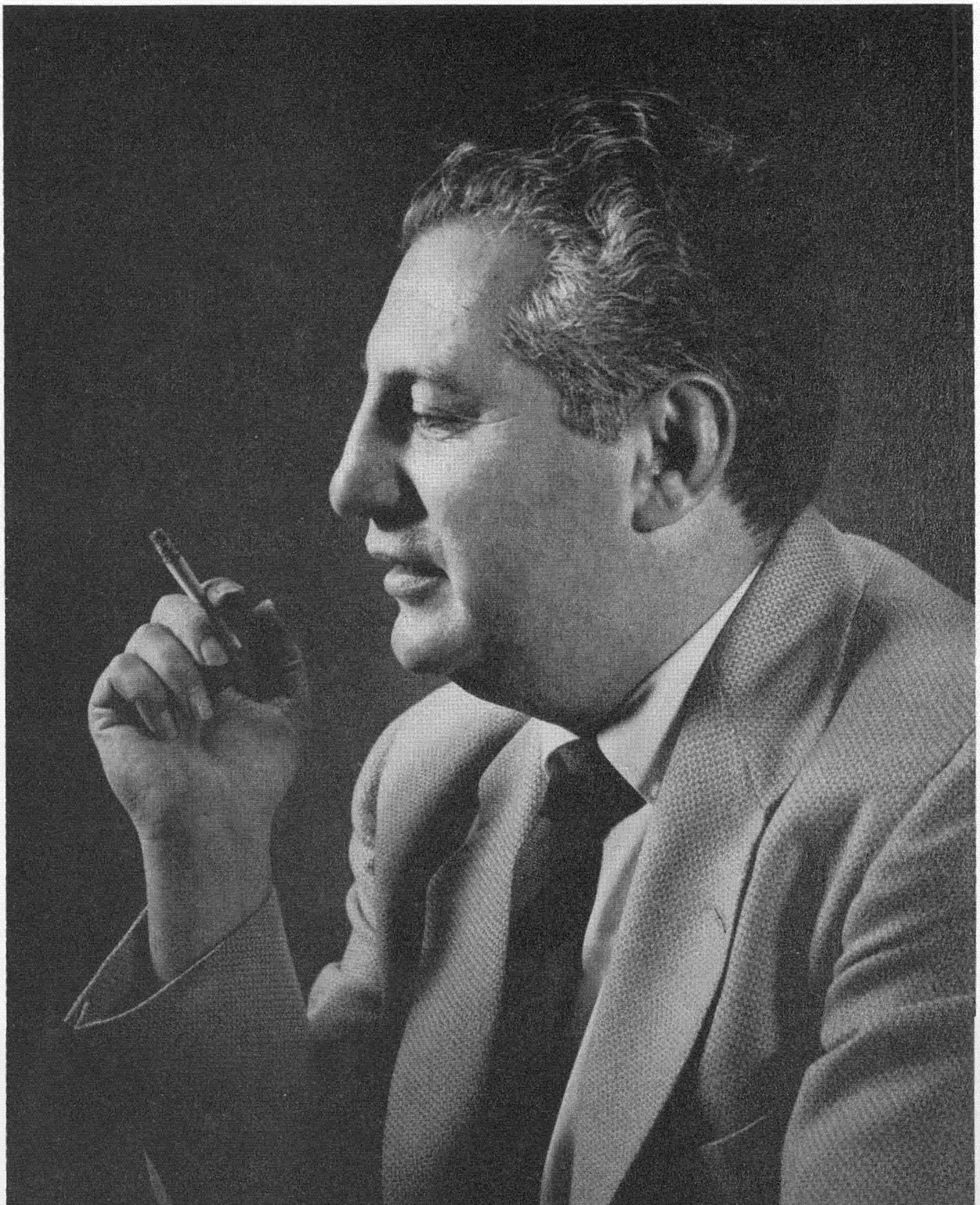
William H. Pickering, director of the Jet Propulsion Laboratory



W. Duncan Rannie, Robert H. Goddard Professor of Jet Propulsion

Thomas Lauritsen, professor of physics

Henry Borsook, professor of biochemistry



Charles R. de Prima, professor of applied mechanics

Richard M. Badger, professor of chemistry

Building from the Ground Down

Thanks to the science of soil mechanics, what happens from the ground down is no longer a complete mystery

by Ronald Scott

The field of civil engineering is split up into three branches: structural engineering, dealing with the study of materials, forces, and stresses involved in the construction of buildings, dams, and bridges – in short, of those generally massive works of man which appear above the ground's surface; hydraulics, in which the flow of water in pipes, canals, rivers, estuaries, and harbors is studied; and foundation engineering or soil mechanics, whose studies concern themselves with the invisible aspect of structures – the part from the ground down.

All building rests ultimately on the ground, which thus becomes the foundation engineer's working material. Dust, earth, loam, peat, clay, sand, gravel – all are soil; a layered, stratified, inhomogeneous, variegated, and problematic material. It is hard to investigate, hard in many places to build things on, and hard to modify in useful quantities. Our field of study is all the earth's sediments in their numberless forms – not as chemical materials (although sometimes we have to force ourselves to look at such properties), and not as agricultural stuff (although agricultural terms and classifications have been used and adopted), but as a structural substance, a material whose deformational behavior in large masses we must learn to understand and to predict.

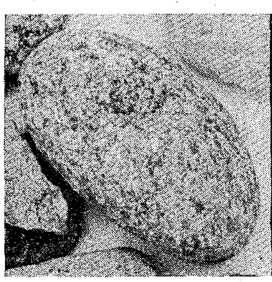
The pictures below show some soil stuff. The first is a piece of rock, familiar to everyone. Rock may occur in massive blocks or it may be jointed and fissured. We tunnel through it and build footings and foundations on it wherever possible. Usually it offers few problems.

Rock is broken up by rain, heat, cold, freezing and thawing, and gravity, into fragments with a wide range of sizes. When the size is fairly large – an inch or two in diameter – we call the soil gravel. Some gravels are angular, indicating that they have only recently been formed from the parent rock. Others are rounded when a river or sea has extensively worked on them.

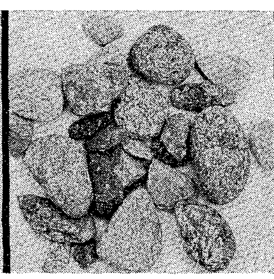
Progressive mechanical erosion results in smaller particles than gravel; these are sands. A sand is generally formed of a range of particle sizes, shapes, and colors. The different colors indicate derivation from different minerals in the parent rock, but the minerals do not greatly affect the mechanical properties of the soil in which we are interested. The size, range, and shape of the grains do influence the soil's strength, however, through different interlocking effects. We call sands those soils whose particle range extends down to the size at which our eyes can just distinguish individual particles.

Still more grinding, reworking, and rubbing – all mechanical processes – result in finer materials called silts. Below this size, however, the soils formed are generally the result of chemical reactions. The last picture shows some lumps of clay.

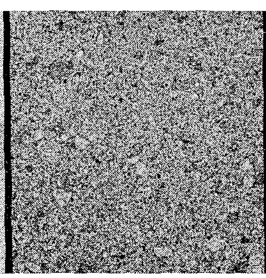
Between sands and clays there is a very obvious



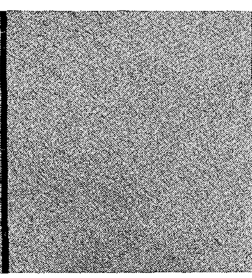
Rock



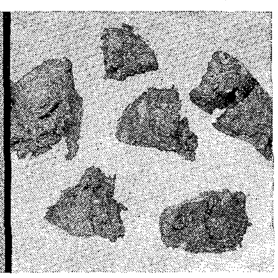
Gravel



Sands



Silts



Clay

division, straddled by the silts; the clays exhibit cohesion – they stick together, wet or dry – and the sands do not. A heap of sand spreads out because the grains have no adhesion to each other, while a piece of clay will stand up because the particles cohere. Silts run somewhere in between, with less cohesion than clay and more than sand.

In the mass, each of these materials behaves differently under a building load, and many studies were made before the appropriate important properties of each material were recognized and methods found to measure them. This is particularly true of clays, whose cohesion is a very complex phenomenon.

Problems of a foundation engineer

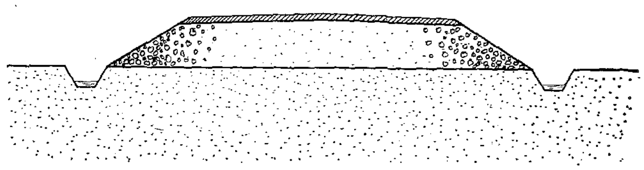
With what foundations does a foundation engineer concern himself? The pictures at the right illustrate some of our problems. Let us begin with what may seem the simplest – roads or airports. The upper drawing shows a cross-section through a typical highway. On top of the natural soil is placed a designed compacted fill material which may vary in thickness depending on the softness or stiffness (we term this "bearing capacity") of the natural soil and the loads and traffic the highway will have to bear. The wearing surface consists of concrete or asphalt, which carries the actual traffic while helping to spread the load on the underlying ground.

The next illustration shows two houses. Local building codes usually require that footings be placed a minimum distance below ground surface. The shaded zones below the footings of the left-hand house show how the stresses due to the weight of the building are spread out in the underlying soil. Usually we find that all of the significant stresses in a soil mass below a footing occur at depths less than one and one-half times the width of the footing, although the behavior of the foundation may be influenced by soft layers at greater depths.

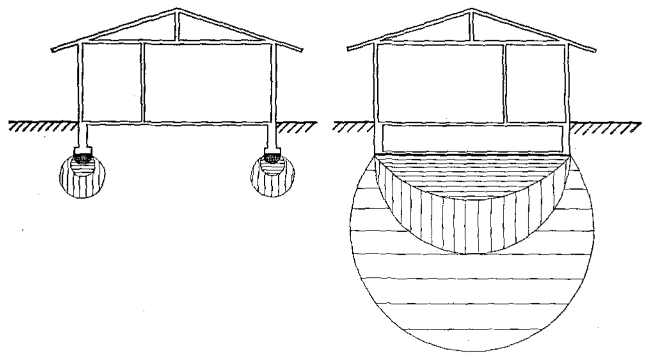
If the soil is not strong enough to bear the weight of the building, we can either reduce the pressure on the ground by using a so-called "raft" footing, as shown in the right-hand house, or we can drive piles to a firmer stratum underneath and build the house on the piles. In some cities, such as Boston, where compressible clays occur to depths of 100-120 feet, heavy buildings are sometimes "floated" by excavating a basement for the building, in which the weight of the soil removed from the excavation is equal to the total weight of the structure. The idea is that if excavation and erection are carried out q u i c k l y enough, the soil under the building will not know the difference between the weight of soil above and that of the building above!

Other areas which concern a foundation engineer are excavations, where it is necessary for him to estimate how high a face will stand unsupported – or, if a wall should be necessary, what soil pressure on the wall will be, so that the wall can be designed strong enough to support the soil behind it.

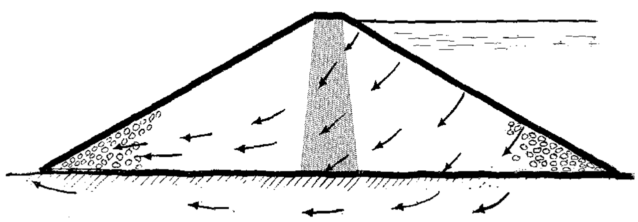
SOME TYPICAL PROBLEMS IN FOUNDATION ENGINEERING



Roads



Houses



Earth Dams

An area of growing interest in recent decades has been the construction of dams of earth. The last drawing shows a cross-section through a typical earth dam and we can use it to point out where soil mechanics problems arise. The most obvious function of a dam, even an earth one, is to retain water, and thus we must study the flow of water through the natural soil underlying the dam and through the artificially placed soil of which the dam is composed. The rate of flow must be ascertained to make sure that materials with small enough permeabilities are used. The water flowing through and under the dam exerts certain pressures on the dam's materials and these pressures must be calculated before, and checked during, construction. If they become too great, measures must be taken to reduce them.

Then, as the dam is built of reworked and remolded natural soil, the soil engineer must know the strength properties of the local material under differing conditions; he must determine how to compact the soil best so that it is, if possible, in its strongest and most impermeable state, and finally must be able to apply his calculations to the slopes of the dam to make sure that they will remain stable during and after construction under all conditions of reservoir heights, through storms, and through earthquakes.

Because of their heterogeneous, unpredictable nature, soils were long avoided as a subject of study and most of the early theories advanced regarding the behavior of soils under stress gave conflicting results in the field.

Civil engineers, of necessity, were hard, practical men, whose job consisted of utilizing the experience gained on previous works to predict the behavior and make designs for new situations. As theories didn't seem to apply to soils, few theoreticians wasted much time on the material — a situation which, to some extent, persists to the present day.

The hard-headed approach

A civil engineer, in general, is still a man who tests all materials by the hardness of his head, goes largely by past performances and is disinclined to trust theories — especially if they appear to contradict his own judgment or personal experience. A foundation engineer has a down-to-earth approach to his subject.

The experiences leading to the gradual growth of sound judgment in such engineers go generally uncommunicated to the rest of the workers in the field; this is the reason the science of soil mechanics has advanced so slowly through all the centuries of man's strivings to improve his environment.

For years it had been observed that many structures settled, without failing, through time. These structures continuously sank, and in many instances cracked. The successful investigation of this problem at last began the modern science of soil mechanics. It was shown that these gradual settlements were caused by the slow drainage of almost impermeable saturated clay layers underlying these settling structures. This process is describable mathematically and, while the variability of the properties of soil inevitably imposes limitations on its exact application, good predictions can now frequently be made of the amount of settlement to be expected.

The old question: "Are you planning to settle in these parts?" now brings from a foundation engineer a more precise answer: "Yes, about 3 to 4 inches."

Where soil conditions are bad and the analyses indicate that normal footings might settle too far or might possibly fail, piles are resorted to. Here is another field of study. How much energy is needed to drive a given pile? How far must we drive it? How much load can we put on it? How much will it settle under that load? Although in many cases these questions are still hard to answer, much information has been obtained. Pile driving, like the other divisions of soil mechanics, will never be precisely predictable.

So far I have indicated without emphasis the main difference between the foundation engineer and his fellow engineers and scientists. *He* must work with his materials as he finds them; he must try to find out about the properties of his working substance as it exists, and do what he can with it.

Other engineers are possibly more fortunate, but certainly less well-entertained men. The metallurgist, for example, makes his materials to the mechanical or structural engineer's specifications; the chemist or the physicist isolates or purifies his working substance to the state he desires and then causes it to operate according to his predictions. Heat, metals, chemicals, and electricity generally behave in a homogeneous, predictable manner. When they don't, a discovery is made, an invention is born.

The soil engineer has not, until very recently, been faced with this situation. The soil exists in its own sweet unconformity and he has had to do what he could with it. His science was a passive one, in which the design of the structure had to yield to the properties of the soil. With the expanding world of transportation, and the establishment of new cities and industries, water, power, highway and railroads were needed to feed them. A need arose for soil as a *construction* material to build bigger embankments, to be used under more highways, and for larger earth dams. It was at last necessary to investigate how the properties of soil could be modified — to find how we could make the soil behave according to our needs; how to make it stronger, less compressible, more impermeable.

Stabilization of soil

The stabilization of soil is the second, or active stage of the science. The first studies in this direction were towards compacting the soil. It was found that the highest soil densities could be obtained by ramming or vibrating the soil at an optimum water content for each soil. Since the highest density is generally associated with the greatest shear strength of a soil, it was obviously desirable to build embankments and earth dams using soil compacted at the *optimum* moisture content.

This was the first step in developing the potential of soil. In this way the strength and performance of the soil in embankments and highways could not only be *predicted,* it could be controlled!

In the studies of compaction methods, new ramming and compaction devices were invented. One of the most widely used is called a "sheep's foot roller." Not long ago I was reading a Scottish magazine, in which there was an article about the old crofts and crofters in the Highlands in that country. The author, with a fondness for the old way of life, had come across a description of the construction of these crofts. "The floor would be covered with a layer of mud and fine clay and trampled down by the men's feet. A flock of sheep was then driven in within the walls. The sheep were kept on the move for a whole day, and then let out. The result was a fine smooth floor, which needed nothing else but a good fire to dry it out and perhaps a goodly sprinkling of white sand from the shore. The surface was called a 'sheep's feet floor.'"

The investigations of the causes of the shearing strength of soil, and the discoveries about compaction began interest in a whole new field of soil studies, namely the study of changing the properties of soils by means of additives, usually chemicals.

The first main division and object of this field of study was the most obvious one of stabilizing the soil. Where we have a loose sand under a foundation, or when we want to build a structure or a road on a soft clay or peat bog, it would be pleasant if all we had to do was inject an appropriate chemical into the ground, whereupon the soil would harden sufficiently to take the applied loads.

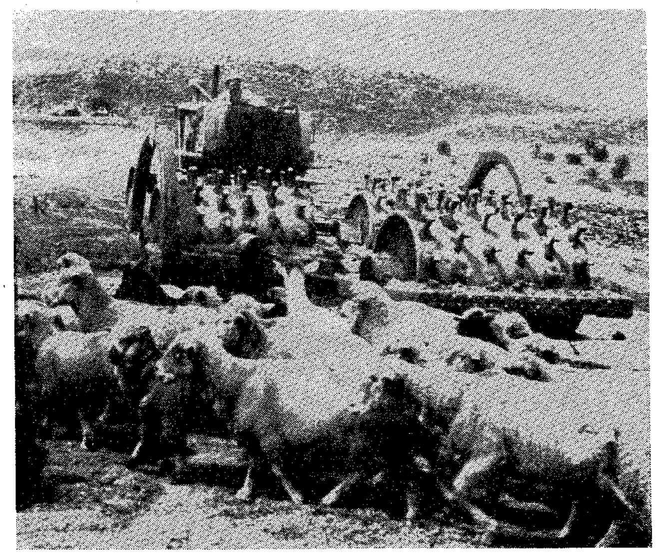
Several chemicals have been discovered which can do this. Soil-cement and soil-lime mixtures have long been used in certain areas to build successful roads, and small quantities of other chemicals induce useful amounts of bond in otherwise soft or loose soils. However, to obtain the best, most desirable effects, the chemicals have to be thoroughly mixed with the soil under study. In sands and in silts it is possible to do a certain amount of this mixing merely by injecting the chemical into the soil. This method, of which there are several variations, has been successfully used in stopping loose soils from flowing into mine shafts and tunnels and has also been employed in stabilizing loose granular soils under existing foundations. It is not, however, possible to utilize injection procedures in fine-grained clays; the liquid simply will not percolate.

Mixing chemicals with soil

In the latter case, the chemical, liquid, or powder must be mixed with the soil. This immediately implies that the soil will be reworked, that its undisturbed in-place properties cannot be altered. That is a regrettable limitation, but reworked soils still offer a vast useful potential in highways, embankments, and dams.

The difficulty is in the mixing. In general, if large quantities of chemical are needed to stabilize a soil (say, one part chemical to 7-10 parts soil) then mixing need not be too efficient to achieve reasonable average results. If only small quantities (1 or 2 percent chemical) achieve a useful degree of stabilization, mixing must be thorough.

We immediately become involved in economics. How much do various chemicals cost per pound or ton, and in what proportions must they be used? How much does it cost to achieve adequate mixing of a given chemical? Is more mixing required than the soil gets during normal transportation and compaction? Can mixing be achieved more efficiently at less cost?



The sheep's foot roller — a widely-used compaction device — meets up with its natural inspiration.

The use of any of these chemicals depends on their cost which, in any world, depends on how much of a demand there is for them. In some cases useful chemicals could become much cheaper with better production if there were a greater demand for them — a demand which is strangled by the initial cost!

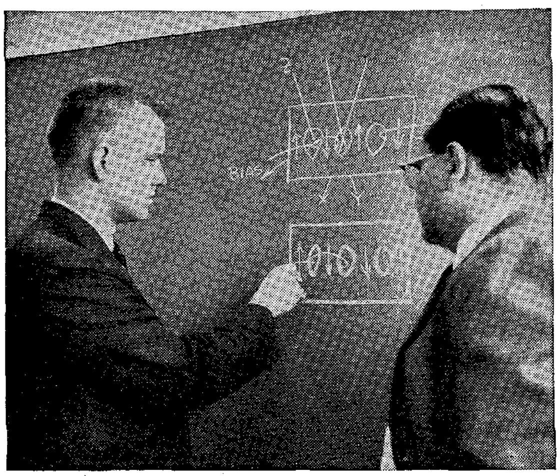
One such chemical is calcium acrylate. In quantities of 1 to 5 percent of the dry weight of soil it can usefully modify the strength and permeability properties of soil, but unfortunately it is at present produced in pilot-plant or laboratory quantities only and the cost at this time is $2 per pound. Since there are approximately 3,000 pounds of dry material in one cubic yard of soil, it would take 150 pounds of calcium acrylate to achieve stabilization, at a cost of $300 per cubic yard of stabilized soil. Since the normal cost of concrete is about $15 to $20 per cubic yard and the cost of earth placed in construction projects is about 70 or 80 cents per cubic yard, calcium acrylate is scarcely an economical substance to use as a stabilizing material. If, however, some other demand were to arise for it so that its price would drop the way the other acrylic resins have done since the war, it may yet be possible to use it for stabilizing purposes.

While this stage of the science is in its infancy, sufficiently promising results have been obtained with certain chemical additives to warrant the prediction of a bright future for such processes in the field of construction.

If I have done nothing else in this article I hope that I have indicated that there *is* a science of soil mechanics — and that what happens from the ground down is not a complete mystery to us any longer. It is possible to *design* foundations, piers, retaining walls and dams. There is no doubt whatever that our engineering abilities in this direction will continue to develop in the future.

Product Development at IBM

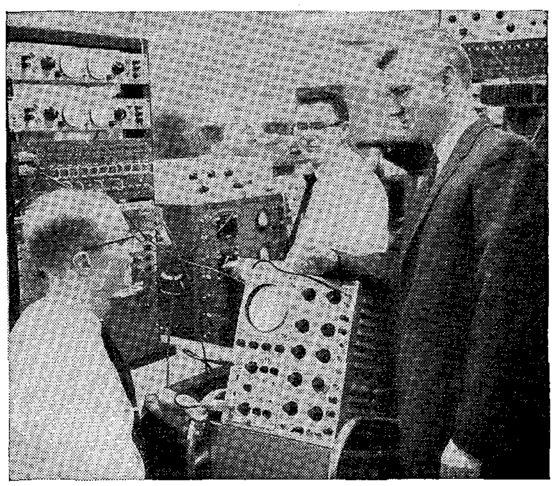
IBM Engineer Richard R. Booth explores electronic frontiers to develop new, faster and larger storage devices for tomorrow's computers.



Computing time cut from six months to one day

"My job is to design and develop new, high-speed storage devices for a powerful new computer that will perform, in one day, operations requiring six months on present equipment," said Dick Booth as he began a typical day recently. A product development engineer at the IBM Laboratories in Poughkeepsie, N. Y., he started his morning with a conference on a product of great interest to him: a magnetic core storage device with a nondestructive read-out feature. For an hour, he discussed with circuit design engineers the logical devices needed for the register—such as magnetic core drivers and sense amplifiers. Should such devices not be available, the group would work on designs for new ones.

Dick Booth next met with members of the Magnetic Materials Group to establish specifications for the magnetic core memory elements to be used in the register. He also discussed with the group the development of equipment to test the memory elements. "This magnetic core register is based on an original idea of mine," he explained. "When you have a worthwhile idea, you will be given a free hand in proving it out, backed by IBM's resources — plus the assistance of skilled specialists."



Increasing responsibility

At 10:30, Dick Booth reviewed the status of the entire project with the two engineers, two technicians, and one logic designer who make up his team. "My present position is staff engineer," he explained. "It's the second promotion I've had since I joined IBM three years ago with a B.S.E.E. degree from the University of Illinois. I know that there are plenty of other opportunities to move ahead. Furthermore, parallel advancement opportunities exist for engineers in either engineering development or engineering management."

The Month at Caltech

National Academy

Rudolph L. Minkowski, research associate at Caltech and a staff member of the Mount Wilson and Palomar Observatories, was elected to the National Academy of Sciences last month – one of the highest scientific honors in the nation.

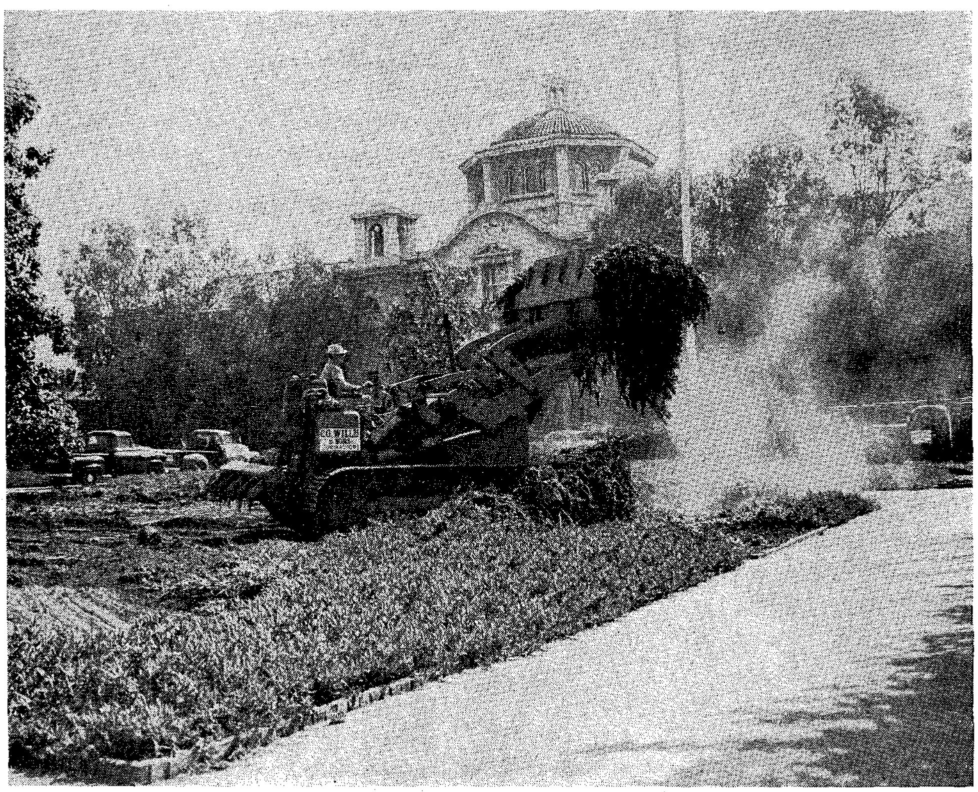
Election to the Academy is in recognition of outstanding achievement in scientific research, and membership is limited to 500 American citizens and 50 foreign associates. The election of Dr. Minkowski brings the number of Caltech staff members to 32.

A native of Strasbourg, France, Dr. Minkowski received his PhD in physics at Breslau University in Poland. He was assistant, privatdocent and professor at the Physikalisches Staatsinstitut in Hamburg, Germany, from 1922-35.

Among various investigations Dr. Minkowski made in Germany were several in which he successfully applied kinetic theory and quantum theory to the interpretation of observed effects in the spectra of gases. His first astronomical investigation was a thorough study of relative intensities of lines in the spectrum of the Great Nebula in Orion.

He became a staff member of the Mount Wilson and Palomar Observatories in 1935 and received his American citizenship papers in 1940. He has been a research associate at Caltech since 1948.

At Mount Wilson, Dr. Minkowski became interested in the challenging problems of gaseous nebulae and of novae. By studying slit spectra obtained with the large telescopes, he discovered a large number of planetary nebulae from objects found on a smaller telescope on Mount Wilson. His discussion of the new data, together with his superior direct photographs of planetaries, which disclosed many remarkable geo-



THE ICEPLANT GOETH

– and most of the central campus is uprooted as bulldozers pave the way for construction of an underground room to house the $1,000,000 electrostatic generator for the new Alfred P. Sloan Laboratory of Mathematics and Physics.

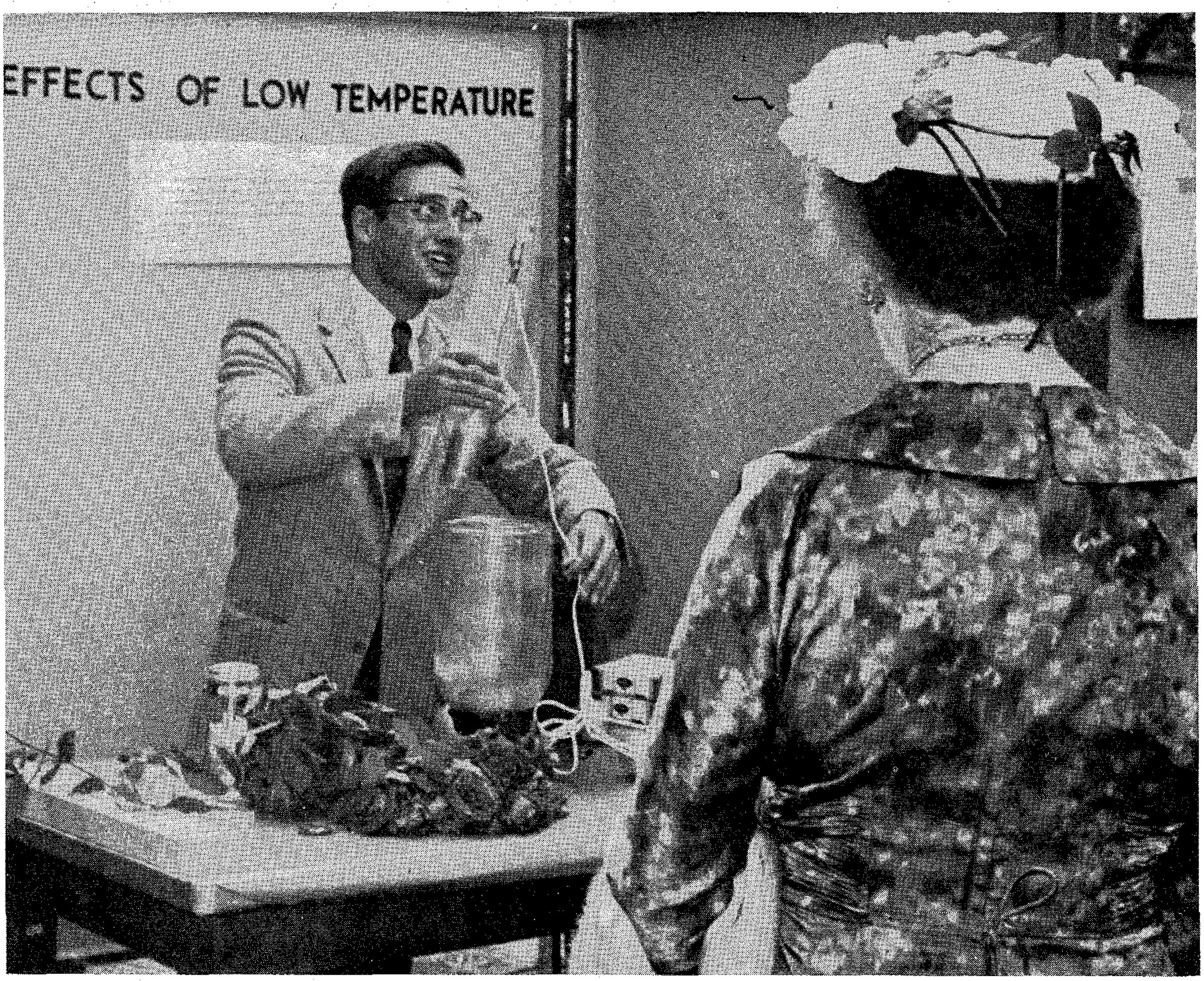


EXHIBIT DAY

An enthralled visitor and an enthusiastic demonstrator at the spring party given for the California Institute Associates on May 7. Scientific demonstrations and exhibits, which filled Dabney Lounge and Gardens, were shown to Caltech students, faculty and employees on May 8.

metrical forms, has greatly enlarged our knowledge of this subject.

Once every few centuries, one star out of the billions in the Milky Way system may explode into a supernova, several times brighter than the sun. One of these is the Crab Nebula, known to be a fragment of the supernova of 1054. Dr. Minkowski made a valuable physical analysis of his spectroscopic observation of the Crab Nebula, and his painstaking studies of other supernovae have been the source of most of our knowledge about these objects.

Some of his recent research has been concerned with the identification of strong radio sources with faint objects on photographs taken with the large reflectors. Several of these radio sources are believed to be galaxies in collision. A detailed spectroscopic observation of NGC 1275 has indicated relative velocities of 3,000 kilometers per second within this object and has greatly strengthened the hypothesis of colliding galaxies.

Dr. Minkowski also acted as general director of the Sky Survey, a seven-year research project sponsored by the National Geographic Society and the Palomar Observatory.

Guggenheim Fellowships

Three Caltech faculty members were awarded Fellowship grants by the John Simon Guggenheim Memorial Foundation last month — W. Barclay Kamb, assistant professor of geology; Vincent Z. Peterson, assistant professor of physics; and Walter A. Schroeder, research associate in chemistry.

Dr. Kamb will continue his studies of the relation between state of stress and preferred orientation of ice crystals in selected glaciers of the Alps; Dr. Peterson will study the photoproduction of mesons and hyperons of high energy x-rays; and Dr. Schroeder will continue studies of the total structure of human hemoglobin.

Leif Erikson Award

President L. A. DuBridge received the Leif Erikson Foundation Award at a banquet at the Huntington-Sheraton Hotel in Pasadena on April 24. The award is given each year to a man whose work commemorates the pioneering spirit of the Scandinavian people.

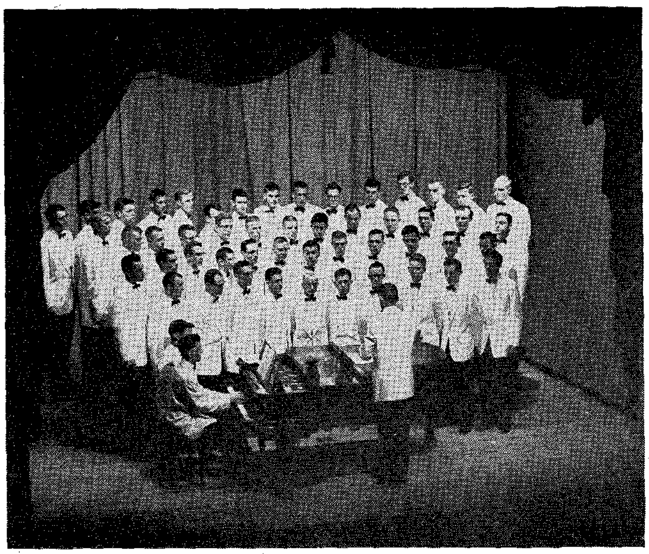
Although Dr. DuBridge has received many honors and awards for original research in the physical sciences and for administrative work on national scientific projects, this award is for his work in the field of education.

The bronze plaque was presented to Dr. DuBridge by Vaino Hoover, president of the Leif Erikson Foundation and a Caltech alumnus. The award is made jointly by societies representing the five Scandinavian countries — Finland, Sweden, Denmark, Norway and Iceland.

Cancer Grant

Henry Borsook, Caltech professor of biochemistry, received the largest research grant ever awarded by the American Cancer Society to a Los Angeles County scientist. The $58,539 grant will support a three-year attempt to isolate and identify a hormone involved in the function of red blood cells.

The hormone stimulates production of red blood cells in the bone marrow but its origin and composition are uncertain. Important clues to such problems as anemia and other abnormal blood conditions may result from these studies.



BOOMING GLEE CLUB

The Caltech Glee Club, under the direction of Olaf Frodsham, has grown from a once-a-week community sing involving about 10 men, to its present membership, limited to 62 — or about one-tenth of the undergraduate student body. This year the club made a one-week tour of California cities; this month its annual spring concert filled Culbertson Hall for two nights; next month it puts out a two-record LP album. And on May 24 the club winds up the current Caltech TV series, "The Next Hundred Years," when it appears with President DuBridge on the final show of the season, on Channel 4, at 4 p.m.

Making the Big Spring Scene

In the reign of Spring, the young Techman's fancy turns to a great deal more than love. First and foremost in his nimble mind is the thought of his possible GPA for the term, as of midterms. Then, when there is no cramming for tests, he daintily snatches at intellectual stimulation – the harder to grasp, the better.

In the last few weeks, the stimulus has been provided in a way that could only help to lower the prestige of Caltech in the surrounding community. On two consecutive days, the Y lounge was the scene of small, subversive group discussions with representatives of lower San Francisco society. The first was one Eric Nord, the "big daddy of the Beatniks." When Nord arrived some ten minutes late, the room was already filled with shabbily dressed, bearded fanatics. Nord (all 350 pounds of him) stooped to get through the door, and, on seeing the crowd, smiled broadly through his red beard. He felt at home.

As soon as he had settled down in the big easy chair, the proteges closed in a little so that they could hear every word and hang on to every sentence to catch its fuller implications. Nord talked all about the big scene up in San Fran and how the L.A. cats could make the same scene out in Venice and really that this was the way to live and the nine-to-five scene was a drag and society was a rat race and the beats can't make their own scene because the nine-to-fivers are trying to make it for them. Mainly the cops. The room was absolutely quiet when Nord wasn't speaking; an outsider could feel the relationship that had been established between this big man and his prospective followers. Only trouble could result from such a union.

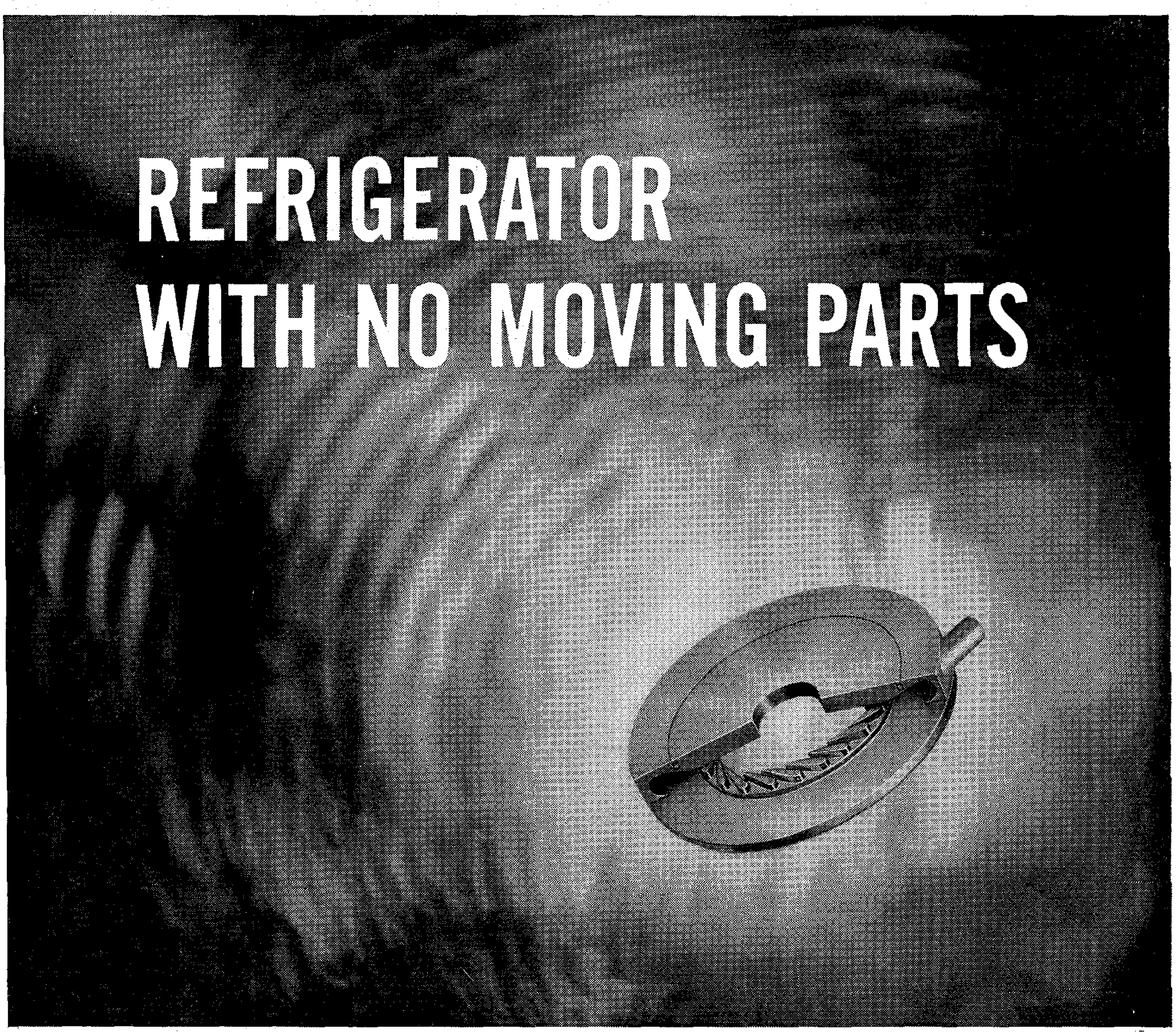
As if this weren't enough, a Congregational missionary from North Beach arrived the next day to further incite the subversives. Even though Pierre Delattre was supposed to be nothing more than an observer and source of aid to these beat people, he very unsubtly colored his statements to make the beat ones appear better and their philosophy more appealing to young, moldable minds. He actually thought that only working a couple of days a week and wasting the rest of your time thinking or "self-relating" was good for some people. Worse, some Techmen believed him.

In the next few days, the increase in sandals worn and beards in the process of growing was astounding. One downtown record store claims to have completely sold out Theodore Bickel in one afternoon – mostly to Techniks. An instructor was actually heard by more than fifteen students to say, "Let's see if we can dig this problem." Chaos reigned as classes became meaningless. In reply to inquiries as to the whereabouts of some of the missing students, friends would casually rub their stomachs through faded yellow T shirts, lick their lips, and answer, "Man, don't bug me. How should I know? He makes *his* scene and I make *my* scene. Dig?" Or, if the friend happened to be in a more relating mood: "Yes, yes, yes. Man, he's up in San Fran visiting old Dean Moriarty. Yes, yes, yes. He knows, man."

The completely amoral effects of this movement were most felt, however, not on campus. The stalwart citizens of fair Pasadena soon became conscious of dirty, unkempt young men sitting on bus-stop benches, seemingly waiting for one of the popular Pasadena buses to speed them to their rendezvous. But the buses came and left, and the scowling young men were still there on the benches; sometimes the buses even brought new young men from areas where the stops had no benches.

At an exchange with a group of women on the Friday night of Delattre's visit, one of the brooders, who had been sitting in the dining room since dinner contemplating the pitiful piece of meat he had found on his sparerib, was approached by a do-gooder coed. After talking to the Techman for about seven or eight minutes and receiving absolutely no response, the poor girl decided that it was really *true* what she had heard about Techmen and she began to walk away. Just then, he uttered, "What a drag," and resumed contemplation. The coed turned around. She looked as if she had been struck with a large heavy object. Quivering with delight, she ran to his side and amid sobs managed to blurt out, "You spoke! You actually said something!"

"Materialism is a drag," the brooder continued.



The vortex tube is a refrigerating machine with no moving parts. Compressed air enters the vortex chamber pictured here and spins rapidly down an attached tube. Pressure and temperature differences build up, forcing cold air out one end and hot air out the other. Requiring no maintenance, a large vortex tube developed by AiResearch scientists and engineers can be permanently sealed in nuclear reactors, and has many uses in industries with spot cooling problems.

Many such pioneering developments are underway in challenging, important work at AiResearch in missile, electronic, nuclear, aircraft and industrial fields.

Specific opportunities exist in system electronics and servo control units; computers and flight instruments; missile auxiliary power units; gas turbine engines, turbine and air motors; cryogenic and nuclear systems; pneumatic valves; industrial turbochargers; air conditioning and pressurization; and heat transfer, including electronic cooling.

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"The nine-to-fivers can have it. Man, all I want to do is live; to understand; to know; to relate with life. All I want is just once to walk to my arbitrarily chosen place in this out dining room and find some meat on *my* spareribs. How come all the other cats get meat and I don't? I'll tell you why – it's because of the bomb and materialism and the rat race and the nine-to-fivers – that's why!"

The coed's mouth dropped a little, and she panted ever so slightly; ever so gently her breath warmed his cold buttered broccoli. "Let's go to my pad," he said, still searching his sparerib. He got up and walked away without waiting for an answer. She followed, not knowing why nor questioning.

The whole scene was in quite poor taste.

Luckily for everyone, this potentially harmful fad quickly died out as midterms approached, and the necessary preparation for future work in the "big world outside," took on added urgency. The men began to realize that all this beat stuff was simply an escape from reality, and that they must assume their responsibility as good little citizens along with everybody else. There was no question that studying and going to college and succumbing to the social pressures of the student houses (i.e., wise up and get humble) was not the ideal way to live, but after all, it was as good as any other. So why fight it and be considered a radical and lose friends and have a lower GPA than your roommate? One has to plan for the future, does one not? And when you graduate from Caltech, you get great jobs – so what if it is from nine-to-five? Look at all the things you can buy with the money you earn – television, three cars, a lovely home, vacation for two in Europe in all the best places.

Well, you don't get to read all the books or write very much or get to do some of the things you want to, but you've got all those tremendous things to make life easier and more relaxing – things that everybody wants because they're so good. And besides, socially you're accepted and you can raise your children in a healthy atmosphere and they will never feel that the neighbors' children have more than they do.

And when you come home in the evening after a hard day of robust creativity, you can sit in front of the TV set for a couple of hours or go bowling with the boys like you do every Thursday or play bridge like you do every Sunday. You're comfortable and secure – and ignorant. That's the Right Way To Live.

– Martin Carnoy, '60

Alumni News

Annual Alumni Meeting

Charles B. Thornton, president and chairman of the board of Litton Industries, Inc., will be the dinner speaker at the annual banquet and meeting of the Caltech Alumni Association, to be held at the Rodger Young Auditorium in Los Angeles on June 10. Mr. Thornton's talk – "What is This Electronics Business Anyway?" – will deal with the necessity of looking at the electronic field with a broader point of view, now that the industry has mushroomed into a leading business enterprise. Mr. Thornton's capability to speak with authority on this subject stems from the fact that he has directed Litton Industries' growth from its inception. Since it was founded in 1953, Litton has developed into one of the country's major electronics companies, with 22 manufacturing and laboratory locations in the United States and Europe. Mr. Thornton was also largely responsible for moving Hughes Aircraft Company into the field of advanced electronics during his service as vice president and assistant general manager with that company from 1948 to 1953.

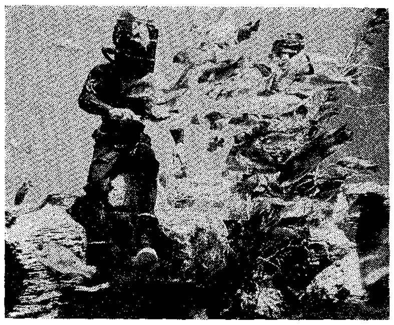
Another main feature of the evening will be President DuBridge's year-end review of developments at the Institute. Reunion classes at the annual meeting will include 1914, 1919, 1924, 1929, 1934, 1939, 1944, 1949 and 1954. Cocktails will be served at 6:30 p.m. and dinner will start at 7. Reservations should be in at the Alumni Office by June 5.

– Charles Pearson, '42
Chairman, Annual Meeting

Alumni Seminar

The 22nd Annual Alumni Seminar held on the campus on Saturday, April 11, was one of the most successful – and certainly the largest – Caltech seminar on record, with 1,464 alumni, wives and guests in attendance.

The theme of this year's seminar was "The Space Age" and the program featured 13 lectures which dealt with all phases of future space exploration. At the banquet in the evening, William H. Pickering, director of JPL, spoke on "The Exploration of Space."



ANNUAL
ALUMNI
PICNIC

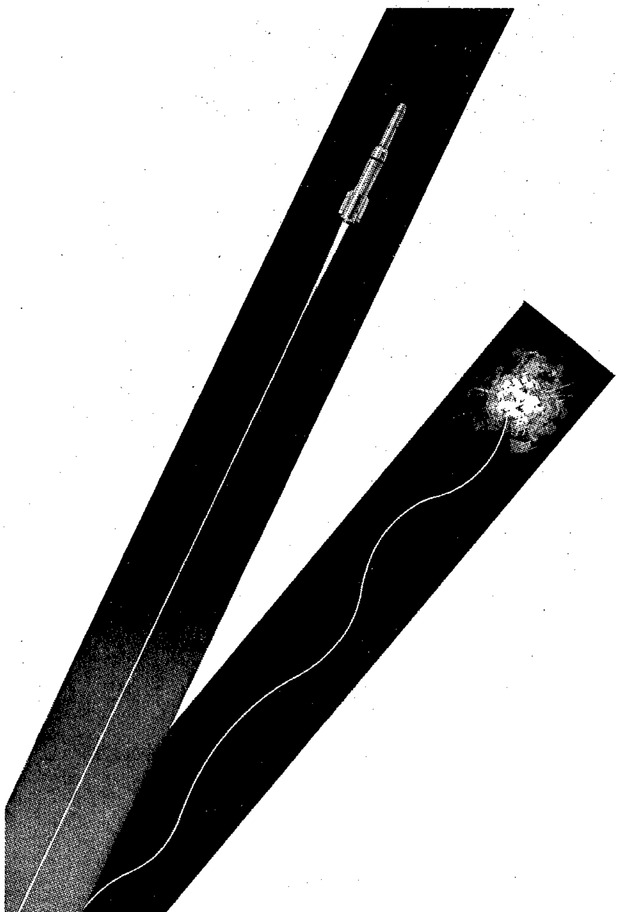
SEE – The Marineland Three Ring Sea Circus
Sea Arena – Porpoise Games and Seal Show
Whale Stadium – Bubbles, Squirt and Bimbo, the Dancing Whales
Fishbowl – 5,000 Underwater Creatures fed by hand

AT – Marineland of the Pacific, Palos Verdes

WITH – Family, Friends & Fellow Alums

ON – Saturday, June 27

Stan Groner '52
Chairman, Picnic Committee



COMMAND DESTRUCT

The flight testing of second generation missiles—more versatile and powerful than their predecessors—requires a device for sure termination of any missile flight that might endanger the test range or surrounding area.

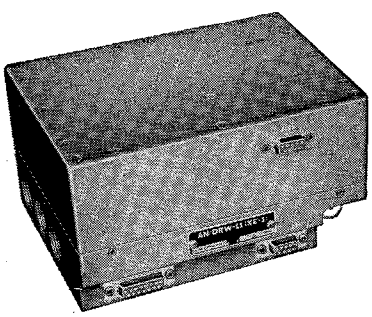
Ramo-Wooldridge engineers, under a United States Army Signal Corps contract, have successfully developed and delivered the first sub-miniature, completely transistorized radio "command destruct" receivers.

Specifically designed for missile flight safety operations, the receiver (AN/DRW-11) can actuate safety mechanisms or destruct devices. It has three command channels, each of which actuates a control relay.

The "command destruct" receiver accepts frequency modulated signals in the UHF radio command control band. It is designed to operate with closer radio frequency and command frequency channel spacing than has been used to date, thus making possible more efficient use of the available radio spectrum.

Compact and rugged, the radio receiver's modular construction permits rapid and complete accessibility to all components. One module houses the basic receiver. The second module contains the three command channels and relays. This integrated package occupies 115 cubic inches, and weighs 4 pounds. The receiver requires no pressurization and operates reliably under the adverse environmental conditions encountered in missile flight testing.

Engineers and scientists interested in being associated with some of the nation's most advanced research and development programs are invited to acquaint themselves with current opportunities at Ramo-Wooldridge. The areas of activity listed below are those in which R-W is now engaged and in which openings exist.



Missile electronics systems
Advanced radio and wireline communications
Information processing systems
Electronic language translation
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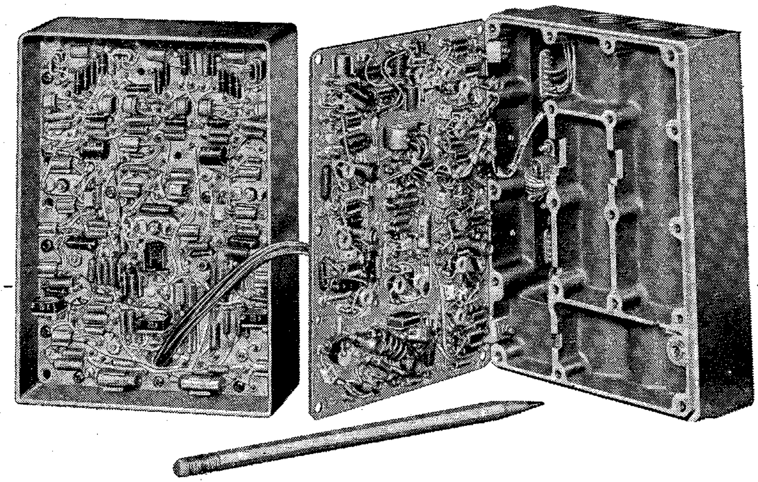

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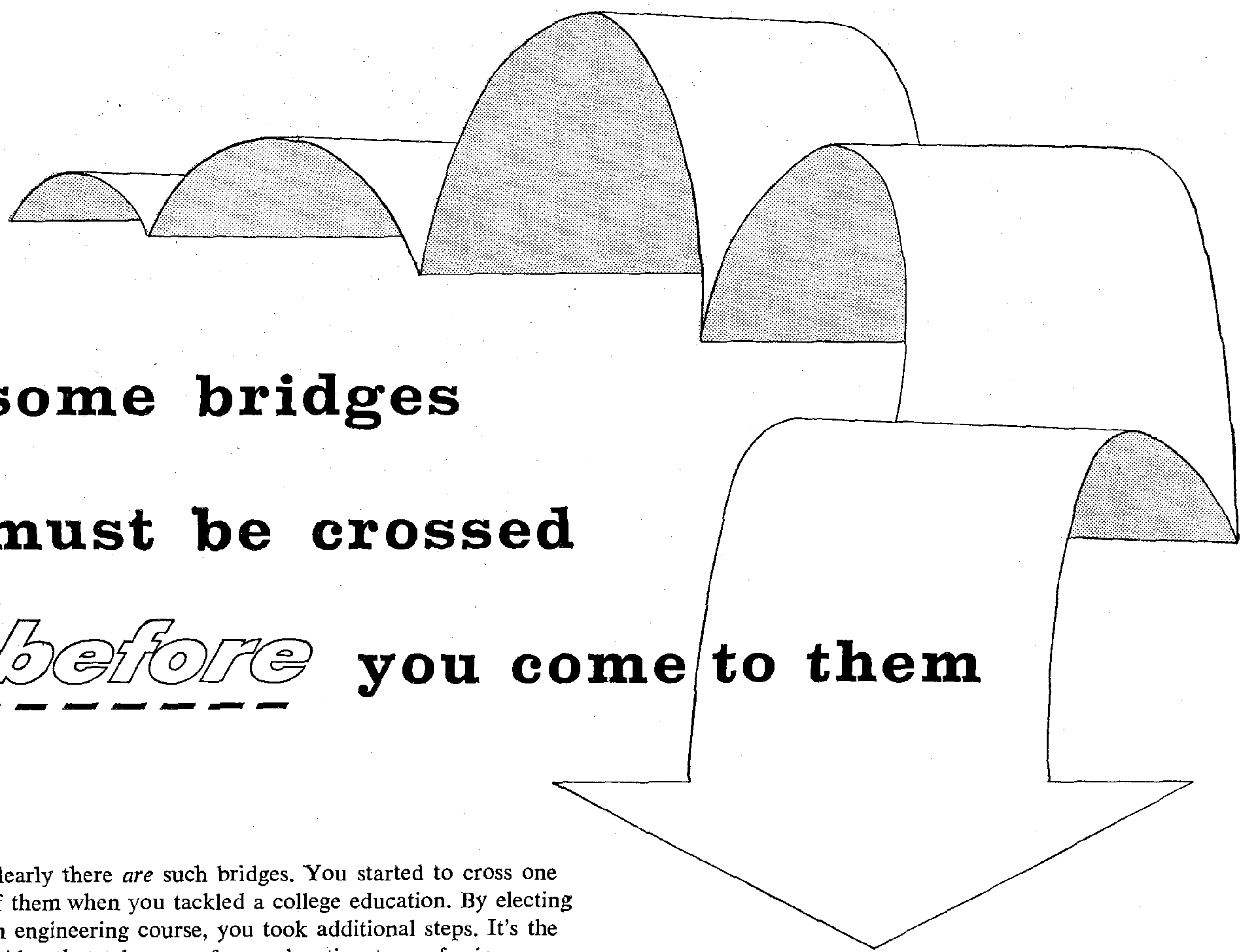

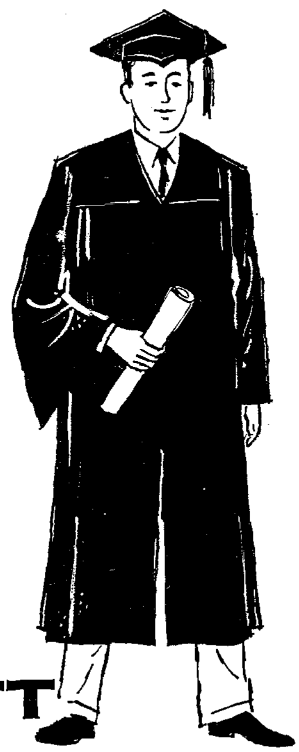

Personals

1929

Lee R. Brantley, MS, PhD '30, chairman of the department of chemistry at Occidental College, was a guest lecturer in the Lebanon Valley (Pennsylvania) College department of chemistry last month. He gave two lectures – "The Extracurricular Training of a Chemist" and "Surface Chemistry" – and conducted a research conference.

1932

John L. Cox, associate head of the engineering department at the Naval Ordnance Test Station in China Lake, has a new daughter, Margaret Elizabeth, born last October 27. John's two older children live in Pasadena and the girl, now 18 years old, expects to be married sometime this spring. John also reports that he has been chairman of the China Lake Chapter of the American Ordnance Association for the past two years.

Euclid V. Watts has been appointed manager of producing for Socony Mobil in New York. He has been with the company since 1936. The Watts', who live in Darien, Conn., have three children – Joanna, Robert and Charlotte.

Paul G. Burman writes that he is now in his twentieth year with the American Bosch Arma Corporation in Springfield, Mass. "My present position is consulting mechanical engineer in the advanced engineering section. In addition to advisory service on diesel fuel injection, I am involved in projects on gas turbine injection, liquid propellants, hydraulic controls, and missile components.

"My son, Bruce, is now a junior in electronics at Lowell Tech, and my daughter is a senior in high school. My spare time is spent skiing and sailing."

Karl Hegardt is now outside plant engineer and personnel supervisor in the chief engineer's department of the Pacific Telephone Company in Los Angeles. He is serving this year as director of the Pacific Telephone's Executive Conference in Palo Alto. The Hegardts' second son, William, was born last October.

1933

Philip C. Efromson, formerly a partner of the Calidyne Company in Winchester, Mass., is now treasurer. The company has become a subsidiary of Ling Electronics in Culver City, Calif. With the addition of another boy last October, the Efromson family now consists of three sons.

Lee Carleton writes: "I'm still doing scientific work at the Aerojet General

Corporation in Azusa, in an interesting field covering rocketry and high-energy radiation. I was remarried last year, thereby adding two fine teen-agers (boy and girl) to my original one son. We recently returned from a delayed honeymoon at the Mardi Gras in Mazatlan."

1938

Harper Q. North writes that, since 1954, he has been president and chairman of the board of Pacific Semiconductors, Inc., in Los Angeles, a subsidiary of Thompson-Ramo Wooldridge. He has also been made a fellow of both the American Physical Society and the Institute of Radio Engineers.

1939

Paul L. Smith has been with Douglas Aircraft for 20 years now and is, at present, "chief cook and bottle washer of the new office in St. Louis." He writes: "Our daughter, Susan, was married last summer and is now living at Cape Canaveral; our son, Stephen, is a junior in high school; and Chuck is in the 7th grade.

1940

Victor Wouk, vice president of research and development at Sorensen & Company in South Norwalk, Conn., brings us up to date with: "In July 1956 I sold Beta Electric Corporation to Sorensen & Co., Inc., and at the time of sale it had grown from a two-man operation in 1946 to the world's largest exclusive manufacturer of high voltage power supplies. For this I bow very deeply in the direction of the high voltage labs of Caltech and the leadership of Professor Royal W. Sorensen.

"The relief from many administrative details at Beta has allowed me to be more active in community activities such as: Board of Directors of the 92nd Street Y (the largest in the country), chairman of the New York Commission on Hebrew Religious School Education, and interviewing Caltech applicants, one of the most enjoyable extracurricular activities in which I have ever engaged."

1941

Paul Lieber, MS, PhD '51, was appointed professor of engineering science at the University of California in 1956, and in 1957 was awarded a Fulbright lectureship at the Israel Institute of Technology at Haifa, to conduct research in field theory and advise on programs of studies in engineering.

"We found Israel a very interesting country," Paul writes. "The internal and external problems facing her are formidable and are being met with unflinching courage by some of her people. From a practical standpoint, however, these problems can be realistically met only with the support of a superior technology. To this end Israel must provide maximum opportunity and facilities for training and employing her outstanding talent in technology.

"As for our family, we have five children – Michael, 16; Leonardo, 11; Joseph, 9; Victoria, 7; and Jonathan, 4."

1942

Charles Rutherford writes that "with the exception of a three year period in Washington, D.C., from 1944-47, we've been in the local area. In 1950 I founded my own company in Culver City, and after a short discussion at the board of directors meeting (I'm chairman of the board and my wife and mother are the other members) the company was named the Rutherford Electronics Company. I was also elected president of the company – by a coincidence. After 8 years, we're making a living at it with the help of about 50 employees. I've also got four children to help spend the paycheck."

1944

Philip B. Smith writes that he's settled for a while in Utrecht, Holland, as vice group leader of the nuclear physics section at the University. "For the past year and a half," writes Philip, "I've been catching up on my field of work after six years of complete isolation from physics in Brazil."

Joseph M. Phelps, MS '47, has recently gone into partnership with William Rucker as Associated Business Consultants. Located in Pasadena, the new outfit designs and writes technical books, produces industrial films and filmstrips, and takes aerial and industrial photographs. For a hobby, Joe has a boat and he and his family (wife, daughter, and two sons) are all interested in water skiing.

1946

Harold Lambertus, MS, is now general manager of the newly created nuclear fuels department of the Spencer Chemical Company in Kansas City, Mo. He was formerly vice president of the American Bearing Corporation, a division of the National Lead Company. The Lambertuses and their two children will now be living in Kansas City.

1947

William T. Russell, MS, PhD '50, director of the electromechanical laboratory at Space Technology Laboratories, Inc., is now a member of the committee on control, guidance, and navigation for the National Aeronautical and Space Administration.

Jerry Donohue, PhD, professor of chemistry at the University of Southern California, has received a $57,200 three-year grant by the National Science Foundation. He will spend his first year at the Swiss Federal Institute of Technology in Zurich, as a senior postdoctoral research fellow. His research proj-

continued on page 40

ect is on structural chemistry, determining how atoms are arranged in certain crystalline substances. He is also working on a one-year $11,000 contract from the Office of Ordnance Research to determine interatomic distances of molecules in crystals. His wife, son (Terry, 12) and daughter (Nora, 10) will accompany him to Switzerland.

John R. Scull, assistant chief of the electro-mechanical development section at JPL, will take a temporary leave to act as scientist for guidance and control in the office of program planning and evaluation of the National Aeronautics and Space Administration in Washington, D.C. The Sculls and their three children will live in Washington.

1948

David B. Wilford, MS '51, is now supervisor of a newly-formed unit at Rocketdyne in Canoga Park. The new unit was created to direct analytical effort and handle all of the data reduction and processing activities of the combustion devices section of the engineering division.

1949

George M. Petzar has been transferred from L.A. to a new district office of the Portland Cement Association in Phoenix, Arizona. He will be district engineer in charge of the new office. George has been with the Association since 1954.

1950

J. Robert Holmes, MS, is now senior engineer in reliability evaluation at the Owego, N.Y., plant of IBM. The Holmeses and their three sons live in Vestal, N.Y.

Norman F. Jacobson, PhD, '56, has been made chief of the newly formed reliability section at JPL. He has been with JPL since 1956 and was responsible for payload reliability in connection with the building and launching of the Explorer satellites and the Sergeant weapons system. The Jacobsons and their three children live in Pasadena.

Robert L. Nelson, MS, PhD '52, writes that: "We have been in Oklahoma City for just about three months, after spending the last three years in Jackson, Miss. Our stay there was a real education in every sense of the word, but we were ready and willing to try a new spot. We now have had a taste of doodlebugging from Peace River in Alberta, Canada, to the Florida Panhandle, with most of our time prior to Mississippi spent in Bismark, Billings, and Casper. Our one winter in Canada produced some wonderful skiing and skating.

"I've taken over as division geophys-

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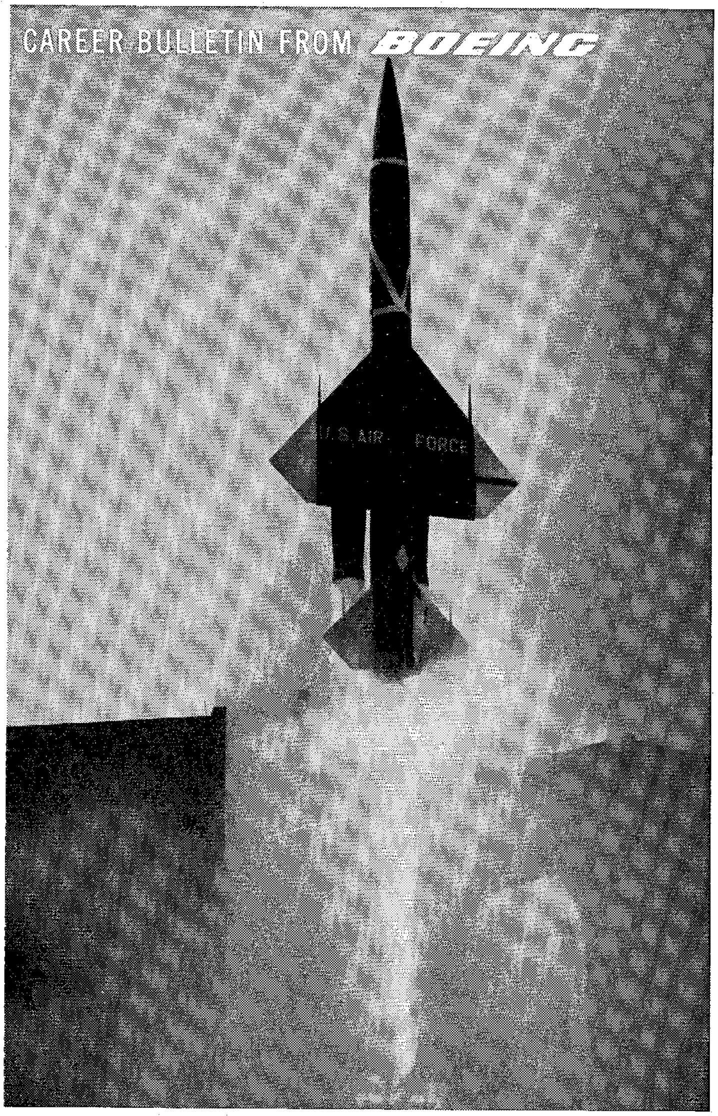
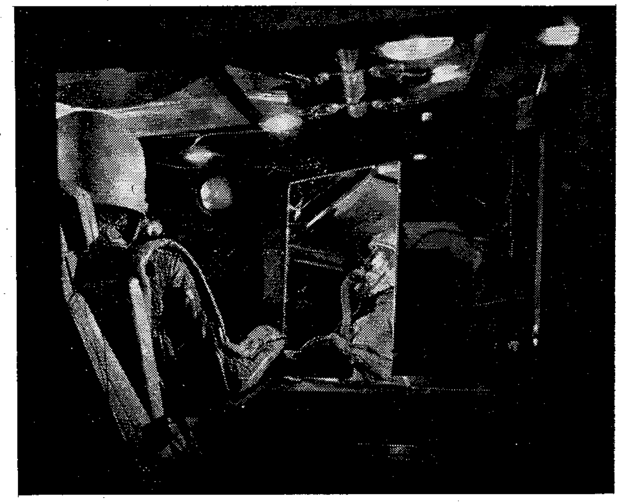


BLAST-OFF of supersonic Boeing BOMARC, the nation's longest-range defense missile. Now in volume production for Air Force bases under construction. Other Boeing missile projects that offer engineers and scientists outstanding career opportunities include Minuteman, an advanced solid-propellant intercontinental ballistic missile system.



SPACE-AGE projects are expanding at Boeing. Above is human factors laboratory in which problems of providing environments and controls for space vehicle crews are investigated. Celestial mechanics, lunar orbital systems and interplanetary systems are other areas that offer long-range space-age career opportunities to qualified engineers and scientists.

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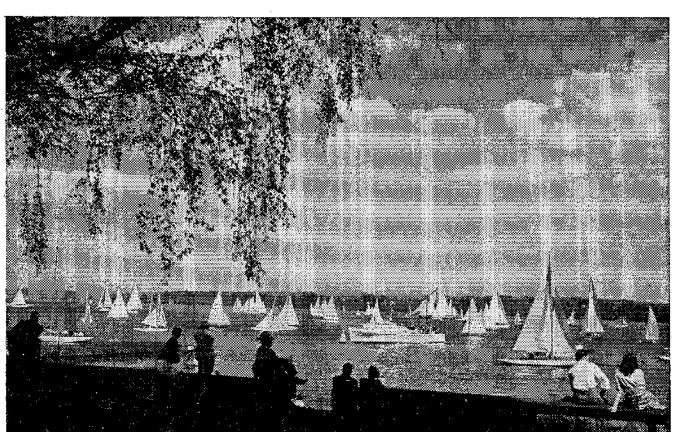

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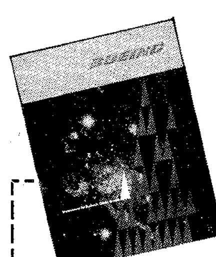

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Experience ....

BOEING

Personals . . . *continued*

ical supervisor here in Oklahoma in one of the four domestic divisions of the Pan American Petroleum Corporation."

Kam L. Wong writes that he's been working at Hughes Aircraft Company for almost 8 years and is now heading a group working on the reliability of an advanced electronic fire control system. The Wongs live in Culver City with their two children – LeRoy and Elaine.

1951

David G. Elliott, MS '52, received his PhD in mechanical engineering from Purdue University last March and is now a senior research engineer in the propulsion research section at the Jet Propulsion Lab in Pasadena. The Elliotts have a 2½-year-old daughter, Sandra.

Edwin A. Matzner, BS '51 biology, BS '51 chemistry, writes that "since leaving the smoggy Southland, I far outstripped the run-of-the-mold Harvard products and obtained a PhD from Yale University in organic chemistry (minor in teenage cavemanship). Besides claiming spiritual paternity of the New Haven riots last winter, I am now working for the Monsanto Chemical Company in St. Louis, Mo., lengthening the frontiers of science with painful ardor."

1953

Major Levi A. Brown, MS, writes that he received his promotion to Major in 1958. After three years in Japan, from 1954-57, he was stationed in Detroit with the Detroit District, Corps of Engineers, U.S. Army. He became a registered professional civil engineer in the State of Michigan in 1958. The Browns now have three children – Pat, 6, Tim, 5 and Mike, 1.

James T. La Tourrette, graduate student at Harvard University, writes that he now has a son, John Emery, born on March 28. The family is sailing on May 20 to begin a long-awaited year at the Physikalishes Institute Der Universitat Bonn in Germany on a National Science Foundation postdoctoral fellowship.

H. Robert Hunt, MS, writes that "since graduation I have been working for the California Company, except for a two-year stint with the Army at Aberdeen Proving Ground in Maryland. Military life proved uninspiring but provided opportunities for leaves to Bermuda and Europe. Although my experience in oil exploration has all been domestic thus far, I moved from offshore Louisiana to the Rocky Mountains, where I followed gravity crews – then to Mississippi, where I have been 'bird-dogging' a seismograph crew for the past two years."

1954

Franklin D. Dryden, MS '57, writes that he will be married on June 7, in Stockton, to Marianna Tuttle, a speech therapist for the Azusa School District. They originally met at Asilomar in 1956 when they were elected as co-chairmen of the Regional Student YM-YWCA. Frank is a design engineer for the L.A. County Sanitation District.

Curt Johnson, MS '55, is now with the Hughes Research Laboratories in Culver City where he is working on low-noise parametric devices. Curt got his PhD from Stanford in 1958. The Johnsons and their two children are living in the Palos Verdes area.

1956

Samuel R. Phillips, MS '57, writes that "after graduating, I joined *Jim Koontz,* '56, and *Dan Chilton,* '56, in the training program of the Joy Manufacturing Company, makers of mining machinery with headquarters in Pittsburgh. After 7 months and 10,000 miles, I wound up as half of the two-man R&D department of the Baash-Ross oil tool division in Houston. Early this year I started working for Cosmodyne Corporation in Manhattan Beach, a six-month-old company which designs auxiliary power units for space vehicles. I see a good deal of *Ross Brown,* '56, and *Gil Beebower,* '55. Ross is one of the original hands at Cosmodyne and so is *Dan LeMay,* '51."

Ted Johnson has completed Harvard Business School and is now working as a sales engineer for the Digital Equipment Corporation, a new company in Maynard, Mass.

1957

Major S. H. Carpenter is now Marine Corps liaison officer at NOTS in China Lake. After getting his degree at Caltech, Stan and his family moved to Edenton, N.C., where he was variously exec of Headquarters Squadron and MAG-14 Aircraft Maintenance Officer. At China Lake, Stan relieved *Major William C. Benton,* USMC, AE '55. The whole family, including a boy, 11, and the girls, 7, 3½ and 2, agree that the desert beats the swamps of North Carolina for living conditions.

Lt. James H. Berrian, PhD, who is in the Navy Medical Service Corps, represented the Research Institute of the National Naval Medical Center at Bethesda, Md., at the International Colloquium on Biological Problems of Grafting, held in Liege, Belgium in March.

Richard J. Kerr, PhD, is now production manager of Urethane Intermediates in the new chemicals group of the Union Carbide Chemicals Company, a division of the Union Carbide Corporation. He was formerly a new chemicals technical representative.

Career Opportunities at NASA

NASA directs and implements the Nation's research efforts in aeronautics and the exploration of space for peaceful purposes and the benefit of all mankind. We offer unique opportunities in basic and applied research to scientists and engineers with degrees in the various disciplines.

Briefly described here are representative current NASA programs. Openings exist in all of these programs, at the facilities named.

SPACE TECHNOLOGY

Space vehicle development, including basic planning, development, contract coordination, and operational programming and planning for manned and unmanned satellites. Systems studies for auxiliary power supplies, air regenerative systems, instruments, guidance and communication equipment for space vehicles.

Space probes: Development and operation of vehicles, payload and instrumentation, programming and operation of flight, trajectory, communication systems, and ground support systems for near space and deep space probes.

Beltsville

SPACE MECHANICS

Experimental and analytical study of orbital mechanics including parameters of preliminary and refined orbits, ephemerides, lifetimes, equator crossings and perturbations.

Beltsville; Langley; Ames

PROPULSION AND PROPULSION SYSTEMS

Developmental studies of boosters, launchers, multi-stage engines, guidance and attitude control systems for space vehicles.

Basic research on the interrelationships between electrical, magnetic and thermodynamic energy, and application of such knowledge to space propulsion.

Magneto hydrodynamics: Research on plasma and ion accelerators for space propulsion and auxiliary power systems.

Research on reactors and reactor shielding for aeronautical and space propulsion systems.

Beltsville; Lewis

AERODYNAMICS AND FLUID MECHANICS

Investigation of the thermodynamics and transport properties of gases at high temperatures as encountered in entry into planetary atmosphere.

Research on performance, stability and control, automatic guidance, and navigation for subsonic, supersonic, and hypersonic aircraft.

Aerodynamic heating and satellite re-entry phenomena.

Langley; Ames; Lewis; High-Speed Flight Station

(Positions are filled in accordance with Aeronautical Research Announcement 61B)

INSTRUMENTATION AND COMMUNICATION

Research and development of new sensing devices and instrumentation techniques in electronics, optics, aerodynamics, mechanics, chemistry and atomic physics.

Systems studies and evaluation of control, guidance, navigation, and communication equipment for space vehicles and other high performance applications requiring rugged and compact design.

All Facilities

GEOPHYSICS, ASTRONOMY AND ASTROPHYSICS

Experimental programs and evaluation studies of astronomical and geophysical measurement and scientific equipment used in space vehicle payloads.

Studies of fields and particles in space, investigations of the composition of planetary atmospheres, and development of instrumentation and experimental techniques for these investigations.

Beltsville

STRUCTURES AND MATERIALS

Investigation of the characteristics of high temperature structures and materials. Study of fatigue, structural stability, and other problems of structural dynamics.

Solid State Physics: Study of the elementary physical processes involved in mechanical behavior of materials, such as fractures; the nature of the corrosion process; and physical-chemical relationships governing behavior of materials.

Langley; Ames; Lewis

MATHEMATICS

Application of advanced mathematical techniques to the solution of theoretical problems in aeronautical and space research, involving the use of large modern computing equipment.

All Facilities

RESEARCH FACILITY ENGINEERING

Translation of research specifications into complete experimental facilities, involving mechanical, electrical, structural, architectural and machine design, and construction engineering.

Langley; Ames; Lewis

Please address your inquiry concerning any of the programs listed here to the Personnel Director of the appropriate NASA research center:

Langley Research Center, Hampton, Virginia
Ames Research Center, Mountain View, California
Lewis Research Center, Cleveland, Ohio
High-Speed Flight Station, Edwards, California
Beltsville Space Center, 4555 Overlook Ave., Washington, D. C.

NASA National Aeronautics and Space Administration

CALTECH CALENDAR

ALUMNI CALENDAR

June 10 — Annual Meeting
Rodger Young Auditorium

June 27 — Annual Picnic
Marineland

SUNDAY TELEVISION PROGRAMS

THE NEXT HUNDRED YEARS

Channel 4 — 4:00 p.m.

May 17
Measuring the Universe
— Halton C. Arp

May 24
Scientists of Tomorrow —
The Caltech Story
— L. A. DuBridge
The Caltech Glee Club

FRIDAY EVENING DEMONSTRATION LECTURES

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

May 22
Nuclear Energy
— Milton Plesset

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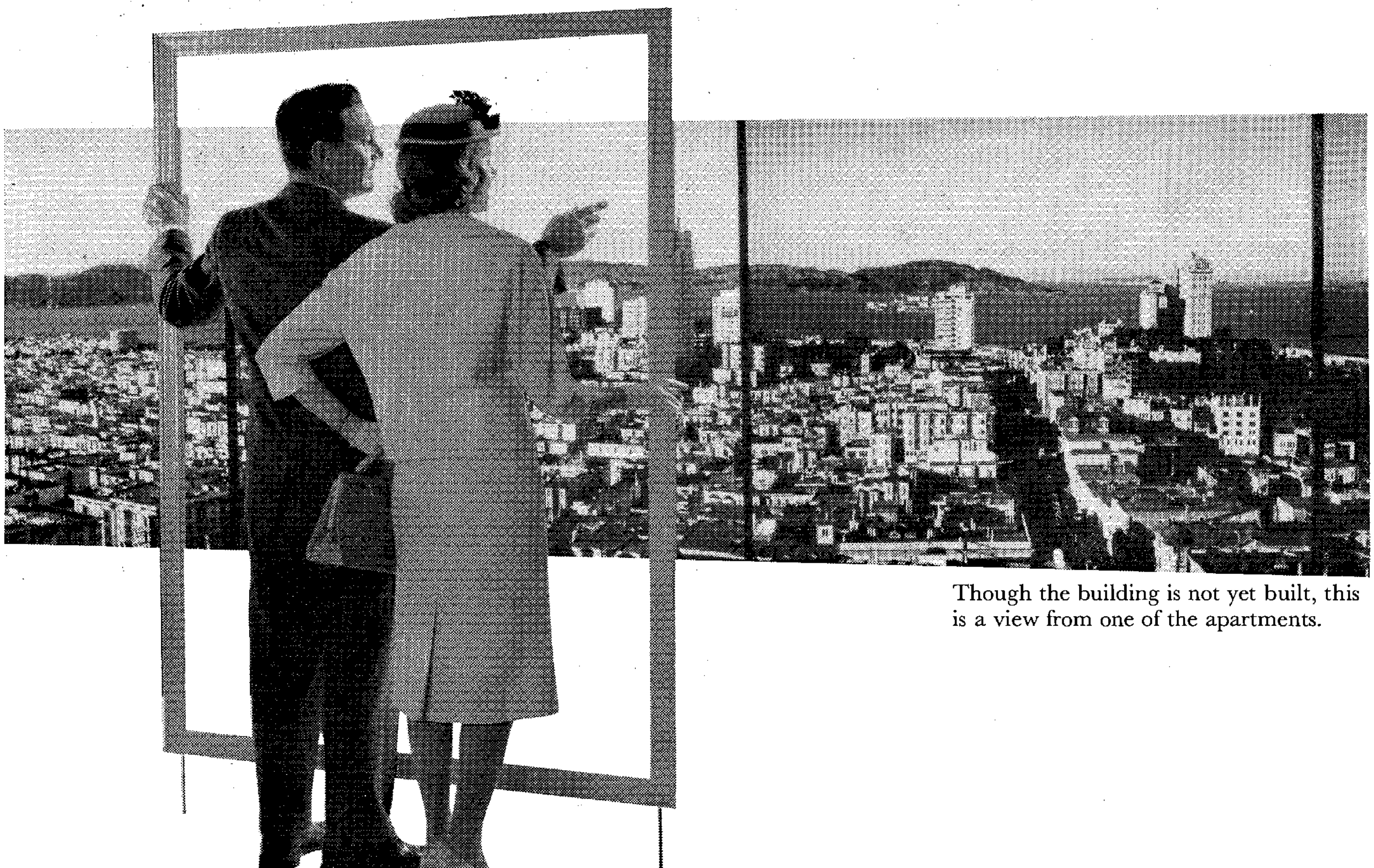
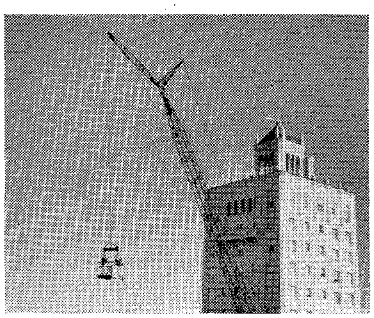


Though the building is not yet built, this is a view from one of the apartments.

How to look out a window before the building is up



With 180 "view" apartments to sell, the developers of The Comstock turned to photography to get a jump on sales

A feature of The Comstock, San Francisco's new co-operative apartments on top of Nob Hill, will be the spectacular panoramic views of the Bay area from their picture windows.

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