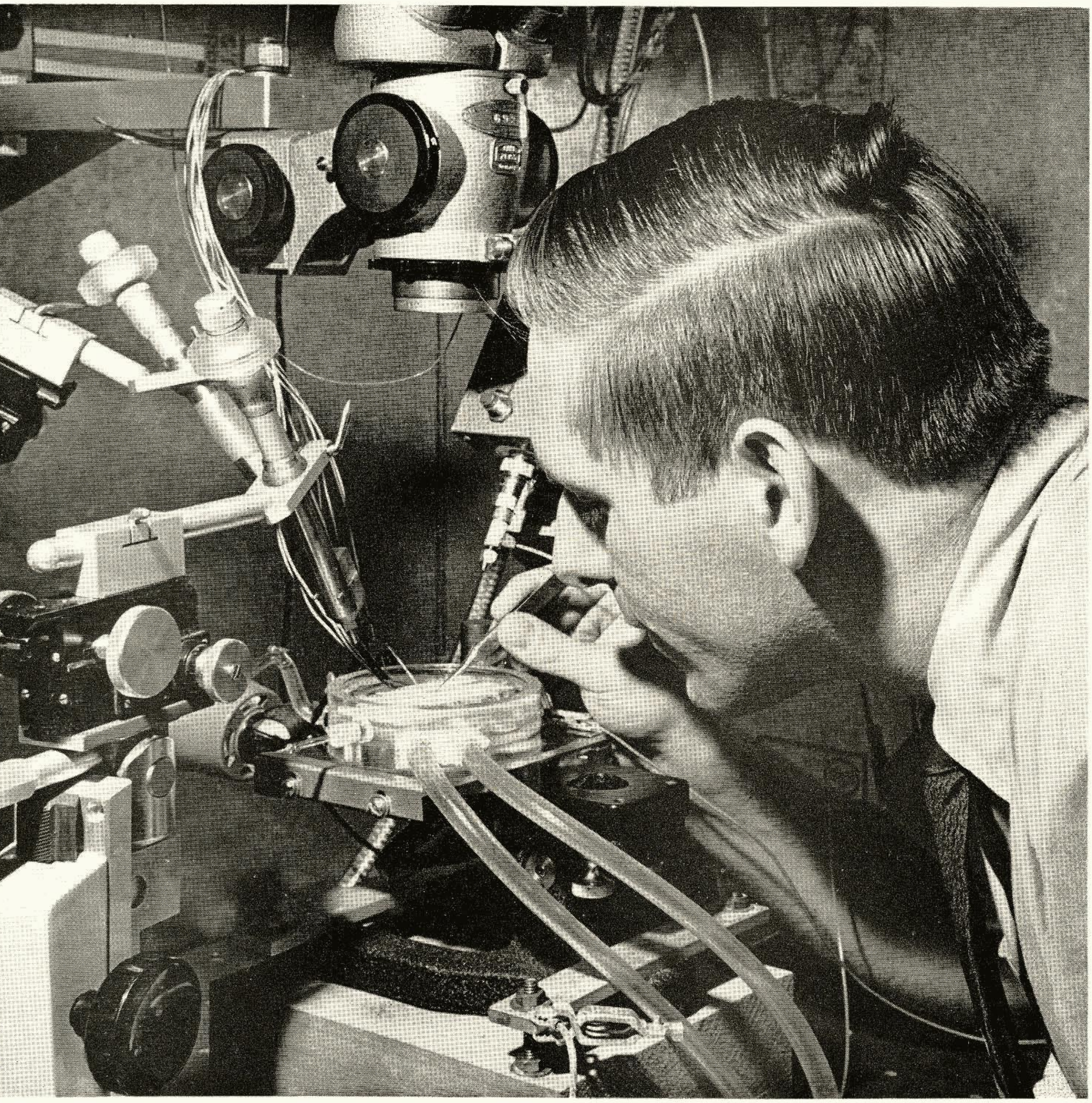
DECEMBER 1965

ENGINEERING AND SCIENCE



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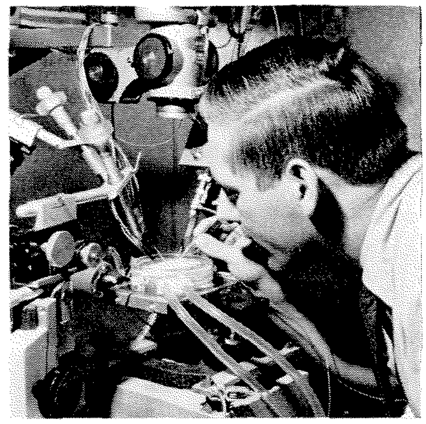

On Our Cover

Felix Strumwasser, associate professor of biology, makes some delicate adjustments of equipment in an electrophysiological station as he prepares to record the electrical activity of a nerve cell. For the past several years, he has been studying part of the nervous system of the sea hare, a large slug-like animal, in pursuit of basic information about the mechanisms that a nerve cell uses for information storage and retrieval. Among his findings are that certain single nerve cells from the sea hare can act as biological clocks and that their schedules can be modified by external means even after removal from the animal. The story is on page 12.

Alfred H. Sturtevant

has made many important contributions to genetics during his long career. In addition, he has known and worked with many of the distinguished biologists of the twentieth century. His recently published book, *A History of Genetics* (Harper & Row, $5.50), is a concise record that is enlivened by his considerable personal experience. One of the chapters, "The Genetics of Man," is particularly relevant today for both the scientist and non-scientist. It appears on page 14.

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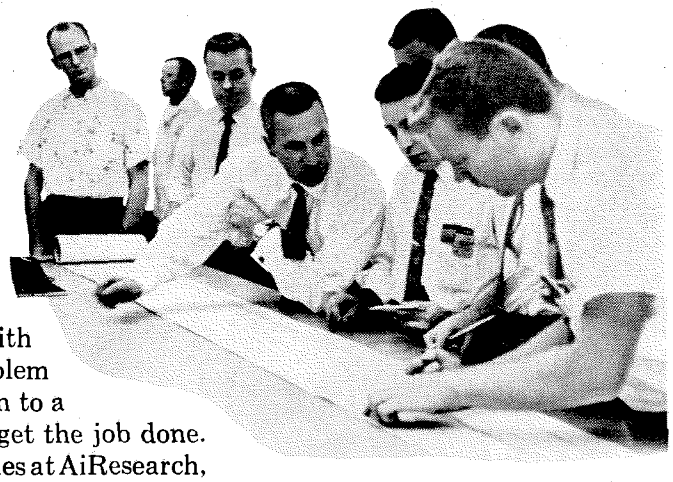

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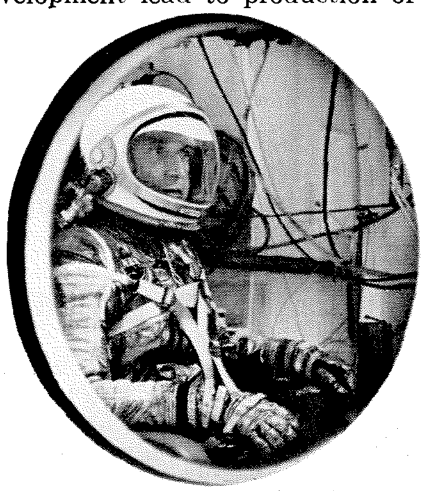

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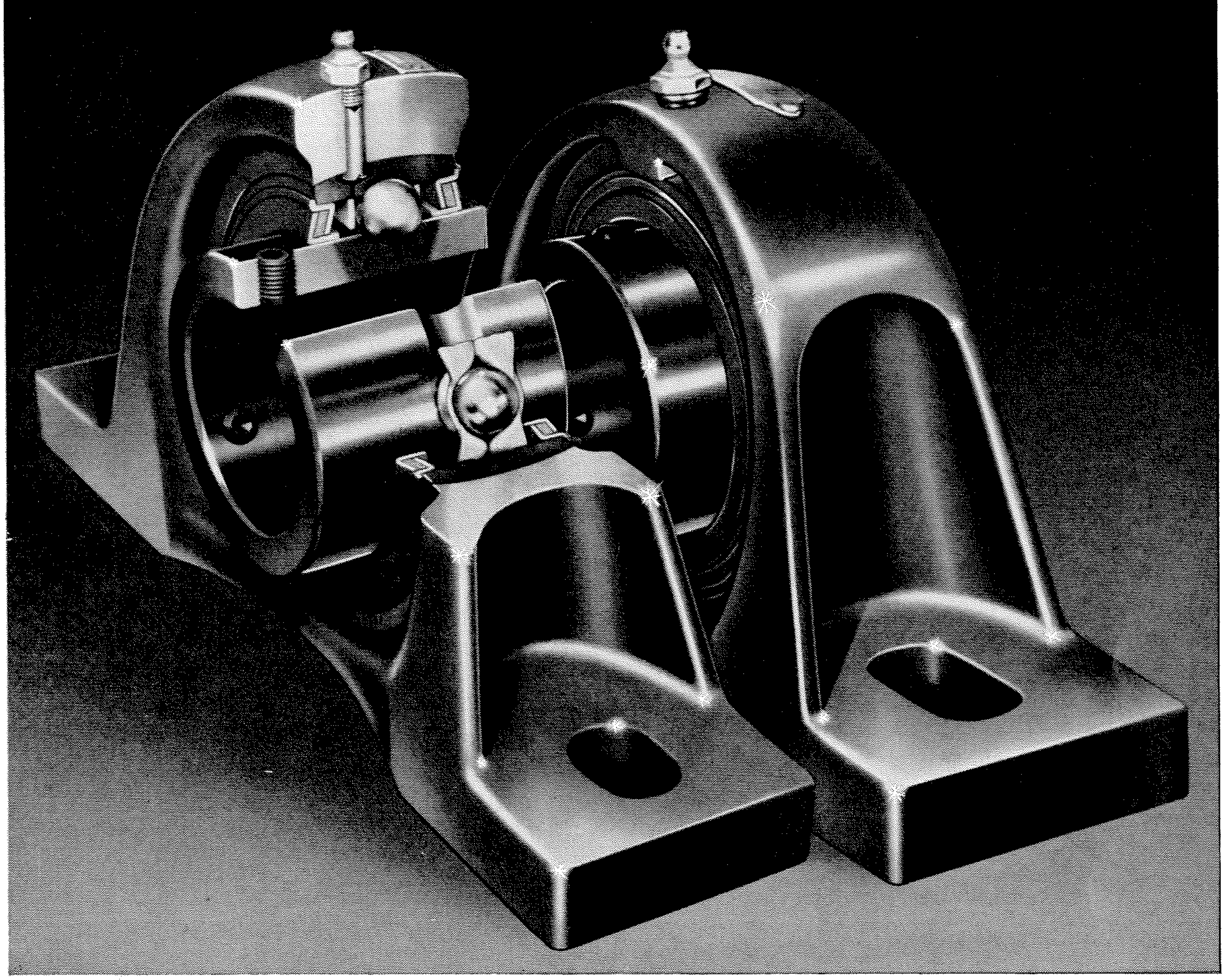

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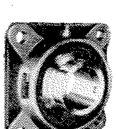

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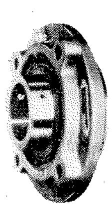

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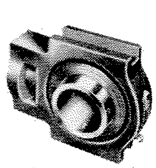

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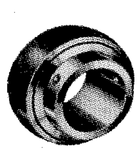

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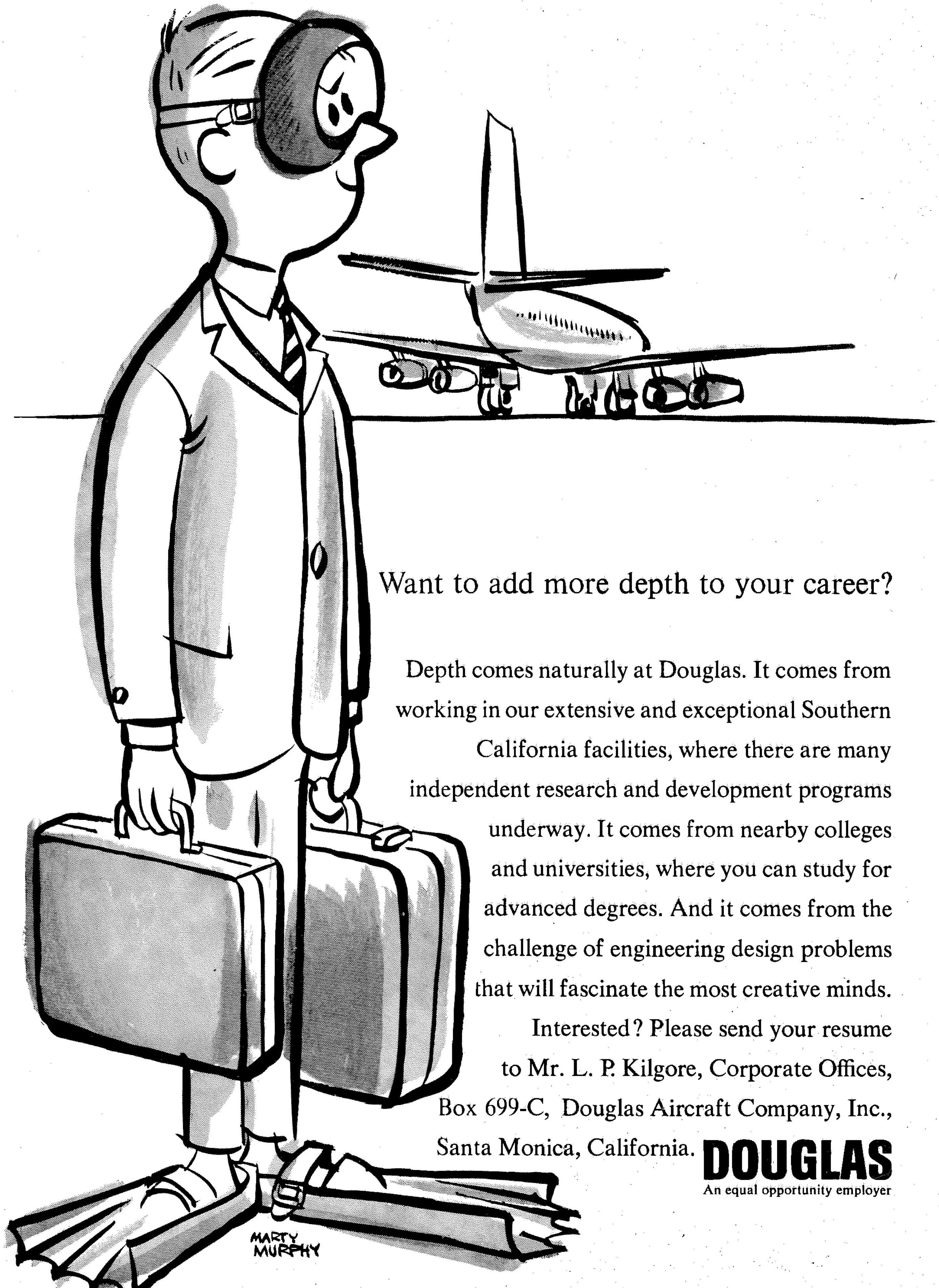

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ENGINEERING
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December 1965, Vol. XXIX, No. 3

AREAS OF NEW KNOWLEDGE

Some important, even astonishing, developments in our universities — and some thoughts on how to support them

by Lee A. DuBridge

Any discussion of higher education is so complex that no speaker or author can cover the whole field. I can select only a few topics and draw conclusions based on my own interests and experience. From a different set of relations another speaker may draw radically different conclusions. The poor layman who wants one simple yes-or-no, good-or-bad answer is disillusioned and disappointed.

It may be possible, however, to say a few things that will help us establish some principles on which we can begin to find answers in a multiplicity of special cases. The Pythagorean theorem in geometry, after all, enables us to solve an infinite number of geometric problems. Are there a few Pythagorean theorems we can discover in this field?

Before developing theorems, however, one must always set forth one's axioms or assumptions and attempt, where necessary, to justify these assumptions. The assumptions I am making are these:

1. *Science and engineering are of great importance to each other and to our society.*

2. *American universities play a vital role in advancing our knowledge in the fields of science and engineering.*

3. *Government and industrial agencies, as well as universities, play a prime role in putting our knowledge of science and engineering to practical use.*

4. *The progress of science and engineering is so important and so expensive that it is appropriate that both the public and private sectors of our economy participate in their support.*

It is no longer necessary—in the year 1965, in America—to attempt to support the thesis that the progress of education and research in science and engineering are vital factors in the growth of our economy and in the improvement of our society. Nevertheless, because other things are important to our society also, there are many people who deprecate the value of extending scientific knowledge, claiming that we should instead devote our energies and dollars to improving the moral, social, political, and economic aspects of our civilization.

I would not for a moment deny the importance of these areas of effort. I would only point out two things:

First, the solution to some of our social, economic, and political problems will surely depend upon further technological advances.

Second, it is not a question of either/or, since the energies and dollars devoted to science and technology need not be subtracted from the energies and dollars devoted to other problems.

As we contemplate some of the problems that modern civilization faces—including overpopula-

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"Areas of New Knowledge" has been adapted from an address given by President DuBridge at a conference sponsored by the Council for Financial Aid to Education, held in New York City on October 1, 1965.

tion, overcrowded cities, unemployment, juvenile delinquency—we are tempted to ask whether modern civilization is any better, after all, than the civilization of the Middle Ages. It is too bad that we cannot turn back the hands of time so that we could all experience briefly what life in the Middle Ages was really like. My guess is that we would return to modern living with great joy and relief.

If, then, we ask the question of what has made the difference between the year, say, 1665 and the year 1965, I think the answer would be that the primary difference lies in the extension of man's knowledge and understanding of the physical world.

We need only recall that the pioneering work of men like Galileo and Newton first led to the idea that man's world and his universe were governed by natural laws, and that these natural laws could be understood and put to effective use. The age of machinery and the Industrial Revolution soon followed. Later, the work of Faraday and Maxwell led to the age of electricity and to the modern age of electrical communications. The work of Bohr and Rutherford and Einstein led to the nuclear age. And the work of Schrödinger, Heisenberg, and others led to the quantum age in which quantum effects are put to use in such things as the transistor, the maser, the laser, and other devices just now coming into use.

Paralleling this development in the physical sciences has been an equally revolutionary development in biology and medicine as men have come to understand more and more thoroughly the evolution of life, the nature of disease, and, in recent years, the molecular basis of life processes, including the molecular basis of heredity.

Elementary particles

At the beginning of the present century physicists were beginning to understand the structure of the atom. A third of a century later they were beginning to understand the structure of the atom's nucleus. Today they are reaching a step beyond and are trying to understand the nature of the so-called "elementary particles" which are involved in nuclear phenomena. The role, behavior, and interrelationships of these elementary particles are still matters of mystery. At one time the accumulation of new facts outran our theories. Now the theories have nearly caught up with the facts and find themselves stymied until new facts can be learned. That is the reason for the present interest in very-high-energy accelerators—200 billion electron volts and above—since only at such energies can some of the basic facts about elementary particles be examined. No one can foresee what the practical results of understanding elementary particles will be.

There is also great excitement today in the fields of astronomy and of the space sciences. Radio and optical telescopes have discovered new kinds of objects in the sky which look like stars but which emit energy at a rate 100 billion times or more greater than previously known stars. There is a real mystery as to the source of this colossal energy. Are we witnessing the results of tremendous thermonuclear or hydrogen-bomb reactions on a grand scale? Or are we getting astronomical evidence for a new kind of energy-release process, possibly involving these same elementary particles themselves? We do not yet know.

The moon and the planets

As we send spacecraft into outer space, we are learning about the moon and the planets, and we are developing spacecraft from which astronomical observations can be made of the most distant objects in the universe. We have taken close-up television pictures of the moon. We have had our first somewhat crude but extraordinarily interesting pictures of Mars. We have measured important properties of Venus. Visits to these objects by both manned and unmanned space capsules will add enormously to our knowledge during the next decade and beyond.

As our eyes are turned to the moon and the planets, and as we try to understand their composition, structure, and history, our interest has also been enhanced in the planet which we call the earth. We are probing the depths of the oceans; we shall in a few years be drilling through the earth's crust to find what lies beneath; we are observing natural and artificial seismic waves bouncing back and forth through the interior of the earth, reading their messages as to its structure, composition, and condition. We shall be learning more about earthquakes and volcanoes. We shall be learning more about the motions of our atmosphere and the storms and weather changes which it carries. Someday we might even be able to do something about the weather.

Biologists and biochemists are untangling the structure, behavior, and properties of the most complex of all chemical molecules, DNA, and the role it plays in heredity and in guiding the development of living things. Those long, coiled, double-helical molecules which appear in fantastically twisted forms can now be unraveled and literally taken apart piece by piece while the structure and function of each piece is examined. We can identify the pieces that govern the manufacture of particular proteins and enzymes in living things and can trace the way in which the elaborate instructions, which come coded in the original DNA molecule, are transmitted cell by cell to guide the development of a living creature, whether it be a bacterium or a human being. We are getting closer to an understanding of the very basic chemical-physical processes in living things, and men are already visualizing the day when life forms can be synthesized in the laboratory.

Just how or when scientific discoveries will come into practical use will depend on the applied scientist (including the medical scientist) and the engineer. In every university and industrial laboratory the applied scientists are watching the new developments in basic science with great care, alert to the possibility of carrying these developments over into practical application. More than ever before scientists and engineers are maintaining close contact with each other. They are maintaining closer contact within our universities, and there is a closer contact between universities and industry and government laboratories.

I recite all this in support of my thesis that science and technology are of vast importance to the progress of our society.

What I have said also supports my second point —that the universities are the seat of these new developments. The universities of America and of other parts of the western world are the most exciting places imaginable at the present time. But they are more than centers for the advancement of knowledge; they are centers for the training of new scientists and technologists who will carry these developments into the future. They are also the centers for the training of our businessmen, our government officials, our professional men and women, our artists and writers. Let us hope that in their university studies these non-scientists are also getting a glimpse of the exciting advances in science and technology, so that their understanding of these can be carried into the professions, into business, into journalism, and into the government.

Supporting science and technology

I think what I have said also supports my final thesis: that modern science and technology are expensive and must be supported by all sectors of our society. Modern instrumentation in physics, in chemistry, in astronomy, in biology, in geophysics, as well as in engineering, has passed far beyond the days of string and sealing wax. Electronic data processing machines, elaborate spectroscopic equipment, space vehicles, nuclear accelerators, expensive radio and optical telescopes, and a host of other essential instruments of modern scientific and engineering research make the million-dollar project the commonplace one rather than the extraordinary one. It will cost $300 million to build a 200-billion-electron-volt nuclear accelerator. It costs tens or hundreds of millions of dollars to send a spacecraft to the moon, to Venus, to Mars—or simply to circle the earth. A modern electronic computer may cost several million dollars, and a host of essential research tools may cost $20,000 to $100,000 each.

It is not that scientists have simply become extravagant in their demands and are using complex equipment where simple equipment would do the same task. Old-fashioned equipment will not do the task at all or, in some cases, would do it only at a thousand or a million times slower rate of production of results. It is said, for example, that Kepler spent nearly a lifetime in computing the orbits of the planets around the sun and proving that these orbits were elliptical. Recently a graduate student decided to perform these same computations on a modern computer and found that, after he had spent a modest amount of time in programing, the entire computational procedure took him but five minutes. Very few men can afford to spend a lifetime making measurements and interpreting them. But when the measurements and calculations can be made in a few minutes or a few days, impossible projects come into the realm of possibility.

Some important developments

The facts I have been outlining have come to be widely realized in this country and have led to some important, and even astonishing, developments in our universities during the past 15 years.

1. There has been a great increase in student enrollment in the colleges and universities. This increase is partly due to the "population explosion" and partly due to the fact that a larger fraction of American high school graduates are seeking to attain some higher education. Rightly or wrongly, nearly everyone wants to go to college. In this exciting and complex world a college education is more and more necessary.

2. There has been a great expansion in the total university research program in the country. The growing interest in scientific and engineering research and the growing support of such research have lifted America into a position of world leadership in the progress of pure and applied science.

Both of these developments—enrollment pressures and expansion of research—have put great burdens on the financial resources of colleges and universities. Although the current financial needs have not been met fully, there has been substantial expansion in the support provided to institutions of higher education for both teaching and research. The sources of these funds are as follows:

1. *Federal funds,* largely devoted to the support of research in science, medicine, and engineering, for building laboratories, for teaching and research in these fields, and for the support of graduate fellowships. Only recently has the government entered the field of undergraduate scholarships and support for the arts and the humanities.

2. *State tax funds,* provided often in very large amounts to the state colleges and universities for expansion of physical plants, expansion of faculty, and the general support of teaching and research and other operating costs.

3. *Private funds,* for endowment, for buildings, and for operating expenses—largely, but not wholly, provided to the private independent colleges and universities. The sources of these funds have been individuals, private foundations, and corporations.

Even if we assume that the sum total of the funds available at the present time is adequate to our needs (which in truth it is not), one can easily grow alarmed as one looks to the future. The expansion in size of our colleges and universities continues. The expansion in the extent and intrinsic cost of research programs is on the increase. Faculty salaries and other operating expenses are rapidly rising. It would be an extremely conservative estimate to predict that the budget requirements for higher education in this country will double during the next ten years. Many experts would predict a higher rate of increase, but the conservative estimate is staggering enough to give us cause for concern and for action. Clearly, all sources of support—private, state, and federal—must participate in meeting this crucial problem.

The role of private support

Let us assume for the moment that state and federal sources will do their share in meeting this problem. While this is by no means a foregone conclusion, it is a useful working hypothesis. What, then, is the role of private support? What critical functions does it play? And what must be its relation to the various public sources of support?

Let me focus my remarks now primarily on the *private* institution—particularly the private university—with particular attention to that handful of institutions, be it 20, or 30, or 50, which have historically played the role of leadership in the progress of advanced education and research in all fields of knowledge and, more particularly, in the fields of science and engineering.

A typical private university in America today is largely or wholly independent of *state* tax funds, and receives its funds from either private or federal sources. The federal sources are confined largely to support of research and graduate education in the sciences and engineering.

In a typical private university, the total federal funds for these purposes may amount to between 30 and 50 percent of the institution's total operating budget, depending, of course, upon the relative size of its scientific research program. While 20 years ago the federal portion of the budget was far smaller than this, it seems to be true that in recent years the federal portion of a typical private university budget has not substantially changed.

Private and federal funds

There are many reasons why this ratio is leveling off. There are also many reasons why it *should* level off, and why future budgetary increases should be provided in approximately the present ratio by private and federal funds. There are three basic reasons for my belief:

1. It is unlikely that federal funds will be available to these universities along the rising trend which characterized the years before 1962.

2. In order to command and use federal funds, a university must have its own funds in at least equal amount in order to build the staff and facilities to support a research program that will attract federal funds.

3. Private funds are needed to maintain and support those activities which federal funds do not, probably will not, or cannot support.

As to the first point, it may seem surprising that one would predict that the major private universities in the country will not continue to receive rapidly increasing federal support in scientific and engineering areas or in other areas which the federal government will soon or may soon enter. The reason is very simple: There is a growing feeling in high circles in Washington that federal funds should be more "widely spread," that it is wrong for a relatively small number of institutions to receive such a large fraction of the total federal funds allocated for support of research and graduate education. Recent directives instruct federal agencies to spread their research support to lesser or "emerging" institutions and to give more attention to wide geographic support. *Thus, even though total federal funds should continue to increase, it is clear that the leadership institutions will receive a declining share of this support.*

Now, I am wholly in favor of placing research support widely throughout the country and in institutions which are sincerely striving for excellence in research and graduate study. However, several facts stand out:

First, the number of brilliant and creative research scholars in the country is limited.

Second, these scholars tend to congregate at institutions with strong research traditions, with excellent research facilities, including laboratories and libraries, where the individual will have many colleagues who can help and stimulate him not only in his own special field of interest but in related fields.

Third, the number of institutions which have built this atmosphere, acquired the staff, and, largely through their own funds, provided the research facilities, is relatively small. There are only a hundred or so institutions that even pretend to call themselves "universities" in the sense of having substantial graduate and research programs. About half of these could be classed as leadership institutions. Half of these, in turn, are private and half are public. Assuming that the public institutions will and should continue to receive state support, the problem remains: What shall be done with the top 25 private institutions in the leadership category and (let us say also) the next 25 institutions with the potentialities of emerging as leaders? Present federal policies will mitigate against a rapid rate of increase of the support of activities in these institutions. Thus, even though they wish to increase their federal support, they will probably have a difficult time attaining such an increase.

Federal support is not enough

On the other hand, there are urgent reasons why the private sources of support in these institutions must continue at least to equal the federal sources. First, for example, federal sources support only restricted areas of scholarship, and the university must support other areas in the humanities, social sciences, arts, business, law, and other fields not eligible for federal support.

Second, even in those areas where federal funds are available, they do not pay the full costs of maintaining the university's activities in those areas. Teaching costs are almost wholly neglected by the federal government; faculty salaries must be paid very largely by the university from non-federal sources; and the cost of new buildings must come primarily from private sources. Even for science buildings the federal government, if it assists at all, provides only one-third to one-half the funds on a matching basis.

Third, even in the areas of science and engineering, federal support is not uniformly available in various fields. Because much of this support comes from mission-oriented agencies—such as the Defense Department, the Atomic Energy Commission, the National Aeronautics and Space Administration, and the National Institutes of Health—there are broad areas of science and engineering left with inadequate federal funding. Some of these areas which are omitted are most critical to the future progress and prosperity of this country. If funds, personnel, and facilities are largely channeled into those areas of science and engineering which are related to health, atomic energy, space, and defense, the areas of consumer products, housing, building, transportation, air pollution, water supply, public safety, good urban living, and a host of other practical and urgent problems will be neglected.

A Pythagorean theorem

The Pythagorean theorem that I come to as a result of all these assumptions and arguments is simply this: *The present ratio of private to federal support in our leadership universities must be maintained.* That means that private support of operating costs in these universities must at least double during the next five to ten years. Only if this happens can the universities maintain their vital activities in non-science fields, maintain their faculty salary and teaching budgets, support those areas of science and engineering not eligible for federal funds, and generally maintain the health, integrity, vigor, and leadership that the future of higher education and the future of the country so insistently demand. Nothing less is at stake than the continuation of private enterprise in the university world. The growing federal trend toward egalitarianism in higher education is wholly contrary to the meaning and value of higher education. Education and research depend upon a few brilliant people. Only they can carry on these critical tasks, and they must be supported wherever they may be found.

Innovation has always been a characteristic of private rather than of government enterprise. It is true in higher education, as it is true in business and industry.

Private fortunes, private benefactions, private foundations, and private industry have built private higher education in America. They can be proud of the structure they have created. If they abandon the structure to the whims, the controls, the inequalities, the imbalances of federal support —valuable as it may be in itself in its appropriate and proper field—American higher education will be destined to stagnation and decay. I believe no one would wish to see this happen.

BIOLOGICAL CLOCKS AND NERVE CELLS

Eventual understanding of the mechanism of man's memory may owe a great deal to current experiments using a large ocean mollusk called a sea hare, in which certain single nerve cells have been found to act as biological clocks, producing patterns of electrical pulses that reflect natural cycles in the sea hare's environment. Felix Strumwasser, associate professor of biology, by instrumenting and studying the electrical activity of the animal's extremely large nerve cells (up to one-half millimeter diameter), has found that certain individual cells produce pulse bursts at the time of transition from night to day and day to night. In addition, cyclic variations in the time at which the pulse bursts occur correspond to similar variations in the bi-monthly ocean tides.

The sea hares can be entrained to artificial light/dark cycles in the laboratory in about three days. Once studies of the nerve cells begin, these artificial cycles govern electrical activity, even though the light cycling is discontinued.

These electrical pulses, which are a little less than a tenth of a volt, are recorded through an electrode made of a finely drawn glass tube filled with a saline solution, which is inserted through the cell wall. Electrical activity continues for about 48 hours after the ganglion containing the nerve cells is removed from the sea hare; however, longer cycles can be investigated, since it has become possible to culture the ganglion for periods of at least one month after removal. Moreover, because the same cells are identifiable in other sea hares, nerve cells from a colony of animals taken from the same location can be studied "in tandem" for longer periods of time.

The particular cells used are in an abdominal ganglion, which is concerned with feeding, respiration, excretion, reproduction, and protection – some of which must rely on time of day and tides.

Pulse rates vary from a few per minute during quiet periods to about 40 per minute at "dawn," and remain that high for about three hours. There is less activity corresponding to "dusk," indicating that it is probably less important to the sea hare.

The mechanisms by which information can be stored chemically within the cell, then converted to an electrical discharge at the cell membrane at some later time, then transferred between cells chemically are not yet known. They are key questions in biology. There are, however, indications that messenger RNA is involved in one aspect of the read-out process, and Dr. Strumwasser is investigating this involvement.

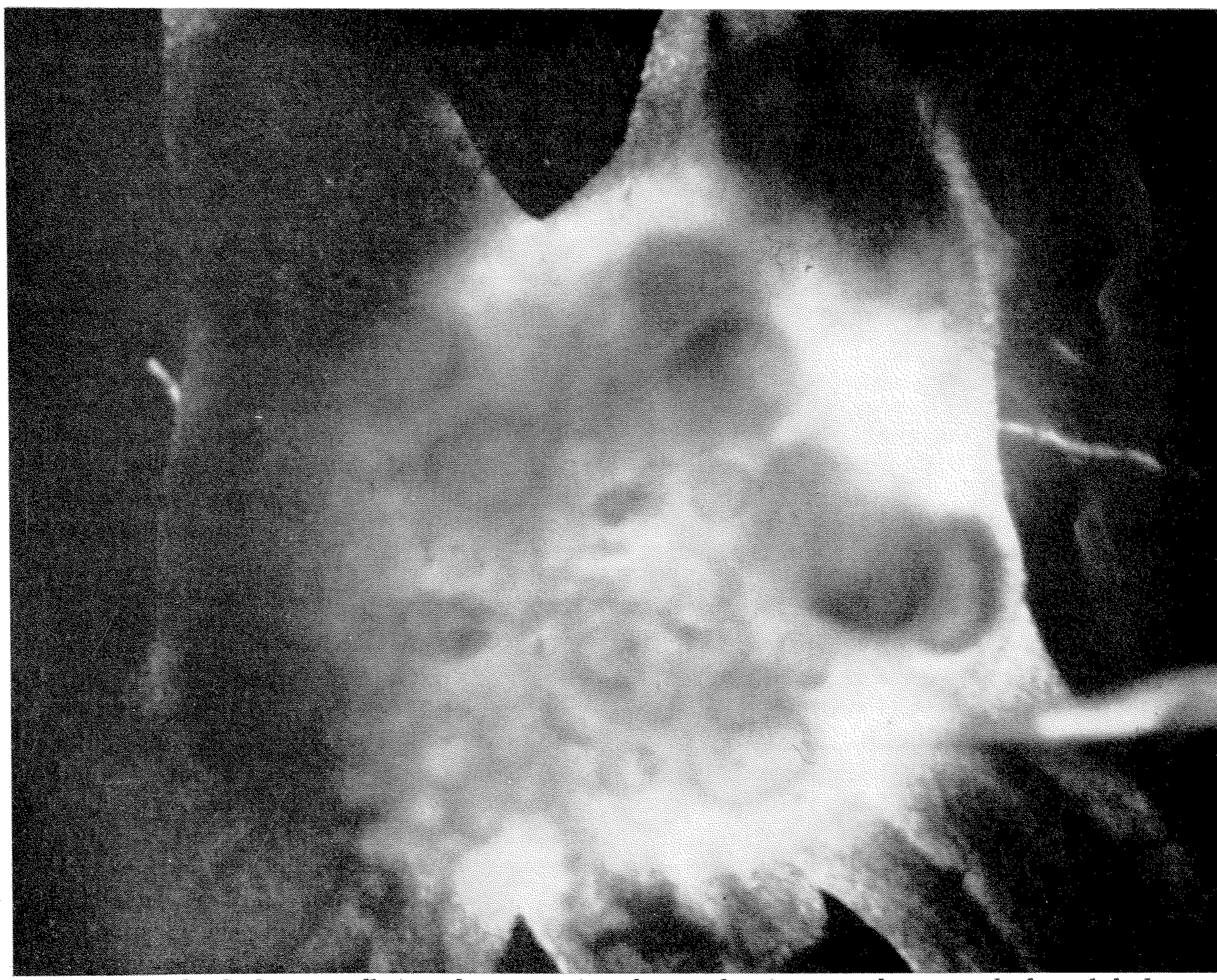
He believes that the electrical impulses are induced by build-up of an excitatory chemical substance in the nerve cells that is triggered by a timed production of messenger RNA. Nerve cells in the sea hare, as well as those in other animals, are unusually rich in RNA. In many of the sea hare's nerve cells, the DNA-rich nuclei occupy about half the cell body's space. Yet these nerve cells do not divide in the sea hare (nor in the human brain). Nor do they export many different chemical agents, since each nerve cell is known to produce only one chemical transmitter substance. Therefore, the large amount of nucleic acid must be used for other purposes.

Evidence that there is a timed release of a stored excitatory substance has been found with several different experiments. In one, the temperature of the nerve cell's salt water bath was increased from 58° to 76° for an hour. When the heat was applied during the cell's projected night cycle, it caused release of the excitatory substance, resulting in a premature expression of the pulse burst that, in the absence of heat treatment, would have occurred at the light/dark transition. Heat applied in the light cycle produced little or no effect, possibly because there is no excitatory substance built up in the cell at that time.

Another experiment showed a direct link with RNA activity in the cell. Actinomycin D is a substance that, by binding to DNA, can inhibit the synthesis of RNA. It is also possible that when it binds to the DNA it displaces messenger RNA, which then moves out into the cytoplasm. When this substance was injected into a nerve cell during the dark period, it caused a large pulse burst almost immediately and, as in the case when heat was applied in the dark period, eliminated the expected response at the time of light/dark transition. When injected during the light period, it caused only a small burst, after which all electrical activity stopped, as if the cell had died. However, 24 hours later there was another large burst, timed not with the light/dark transition, but with the injection of actinomycin D. The nerve cell had been reset by the drug.

Dr. Strumwasser began this work at the Walter Reed Army Institute of Research in Washington, D.C., and has been continuing it at Caltech under sponsorship of the Air Force Office of Scientific Research and the National Aeronautics and Space Administration. He is now beginning experiments to determine if the amount of messenger RNA in the cell's cytoplasm increases just before and during the heightened electrical activity.

One of the interesting techniques he is now trying makes use of autoradiography, in which uridine (one of the bases in RNA) treated with tritium is injected into the cell, where it is incorporated into RNA being manufactured. Ganglia are then frozen at various stages of the electrical cycle and cut into thin sections. The sections are coated with photographic emulsion, in which silver ions are reduced by the emission of electrons from the radioactive RNA. The result is a visual record, in the form of black dots, of RNA concentrations. Comparison of sections made at different times shows the RNA movement within the cell. If the quantity of messenger RNA does increase at the time of electrical activity, it will indicate RNA involvement in recall, one of the important components of memory.



Some of the individual nerve cells (circular features) in this ganglion from a sea hare act as biological clocks, using electrical pulses to communicate with other cells. A micro-electrode (entering a cell from the lower right of this picture) detects this electrical activity, which is then recorded and correlated with the time of environmental cues previously given to the sea hare. The width of the ganglion shown here is about three millimeters.

Alfred H. Sturtevant, Thomas Hunt Morgan Professor of Biology, Emeritus

THE GENETICS OF MAN

by A. H. Sturtevant

Man is, in many ways, very unsuitable as an object for the study of genetics. Families are too small for dependable determination of ratios, desired test matings cannot be made, and study of more than a very few generations for any particular purpose is not often possible. The social implications of human genetics are so great, however, that the subject *must* be investigated; and there are some real advantages in the material. For no other organism do we have such detailed and extensive information on anatomy, development, biochemistry, physiology, pathology, evolution, and population statistics.

A large list of more or less clear-cut Mendelian differences in man has gradually been built up, largely concerned with relatively rare defects or with less obvious biochemical variations such as blood groups, hemoglobin types, or variations in urine composition.

These cases have been important in the understanding of the genetic components of some diseases and have also been occasionally helpful in diagnosis. Mainly for these reasons, many medical schools now have departments of medical genetics, and several standard books on the subject have been published. The clear-cut cases have also been of importance in physical anthropology.

The more obvious and familiar human differences, such as stature, hair form and color, eye color, skin color, right- vs. left-handedness, or fingerprint patterns, although obviously inherited, are difficult to analyze. In other mammals, hair color and eye color are among the best understood of the inherited characteristics, but in man there are so many intermediates that analysis is difficult. Red hair and blue eyes are often listed as due to recessive genes, which they may be, but in both cases classification is often uncertain, and if one depends on the usual popular descriptions, there will be contradictory observations.

Even more difficult to analyze are mental prop-

"The Genetics of Man" is adapted from A. H. Sturtevant's book, A History of Genetics, *published last month by Harper & Row.*

erties, and obviously these are the human characteristics that are of the greatest interest and importance to society. At the sensory level, there are well-established Mendelian differences that must have indirect effects on behavior—such things as taste sensitivity, night blindness, or color blindness. Since I am partially color blind, I am acutely aware of some of the effects of my relative insensitivity to redness. Sunsets or desert colors are clearly lesser sources of esthetic satisfaction to me than they are to most people, and I am so unaware of the redness caused by inflammation that I could never have been a successful practicing physician.

At the other extreme, there are more or less clearly established Mendelian cases that involve serious mental conditions—such things as Huntington's chorea and phenylketonuria.

It is the range between these extremes that is both the most interesting and the most difficult to analyze. One of the first attempts was made by Galton. He was responsible for the expression "nature vs. nurture" in the determination of human characteristics, although it is probable that he assumed his readers would recognize Shakespeare as the source of the expression (in *The Tempest*, concerning what led to Caliban's character). Galton (1869) collected a series of pedigrees showing the concentration of particular kinds of exceptional achievements in particular families, such as musicians in the Bach family. He minimized the effect of family tradition and concluded that the results were primarily due to biological inheritance, despite one case that he pointed out but did not emphasize. In the Roman family of the Scipios there was an extraordinary concentration of generals and orators, but one of them (Scipio Aemilianus) "was not of Scipio blood" but was an adopted son, suggesting (though not to Galton) the importance of family tradition rather than genetic composition.

This same approach was later followed by Davenport (*Heredity in Relation to Eugenics*, 1911). Here there is a description of the Tuttle-Edwards family of New Haven, from whom descended two presidents and one vice president of the United States, six college presidents, and other notables; and of the Lees of Virginia, who ran to generals and political figures. There follow accounts of the Jukes and Kallikak families, with their dreary procession of prostitutes, thieves, drunkards, and paupers. Here again was little or no recognition of the overwhelming importance of family environment and of the resulting opportunities or lack of opportunities in these examples. Surely Davenport must have understood that a potential college president, or member of the Virginia legislature, born into a Jukes family would have had no chance of realizing those potentialities—but the book does not bring out this point.

Similar views have been expressed since 1900 by other biologists—including some who were more sophisticated than Davenport. Two examples follow:

Bateson (1912, "Biological Fact and the Structure of Society," Herbert Spencer lecture, Oxford):

Alfred H. Sturtevant

is a distinguished elder statesman of biology who is recognized as a pioneer in the study of genetics. His career began nearly 60 years ago at Columbia University where he was a student of Thomas Hunt Morgan. Together with Morgan and several other brilliant colleagues (including Hermann Muller and Calvin Bridges), he studied the genetics of the fruit fly Drosophila in a small, crowded laboratory that came to be called the "Fly Room." There, modern genetics, which had its basis in Mendel's unheralded work 50 years before, finally came of age. Results of the early work done at Columbia were published in 1915 in a monumental book by Morgan, Muller, Bridges, and Sturtevant, *The Mechanism of Mendelian Heredity.*

After receiving his PhD from Columbia in 1914, Dr. Sturtevant remained in the Fly Room as a Carnegie Institute research fellow. His work through the 20s included discovery that a gene's action depends on what genes are next to it in the chromosome—the phenomenon of position effect. He studied sex determination, and sexuality and sexual selection. He worked out the non-random segregation of the tiny, fourth chromosome in Drosophila. He drew new conclusions about evolution from studies of inversions of chromosomes. He investigated the comparative genetics of Drosophila and found the same gene showing up in different species. He recognized that a gene can exist in multiple alternative forms. He worked on the bizarre aspects of evolution in the social insects, where selection operates not so much on what the individual is, as on the groups into which his progeny fall. He made important contributions to understanding the sterility of hybrids. And he has delved into the genetics of organisms having more than two sets of chromosomes in his studies of iris.

In the course of this work he came, with Morgan, to Caltech in 1928 to take his place in the newly organized division of biology and for five years after Morgan's retirement in 1941 was a member of the team of four administering the division. In 1951 he was named the first Thomas Hunt Morgan Professor of Biology at Caltech. In 1962 he retired, but still continues his research activities on the campus.

In addition to extensive participation in professional organizations, Dr. Sturtevant has received many honors, including the Kimber Genetics Award from the National Academy of Sciences in 1957 "for his distinguished career as discoverer and interpreter of fundamental genetic phenomena"; and the Carty Medal of the National Academy of Sciences in 1965 "for noteworthy and distinguished achievement."

Much of the discussion about nature versus nurture has been on the emotional level, because unambiguous objective evidence is so difficult to get.

"How hard it is to realize the polymorphism of man! Think of the varieties which the word denotes, merely in its application to one small society such as ours, and of the natural genetic distinctions which differentiate us into types and strains – acrobats, actors, artists, clergy, farmers, labourers, lawyers, mechanics, musicians, poets, sailors, men of science, servants, soldiers, and tradesmen. Think of the diversity of their experience of life. How few of these could have changed parts with each other. Many of these types are, even in present conditions, almost differentiated into distinct strains . . . I never cease to marvel that the more divergent castes of civilized humanity are capable of interbreeding and of producing fertile offspring from their crosses. Nothing but this paradoxical fact prevents us from regarding many classes even of Englishmen as distinct species in the full sense of the term."

Darlington (1953, *The Facts of Life*): "In England, for example, it is not lack of research which limits food production but the genetic unfitness of a large part of the tenant farmers, the legally secured occupiers who are organized to keep better men off the land."

Such extreme views have not gone unchallenged. Especially among anthropologists (largely under the influence of Boas) and among psychologists there has been a strong tendency to minimize the effects of genetic composition on human behavior. The most extreme statement of this position that I know is by Watson (1925, *Behaviorism*): "In the case of man, all healthy individuals . . . start out *equal.* Quite similar words appear in our far-famed Declaration of Independence. The signers of that document were nearer right than one might expect, considering their dense ignorance of psychology. They would have been strictly accurate had the clause 'at birth' been inserted after the word equal."

Much of the discussion of this question has been on the emotional level, because unambiguous objective evidence is so difficult to get. By and large, the extreme proponents of genetic determination have tended to be political conservatives with their views ultimately rooted in the caste system of feudalism, while the extreme advocates of environmental control have tended to represent a political philosophy derived more from the egalitarianism of the French Revolution.

As it happens, the most effective approach to this question was initiated by Galton (1883, *Inquiries into Human Faculty*). In a series of studies on pairs of twins, he recognized that they were of two kinds, "similar" and "dissimilar," and concluded that these arose, respectively, from a single fertilized egg and from two independently fertilized eggs. This conclusion has since been confirmed by embryological evidence and by extensive genetic studies; the two types are now usually referred to as monozygotic (or identical) and dizygotic (or fraternal). Galton saw that they offered an opportunity to test the relative importance of nature and nurture, since the monozygotics should be alike in genetic makeup, whereas the dizygotics should be no more alike than ordinary brothers and sisters. He carried out a few tests on mental properties and concluded that the monozygotics were in fact more alike in behavioral attributes.

The next step was taken by Muller (1925). He found a pair of monozygotic twins who had been separated in early life and brought up in different families. He gave them a series of psychological tests, and found them to be quite similar. This method was greatly extended by Newman, Freeman, and Holzinger (1937). They found a considerable series (20) of such separated monozygotics and, as controls, carried out the same tests on a series of monozygotics, and also of dizygotics, reared together. The book makes fascinating reading – especially the detailed case histories – but the authors admitted to disappointment at the inconclusiveness of the results. Later series of such studies have also been rather disappointing, although there can be no question of their importance. Among the difficulties encountered may be mentioned the uncertainty as to just what the psychological tests are measuring, the varying ages at which the separations took place in the different pairs, the inaccuracy of the underlying tacit assumption that twins reared together are exposed to identical environmental effects, and the circumstances that the separated twins were usually reared in rather similar families (never was one brought up as a Lee and his twin as a Jukes). Nevertheless, these studies have convinced most unbiased students that there is an appreciable inherited com-

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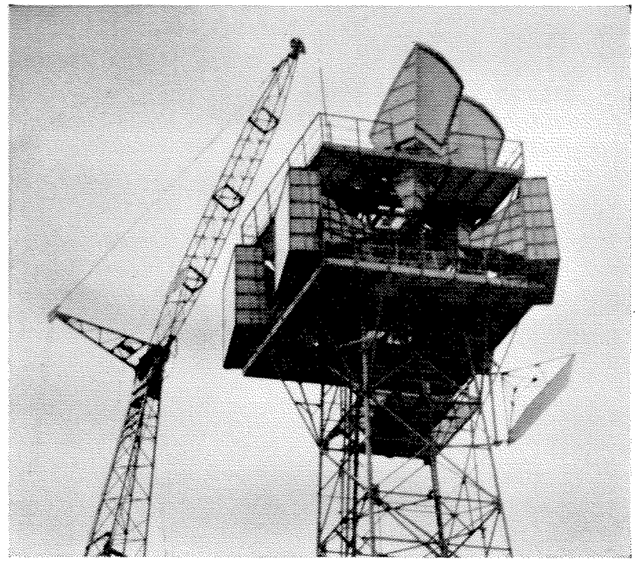

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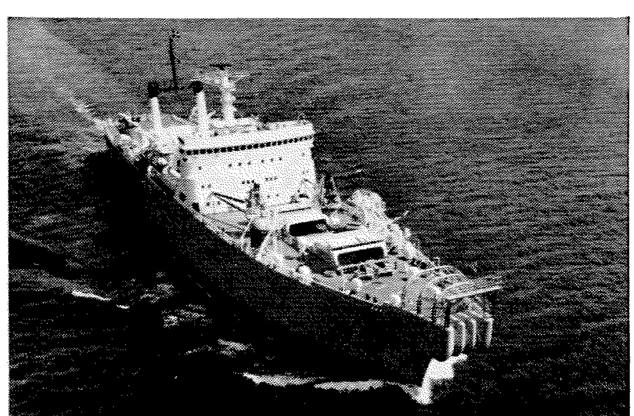

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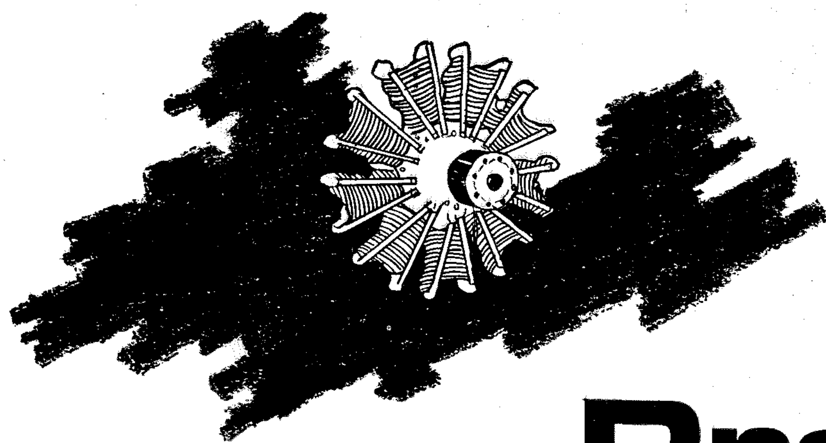

The Company's first engine, the Wasp, took to the air on May 5, 1926. Within a year the Wasp set its first world record and went on to smash existing records and set standards for both land and seaplanes for years to come, carrying airframes and pilots higher, farther, and faster than they had ever gone before.

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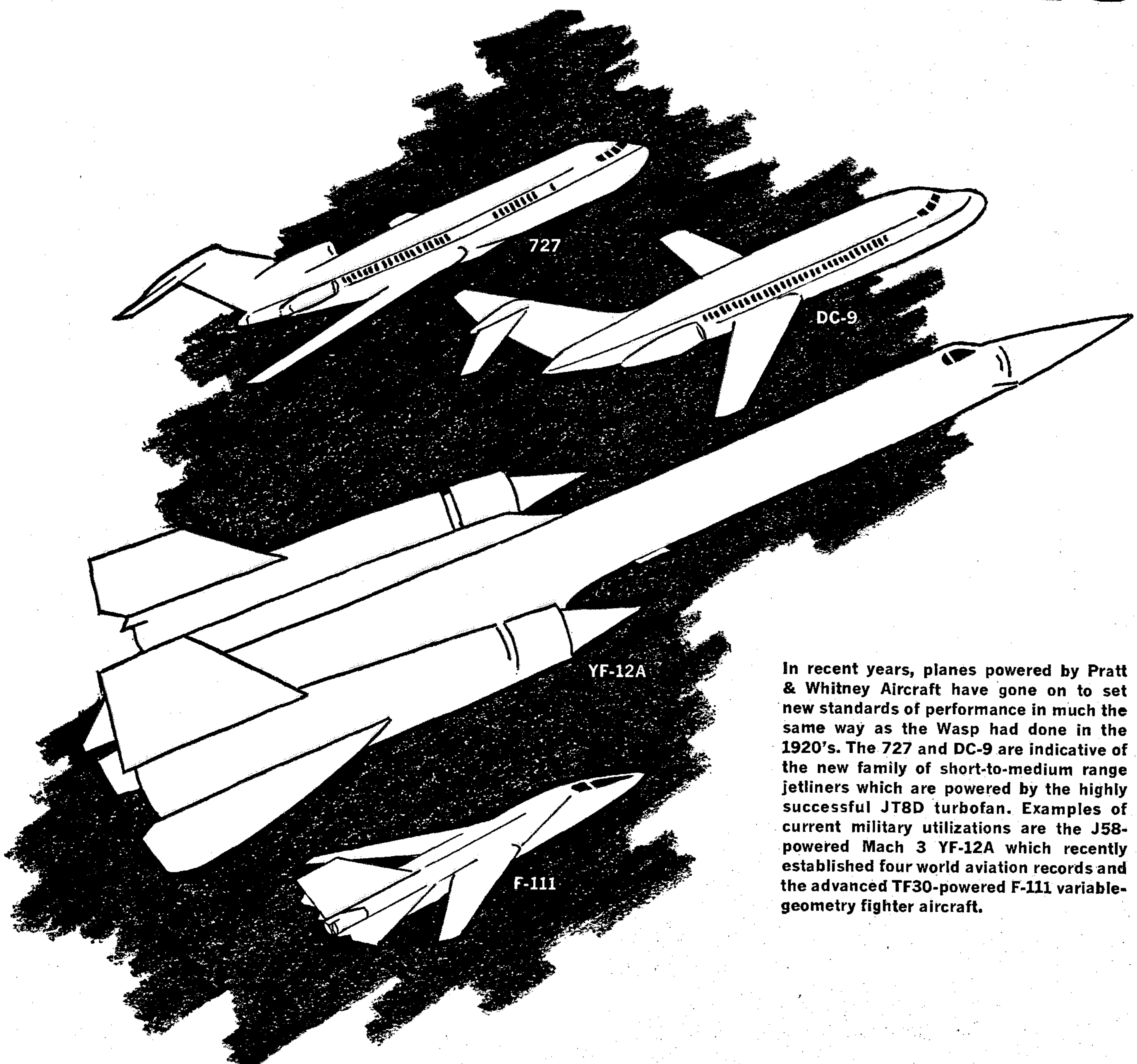

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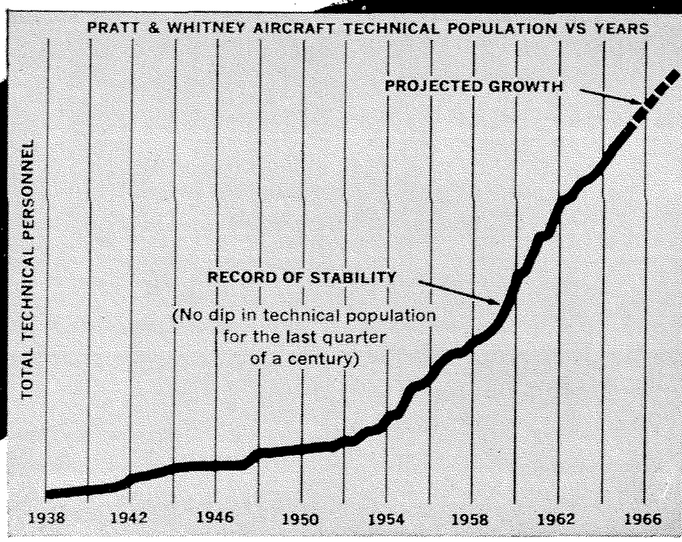

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ponent in the determination of human mental differences.

The difficulties of objective study of mental differences reach their maximum in the case of racial differences. If it be admitted that there are inherited individual differences, then on general grounds one must conclude that there are statistical differences between races. If one is inclined to look upon individual mental differences as largely genetic in origin, he then is likely to consider the observed (or imagined) cultural differences between the races as being genetically determined and to conclude that some races (inevitably including the one to which he belongs) are inherently superior. The extreme examples of this attitude have not usually been scientifically trained; the terrible example is Hitler, of course, but he was preceded by many pseudo-scientific writers (such as Gobineau, Houston Chamberlain, and Madison Grant), most of whom would have been horrified by Hitler's methods. There have, however, been biologists with some background in genetics who have leaned in this direction. Since *racism* is a dirty word, it is perhaps kinder (and certainly more agreeable to the writer) not to name them.

Can genetics be controlled?

Galton was one of the first to suggest the possibility of the genetic improvement of human populations; he introduced the word *eugenics* to designate this field of study and planning. There are two approaches here, which have been described as "negative" and "positive." The first proposes to decrease or eliminate the more extreme inherited defects – physical and mental – and the second proposes to increase the number of better individuals, and thereby to make possible the production of still better ones. Both approaches, especially the positive one, are based on the obvious success of animal and plant breeders in improving the populations with which they work.

It is estimated that something like 4 percent of human infants have tangible defects that can be detected in infancy – some of them very serious and others much less so, and some of them remediable and others not. It is also estimated that perhaps about half of these are largely genetic in origin. If it were possible to eliminate these by preventing their birth, this would obviously be a great advantage to society, in economic and, especially, in humanitarian terms.

In the early days of Mendelism, there were many people who felt that this objective could be rather simply achieved, but with increased knowledge this hope has been somewhat dimmed. The easiest class of defects to eliminate should be the dominant, but it has turned out that the more serious of these are apt not to appear until the normal reproductive age has largely passed (the typical example here is Huntington's chorea). Presumably those that appear earlier in life have, for the most part, been eliminated by natural selection. Any appreciable decrease in the incidence of recessive defects would depend on the identification of heterozygous carriers – which is not usually possible. There has also come to be a growing realization that, in some cases, heterozygosis for a particular gene may (at least under certain conditions) confer an advantage even when homozygosis is very disadvantageous. The best-known example here is sickle-cell anemia in man. Homozygosis for this gene causes the serious defect from which the name is derived; but it was shown by Allison (1954) that heterozygosis for it confers considerable resistance to malaria and so is of selective advantage where malaria is prevalent. It remains uncertain how frequent this type of relation is, but the possibility suggests that caution be exercised in any attempt to eliminate undesirable recessives. A further point has been emphasized by Haldane, namely, that a recessive which interferes with the fertility of the individual must be retained in the population largely by recurrent mutation and therefore cannot be eliminated by artificial selection, although its frequency may be reduced.

Who sets the goals?

Positive eugenics seems even more difficult, for several reasons. It is evident that animal breeders have, by selection from mixed populations, produced many reasonably uniform breeds, possessing desired characteristics and including many individuals more extreme in these respects than any found in the original population. There is no reason to doubt that similar results could be obtained with human populations. But there is a whole series of obvious difficulties – of which the greatest is: Who sets the goals? Who functions as the animal breeders have, in determining the basis of selection? Obviously no sane person would want a Hitler to have this power and responsibility, and most of us would agree with Bateson in mistrusting even a committee of Shakespeares.

The Month at Caltech

Grant for Star Study

The Institute has received a $357,200 grant from the National Science Foundation to support continuing nuclear astrophysics research under the direction of William A. Fowler, Caltech professor of physics. The funds are to finance further studies on the structure and evolution of celestial objects and on the synthesis of the chemical elements in them. These include meteorites, the sun and other stars, the material in space between galaxies, and quasars.

Dr. Fowler, who has been the principal investigator in this research, will work with some 15 other scientists, including Gerald J. Wasserburg, professor of geology and geophysics; John N. Bahcall, assistant professor of theoretical physics; Donald S. Burnett, assistant professor of nuclear geochemistry; and Fred Hoyle, visiting associate in physics.

The work of the Caltech group covers six broad areas:

1. The synthesis of the elements in stars. Dr. Fowler said he now believes that the heavier elements were created in such grand catastrophies as explosions involving stars millions of times more massive than the sun.

William A. Fowler

2. Properties of super-massive stars as possible models for the mysterious quasars. The nature of these most energetic objects in the universe intrigues astronomers. The quasars may be enormous stars unlike any that have been observed in our galaxy.

3. Use of the bright light from the distant quasars to reveal something about the composition and excitation of the matter in space between them and the earth.

4 Calculations of stellar structure and evolution based on the rates of nuclear reactions that are determined in the laboratory. Many of these rates are obtained with the electrostatic accelerators in Caltech's Kellogg Radiation Laboratory and in its Sloan Laboratory of Mathematics and Physics.

5. Development of methods to test directly by observations the theory that the sun and stars shine because of nuclear processes in their cores. This will be done in a "neutrino observatory" 4,500 feet deep in the Sunshine Mine in Kellogg, Idaho.

6. Contributions of Drs. Wasserburg and Burnett to the understanding of meteorites in studies of the chemical and isotopic composition of different kinds of these visitors from space.

Honors and Awards

Fritz Zwicky, Caltech professor of astrophysics and staff member of the Mt. Wilson and Palomar Observatories, has been elected vice president of the International Academy of Astronautics. The 180-member academy also named Dr. Zwicky finance chairman and a member of two committees – one concerned with an international lunar laboratory and one with space relativity.

Jack E. McKee, Caltech professor of environmental health engineering, has been appointed a member of the Atomic Energy Commission's advisory committee on reactor safeguards. The 15-member

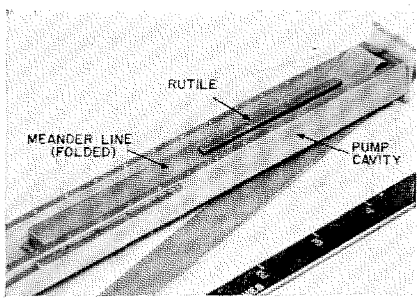
continued on page 26

Engineering and Science at RCA

Traveling Wave Masers

RCA's recent maser research and development has yielded systems with outstanding low-noise microwave amplifier performance along with adaptability for field use. These amplifiers exhibit ultra-low noise temperature (8-10°K) and high gain (30-40 db) with extreme gain stability. Wide tunability (up to 50%) and large instantaneous bandwidth (up to 150 MHz) have been achieved.

Several technique areas involved with this work are of particular interest. Iron- and chromium-doped rutile (titanium dioxide) are employed as active paramagnetic materials, in a "meander-line" slow wave structure, providing wide bandwidth and high gain. Ferrite reverse isolators function to provide a high degree of gain unidirectionality. The requisite magnetic field is provided by a superconducting magnet within a cryogenic enclosure, and the entire system is operated by a closed-cycle refrigerator requiring no helium replenishment, so that field use in radar systems, satellite communications and radiometry is practical. Sectionalized magnet structures with independent controls permit "stagger-tuning" the maser, so that its very high gain can be traded for even greater bandwidth.



The illustration shows the active elements of a maser amplifier typical of such a high-performance system. The meander line, seen as a zig-zag conducting path on a flexible insulating sheet, goes down one side of the pump cavity, folds over, and returns on the other side. The cavity is the terminal portion of a waveguide assembly, with microwave pump energy being introduced at the other end. One of two rutile paramagnetic crystals is shown in close proximity to the meander line, the ferrite isolator being on the opposite side of the meander line and not visible. In operation, the entire structure shown in the photograph lies between pole faces of the superconducting magnet, which provides a precisely controlled and distributed transverse field, typically, of a few thousand gauss. The assembly including the magnet is enclosed in a chamber maintained at 4.2°K.

Amplifiers with performance as described above are by no means the end, however. New advances are in the offing through research in areas including optical inversion (pumping), operation at temperatures above 4.2°K, higher frequency operation, and the use of active materials in powder rather than single-crystal form.

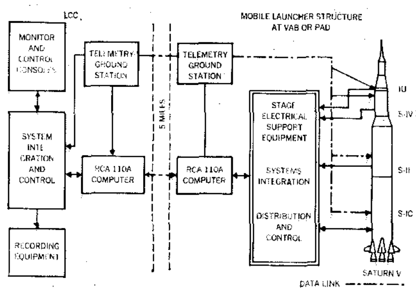
References:

(*a*) *L. C. Morris, "A New Class of Traveling Wave Masers," International Conference on Microwave Circuit Theory and Information Theory, Tokyo, Sept. 11, 1964.*

(*b*) *L. C. Morris and D. J. Miller, "Traveling Wave Masers Employing Iron-Doped Rutile," Proc. IEEE, Vol. 52, #4, p. 410, 1964.*

Integrated Launch Control and Checkout Systems for Saturn Lunar Vehicles

Highly sophisticated Saturn automatic ground checkout and launch sequencing equipment has been under development by RCA since late 1960 for the National Aeronautics and Space Administration, Marshall Space Flight Center. The original Saturn Ground Computer System (SGCS) was used on the highly successful Saturn I program; an advanced version of the SGCS is currently being readied for the Saturn IB and Saturn V programs. The RCA 110 computer was the heart of the Saturn I SGCS; the RCA 110A is the heart of the Saturn IB and Saturn V SGCS.



The block diagram shows the tandem, two computer configuration for Saturn V at Complex 39, the lunar program "space port" at NASA's Kennedy Space Center. Complex 39 is based on a mobile launch concept to gain high efficiency in launch operations. Vehicles are assembled in the Vehicle Assembly Building (VAB) on a Mobile Launcher structure. After the Saturn V with its Apollo Spacecraft is completely checked out, the vehicle in its Launcher is transported to one of three launch pads for a remotely controlled launch. The computer in the Launch Control Center (LCC) controls the activities of the "slave" computer in the Mobile Launcher via a 250 kilobit/sec digital data link. The configuration thus remains the same for both VAB and pad operations; only the length of the data link changes. The complex umbilical interface between the vehicle and ground support equipment remains undisturbed until launch. The LCC computer controls the sequence of checkout and launch countdown programs performed by the Mobile Launcher computer via commands transmitted over the data link. The "slave" computer in turn performs the detailed testing and sequencing, performs evaluation and data compression of test results, and transmits the data back to the LCC computer which relays it to the correct operator for display. LCC operators can override, via their console request keyboards, the predetermined sequence of programs stored in the Mobile Launcher computer or handle unusual test situations.

In addition to conventional serial computer functions, special parallel input/output capabilities are included for control of 1008 discrete (relay driver) outputs, monitoring of 1512 discrete (contact closure) inputs, a wide range of DC and AC analog outputs (72 in quantity), a wide range of DC and AC analog inputs (300 in quantity), telemetry interface, 3 internal interval timers, several external clock inputs, and an interface with the spaceborne computer.

In line with the developmental nature of the total Saturn program, the role of RCA's Saturn Ground Computer System is continuing to expand in factory and static testing, as well as launch operations, as automation techniques are applied to other Saturn subsystems.

Reference—J. E. Sloan and J. F. Underwood, "Systems Checkout for Apollo"—Astronautics and Aerospace Engineering, March 1963.

A Light Detector That Makes Laser Communications Practical

RCA has developed a photoconductive device that operates on an alternating current that can sense up to 100 million changes in light intensity per second. This is sufficient to distinguish as many as 25 separate television programs, all carried on a single laser beam. This major breakthrough in light detection is extremely fast, enormously sensitive and is responsive to the whole range of optical frequencies, ranging from infra-red through the visible spectrum to ultra-violet.

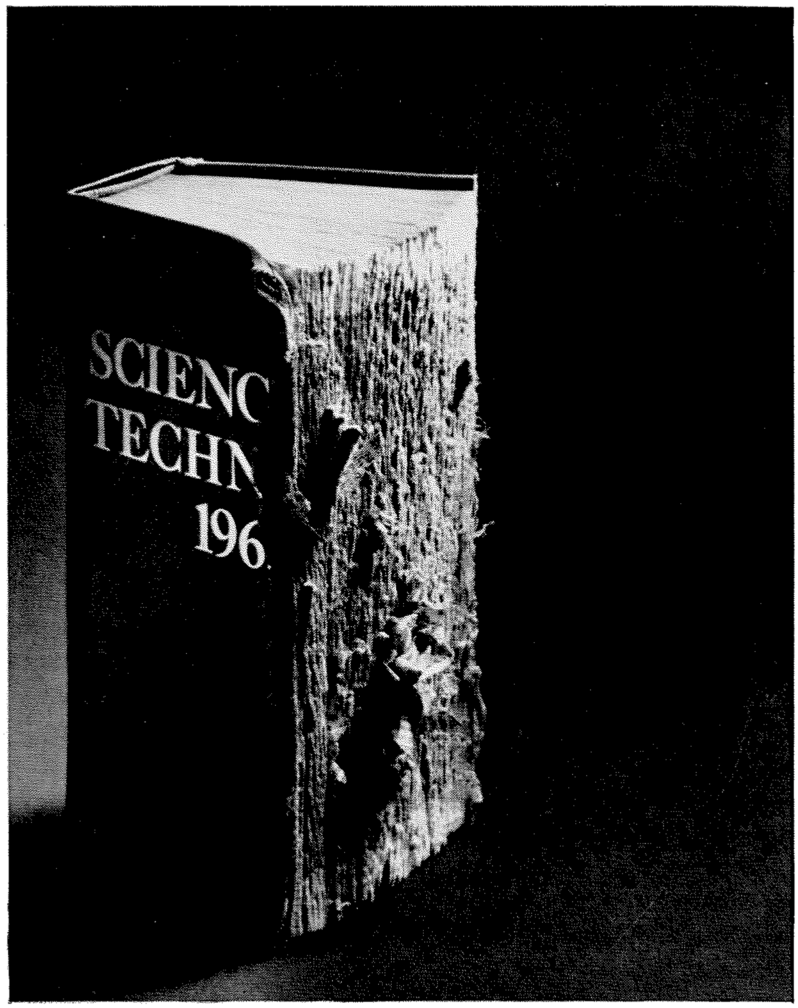
By contrast, previous means of detecting laser light employed photoconductors operated by direct current, photoelectric cells, semiconductor photodiodes and electron photomultiplier tubes. The major drawbacks were that these methods were either too slow, too insensitive, or too limited to the portions of the electromagnetic spectrum where most lasers operate poorly, if indeed, at all.

The laser is, to state it simply, a high frequency transmitter with the capacity to carry a fantastic amount of information. The real problem has been to develop a receiver both fast enough and sensitive enough to detect and process incoming information. This new device has the sensitivity, speed and frequency range that can make possible a practical system for laser communications.

This radical new detector is a tiny speck-sized piece of photoconductive material mounted in a small cavity continuously bathed in microwaves oscillating at 10 billion cycles per second.

When a laser beam bearing information in the form of intensity variations enters the cavity, it strikes the photoconductor and frees electrons. They, in turn, begin to oscillate rapidly up and down within the material, in direct response to the alternating electric field inherent in the surrounding microwaves. These electron oscillators control the amount of microwave power that leaves the cavity. The variations in the incoming light are then converted to intensity variations in the outgoing microwaves. Conventional microwave techniques make it possible to process these variations. These techniques are similar to those used in modern radar and commercial television systems.

Reference—H. S. Sommers, Jr. and E. K. Gatchell, presented at Annual Meeting, Optical Society of America, Philadelphia, October 5-8, 1965, Paper WE-1.



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committee reviews applications for new nuclear power reactors and advises on the safety of the proposed reactors. Dr. McKee, who has been a member of the Caltech faculty since 1949, received his MS and PhD degrees in sanitary engineering from Harvard University.

Eugene M. Shoemaker, Caltech research associate in astrogeology, has received the John Price Wetherill Medal from The Franklin Institute of Philadelphia. Dr. Shoemaker, who is also chief of the astrogeology branch of the United States Geological Survey in Flagstaff, Arizona, and Edward Ching-Te Chao of Arlington, Virginia, both received medals for their discovery of natural coesite in craters in various parts of the world – proof that these craters were made by meteorite impact rather than by volcanic activity.

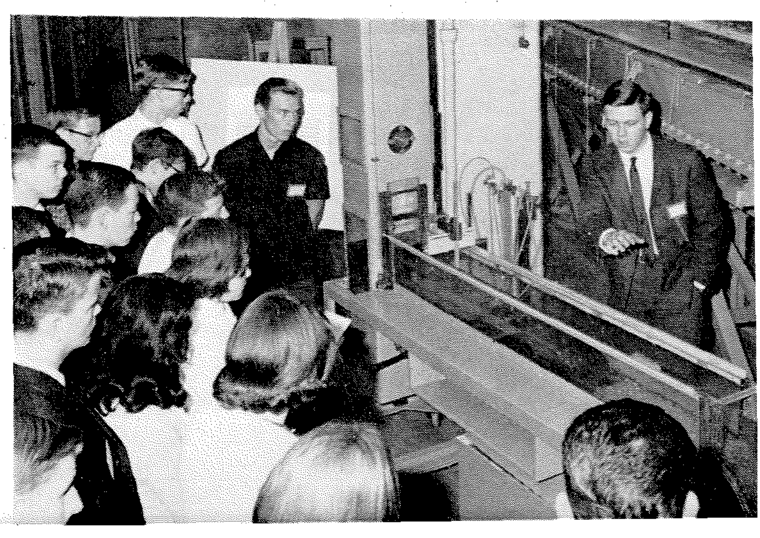
First AUFS Visit

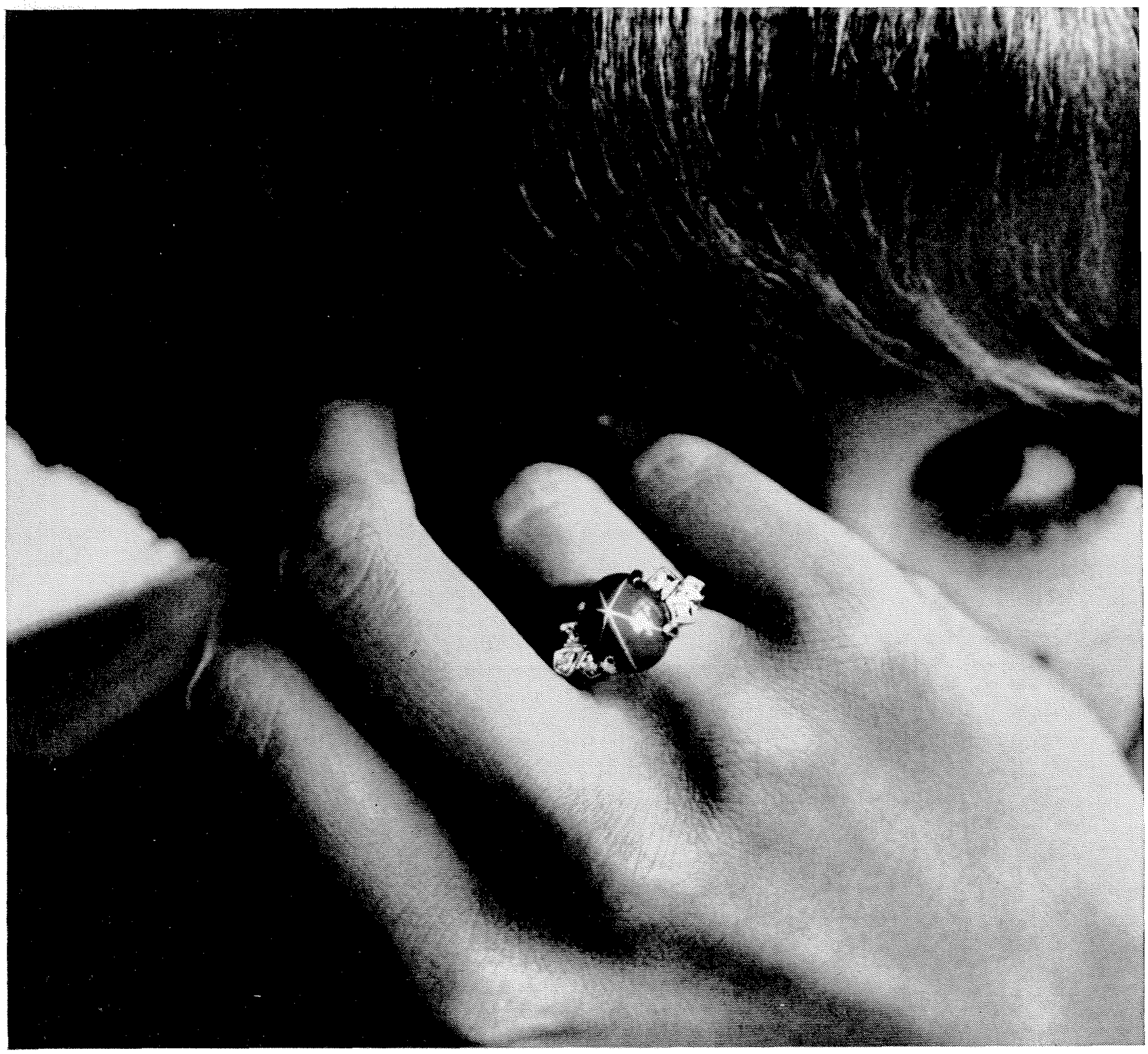
The first of the representatives of the American Universities Field Staff will arrive on campus January 4 for 10 days of lectures and informal talks with Caltech students and faculty. Richard W. Patch, specialist in Latin American affairs, will report on Boliva and Peru in a series of discussion and luncheon groups, classes, and seminars until January 13. Lawrence Olson will be at Caltech from January 18 to 27 to discuss conditions in Japan.

An unscheduled exhibit tops them all on Caltech's Students' Day, as the old Throop Hall clock becomes an oversized Mickey Mouse watch. The contrivance was a contribution of a group of student steeplejacks called the Fleming House Mickey Mouse Club.

Students' Day

A record number of students (1020) from a record number of southern California high schools (211) visited the Caltech campus for the 16th annual Students' Day on December 4. Caltech student guides toured the guests through more than 50 research exhibits, including a model of the Mariner IV spacecraft in front of Throop Hall (left), and a demonstration of free surface flow phenomena (below) in the Keck Engineering Laboratories. Afternoon lectures in Beckman Auditorium were given by Arnold O. Beckman, chairman of Caltech's board of trustees, and three members of the Caltech faculty.





Student Life — Some Problems and Proposals

The Caltech YMCA, at the start of each school year, holds a conference to plan projects and activities for the year. Since this is the 50th anniversary of the Y, the 1965 conference was seen as a valuable opportunity for discussions probing deeper and ranging wider than merely the program for the coming year. This conference, then, was designed "to identify deep-felt student needs, to see how these needs are being met or how they are not being met on the campus today, and to discover the Y's role in meeting these needs."

On the weekend of October 22-24 approximately 25 interested faculty members and 30 student leaders met together at the home of Kenneth Rhodes, chairman of the Y Board of Directors, with the hope of producing provocative discussion.

The aim of the first discussion Friday evening was to identify the difficulties that face Caltech students and to evaluate in a general way how these are being met. The four independent discussion groups which were formed moved, surprisingly enough, in the same general directions, with a consensus that there are some important problems which are not being adequately dealt with. Four major problem areas were identified. First, and quite obvious, is the fact that Caltech is all male. An overwhelming majority of students felt that, despite intensive house social programs, this remains a serious problem. There simply is no opportunity to meet girls on a casual everyday basis, and this stifles students' development of social skills and emotional maturity.

Second, students feel isolated and cut off from other students, faculty, graduate students, and the Pasadena community as a whole. Students view Caltech as a "walled city," and there is a noticeable lack of beer joints, coffee houses, or bookstores nearby where students can go.

Third is the apparent conflict between grades and learning which the student faces. Many have learned to expect a level of academic achievement from themselves which is simply impossible at Caltech. Ideally this should lead to a re-evaluation of motives and a more mature view. Instead, there seems to be a collapse of the whole motivational structure, which ties in with the fourth problem.

The fourth problem is a loss of perspective and commitment. Students feel they are racing on, but somewhere along the way they've forgotten why they entered the race in the first place. A large number of courses seem pedantic and concerned only with trivia, primarily because the instructors fail to relate the material to work which is important and going on now, or to show students a glint of the enthusiasm which they obviously must feel for their profession. When students lose sight of the over-all goal, not many courses are fascinating enough in themselves to provide adequate motivation. Caltech requires a great deal of its students, and when sight of the goal is lost, students begin to feel as though they're being pressed into a mold which does not fit them or their desires. Outside of courses there is a lack of involvement in contemporary social, political, and cultural problems and issues. Too often commitments to science, politics, or a religion are subjects for derision.

With problems better defined and out in the open, the discussion on Saturday turned to concrete proposals for alleviating some of them. Out of the ebb and flow of discussion during the day evolved seven specific ideas:

1. Establishment of an associated women's college.
2. Creation of a coffee house for students, faculty, and outsiders with a relaxed and intimate atmosphere.
3. Evaluation of the Institute's campus development plan with the goal in mind of providing areas for students conducive to relaxation and reflection.
4. More weekend conferences and retreats like the annual Caltech-Scripps conference.
5. Arrangements to involve faculty and grad students more closely with the student houses. Programs in faculty homes.
6. A course for credit involving work projects on cultural, social, and political problems in the Los Angeles area, perhaps in cooperation with a girls' school.
7. Means of transportation which would be open to students, such as a car pool.

Many of these proposals are not new, and some of them are perhaps unrealistic, but they *do* provide a nucleus for constructive efforts to help Caltech students solve their problems. Already, fresh discussion is raging, and working groups have been formed.

— Fred Lamb '68

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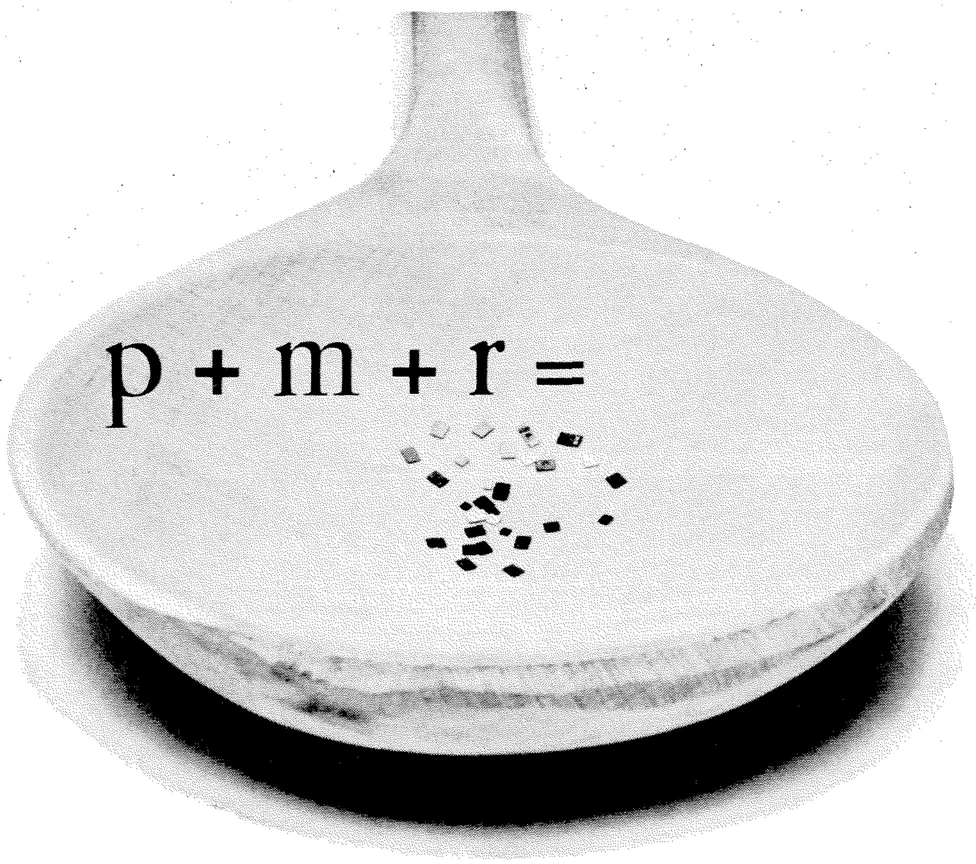

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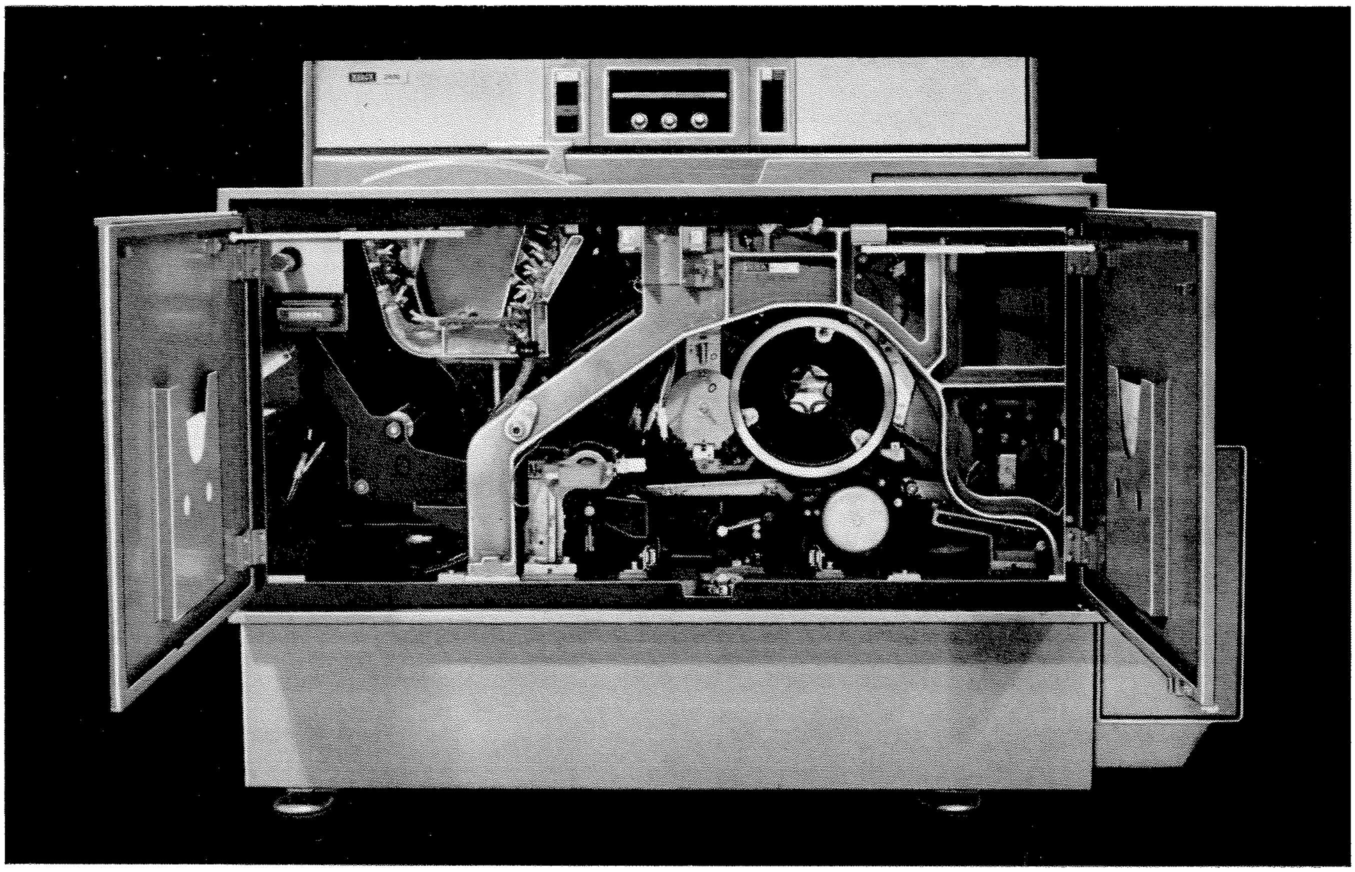


Address Unknown

The Institute has no record of the present addresses of these alumni. If you know the current address of any of these men, please contact the Alumni Office, Caltech.

1906
Norton, Frank E.

1907
Miller, James C., Jr.

1911
Lewis, Stanley M.

1921
Arnold, Jesse
Seaver, Edward D.

1922
Bruce, Robert M.
Cox, Edwin P.

1923
Neil, W. Harvey
Skinner, Richmond H.

1924
Carr, John
Henderson, William G.
Tracy, Willard H.
Young, David R.

1925
Waller, Conrad J.
Winckel, Edmond E.

1926
Chang, Hung-Yuan
Yang, Kai Jin

1927
Evjen, Haakon M.
Marsland, John E.
Moore, Bernard N.
Peterson, Frank F.

1928
Chou, P'ei-Yuan
Martin, Francis C.
Wingfield, Baker

1929
Briggs, Thomas H., Jr.
Burns, Martin C.
Espinosa, Julius Nelson
also known as:
Nelson, Julius
Lynn, Laurence E.
Robinson, True W.
Wolfe, Karl Morgan

1930
Allison, Donald K.
Chao, Chung-Yao
Forney, Morgan T.
Kelley, William
Moyers, Frank N.
White, Dudley

1931
Hall, Marvin W.
Ho, Tseng-Loh
McGarry, John F.
West, William T.
Yoshioka, Carl K.

1932
Patterson, J. W.
Schroder, L. D.

1933
Downie, Arthur J.
Koch, A. Arthur
Larsen, William A.
Michal, Edwin B.
Murdock, Keith A.
Rice, Winston R.
Shapell, Maple D.
Smith, Warren H.

1934
Core, Edwin J.
Harshberger, John D.
Liu, Yun Pu
Moore, Morton E.

1935
Bertram, Edward A.
Huang, Fun-Chang
McCoy, Howard M.
McNeal, Don
Ricketts, Donald H.

1936
Chu, Djen-Yuen
Kelch, Maxwell
Ohashi, George Y.
Van Riper, Dale H.
Young, Larry L.

1937
Burnight, Thomas R.
Cheng, Ju-Yung
Easton, Anthony
Fan, Hsu Tsi
Jones, Paul F.
Lotzkar, Harry
Maginnis, Jack Lt.
Munier, Alfred E.
Nojima, Noble
Odell, Raymond H.
Penn, William L., Jr.
Servet, Abdurahim
Shaw, Thomas N.

1938
Goodman, Hyman D.
Gross, Arthur G.
Guiterrez, Arnulfo G.
Kantemitsu, Sunao
Lowe, Frank C.
Rhett, William
Rynearson, Garn A.
Tsao, Chi-Cheng
Wang, Tsun-Kuei
Watson, James W.

1939
Aime, Edgar A.
Burns, Martin C.
Gombotz, Joseph J.
Hsueh, Chao-Wang
Liang, Carr Chia-Chang
Weinstein, Joseph
Wilson, Harry D.

1940
Abraham, Lewis
Batu, Buhtar
Compton, Arthur M.
Gentner, William E.
Gibson, Arville C.
Green, William J.
Hsu, Chang-Pen
Karubian, Ruhollah Y.
King, James L.
Lovoff, Adolph
Menis, Lnigi
Tao, Shih-Chen
Torrey, Preston C.
Wang, Tsung-Su

1941
Clark, Morris R.
Dieter, Darrell W.
Easley, Samuel J.
Geitz, Robert C.
Green, Jerome
Hardenbergh, George A.
Harvey, Donald L.
Helmick, Benjamin W.
Hubbard, Jack M.
Nicholson, George H.
Noland, Robert L.
Robinson, Frederick G.
Standridge, Clyde T.
Taylor, D. Francis
Vaughn, Richard
Wolfe, Samuel
Yui, En-Ying

1942
Bebe, Mehmet F.
Devault, Robert T.
Drake, John A.
Emre, Orhan M.
Go, Chong-Hu
Johnston, William C.
Levin, Daniel
Martinez, Victor H.

1943
Angel, Edgar P.
Brown, James M.
Bryant, Eschol A.
Burlington, William J.
Carlson, Arthur V.
Colvin, James H.
Eaton, Warren V., Jr.
Gaffney, Thomas A.
Gould, Jack E.
Hamilton, William M.
Hillyard, Roy L.
Johnsen, Edwin G.
King, Edward G.
Koch, Robert H.
Kong, Robert W.
LaForge, Gene R.
Lee, Edwin S., Jr.
Leeds, William L.
Ling, Shih-Sang
Lundquist, Roland E.
Mampell, Klaus
McNeill, Raymond F.
Mixsell, Joseph W.
Mowery, Irl H., Jr.
Nesley, William L.
Neuschwander, Leo Z.
O'Brien, Robert E.
Patterson, Charles M.
Pearson, John E.
Rivers, Naim E.
Roberts, Fred B.
Rupert, James W., Jr.
Scholz, Dan R.
Shannon, Leslie A.
Smitherman, Thomas B.
Tindle, Albert W., Jr.
Vicente, Ernesto
Waldrop, Nathan S.
Walsh, Joseph R.
Washburn, Courtland L.
Weis, William T.
Wheeler, Rodney S.
Wood, Stanley G.

1944
Alpan, Rasit H.
Baranowski, John J.
Barriga, Francisco D.
Bell, William E.
Benjamin, Donald G.
Berkant, Mehmet N.
Birlik, Ertugrul
Burch, Joseph E.
Burke, William G.
Cebeci, Ahmed
Clendenen, Frank B.
Cooke, Charles M.
De Medeiros, Carlos A.
Fu, Chieng Yi
Harrison, Charles P.
Hu, Ning
Johnson, William M.
Labanauskas, Paul J.
Leenerts, Lester O.
Mattinson, Carl O.
Onstad, Merrill E.
Pi, Te-Hsien
Pischel, Eugene F.
Ridlehuber, Jim M.
Shults, Mayo G.
Stanford, Harry W.
Stein, Roberto L.
Sullivan, Richard B.
Sunalp, Halit
Trimble, William M.
Unayral, Nustafa A.
Wadsworth, Joseph F., Jr.
Wight, D. Roger
Williams, Robert S.
Wolf, Paul L.
Writt, John J.
Yik, George

1945
Ari, Victor A.
Bryner, Dean L.
Budney, George S.
Bunze, Harry F.
Fanz, Martin C.
Fox, Harrison W.
Gibson, Charles E.
Grossling, Bernardo F.
Jenkins, Robert P.
Levy, Charles N.
Rice, Jonathan F.
Tseu, Payson S.
Turkbas, Necat
Yank, Frank A.

1946
Allison, Charles W., Jr.
Behroon, Khosrow
Bowen, Mark E.
Brinkhaus, Harvey H.
Burger, Glenn W.
Dethier, Bernard
Dougherty, Charles B.
Dyson, Jerome P.
Esner, David R.
Foster, R. Bruce
Halvorson, George G.
Hoffman, Charles C.
Ingram, Wilbur A.
Jacobsen, John R.
KeYuan, Chen
Lewis, Frederick J.
Lowery, Robert H.
Maxwell, Frederick W.
Olsen, Leslie R.
Prasad, K. V. Krishna
Rice, Jerry H.
Salbach, Carl K.
Shepard, Elmer R.
Sledge, Edward C.
Smith, Harvey F.
Stephenson, Robert E.
Tung, Yu-Sin
Webb, Milton G.

1947
Asher, Rolland S.
Atencio, Adolfo J.
Atkinson, Paul G., Jr.
Brown, Raymond A.
Clarke, Fredric B.
Clements, Robert E.
Clock, Raymond M.
Collins, Hugh H.
Dagnall, Brian D.
Darling, Donald A.
Darling, Rodney O.
Hsu, Chi-Nan
Huang, Ea-Qua
Lane, James F.
Lim, Vicente H., Jr.
Leo, Fiorello R.
MacAlister, Robert S.
Manoukian, John
Martin, Sidney T.
McClellan, Thomas R.
Molloy, Michael K.
Moorehead, Basil E. A.
Olson, Raymond L.
Orr, John L.
Ray, Kamalesh
Rust, Clayton A.
Sappington, Merrill H.
Schroeder, Henry W.
Thompson, Russell A., Jr
Torgerson, Warren S.
Veale, Joseph E.
Wan, Pao Kang
Wellman, Alonzo H., Jr.
Wimberly, Clifford M.
Winters, Edward B., Jr.
Ying, Lai-Chao

1948
Agnew, Haddon W.
Bunce, James A.
Clark, Albert R.
Collins, Burgess F.
Cotton, Mitchell L.
Crawford, William D.
Herold, Henry L.
Holm, John D.
Hsiao, Chien
Hsieh, Chia Lin
Lambert, Peter C.
Latson, Harvey H., Jr.
Lawton, G.
Leavenworth, Cameron D.
Mason, Herman A.
Oliver, Edward D.
Rhynard, Wayne E.
Stein, Paul G.
Swain, John S.
Voelker, William H.
Winniford, Robert S.
Woods, Marion C.
Wray, Robert M.
Yanak, Joseph D.

1949
Abramovitz, Marvin
Barker, Edwin F., Jr.
Bauman, John L., Jr.
Bauman, Laurence I.
Bottenberg, William R.
Brown, John R.
Bryan, Wharton W.
Cheng, Che-Min
Clancy, Albert H., Jr.
Clendening, Herbert C.
Cooper, Harold D.
Dodge, John A.
Foster, Francis C.
Galstan, Robert H.
Gilkeson, Fillmore B.
Hardy, Donald J.
Heiman, Jarvin R.
Krasin, Fred E.
Krauss, Max
Leroux, Pierre J.
Lowrey, Richard O.
MacKinnon, Neil A.
McElligott, Richard H.
Parker, Dan M.
Petty, Charles C.
Rinehart, Marion C.
Ringness, William M.
Saari, Albert E.
Sinker, Robert A.
Stappler, Robert F.
Vrabec, Dale
Wilkening, John W.
Yu, Sien-Chiue

1950
Bryan, William C.
Edelstein, Leonard
Gimpel, Donald J.
Goodell, Howard C.
Li, Chung Hsien
Mayner, Gerald S.
McDaniel, Edward F.
McMillan, Robert
Montemezzi, Marco A.
Pao, Wen Kwe
Paulson, Robert W.
Petzold, Robert F.
Scherer, Lee R., Jr.
Schmidt, Howard R.
Whitehill, Norris D.

1951
Arosemena, Ricardo M.
Chong, Kwok-Ying
Davison, Walter F.
Hawk, Riddell L.
Lafdjian, Jacob P.
Li, Cheng-Wu
Padgett, Joseph, Jr.
Palmer, John M., Jr.
Summers, Allan J.

1952
Abbott, John R.
Arcoulis, Elias G.
Bissett, Charles F.
Bucy, Smith V.
Harrison, Marvin E.
Helmuth, James G.
Lunday, Adrian C.
Meyer, Robert F.
Primbs, Charles L.
Robieux, Jean
Robison, William C.
Shelly, Thomas L.
Weber, Ernesto J.
Wiberg, Edgar
Woods, Joseph F.
Zacha, Richard B.

1953
Bhanjdeo, Swaroop C.
Crespo, Manuel J.
Elliott, David D.
Lennox, Stuart G.
Robkin, Morris A.
Rochefort, Joseph J., Jr.
Schroeder, Norman M.
Sutton, Donald E.
Wilburn, Norman P.
Wilson, Howard E.

1954
Coughlin, John T., II
Feuchtwang, Thomas E.
Graves, Jack C.
Guebert, Wesley R.
Gutierrez, Reinaldo V.
Heiser, David
Mertz, Charles, III
Rogers, Berdine H.
Sergeyevsky, Andrew
Von Gerichten, Robert L.

1955
Campbell, Douglas D.
Huber, William E.
Lim, Macrobio
Moore, William T.
Roman, Basil P.

1956
Edwards, Robert W.
Frignac, Jean-Paul
Garnault, Andre F.
Kelly, James L.
Kontaratos, Antonios N.
McAllister, Don F.
Spence, William N.
Tang, Chung-Liang

1957
Brust, David
Goebel, Charles V.
Howie, Archibald
Lawrence, Alfred F., Jr.
Schwartz, Lowell M.
Stuteville, Joseph E.

1958
Ackley, David A.
Chang, Berken
Dundzila, Antanas V.
Horowitz, Daniel H.
Jones, Laurence G.
Knight, Harold G.
Palmiter, Hugh D.
Wille, Milton G.

1959
Baekelandt, Victor
Bailey, John S.
Byun, Chai B.
Cheng, Hung
Guillemet, Michel P.
Havey, James H., Jr.
Idriss, Izzat M.
Monroe, Louis L.
Muraoka, Kenneth A.
Weber, Walter V., Jr.

1960
Campbell, John H.
Farha, Norman S.
Mauger, Richard L.

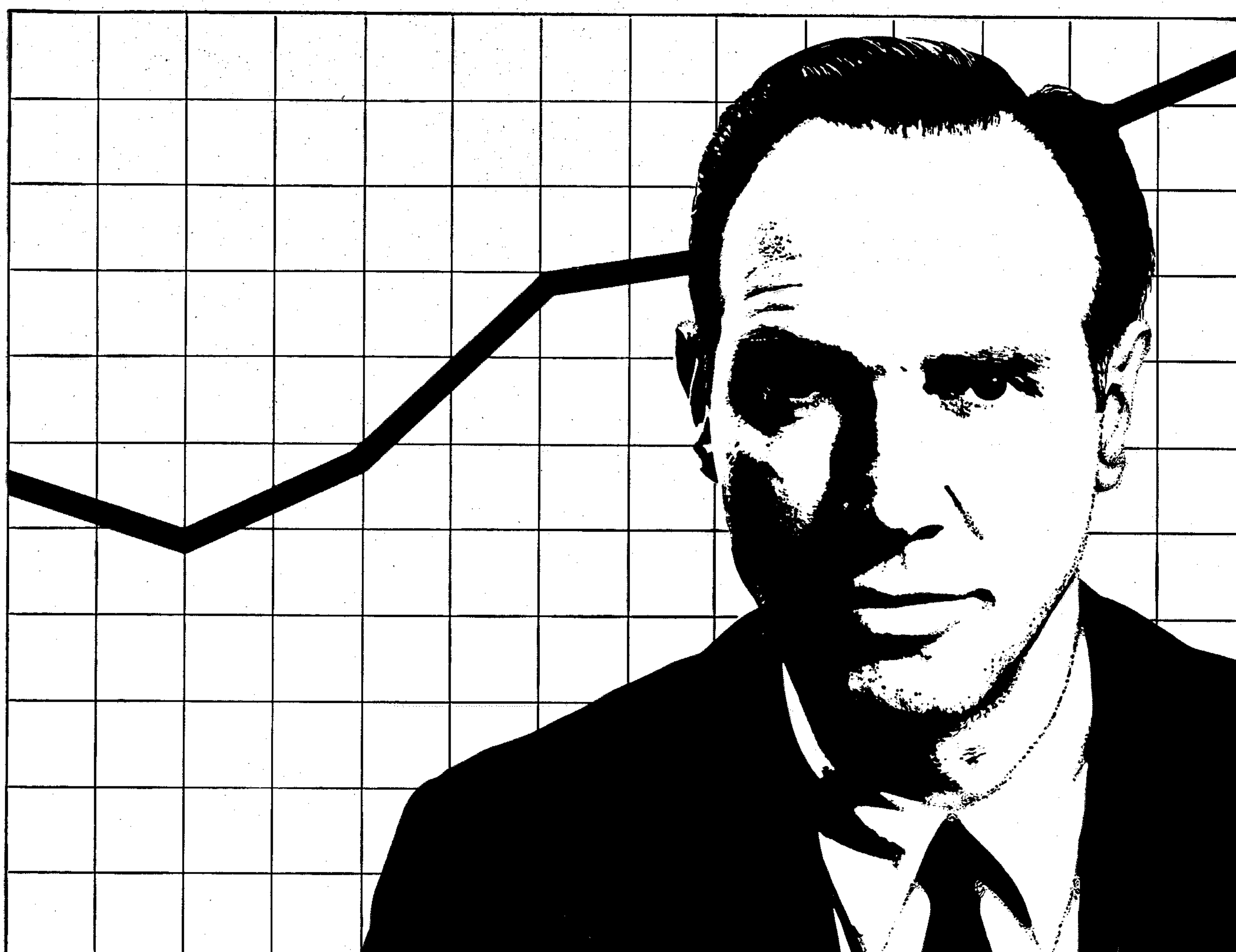
1961
Allen, Charles A.
Dombey, Norman
Hammond, John N.
Lindner, Milton S.
Pollock, Gerald D.
Richter, Rolf
Smith, Warren D.
Steinberg, Charles M.

1962
Dorlhac, Jean-Pierre
Dubois, Jean Claude
Osorio, C. Meirelles
Ruddick, Robert C.
Wik, Dennis R.

1963
Bury, Klaus Victor
Couzin, Dennis I.
Russell, Charles D.
Spiegelman, Will G.

1964
Akinrimisi, E. Olabisi
Howenstine, Robert J.
Kanus, Karl H.
McKinley, John H.
Meisel, William S.
Schoene, William J.
Slonski, John P., Jr.
Vinsonhaler, Charles I.

1965
Aimelet, Bernard A.
Arrathon, Raymond
Austin, Philip R.
Bliss, Vernon LeRoy
Casanova, Jose C.
Chao, Chang-Chih
Comte, Pierre Yves
Espinosa, James M.
Essenberg, Richard C.
Faulconer, David W.
Frosch, Robert P.
Goddard, Wm. A., III
Grange, Jean-Marie
Harris, Robert H.
Hutton, Ronald E.
Kindle, James T.
LaGorce, Michel A.
Lambert, Joseph B.
Levenberg, Milton I.
Levin, Robert D.
Mukatis, Werner A.
Oliver, Lawrence K.
Servis, Kenneth L.
Stephens, Melvin M., II
Williams, Anthony B.



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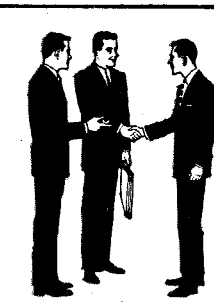

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Personals

1922

WILLIAM D. POTTER retired on November 27 from the Bureau of Public Roads of the U.S. Department of Commerce, in Washington, D.C., after 30 years of service with the federal government. He was head of the work group on hydraulics and hydrologic research.

1925

ROBERT W. FULWIDER, senior partner in the law firm of Fulwider, Patton, Rieber, Lee & Utecht in Los Angeles, was chosen chairman-elect of the patent, trademark, and copyright law section of the American Bar Association at their annual meeting in Miami recently.

1928

FRANK NOEL and his wife, Jean, have been touring Europe in their camper since May and have visited England, France, Germany, Switzerland, Austria, Czechoslovakia, Denmark, Sweden, Norway, and Holland. Noel writes that they expect to tour the Mediterranean next and be in Australasia for Christmas.

1932

ROBERT W. ST. CLAIR, who organized the Asco Sintering Corporation of Los Angeles and operated it for 18 years, recently sold the business to retire. Instead he started the Westcliff Travel Service in Newport Beach, Calif., last year and is now about to embark on a two-month, globe-circling, familiarization tour for travel agents which will take him to 14 countries.

1935

WILLIAM B. McLEAN, MS '37, PhD '39, technical director of the Naval Ordnance Test Station at China Lake, Calif., has been given the 1965 Rockefeller Public Service Award in science for his peacetime achievements in oceanographic research. McLean, one of the nation's leading researchers on the communications system used by porpoises, is also well known for his role in the development of the Sidewinder air-to-air guided missile.

1938

HARRY K. EVANS, who, since 1956, has been head of the San Francisco office of Wilbur Smith and Associates, Inc., California, consulting engineers, has been named vice president of the firm.

COL. SIDNEY OFSTHUN, USAF, retired, MS, died on November 10, 1965. He was a resident of La Jolla.

HARRY D. EVANS, MS, has been appointed head of the department of licensing and design engineering at Shell Development Company's Emeryville research center. Evans has been with Shell since 1938.

ELBURT F. OSBORN, PhD, vice president for research at Pennsylvania State University, received an honorary degree of doctor of science from Alfred University in Alfred, N.Y., last June. Since 1946, when Osborn became a member of the faculty at Penn State, he has served as professor of geochemistry, head of the department of earth sciences, and dean of the college of mineral industries.

1941

FRED W. BILLMEYER JR., professor of chemistry at Rensselaer Polytechnic Institute in Troy, N.Y., and noted authority in the fields of polymer chemistry and color measurement, has been elected to the board of trustees of the Munsell Color Foundation, Inc., of Baltimore, Maryland.

1942

CARL H. SAVIT, MS '43, has been named vice president of systems research and development for the Western Geophysical Company, a division of Litton Industries, in Los Angeles. Savit, who has been with Litton for 17 years, was formerly director of Western's systems research.

1945

MELVIN N. WILSON JR., MS '46, one of the survivors of the November 11 jetliner crash in Salt Lake City, is in good condition and has returned part time to his JPL office. Wilson, one of the first passengers out of the wrecked plane, returned to help other survivors until eye burns made him totally blind. He remained unable to see for 10 days, then slowly began to regain his sight. He also suffered a broken arm, severe third degree burns, and lung damage. At JPL Wilson works on project management assignments in the technical facilities office.

WILLIAM H. COOK has been appointed exclusive U.S. sales agent for the surveying, geodetic, and photogrammetric instruments produced by Carl Zeiss Jena, and for the entire line of the Jenaer Glaswerk Schott & Gen., Jena, in Germany. His office is in Woodland Hills, Calif.

1947

RICHARD C. GERKE, MS, has been appointed district engineer for waterfront construction in South Vietnam by RMK-BRJ, a joint venture of Raymond International, Incorporated, Morrison-Knudsen Company, Brown & Root, Inc., and the

the

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J. A. Jones Construction Co. He expects to be in Saigon for at least 18 months.

DAVID O. CALDWELL has accepted a position as professor of physics at the University of California at Santa Barbara. In 1964-65 he was at the Berkeley campus and the preceding year was at Princeton. Before that time, Caldwell was associate professor of physics at MIT.

1949

LIEUT. COL. DALE D. RYDER, USAF, MS '50, writes that his present assignment is assistant for limited war at the electronics systems division of the Air Force Systems Command. His responsibility is the coordination and management of all limited war activity at the electronic systems division.

ROLF M. SINCLAIR, on a year's leave of absence from Princeton University, is doing experimental studies of plasma physics at the United Kingdom Atomic Energy Authority's Culham Laboratory in England.

WILLIAM R. MUEHLBERGER, MS '49, PhD '54, writes that he has been at the University of Texas in Austin since 1954, and is now professor of geology. He has been director of a project studying buried basement of North America and also has been active in the American Geological Institute's Council on Education of the Geological Sciences.

1951

WILLIAM A. KELLEY JR. has been appointed central district sales manager of the FMC Corporation's organic chemicals division. His headquarters are in Cincinnati, Ohio.

1952

PETER H. VERDIER recently joined the staff of the National Bureau of Standards Institute for Materials Research in the molecular properties section of the polymers division. He was formerly with the Union Carbide Research Institute, doing work on molecular structure and dynamics.

1953

GEORGE W. SUTTON, MS, PhD '55, has joined the AVCO-Everett Research Laboratory in Wilmington, Mass., as a principal research engineer, specializing in re-entry physics research activities. Until recently Sutton was a scientific advisor with the Department of the Air Force.

1954

ROBERT D. DARRAGH JR., MS, a partner in the firm of Dames & Moore, civil engineers, in their San Francisco office, received the Thomas A. Middlebrooks Award of the American Society of Civil Engineers in October for his paper on "Controlled Water Tests to Preload Tank Foundations."

JERRY C. MITCHELL, who is in the chemical physics department of the Shell Development Company in Emeryville, Calif., writes: "We are enjoying the serene setting of our 50-year-old home in the Oakland hills. We have the perfect family, a boy and a girl, whom we managed to leave with relatives for an exciting month's vacation in Europe this year."

1955

HARVEY S. FREY, MD, who is at the UCLA Medical School under a special training fellowship in radiation therapy, and is studying medical physics there, has been awarded the Louis B. Silverman Memorial Fund Award in health physics.

WILLIAM F. LAPSON is a research associate at Stanford University in the mechanical engineering department, developing instruments for the physical and biological characterization of Mars. The Lapsons have a daughter born August 1.

continued on page 36

Personals . . . *continued*

1957

THEODORE G. JOHNSON has been appointed sales manager of the Digital Equipment Corporation in Maynard, Mass. He and his wife, Ruth, and their 1½-year-old daughter live in Sudbury.

1961

C. HERBERT RICE is serving with the Peace Corps in Nepal, at Sallyan, "located on a ridge about 5,000 feet, where the high mountains are visible, but about a 10-day walk away."

NICK S. MOREZ is now assistant professor of mathematics in the University of Cincinnati's McMicken College of Arts and Sciences. He received his PhD in June from the University of Colorado in Boulder, where he was also teaching assistant and associate.

KENDALL E. CASEY, JR., received a PhD degree in electrical engineering from USC, where he has been an instructor.

1962

JOHN R. GOLDEN, who is with the research services laboratory of the RCA laboratories in Princeton, N.J., after having received his master's degree from Kansas University in Lawrence, sends this news about his '62 classmates: "While in Boston recently WARREN TEITELMAN gave me a tour of project MAC at MIT. He will finish his PhD thesis in artificial intelligence by the end of the year. I also spoke with JOEL TENENBAUM and DAVE PRITCHARD, both in physics at Harvard and hard at work on their dissertations. DAVID SELLIN has completed all but his thesis for a PhD in nuclear physics at Duke."

THOMAS J. LITLE IV and his wife announce the birth of Thomas J. Litle V on September 11. The Litles live in Acton, Mass.

1963

ROBERT P. FOSS, PhD, has joined the research staff of the Du Pont Company's central research department at the experimental station near Wilmington, Delaware. For the past two years he has been doing postdoctoral work at the University of California at Berkeley.

1965

JIM EDER is in the Philippine Islands with the Peace Corps. He is working as a co-teacher with a Filipino instructor, as part of a program to improve teaching methods on the islands.

ALUMNI EVENTS

May 7	Annual Alumni Seminar
June 8	Annual Meeting

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