ENGINEERING AND SCIENCE

MAY/1956

Leaders of America . . . page 23

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

Edward J. Stolic, class of '48

speaks from experience when he says . . .

"With U. S. Steel, my future holds interest, challenge and reward."

From his graduation in 1948 with a B.S. degree in Mechanical Engineering, until November of that year, Edward Stolic worked as an operating trainee in the Irvin Works of United States Steel. Following his discharge from the Army in 1950, he returned to work at U.S. Steel. In just 18 months, Mr. Stolic reached a management position as Engineer-Lubrication.

By mid-year 1953, Mr. Stolic was promoted to Foreman-Instrument Repair and Sub-Station. In a recent interview he said: "Opportunities for rapid advancement are almost limitless in U.S. Steel." At 27, Mr. Stolic is supervising a force of 30 men in mechanical and electrical tests as well as instrument repair and maintenance of gas generators, compressors and water purification units. He feels that, "The engineer finds many places to apply the knowledge he garnered in school." The men under Edward Stolic are called on to trouble shoot in any part of the mill. This calls for a wide variety of talents and leads Mr. Stolic to say: "The steel industry has expanded greatly, and with it the need for good men."

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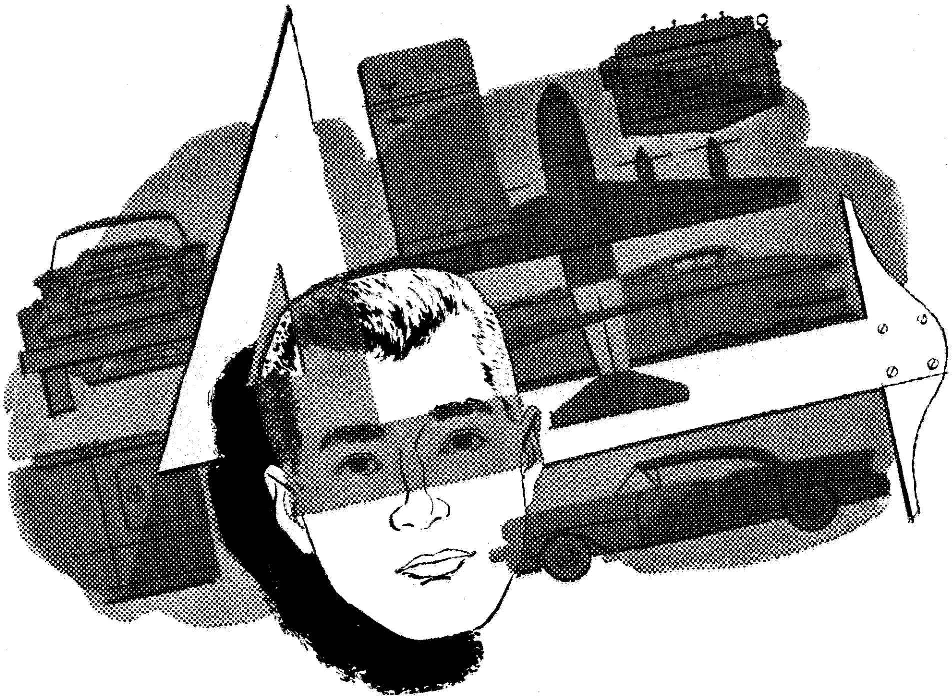

ENGINEERING AND SCIENCE

IN THIS ISSUE

On our cover this month is Dr. Ralph Bunche, Under Secretary General of the United Nations, under escort by a group of student wheels on his recent visit to Caltech in the YMCA Leaders of America program. For further notes on the Bunche visit, see page 22.

Dr. William H. Pickering, who wrote "The Earth Satellite Program" on page 13, adapted this article from the popular talk he gave on Alumni Seminar Day, held on the Caltech campus on April 7. Dr. Pickering, who is director of Caltech's Jet Propulsion Laboratory, is also a member of the National Academy of Sciences committee in charge of the satellite that will be launched during the coming International Geophysical Year. A Caltech alumnus (BS '32, MS '33, PhD '36), and a former member of the Caltech faculty (professor of electrical engineering), Dr. Pickering became head of JPL in 1954.

Heinz E. Ellersieck, who wrote "Muscovite Make-Believe," is assistant professor of history at Caltech, and a man with a remarkably broad knowledge of Russian political history—as you can see on page 19. Dr. Ellersieck's article is adapted from *his* talk at Alumni Seminar Day too.

Leon T. Silver, who took the photographs of the geology field trip on pages 24 and 25, is assistant professor of geology at the Institute.

PICTURE CREDITS

Cover	Stuart Bowen '56
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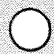

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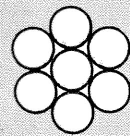

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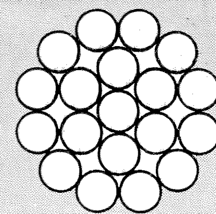

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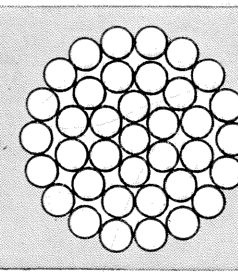

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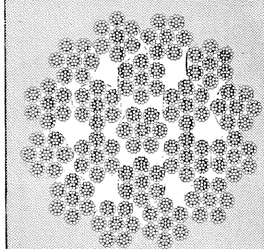

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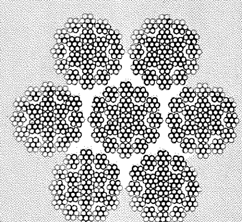

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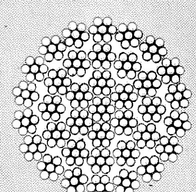

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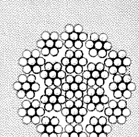

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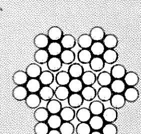

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The Importance of Electrical Conductors

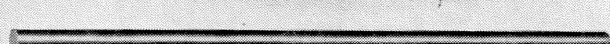
In the ability to transmit electricity, all forms of matter may be divided into two general classes, namely, conductors and insulators. Conductors permit electric current to flow readily; that is, they offer little resistance to its flow, whereas, insulators offer relatively great resistance to the flow of electricity. All substances at normal temperatures offer some resistance to the flow of electric current. In general, the metals are good conductors, while glass, oil and most organic substances are classed as insulators. Although silver offers the lowest resistance to the flow of electricity of the common metals, its cost is such that it is not widely used as a conductor. The conductors most generally used in the cable industry are made of copper or aluminum.

The manner in which electricity flows through elementary material may be readily visualized from the modern concepts of the structure of matter. According to these concepts all elements are made up of minute indivisible particles called atoms. These in turn are composed of a positively charged nucleus around which one or more very small negatively charged particles, called electrons, rotate at high velocity. In conductors, some of these electrons are free to move when only a small difference of potential is applied to the ends of the conductor and, since they are negatively charged, they flow to the positively charged end. This movement of electrons is electric current.

In passing through conductors, *the electrons must pass through the electron fields of many atoms. They thus collide with the atomic nuclei and other electrons. These collisions obstruct the flow of electrons and result in electrical resistance.*

The resistance of a homogeneous conductor of uniform cross-sectional area varies directly as its length and inversely as its cross-section, the length being in the direction of current flow. That is, $R = \rho L/A$ where, R is the resistance in ohms, L is the length in the direction of current flow, A is the area perpendicular to the length and ρ is a constant of the particular material known as its specific resistivity. When the length and area are expressed in the same units such as $L =$ one inch and $A =$ one square inch, $R = \rho \times 1/1$ or $R = \rho$, the specific resistance of the material in ohms per inch cube.

The length and area of a conductor are generally expressed in other units



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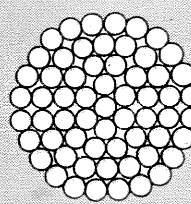

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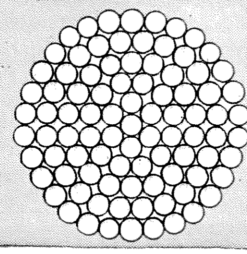

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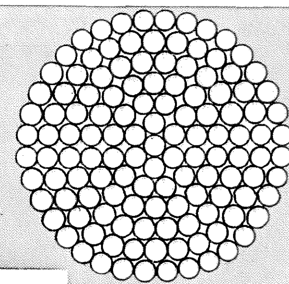


127 strand Concentric Stranding

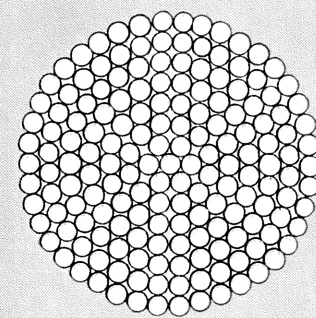
than inches. The most commonly used unit of cross-sectional area in the cable industry is the circular mil, usually designated as cir. mil or CM. This is the area of a circle whose diameter is one mil, 0.001 inch. The area of a circular mil is $\pi/4$ or 0.7854 of a square mil. The unit of length usually associated with this unit is the foot and the resistance becomes ohms per CM-foot. The resistance of annealed copper and aluminum per circular mil-foot at 20C are 10.371 and 17.011 ohms respectively. The resistance of a copper conductor 64 mils in diameter and one foot long thus becomes 10.371 $\div$ 64^2 or 0.00253 ohms.

The sizes of electrical conductors *are expressed in the United States in terms of the American Wire Gauge. This was originally set up on the basis of a geometrical progression of 39 steps or sizes between a wire 460 mils in diameter (Size 4/0) and a wire 5 mils in diameter (Size 36). The ratio of the diameter of a wire to that of the next larger size in this series is* $\sqrt[39]{460/5} = 1.12293$. *This ratio has since been used to extend the American Wire Gauge (AWG) to sizes smaller than 36 AWG (5 mils). The sizes of conductors larger than 4/0 are expressed in circular mil area. The size of a conductor made up of a number of wires is determined from the sum of the circular mil areas of the individual wires.*

When current flows through a conductor there is, according to Ohm's law, a voltage drop of $E = IR$, where E is in volts, I is in amperes and R is in ohms, and power equal to EI watts is converted to heat. Since $E = IR$, this power converted to heat becomes I^2R watts. These two factors, voltage drop and conductor heating, are of prime importance in the design of conductors. Conductors must be of sufficiently low resistance that the voltage drop does not become excessive. In good design this voltage drop should not exceed 3 per cent for power circuits or 1 per cent for lighting circuits. The conductors should also be large enough that, when carrying their current, their temperature does not exceed that for which their insulation is designed. This rated current is referred to as the current carrying capacity. The current carrying capacities of the various sizes of conductors and installation conditions have been established. It should be noted that the temperature attained by a conductor depends not only on the amount of heat generated but also on the thermal resistance of its surroundings.

In addition to providing satisfactory voltage drop and current carrying capacity, conductors must be designed to provide adequate flexibility during installation and service. This is accomplished by building up the conductor from one or more adequately small wires, depending on the flexibility required. For example, the conductor for heater cord or welding cable, which is subject to repeated flexing in service, is usually made up of copper strands having a diameter of .005" or .0063", while the conductor for overhead weatherproof cable may be a single wire.

For reprints of these pages write to United States Rubber, Electrical Wire & Cable Department, Rockefeller Center, New York 20, N. Y.



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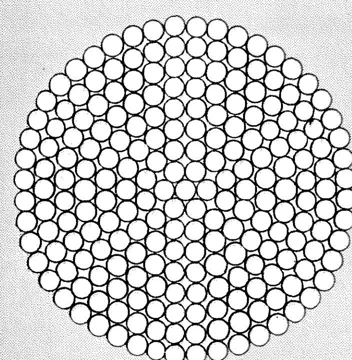

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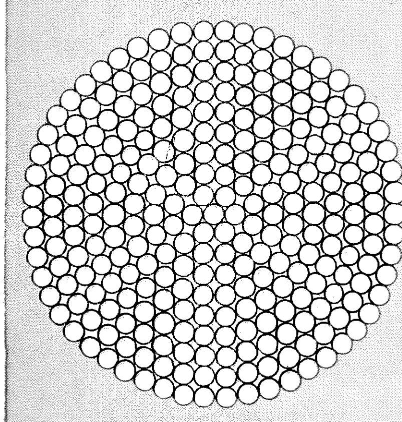

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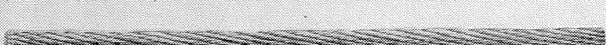
Electrical Wire & Cable Department

United States Rubber



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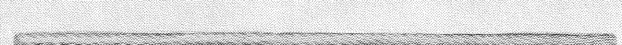

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BOOKS

THE CITADEL OF LEARNING

by James Bryant Conant
Yale University Press $2.00

Reviewed by L. A. DuBridge
President, California Institute of Technology

THIS LITTLE book consists of three essays on education by one of the most distinguished and most thoughtful American educators—the former President of Harvard and now American Ambassador to the Federal Republic of Germany. Like Dr. Conant's other writings, these essays are cogent and stimulating.

The first essay gives its title to the book. The phrase is taken from a quotation from Joseph Stalin, stating the Soviet Policy toward universities: "This citadel (of learning) we must capture at any price. This citadel must be taken by our youth —."

Dr. Conant proceeds to describe from first-hand observation how the Sovietization of the old University of Berlin, now in the Russian sector, has been achieved. Indoctrination has taken the place of learning. "It is the absence of dissenters from the official dogma that signalizes the capture of the citadel of learning," he notes. There follows a penetrating commentary on the necessity for freedom of scholarly research in a university—an admonition not irrelevant in this country. The place of conflict, of arguments, of disagreement in the advancement of knowledge is set forth in illuminating terms.

In the second essay, "An Old Tradition in a New World," (given first as a lecture at Michigan State College) he expands on the role of the free university in a divided world. He points out especially the need for identifying the gifted students at an early age and providing them with something more intellectually challenging than the watered-down curricula of so many high schools. Highly trained minds will be needed by United States citizens in a world of ideological conflict!

The last essay is on the basic problems of American education, seen, as he says, from the vantage point of an American Embassy in Europe. He reiterates his plea that the flood of students in American colleges be absorbed by the creation of many more two-year community colleges, rather than by overloading, and thus diluting, the four-year colleges. He discusses also (in terms which any Caltech faculty man would applaud) the relation between teaching and research in a university and the dangers in letting applied or commercialized research activities impair the traditions of advanced education and free inquiry.

This stimulating book will be read by many professors but should be read also by many laymen.

NEW WORLDS OF MODERN SCIENCE

edited by Leonard Engel
Dell Publishing Co., N.Y. $.35

THIS IS an anthology of writings about science—articles from magazines, chapters from books, a few scientific papers and a few articles specially written for this volume. Most of the material has been written by professional scientists, but when the editor was unable to find any scientists in a particular field who were writing at a popular level, he turned to the work of a competent journalist. (He is himself, by the way, one of the most competent.)

The book doesn't try to cover all the fields of science. It is just a good, big, bargain-package sampler of popular science writing. It covers six broad areas of scientific activity (labeled *The World of Science, The Earth and the Universe, Inside and Outside the Atom, Life, Man, and Tomorrow*).

Some sample articles include: "The Common Sense of Science," by J. Bronowski; "The Origin and Evolution of the Universe," by George Gamow; "Feeling with Electrons," (radar) by A. M. Low; "The Physical Nature of Viruses," by F. M. Burnet; "Poliomyelitis," by Jonas E. Salk; "Rockets, Missiles and Space Satellites," by Willy Ley.

Dr. James R. Killian, Jr., president of MIT, gives this authology a nice send-off when he says in his introduction to the book:

"We have urgent need of more scientists and engineers who can build bridges of understanding between the domain of science and the domain of non-science. We need a growing body of exposition to make science and scientific activity understandable to laymen. Therein lies the importance of books such as this one."

Theodore von Karman, Professor of Aeronautics, Emeritus

A SALUTE TO TODOR

by E. E. SECHLER

Professor of Aeronautics

THE 75TH ANNIVERSARY of the birth of one of the most distinguished of the world's scientists and engineers, Dr. Theodore von Karman, occurs on May 20, 1956. Many words will be written and volumes will be published concerning his contributions to science and engineering, particularly in the field of aeronautics, and to repeat these praises here would be redundant. Suffice it to say that his leadership in this field is outstanding and has been recognized by honors and medals granted him by most of the important countries of the world.

To those who have been so fortunate as to be closely associated with this great scientist, there are other facets to his personality which, if that is possible, overshadow his scientific ability. These include his friendship, his essential humanness, his tolerance, and his kindly helpfulness to his students and co-workers, all of which combine to make him the "Todor" whom we all love and respect.

Since I was one of those lucky first students of Caltech's Guggenheim Aeronautics Laboratory when Karman became its director in 1930 it has been my privilege to have known him for the past quarter of a century. As a young student in awe of the great von Karman (an awe which has never left to this day) I can well remember his patience with my ignorance and his sincere efforts to instill in myself, and others of that small first class, a sense of the important things to be found in science and engineering if one only knew how to look and then looked hard enough for them. This interest in his students was also held by his brilliant and devoted family consisting of his sister, Josephine de Karman and his mother—the latter always being afraid that her Todor was being too harsh on his students.

The warm and friendly home of the von Karmans, which was open day and night to their friends and co-workers, was a living proof that an eminent scientist and engineer need not be narrow minded nor a recluse. There one would meet artists, musicians, writers, and philosophers, as well as scientists, all making their contributions to conversations which were not only cosmopolitan but sometimes became cosmic in their scope.

These meetings were held in rooms filled with fascinating objects received by the von Karmans as gifts from their many friends throughout the world, each of which told a story of someone else who treasured his association with the von Karmans. And, as a final touch there always were available plates of delicacies which seemed to appear continuously from a kitchen inhabited by a Hungarian cook who was a scientist in her own field.

Many are the anecdotes that are passed around between those who have known this great man. Since most of them are connected in some way with the lives of the story tellers they would lose their flavor if committed to print; however, the fact that so many do exist, and that they can be heard in nearly every part of the world, attests to the warm hearted, human respect in which he is held by his friends and colleagues. As a scientist, a world leader in engineering and, moreover as a sincere friend, we would all like to salute you, Todor, on your birthday and to wish you well.

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THE EARTH SATELLITE PROGRAM

How, when, where and why the United States will begin its first scientific observations of outer space

by W. H. PICKERING
Director, Jet Propulsion Laboratory

THE IDEA OF SPACE TRAVEL has become so popular since the war, particularly with the younger generation, that I am afraid that when we actually get around to flying the first satellite, there is going to be a sense of anti-climax. This first satellite is not going to be a particularly spectacular object from the point of view of the general public. It will be just barely visible to the naked eye perhaps a few times a month. It will be quite hard to detect and I am sure the small fry are going to wonder what all the excitement is about.

On the other hand, if we really consider the problem, it is a fantastic engineering task to put any object into an orbit around the earth. Furthermore, such an object will necessarily have a great scientific significance. It is the beginning of scientific observations of outer space.

The earth satellite program of the United States is a part of the International Geophysical Year program. During the period from July, 1957, to December, 1958, there will be a concerted effort on the part of most of the nations of the earth to gather data of geophysical interest. The scope of the program covers most of the scientific disciplines. Among the more highly publicized programs, there are, for example, the Arctic and Antarctic expeditions, which will involve many nations, and the rocket experiments which will be made at several places for upper atmosphere observations.

The international committee which is coordinating the IGY program—the so-called CSAGI committee—recommended in October of 1954 that a satellite program would be of extreme value as part of the IGY activity. In July of last year, the President announced that the United States would indeed fly a satellite as part of our contribution to the IGY program. Since then, the Russians have announced that they also will fly a satellite.

The program for the United States has been established by giving the Department of Defense the responsibility for putting the satellite FOB on orbit. This, of course, is the largest engineering problem; it involves application of large rocket techniques developed over the past ten years. The President has stated that each of the services will contribute to this effort, but the primary responsibility has been given to the Navy. The Naval Research Laboratory has set up what is now known as Project Vanguard.

The scientific part of the program is being coordinated by the National Academy of Sciences, which is responsible for the whole IGY scientific work on the part of the United States. There has been established a U. S. National Committee with Dr. J. Kaplan of UCLA as Chairman. This committee carries out the IGY program through a series of technical panels, one of which is the Technical Panel on the Earth Satellite Program.

In order to get a feeling for some of the numbers involved in the satellite problem, let us consider some freshman physics.

Suppose the satellite is in a circular orbit above the surface of the earth. The velocity required is obtained by equating the centrifugal force to the gravitational force. Numerically we find that for an altitude of 300 miles we need a velocity of just over 25,000 feet/second.

As the altitude increases, the required velocity will decrease; however, the total energy required to take an object from the surface into the orbit will, of course, go up. The total energy, adding the potential and kinetic energies, is a fairly slowly varying function of altitude. At 300 miles it works out at about 11,000,000 ft. lbs. per pound of mass of the object—which is a lot of energy.

The exact height at which one might like to fly a satellite will be determined by the amount of energy available and, secondly, by the desired life of the satellite. The life is limited by the fact that the satellite is not flying in a perfect vacuum, and the residual trace of atmosphere at these altitudes will slow it down, so that the object will eventually lose energy to the extent that it will spiral into the earth and be burned up as it enters the dense atmosphere. An altitude of 300 miles is predicted to give a lifetime which will be measured in weeks or months. There is considerable uncertainty as to the actual density of the atmosphere at these altitudes, and so the prediction of lifetime is uncertain, but the best estimates say that at 300 miles it will be at least several weeks. It may be as long as a year.

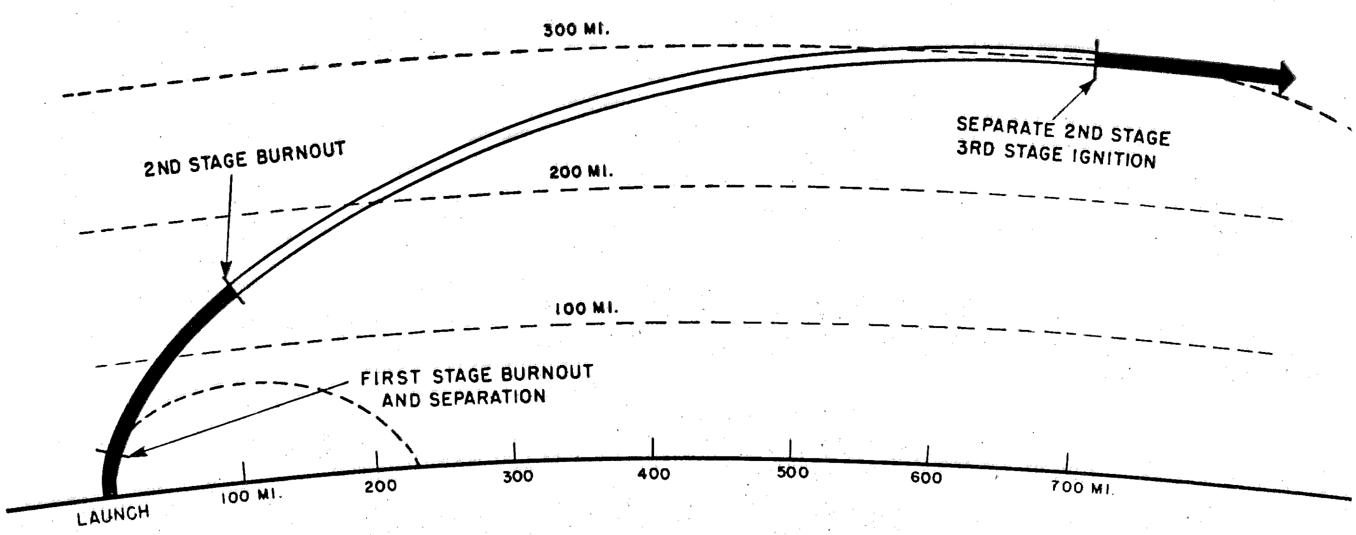
In order to actually place an object in an orbit, it will be necessary to give it more energy than that required for a circular orbit. In this case, the orbit will become elliptical, and, assuming that we launch the object from an altitude of 300 miles in a horizontal direction, the launching point will be the perigee of the ellipse. The altitude of the apogee will depend upon the magnitude of the excess velocity imparted to the object. The expectation is that the Vanguard satellite orbit will be an ellipse which is about 200 miles high at the closest approach and about 800 miles at the apogee.

The period for a circular orbit can be easily calculated from the velocity and the radius of the orbit. For the 300-mile altitude this works out to be about 94 minutes to go around the earth.

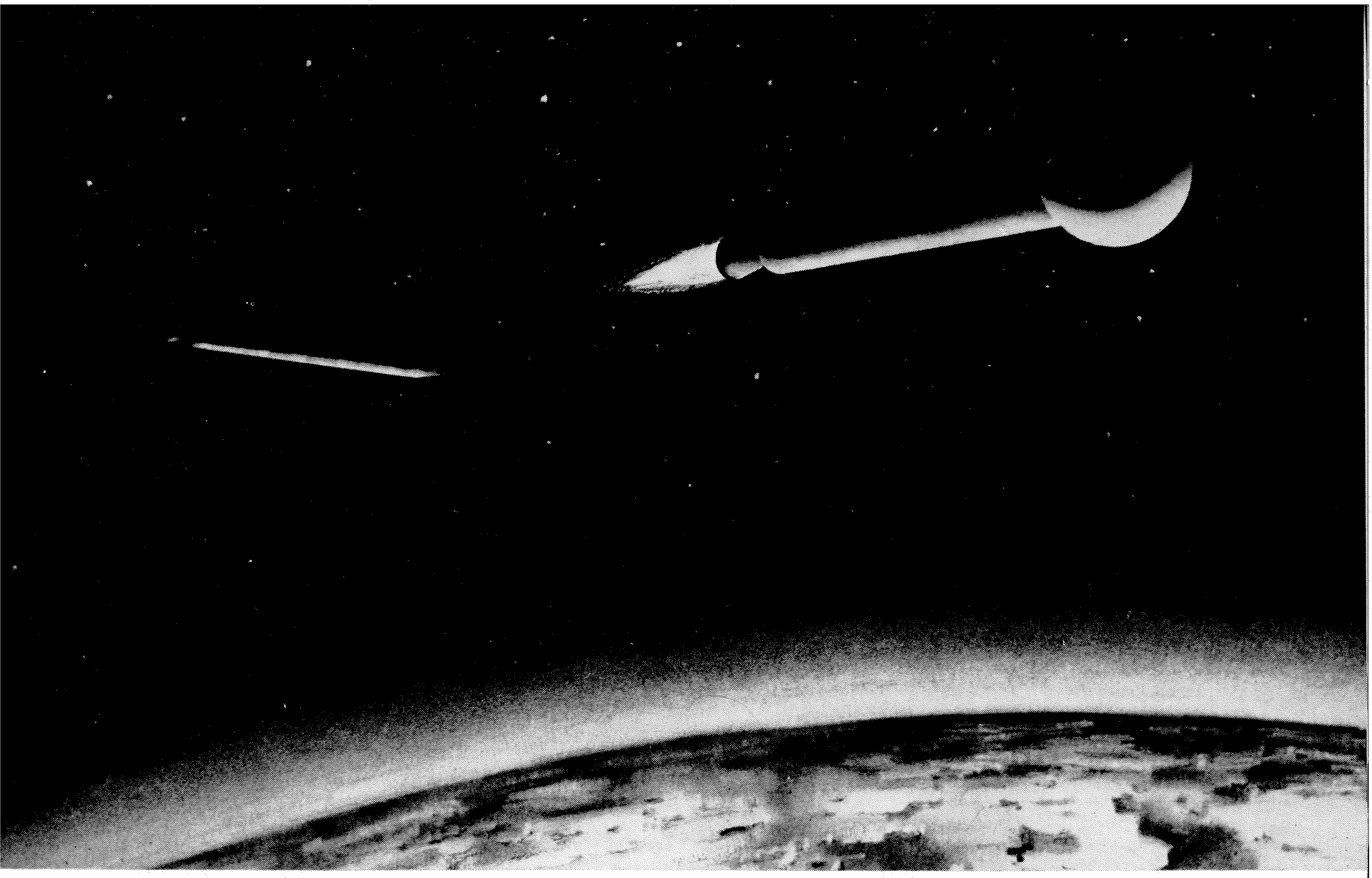
It is interesting to ask: At what altitude would the period become 24 hours? In this case, the object would remain apparently at rest over the launching area. This turns out to be a height of about 5.6 times the earth's radius.

As a practical consideration, if we plan to launch this satellite vehicle, we might just as well take advantage of the fact that the earth is rotating toward the east with a velocity which amounts to 1500 ft/sec at the equator. Therefore, one would like to launch the object from the equator and towards the east. Fortunately, the United States has a long-range proving ground in Florida with a firing line towards the east, and all the necessary facilities to help with launching. Firing directly east from this site would give an additional velocity due to the earth's rotation, of about 1300 ft/sec. The launching direction finally selected will probably be inclined somewhat to the south of east so that the plane of the orbit will intersect the plane of the equator at an angle between 35 and 40 degrees.

Finally, considering the question of accuracy of the direction of launching, we have two problems. The first is the azimuth accuracy which will determine the plane of the orbit. The required accuracy will depend on the location of observing stations, but presumably accuracy of a few degrees would be acceptable. The second problem is the elevation accuracy. This will determine the perigee altitude. If the launching is accurately horizontal, the launching altitude is the perigee altitude. Any other launching angle will lower the perigee. If the direction deviates as much as 1.5 degrees, then the perigee will drop about 100 miles. This means, then, that the accuracy of launching must be somewhere of the order of one degree. So, to sum up, we must



The launching trajectory of the Project Vanguard satellite.



The three-stage rocket is shown here just as the second and third stages are separating. At the end of burning of the third stage, the ball—which is the actual satellite object—will be separated from the rocket by a spring-ejection device.

take our satellite object to an altitude of 300 miles and launch it with a velocity of 5 miles a second in a specified direction with an accuracy of about one degree.

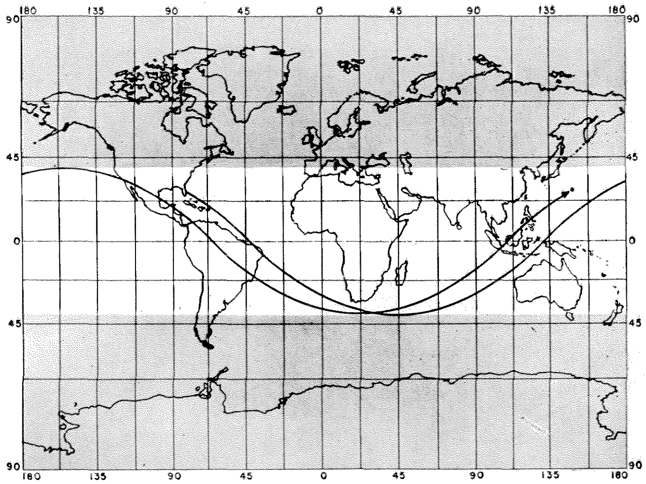
Project Vanguard will consist of a three-stage rocket, the first stage having some similarities to the Viking rocket, the second stage having some similarities to the Aerobee rocket, and the third stage being a solid propellant rocket.

The type of trajectory which will be flown is indicated in the diagram on page 14. The first stage will take the satellite up to about 40 miles and then combustion is complete and the first stage will drop off. At this time the velocity is about 5,000 ft/sec. The second stage will take over and carry it up to about 140 miles with a velocity of 16,000 ft/sec. At this time combustion is complete but the second stage is left attached to the third stage, and together they will coast up to a 300 mile altitude. At the 300 mile altitude, when the object is pointing in the correct direction, the third stage is ignited and off it goes on its orbit. The second stage, of course, is separated and will drop back to earth about 1,000 or 2,000 miles away from the launching site.

Separation between the second and third stages might look something like the picture above, where I have indicated the third stage as having a ball, which is the actual satellite object, attached to the forward end. Of course, in the earlier parts of the flight, this must be covered with some sort of wind shield or stream lining to protect it as it goes through the atmosphere. At the end of burning of the third stage, one will want to separate the ball from the rocket, and this can be accomplished by some sort of simple spring-ejection device.

For something with which to compare this performance, I might note that the present official altitude record is held by the so-called Bumper-Wac rocket, which was a V-2 with a JPL-developed Wac Corporal on the front end. This Bumper-Wac reached an altitude of approximately 250 miles. One can calculate that it required a velocity of about 9,000 ft/sec so that there is a considerable increment from this 9,000 ft/sec to the 25,000 ft/sec needed for the satellite.

The problem of keeping the rocket on its trajectory is a very critical one. Guidance is obviously going to be necessary during the whole combustion process. It is proposed, however, that none of the rockets possess fins or any aerodynamic surfaces to guide them, but that since most of the flight has to be in a vacuum, it be guided by swiveling the rocket motor in each of the first two



The white strip on this map shows the regions of the earth that will be swept over by the satellite's orbit.

stages. In the final stage, since there is a solid propellant motor, the simplest thing is just to give it a spin to maintain its orientation.

The first stage will use liquid oxygen with some kind of alcohol-type fuel; the second stage will be nitric acid with unsymmetrical di-methyl hydrazine as a fuel; and the third stage will be a solid propellant. The exact sizes of these rockets have not been announced, but the general indication is that the first stage is somewhat larger than the present Viking rocket. The present Viking is a rocket weighing about 11,000 or 12,000 pounds, built by the Glenn L. Martin Company for the Naval Research Laboratory as a high-altitude sounding rocket used for research purposes. The Aerobee, which is a prototype of the second stage, likewise has been developed by the Aerojet Corporation as a high-altitude sounding rocket. The size of the satellite object has been announced as weighing about 20 pounds and probably having a diameter of about 30 inches.

The satellite orbit

Suppose that the satellite is launched at an angle of about 40 degrees with the equator. The map above indicates the regions of the earth which will be swept over by the orbit. As time goes on, all that region of the earth lying between ±40 degrees latitude will be covered by the trajectory. Interestingly enough, the object will come over Pasadena—or very close to it—on its first time around. The first chance to get a good look at it will be when it comes back over the southern part of the United States on its first time around. The observations made from this area will be very important in establishing the orbit.

It is interesting to consider the question of visual observations. At any given point, the time that the object is above the horizon is very short. If it goes over the zenith, the time will be of the order of 9 minutes from horizon to horizon—and, by the way, it will rise in the West and set in the East. There will be no question of distinguishing it from the other heavenly bodies. However, an object only 30 inches in diameter is not going to be very conspicuous, and indeed the only hope of seeing it will be when the sun is shining on the object and you, as the observer, are in darkness underneath it—which means that you will have to see it just after sunset or before sunrise.

This means that from the point of view of optical tracking there is going to be a very limited chance that you will see it on any given revolution, because you will have to be at the right place at the right time with the proper seeing conditions. So that for optical observations, it will be necessary to establish stations at carefully selected sites and to set the correct launching time.

For example, if one launched it from Florida in such a way as to obtain good observations from Pasadena, then the passage over Pasadena would have to occur just before local sunrise or just after local sunset. This, then, will determine the launching time in Florida. Given optimum observing conditions, it is calculated that this 30-inch object will be about as visible as a 6th magnitude star, which is about the limit of visibility. If you have some relatively low-powered binoculars and you know where to look, you should be able to locate it.

Observations could be of two types, either optical or radio. There will be a radio transmitter aboard the satellite which will put out a weak signal. Radio direction-finding will then give a rough position of the object, and optical observations, a considerably more precise orbit. The advantage of the radio is that it can be detected every time it comes within the vicinity of a receiving station. Therefore, there will be a network of both radio and optical stations established, and indeed it is expected that amateurs will be invited to contribute to this network.

When the satellite is actually launched, there will be announcement of the approximate orbit and of the approximate time that the satellite will be passing various points on the earth's surface. It is hoped that both radio amateurs and amateur astronomers will be organized to collect data and to channel it in to the central data analysis points.

Data from orbital measurements

Supposing that a precise orbit of the satellite is obtained, the question one might ask is: What kind of information can be deduced from such knowledge? In other words, is it possible to obtain useful data from what one might call external measurements? Four useful areas of investigation are: air density along the path; variations in the shape of the earth; anomalies in the distribution of matter within the earth; and precise knowledge of relative location of points on the earth's surface.

There is considerable interest in the density of the atmosphere at these altitudes. It is of the general order of magnitude of 10^{-15} gms/cc, which by all ordinary standards is an excellent vacuum; but from the astrophysical point of view, one would like to know just how the density does vary with altitude in this region. This small density of perhaps 10^{-15} gms/cc will exert a small drag on the object. If we say the drag force is proportional to the frontal area, the square of the velocity and the density, then we can calculate a loss of energy and of velocity per revolution. For a 30-inch sphere weighing 20 pounds, at 200 miles altitude, the period will change by about .04 seconds per revolution. This means, then, that if we are going to use the satellite to enable us to calculate air densities, we must have a very precise orbit, and we need a very careful analysis of the orbital data. In order to obtain data on the density as a function of altitude, the path must be analyzed as the object gradually spirals down into the dense atmosphere.

The shape of the earth

The next thing I have indicated is the shape of the earth. We know that in a broad sense the earth is an oblate spheroid. This fact will cause the plane of the orbit to precess around the axis of the earth with a period of about 50 days. Again, if we have the precise orbit, we can calculate back to obtain information on the actual shape of the earth.

We know that the earth is not a perfectly symmetrical sphere as far as the distribution of matter within the earth is concerned. The variations of G as we go over the continents and over the oceans imply that there are differing amounts of matter between the surface and the center. Therefore, again, we have the possibility of learning something about the symmetry of the earth.

A surveying problem

The final problem that I have indicated is the surveying problem. If we consider the problem of locating an island some distance off the coast of a continental mass, this can be done by measuring the latitude and longitude of the two points. But in order to do this, one has to use the local vertical, and one wonders if the local vertical is indeed the direction to the center of the earth. With a satellite it becomes possible to put an observing site both on the island and on the continental mass to observe the satellite, and then by simple trigonometry to obtain the separation between the two. Likewise, if the orbital parameters are known precisely, the path of the satellite can be used to survey the observing station.

Thus it appears that, even with data from the satellite restricted to observations from the ground, a wealth of useful information will be obtained, provided only that the object can be tracked visually.

The next problem is to measure various quantities at this 300 mile altitude. This poses a new problem because the only way to get data back is by radio. The satellite will never be recovered. As time goes on and it slows down, it will re-enter the atmosphere and burn up. So, all the data must be presented in a form which can be sent down to the earth by radio. Since radio receiving sites can be located in only a few limited areas, the information will have to be stored in the satellite in some fashion until it is over a receiving site, and then a transmitter at the receiving site will have to interrogate the satellite concerning the data. Unfortunately this will call for some fairly complicated telemetering techniques to go into the satellite. Therefore the types of measurements which can be made will be fairly limited; at least, in the small satellites. The total payload is 20 pounds and that has to include all the structure.

Internal measurements

Suitable internal measurements might include the following. First, one might measure the temperature of the satellite object itself. This temperature will be determined by the radiation balance—the radiation falling on the object and the re-radiation from the object. Knowing something about the infrared characteristics of the surface of the satellite, and knowing what we do about the solar radiation, we can hope to establish a balance that will keep the instrumentation of the satellite at a fairly uniform temperature. However, there will be fluctuations as it goes around the earth and behind the shadow of the earth. The temperature will not go very low during this period because of re-radiation from the earth, although there is considerable question as to just what this re-radiation from the earth actually consists of; and this measurement should add to our knowledge of this particular quantity—the albedo of the earth.

A second measurement could be a pressure measurement. From the point of view of the instrumentation which is carried in the satellite, it will almost certainly be desirable to make it pressure tight. If the satellite is bombarded by small meteorites, these will make holes through the skin and the internal pressure will be lost. By observing the pressure, as a function of time, we can obtain information on the probability of collision with the small meteorites.

Environmental factors

These first two measurements will be made on the first satellite objects for instrumentation purposes, if for nothing else, because future satellites with more elaborate instrumentation aboard will require information about the environmental conditions on the satellite. The pressure and temperature measurements describe the most important environmental factors.

Another class of measurement is that of radiation. We know that all the radiation observed here at the surface has been filtered through the atmosphere and absorbed by the atmosphere. The atmosphere is actually opaque to radiations of many wave lengths. Now, by balloon measurements and by high altitude sounding rocket measurements, direct measurements of the radiation at high altitudes have been obtained, but these earlier types of measurements are limited because of the fact that the measurement is made at one particular point in space and one particular point in time.

In the case of a rocket—for example, a sounding rocket going up to altitudes of the order of 100 miles—the time spent outside of the atmosphere is measured in seconds. Balloons stay up for longer periods of time, but will not reach such high altitudes. The satellite, on the other hand, is up for an indefinitely long time and at higher altitudes than have been attained before.

Cosmic radiation

Of the kind of measurements we can make which utilize these facts, one possible measurement is the intensity of the primary cosmic radiation. There is a great deal of interest in the variation of cosmic rays as a function of latitude, longitude and time. The satellite is particularly useful because of the fact that it sweeps over large areas of the earth's surface in a short period of time. From the cosmic ray point of view, one would prefer to have the orbit going over the poles rather than in an equatorial direction, but the inclined orbit which is planned should provide exceedingly interesting data. Perhaps some later satellite will go over the poles.

Another measurement is that of the intensity of the Lyman alpha line. The Lyman alpha radiation from the sun lies in the far ultra-violet with a wave length of about 1200 angstroms. There is considerable interest in just what the intensity of this radiation actually is. Measurements have been made from sounding rockets; however, the sounding rocket measurements suffer from the disadvantage that they make a single observation on the condition of the sun as it happens to exist at the time. It is believed that the Lyman alpha intensity from the sun varies over very wide ranges and one would like very much to observe the changes in this radiation as the sun goes through some sort of disturbed condition.

Disturbances on the sun

Here again, the continued series of observations possible from the satellite over a period of weeks provides an opportunity for finding the sun in a disturbed condition and therefore obtaining the required information. We may note in passing that the period of the geophysical year was chosen as a period in which the sun would be most disturbed, so that there would be a better chance of catching such conditions.

In addition to the types of measurements which I have indicated here, a wide variety of additional measurements have been proposed. Some 30 papers were presented at a scientific meeting held at the University of Michigan in January of this year. There were some duplications, but many new ideas were presented. Among these I will mention just two.

Magnetic measurements

One was the problem of magnetic measurements. We know that the magnetic field of the earth arises partly from currents inside the earth and partly from currents above the surface. We believe that the contribution arising from currents flowing above the surface may be due to currents in the ionosphere, but the so-called Stormer ring current which is several earth radii above the surface of the earth may also contribute. It would be of considerable interest to know whether this ring current actually exists, and to get some idea of the relative contributions of the ionosphere and the ring system. We need to make measurements, then, above the ionosphere, and if we could measure the disturbances in the magnetic field, then we could obtain these data. In practice, this looks like a very complicated experiment because it requires measurements of small fluctuations in the magnetic field. Furthermore, the observing site is wandering all over the globe, and so observations have to be corrected for local conditions. It is a discouraging experiment but one which would have a lot of scientific interest.

Meteoritic dust

Another experiment is a further investigation of meteoritic dust or micro-meteorites. One might ask, Is the surface of the satellite being eroded by bombardment with some sort of cosmic dust? One proposal is that the satellite should start out with a polished surface which has a certain apparent brightness. As time goes on, will that brightness change, and if so, will the change be due to a change in the condition of the surface brought about by meteoric dust? Alternatively, another proposal has been made: Suppose the surface is coated, in some areas at least, with a certain amount of radio-active material? Then if the surface is being eroded, this material would be worn off, and by measurements of changes in the radioactivity, one could determine how much has been worn off.

The precise experiments which will be carried in the early satellite flights have not yet been established, but it is clear that already a large number of possibilities exist, and it is to be expected that within the year and a half before the first satellite is flown, many more experiments will be under consideration.

The Technical Panel on the Earth Satellite Program has an interesting task ahead of it to formulate the best possible scientific program. The earth satellite program has stirred the imagination of scientists and public alike. It will be a spectacular demonstration of the potentialities of modern technology and the first real step towards the conquest of space.

MUSCOVITE MAKE-BELIEVE

Deceit and self-deception—so vital to the functioning of Soviet society—make the Russians both dangerous and difficult to deal with. Our best move is to face it realistically.

by HEINZ E. ELLERSIECK

IT IS A WELL-ESTABLISHED fact that dealing with the Soviet Union is both difficult and dangerous. One of the main reasons is that throughout Soviet life much that is said and done either is designed to deceive or is based upon self-deception. Make-believe is important in the functioning of Soviet society. The Soviet state and the people of the Soviet Union constantly practice, even in their confessions of past deception, to deceive each other and the outside world. They succeed depressingly well.

The western observer (who is usually handicapped, of course, by his own illusions as well) is hard put to it to separate the fiction from the fact on the Soviet scene. This has had some unfortunate consequences. Some people have become informaniacs. Stimulated and yet frustrated by the tragically unreliable information available, they avidly consume ever-increasing quantities of the stuff. They are, to borrow a term from a related phenomenon, "hooked." Their diet is indigestible.

Others, in the meantime, have decided that the Soviet Union is an unresolvable enigma. Convinced that we shall be duped if we deal with the Soviets, they advocate that we have *nothing* to do with them. There is little to choose between the two extreme reactions. Both are, of course, understandable—but neither is justified.

A more fruitful attitude toward Soviet deception and the problems growing out of it can be built upon the realization that the phenomenon is not new in Russian history, nor is it exclusively Russian. It is a phenomenon which has developed, and inevitably develops, under certain historical circumstances. Just as inevitably will it decline in importance when the circumstances become permissive—but only then. Impatience avails us not at all.

Soviet deception and make-believe have roots and counterparts far back in Muscovite history. They grew up out of weakness and despair, out of isolation and boredom, out of extreme pressure. They grew up as a technique to cope with a reality which was almost always bleak and often unbearably harsh. Deception was an indispensable aid to physical survival. Self-deception followed, not only as a consequence of confusion but as a balm to self-respect.

Russian history is monotonously a story of grinding poverty in a hard land, a story of inadequate resources and recurrent crises. In its struggle to survive and expand, the Muscovite state called upon the people, generation after generation, for extraordinary sacrifices. In order to force compliance, the state, which had few rewards to distribute, had to threaten very severe penalties for those who failed to obey. A subservient Church added terrible religious sanctions. Myths and pretenses were always employed to justify and to facilitate all that the rulers wanted. Unfortunately, such practices were necessary. Without them the Russian people could never have been driven.

As it was, more often than not, the Russian people resorted to massive and ingenious evasion in order to survive the impossible demands. At every social level they countered the orders from above with imaginative, wonderful and endlessly repetitious excuses. They learned to evade every intent of law and contract while performing with great intensity every detail of the rituals prescribed and pretending to slavishly obey every letter of the commands received.

The Muscovite rulers, practicing deception, were well deceived in turn. They started hopeless enterprises based upon false expectations, and when they failed they invented ingenious excuses to rationalize the facts. In dealing with foreigners and foreign powers the Russian rulers, like the people, of course, employed the methods learned at home. Deception was always cheaper than naked force—and when adequate force was lacking, as it often was, deception was mandatory.

The vicious circle

Study of the Muscovite past of the Russian people reveals the operation, through the centuries, of the same vicious circle of deception and self-deception, of belief and make-believe, that characterizes Soviet society in our times. The mechanism in each case is clear. The basic factor has been an acute fear of failure, a fear all the greater because the penalties of failure have always been unacceptably great and because unrealistic aims have often made failure virtually certain.

Deception has either brought success or masked and mitigated failure. The vicious circle will continue just as long as the failures of the Soviet people and of the state continue to be numerous, humiliating, and heavily penalized. The Russians will then continue to deceive themselves and others. They will refuse to face reality, excusing failure in wildly imaginative fashion—or confessing it in abject, grovelling (and equally unrealistic) terms. People in this country and elsewhere, who gloat over every report of difficulties experienced by the Soviets, should stop for a moment and consider the fact that such setbacks are far more likely to give new impetus to the vicious circle than they are to teach the Russians respect for reality as we see it.

Removing the blinders

Actually, if we are interested in seeing a real change in the Soviet practice of deception, we must look forward to the day when failures and shortcomings there become less frequent and less catastrophic, or are offset by major successes. Then we could hope to hear fewer lies and more facts from that corner of the earth. When and if they begin to compare favorably with the rest of the world, the Soviet people may well be permitted to remove their blinders, so that it will—in time—be possible to deal with them and with their state on a more objective basis.

It will be objected, of course, that every success will make the Soviet Union stronger and more dangerous. Soviet leaders will wield tremendous power *before* the agreeable and relaxing effects of success begin to modify their habits materially. That is all too true! It is also disagreeable to contemplate the evidence that Soviet success may have been won to a considerable degree by such dirty methods as force and deception. Coexistence, under the circumstances, will undoubtedly be uncomfortable and dangerous. The question of whether we can afford to deal with nations such as the Soviet Union (and Communist China) will become ever more acute if they enjoy success; it is already an important question. But let's face it. History, including our own history, is full of highly respected ex-bastards who gained their respectability after first gaining success.

Breaking the vicious circle

Very likely the course of discretion and common sense is to see to it first of all that we do not find ourselves victimized by Soviet deception (or force). This we can guard against quite adequately by refusing to be stampeded by superficial changes in Soviet behavior. We can also maintain sufficient strength to prevent overt aggression. But certainly Soviet successes need not be at our expense, nor need they be mainly due, if they come, to deception and myth-making. We should not begrudge them; rather we should welcome them as steps toward the eventual breaking of the vicious circle of deception and make-believe which makes the Soviet Union of today so hard to deal with and so dangerous.

When we consider that vicious circle in the Soviet Union, and the reasons why it has persisted, we might also do well to contemplate the state of our own myths, our own respect for reality, and our own dream world.

Realism or delusion

What are we doing when we choose to regard Soviet successes as defeats for our way of life—are we judging objectively or are we hallucinating ourselves? What are we doing when we refuse to recognize Soviet successes (either belittling them or building them up into monstrous threats)—are we being realistic or are we deluding ourselves? Whom are we fooling with all our talk (in industry, in business, in government, in educational institutions) about superiority of brains, methods, results?

Is it becoming necessary for the United States and the American people to create and market massive myths? Could it be that we fear failure? Why do we constantly have to reassure ourselves that we are doing just fine, or flagellate ourselves with the fear that we are losing ground? Actually we are not in much danger of getting into a Soviet-type bind. But it would be worth our while to avoid even a single step in that direction. At the moment one of the best moves we could make in the right direction would be to start looking at the Soviet Union—our Number One Bugaboo—somewhat more realistically, and with an eye to avoiding make-believe of our own.

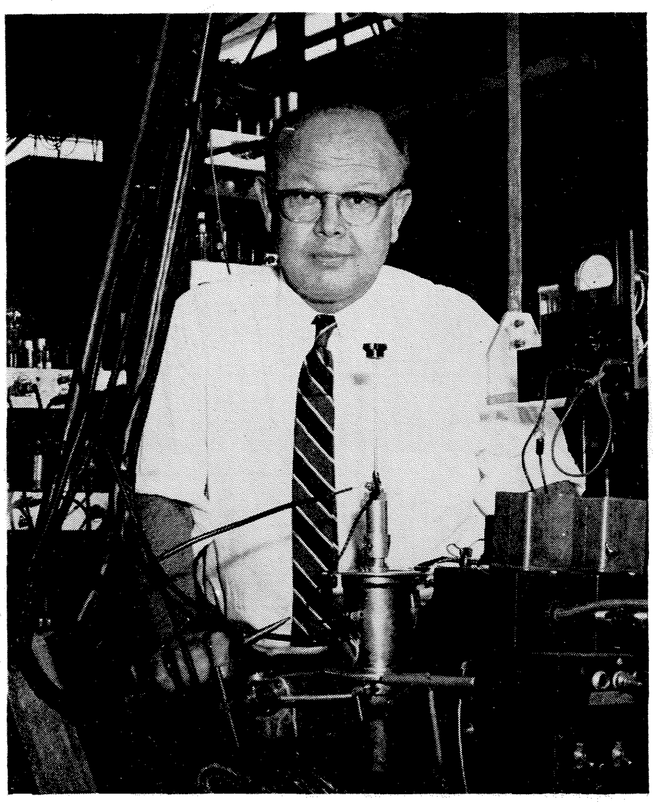
THE MONTH AT CALTECH

John D. Roberts, professor of organic chemistry

National Academy Members

DR. WILLIAM A. FOWLER, professor of physics, and Dr. John D. Roberts, professor of organic chemistry, were elected members of the National Academy of Sciences last month—bringing Caltech staff membership in the Academy to 28. The Academy offers membership to only 500 American citizens and 50 foreign associates who have made valuable contributions in scientific research.

Dr. Fowler's principal scientific work has been concerned with sources of the energy of the stars and the structure, energy levels and conversion of light nuclei from one element into another. He is recognized as a world authority for his theoretical and experimental research on the nuclear reactions believed responsible for the evolution of stars.



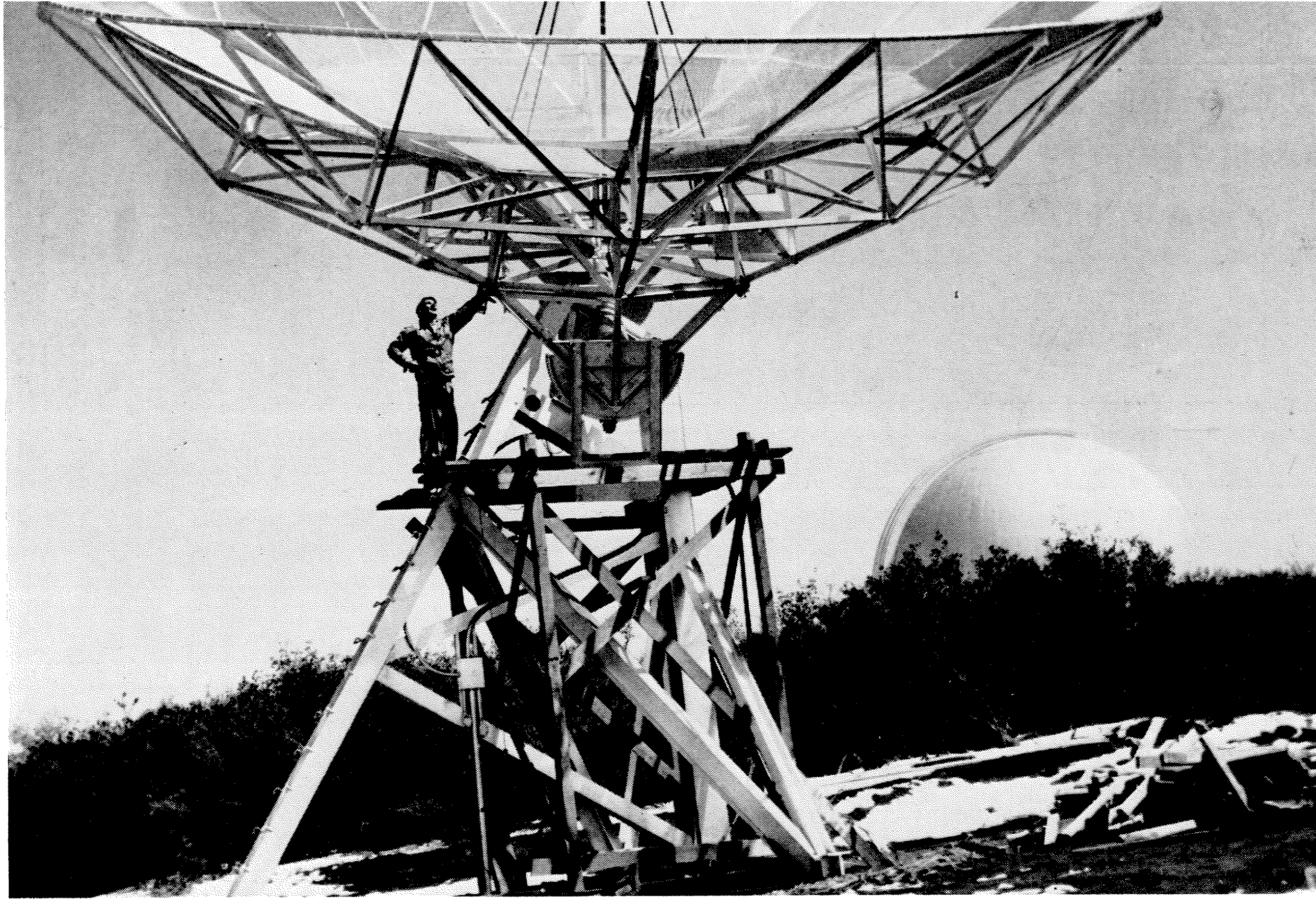
William A. Fowler, professor of physics

He has also pioneered in the development of methods for the precise measurement of gamma ray intensities and energies, and the measuring of nuclear resonances or sound waves. During the war, as consultant to the Division of Rocket Ordnance of the National Defense Committee, he contributed materially to the development of specialized rockets and weapons, and received the Medal for Merit in 1948 for his outstanding services.

After receiving his BS from Ohio State University in 1933, and his PhD from Caltech in 1936, Dr. Fowler joined the Caltech staff as a research fellow. He has been professor of physics since 1946.

Dr. Roberts is known for his contributions to theoretical organic chemistry, particularly his studies with radioactive tracers which have added to our understanding of the reactions of compounds containing carbon. His current research is concerned with the mechanisms of organic reactions, the nature of chemical binding in small-ring compounds and the applications of nuclear magnetic resonances to chemical problems. In 1954, Dr. Roberts received the American Chemical Society Award in pure chemistry for his contributions in fundamental research.

Dr. Roberts was graduated from UCLA in 1941 and received his PhD there in 1944. After working at Harvard as a National Research Fellow for a year, he joined the MIT faculty. In the fall of 1952 he came to Caltech as a Guggenheim Fellow and became a member of the faculty here in 1953.



John G. Bolton, and the new antenna set up on Palomar Mountain to detect radio signals from outer space

Radio astronomy

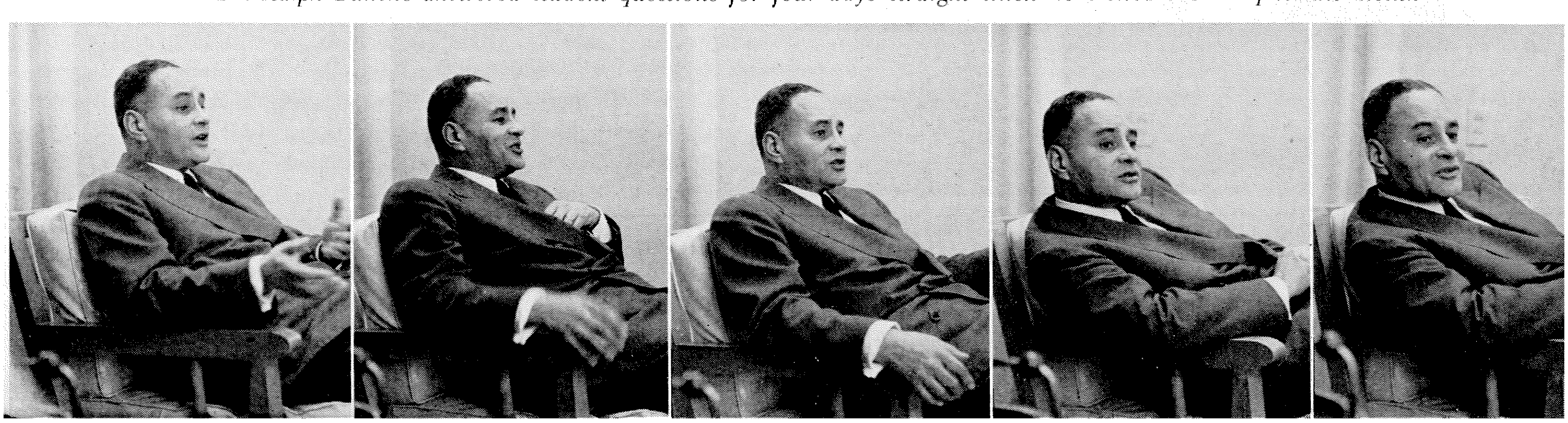
CALTECH'S RADIO ASTRONOMY program went "on the air" last month when scientists started operation of a 32-foot diameter antenna on Palomar Mountain. This radio telescope, designed to detect the sources of radio noise in the cosmos, is the first to be set up on the West Coast.

The Palomar instrument is designed to serve as a pilot model for scientific observation and as a training instrument for astronomers and electronics workers. Within the year, Caltech expects to mount three additional parabolic reflectors—one, 32 feet in diameter, and two others 90 feet in diameter. These will be located on a California desert site, probably in the Owens Valley.

The science of radio astronomy, which has burgeoned since the development of radar during the war, is defined as the study of celestial bodies by observation of the radio waves which they emit or reflect. In some cases it serves as a valuable complement to optical astronomy; in others it has been a source of wholly new discoveries.

The Caltech radio astronomy program has been established under a grant of more than $400,000 from the Office of Naval Research. It is under the direction of John G. Bolton, who came to Caltech last year as senior research fellow in physics and astronomy. Mr. Bolton was formerly principal research officer of Australia's Commonwealth Scientific and Industrial Research Organization, and, in 1947, discovered the first of the so-called "radio stars."

Dr. Ralph Bunche answered student questions for four days straight when he visited the campus last month



Leaders of America

Dr. Ralph Bunche, Under Secretary General of the United Nations, came to the campus last month as the third and final visitor on the YMCA's Leaders of America program for 1955-56. Previous visitors have been Paul G. Hoffman and Justice William O. Douglas. On a crowded schedule, Dr. Bunche gave several formal lectures in the four days he was here, but spent the majority of his time in informal meetings with undergraduates.

Dr. Bunche was graduated from UCLA in 1927, received his MA in political science from Harvard in 1928, and his PhD in 1934. Until 1941 he headed the political science department at Howard University, then served during the war with the Office of Strategic Services. In 1945 he received an appointment to the State Department, and there he took an active part in the formation of the UN. Until he became Under Secretary last year he served as principal director of the UN Trusteeship Division. His work in settling the Arab-Israeli dispute in 1948 won him the Nobel peace prize.

Cooperative Wind Tunnel

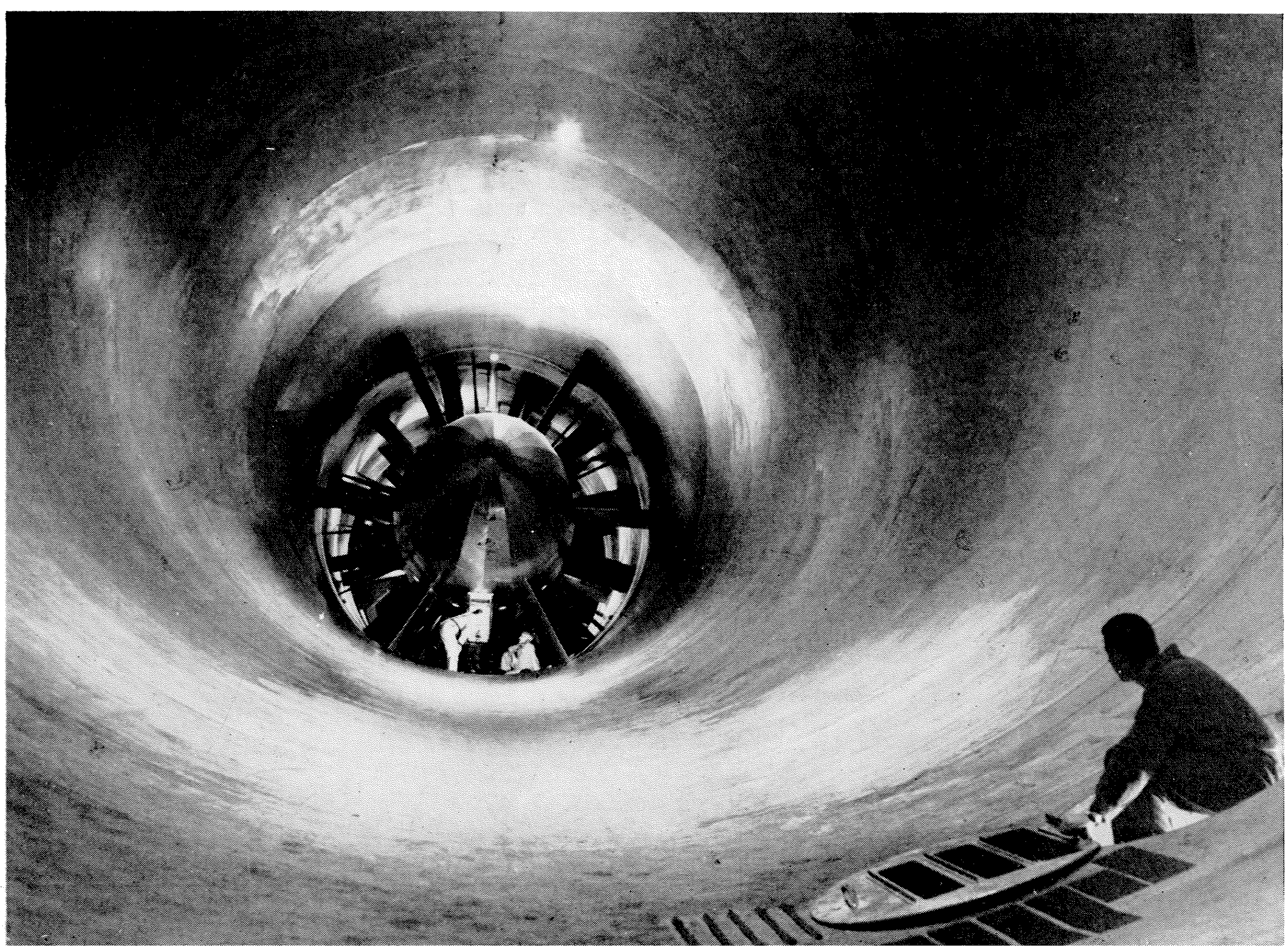
The modernized Southern California Cooperative Wind Tunnel had its formal dedication on April 25. The $8,000,000 remodeling job boosts the wind tunnel's air velocities to a maximum of 1400 miles an hour—almost twice the speed of sound.

The original tunnel was built in the early '40s, when high speed military aircraft were flying at a maximum speed of 400-500 miles an hour. That tunnel produced velocities of 750 mph—a speed which was later increased to 900 mph. The present modification program, begun five years ago, makes it possible to use the tunnel for the development of modern transonic and supersonic aircraft.

The Cooperative Wind Tunnel is neither the biggest nor the fastest wind tunnel in the world. It is very nearly unique, though, in the high level of productive efficiency it has established. In designing high-speed aircraft, manufacturers need to get test information as quickly as possible. Automatic recording devices at the Cooperative Wind Tunnel can provide some of this information in a matter of seconds.

The Cooperative Wind Tunnel is owned by five aircraft companies — Douglas, Convair, Lockheed, North American and McDonnell—and is operated on a non-profit basis by Caltech. Its director is Dr. Clark Millikan, who is also director of the Guggenheim Aeronautics Laboratory and professor of aeronautics at Caltech. Fred H. Felberg, who has served as executive assistant since 1952, is now associate director of CWT.

Workers check giant fans in the newly remodeled Southern California Cooperative Wind Tunnel



GEOLOGISTS IN THE FIELD

A pictorial record of Geology's annual regimented vacation known as the Spring Field Trip

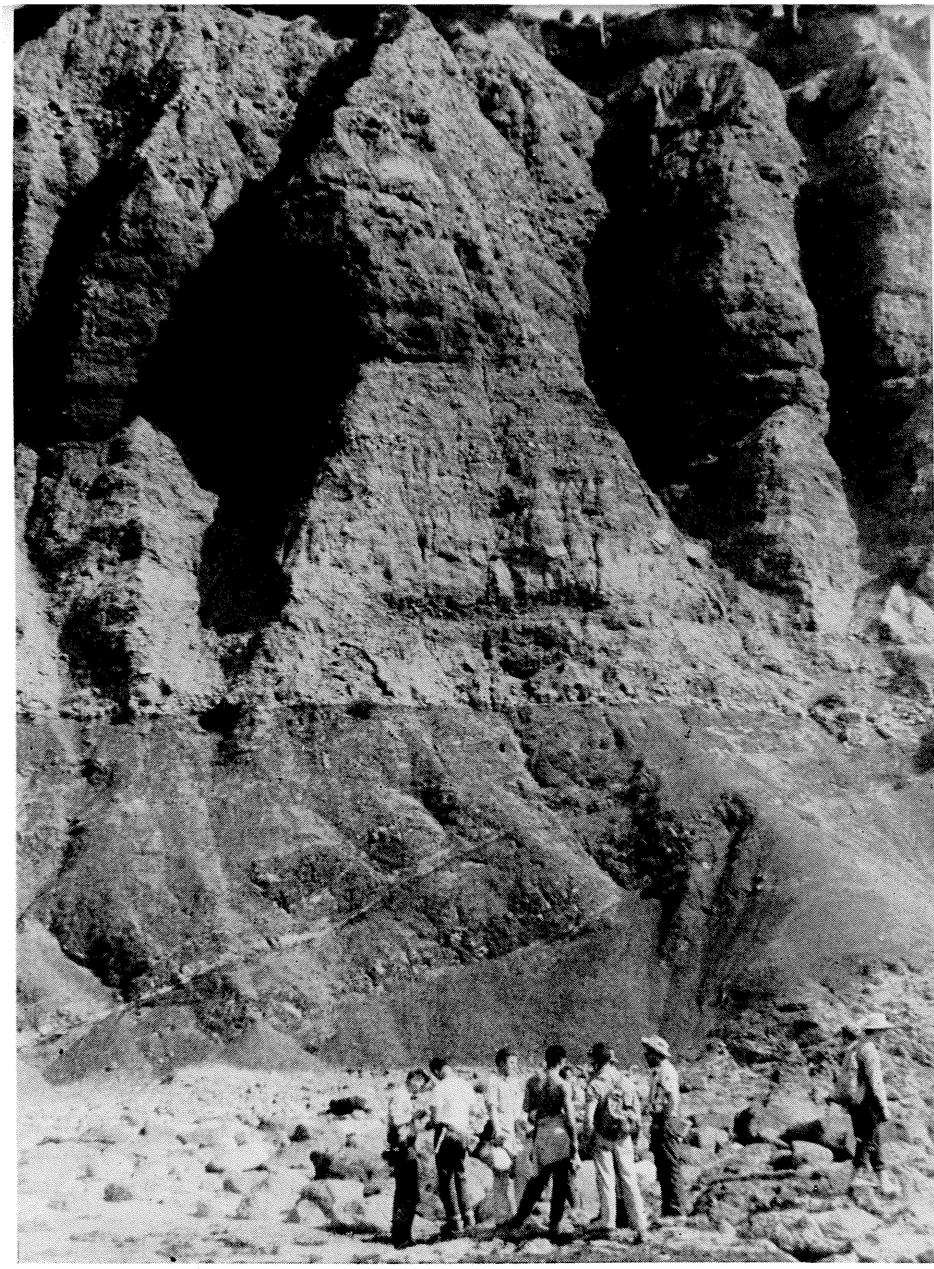
IT'S AN ANNUAL custom with Caltech geologists to hit the dusty trail as soon as spring vacation rolls around, and this year Drs. Frank Stehli and Leon Silver led a caravan of 20 undergraduates into the wilds of Baja California. The pictures on these pages are samples of the record kept by Dr. Silver of this safari.

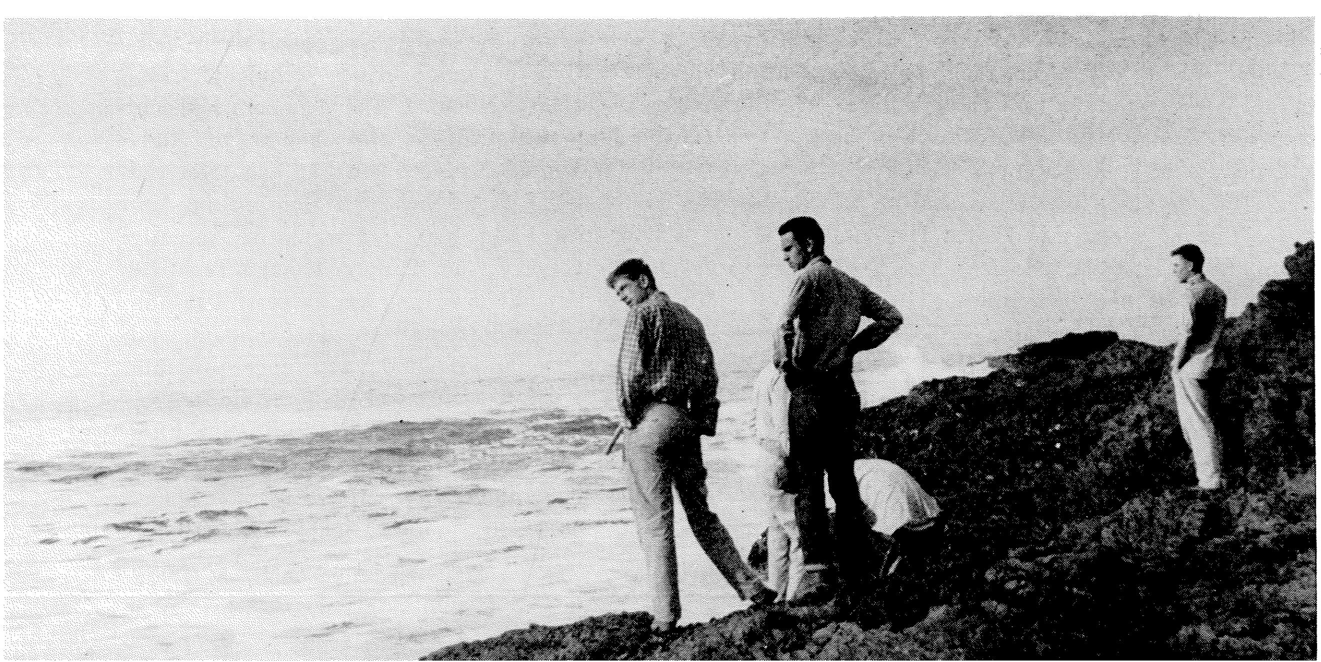
At the left, the party has stopped at Lake Mathews, en route, for a look at some of the oldest rocks in southern California—and for an informal al fresco lunch.

At the lower left, Dr. Stehli is pointing out geological features to a partly-attentive audience as the group rests by a Mexican religious shrine near San Vicente, B.C.

At the right, students compare tide pool samples—apparently oblivious to the fact that the sea cliff rising above them is an unconformity between older tilted and beveled Cretaceous rocks and younger horizontal and overlying Pleistocene strata.

Below, tide poolers on the shore near the main camp at Punta China.





AN INTERNATIONAL AFFAIR

—or How to Think Like a Turk

ISOLATED BEHIND their "great white wall," Tech students have a passion for trying to find out how the rest of the collegiate world lives and thinks. Some of the most successful of these investigations are the intercollegiate conferences, with their liberal-arts and coeducational atmosphere—which is rather lacking at Tech. It is only proper, then, that a survey of campus life should include a report from the largest and most elaborate of these conferences, the Model United Nations, which held its sixth session last month at Oregon State College in Corvallis, Oregon.

Nine Tech men were among the 600 students from 70 participating colleges at this session. Each school represented a member nation in the General Assembly, and in the committees and councils of the UN, following as closely as possible the interests and activities of its country in world affairs. The result was an exceedingly effective demonstration of international problems in an intimate, working way.

Diplomatic affairs

The convention began, for Caltech and a dozen other southern California schools, with the long trip north by chartered train. As strangers thrown together for a day, the delegates started diplomatic relations immediately. Australia (Pomona), Indonesia (Orange Coast J. C.), and the Netherlands (Immaculate Heart College) began lobbying for their rights to West Irian, part of the island north of Australia. South Africa (UCLA) was immediately challenged to defend her racist policies, and (the hyprocrites!) presented the case as soundly as possible. Though such enlightened discussion was in vogue, actual lobbying, taken seriously by the neophytes, failed to ring true for very long in the atmosphere of amiable coexistence that pervaded this United Nations. After 24 hours on the train most delegates had been initiated into foreign affairs and had advanced to the more comfortable realm of social affairs.

The four-day conference was impressively directed by a Secretariat of nearly 900 Oregon State students, who had drawn up the rules of operation and an agenda paralleling current UN problems. Almost every delegation had spent two or three months studying its country and its policies, writing resolutions and preparing speeches; Oregon State students, however, had worked for eight months setting up the conference, both in their classes and in their spare time.

The leadership of this small bureaucracy, complicated by the tenuous nature of part-time student assistance, came from a Mr. Papadopoulo, an Egyptian - Greek Cypriote, studying food technology at the OSC graduate school. Mr. Papadopoulo had been sent to the United Nations in New York over Christmas and consequently had in mind the spirit as well as the proper procedures for a United Nations meeting. He was to be seen everywhere, with the hurried, yet carefully amiable air of an amateur executive with a not-too-subdued love for the spotlight.

Secretary-General Papadopoulo called the first plenary session of the General Assembly to order in the OSC Coliseum, which was restyled in clean, well-lighted grandeur and draped with 76 flags for the occasion.

Though there was to have been no debate at this first session, soon after Dr. Frank Munk's opening address the U.S.S.R., without a sign of a smile, rose to object to the propaganda charges in the speech given by China as one of the Big Five Powers' opening statements. This was the first of hundreds of points of order raised by vocal students with an exacting eye on the procedure and a somewhat too eager interest in getting the floor.

Technically Turkish

The Caltech (Turkish) delegation found little difficulty in overcoming the handicap of "technical" training among liberal arts students. The members had met five evenings in the previous two months to study Turkey and the United Nations, and had even received first-hand information from Richard Robinson, the American Universities Field Staff representative recently returned to this country from Turkey. Though Tech did not claim the distinction of writing any successful resolution, one delegate did introduce to the Economic and Financial Committee an economic assistance program which in real life was a pet project of Mr. Robinson's.

The delegation received some inspiration and a little prodding from three Turkish students at OSC who were naturally interested in those who represented their homeland. In fact, one of the more enlightening auxiliary

events of the conference was the argument over Turkish politics that resulted when these three gentlemen each tried to "explain" Turkey. In the end, they issued a kind, but probably futile, invitation to us to visit their homes in Istanbul.

With this background Tech men found it easy to identify themselves with the Turks, even to the point of acquiring a new national pride and prejudice. "I'm from Turkey," became the simple introduction.

Turkish interests

Turkey's primary interests were in economic aid programs (being in debt, she wants them); in the Arab-Israeli dispute (being nearby, she wants a fair peace settlement); and, most of all, in Cyprus—for which she supports the British administration, in opposition to a plebiscite, which would deliver the island to Greece and thereby threaten the Turkish Cypriote minority as well as Turkey's security. Thus these problems were Caltech's primary concerns during the committee meetings of the next two days. They gave ample opportunity for oration and diplomatic lobbying.

The Cyprus question ultimately resulted in the most violent scene of the conference. Though delegates from Turkey and Great Britain (Lewis and Clark College) vehemently disputed it, an unfavorable resolution, calling for a commission to study conditions for a plebiscite, was passed by the General Assembly.

Out of order—and out

On the podium, the British representative was justifiably outraged at this infringement of domestic jurisdiction, but hardly appropriately decorous in his behavior for a British diplomat. As the slightly confused lad protested, he was declared out of order by the chair, and Oregon State's dignified ROTC "security guards" carried the stunned gentleman from the platform, with much loss of aplomb. The British delegation walked out in a huff, bringing home to the Assembly the point that the United Nations must work *with* its members.

Though official business went through the committees and thence to the General Assembly, much of the "politicking" was carried on in block caucuses. Turkey had a part in three of these six groups; one Turk was vice-president of the Afro-Asian block, and others were active in the NATO and METO caucuses.

It was in an Afro-Asian caucus that one of the most heated discussions occurred. This group—consisting of the Bandung conferees—was disrupted by the vociferous Arab nations, led by Egypt (Reed College) and Lebanon (Occidental). On the third day of the conference it was announced that 130 Egyptians and Israeli had in reality been killed on the Gaza strip. True to its responsibilities, the Afro-Asian group immediately took up this problem, assuming a complete diplomatic authority from its home offices.

Over vehement Arabian objections, by a one-vote majority, Israel (Stanford) was allowed three minutes to present its case (as printed in the New York *Times*) in the crowded, partly antagonistic caucus room. Then, until past midnight, a subcommittee of Turkey and India conscientiously undertook to negotiate a truce, calling in alternately the chairmen of the two delegations involved. The Egyptian chairman, a strikingly handsome, self-confident Reed senior with a smooth oratorical rhythm in his voice, presented Nasser's predicament at the mock conference table, ultimately agreeing to a compromise resolution. Point by point, the Israel chairman, a shrewd, mustachioed and very German student from Stanford, also agreed to or modified these proposals as the night wore on.

Show of strength

Unfortunately the plan was defeated next morning, after a vigorous Syrian delegate caused the Arab block to force Egypt to back down. It so happened that this student, a young man with blazing eyes, curly black hair, and a scar on his cheek, was actually a native Syrian, embittered by the death of relatives in the border warfare.

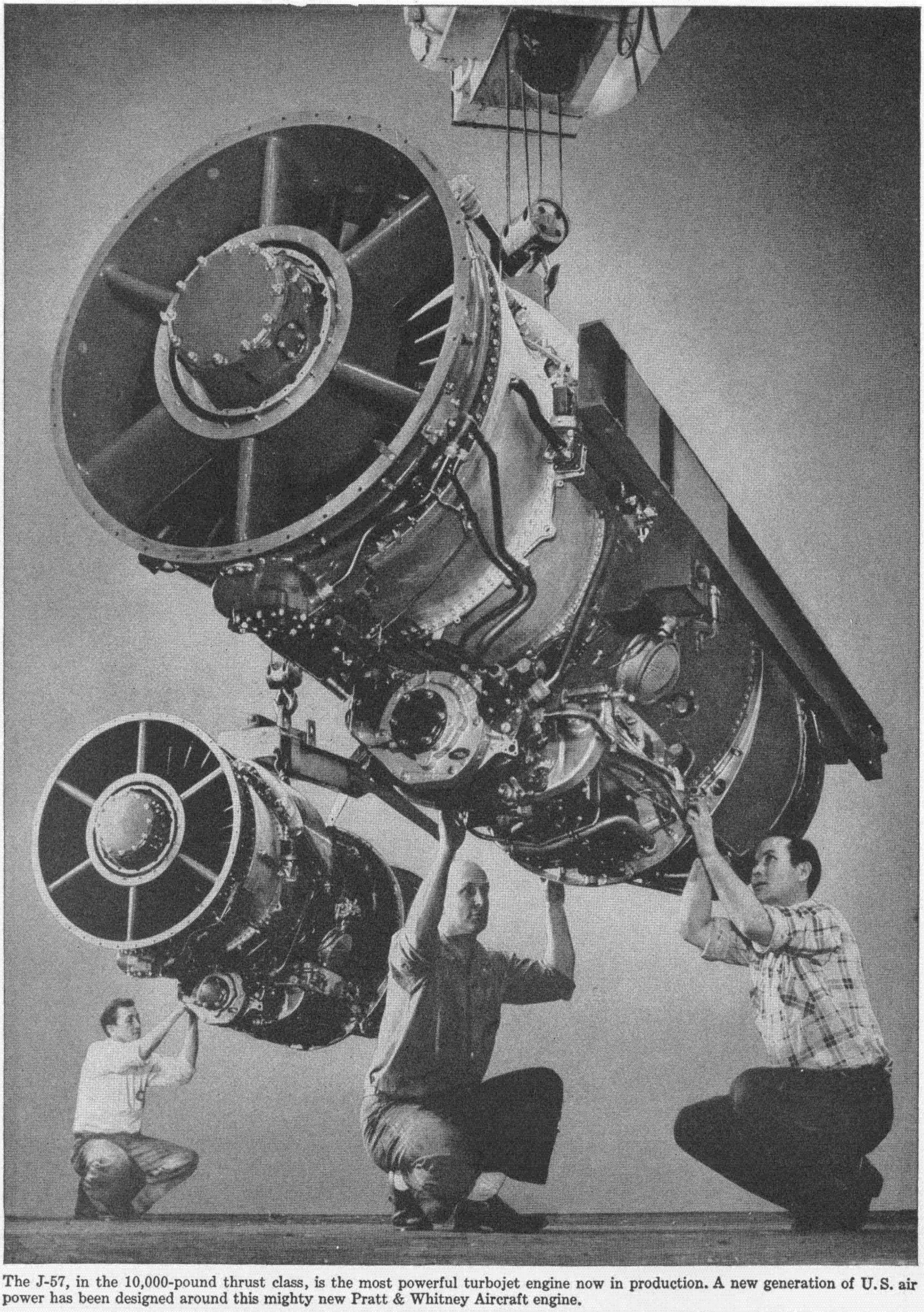
There were many foreign students to lend an international flavor to the affair. Occasionally true loyalties were confused. A tall Negro, with the distinctive bearing of an African prince, introduced himself with, "I'm from Ethiopia—I mean Rumania." Like many others at the conference, he had come to this country to prepare for work with the United Nations after graduation. The greatest incongruity, however, was in the performance of the Negro who defended the notorious racial policies of the Union of South Africa.

International unity

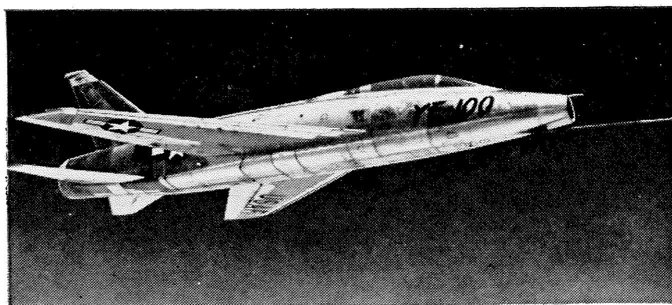
In addition to the weighty problems of state, the delegates attended a banquet, a dance, and a concert sponsored by OSC. By the end of a week most international (and intercollegiate) barriers had been broken down. In the following two weeks, in fact, the southern California delegations managed to stage two joint reunions of the sort that the Washington diplomatic colony is famed for.

Though few Model United Nations delegates would qualify as real diplomats, the temporary pretense was enough to convince most of them that the problems facing the United Nations—Cyprus and Israel included—cannot be solved in four days, nor maybe even in a week.

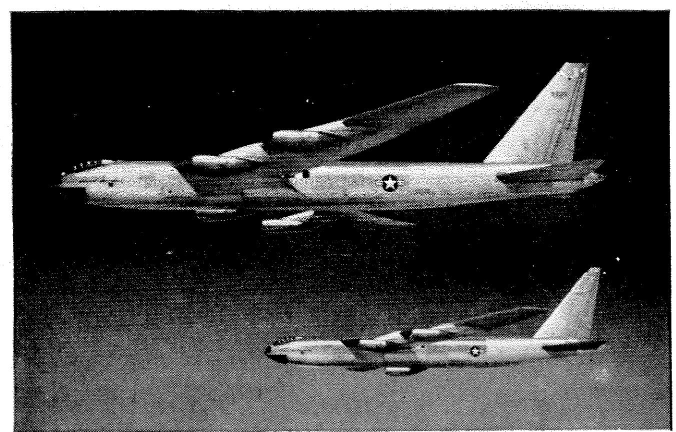
—Tom Bergeman '56



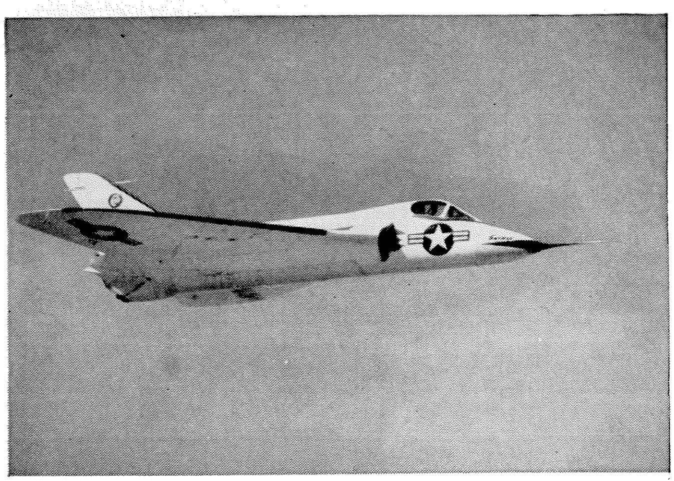
The J-57, in the 10,000-pound thrust class, is the most powerful turbojet engine now in production. A new generation of U.S. air power has been designed around this mighty new Pratt & Whitney Aircraft engine.



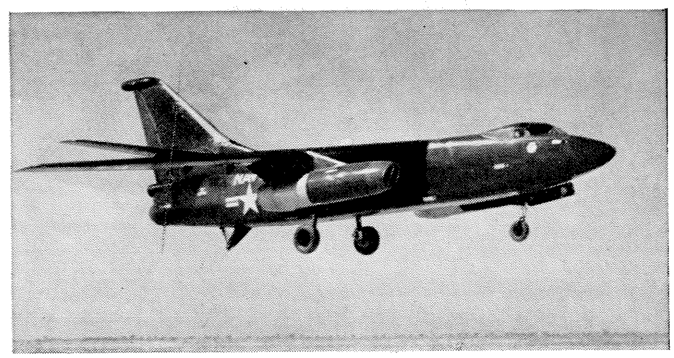
North American's F-100 Super Sabre, fastest Air Force jet fighter, is powered by Pratt & Whitney Aircraft's J-57 engine.



First all-jet heavy U. S. Air Force bombers are the huge Boeing B-52s, powered by eight J-57s mounted in pairs.



The Douglas F4D Skyray, fastest Navy jet fighter, will be powered with the big J-57 engine.



The Douglas A3D, the Navy's most powerful carrier-based attack airplane, has two J-57 engines.

Blazing the Way for a New Generation of Air Power

The most powerful turbojet engine in production is blazing the way for a whole new generation of American aircraft.

That engine is Pratt & Whitney Aircraft's J-57, the first turbojet to achieve an official rating in the 10,000-pound thrust class.

But the J-57 provides far more than extreme high thrust. Its unique Pratt & Whitney Aircraft design, achieved after years of intensive research and engineering, offers as well the low specific fuel consumption so vital to jet-powered bombers and future transports, plus the additional important factor of fast acceleration.

The importance of the J-57 in America's air power program is clearly shown by the fact that it is the power plant for three of the new "century series" fighters for the U. S. Air Force—North American's F-100, McDonnell's F-101 and Convair's F-102—as well as Boeing's B-52 heavy bomber. The Navy, too, has chosen the J-57 for its most powerful attack aircraft, the Douglas A3D, the Douglas F4D fighter and for the Chance Vought F8U day fighter. And the J-57 will power the Boeing 707 jet transport.

The J-57 is fully justifying the long years and intensive effort required for its development, providing pace-setting performance for a new generation of American aircraft.

Engineering graduates who can see the challenge in this new generation, might well consider a career with the world's foremost designer and builder of aircraft engines.

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Harry Rubin, senior research fellow

A report on research in progress at Caltech on the viruses that —instead of killing cells—cause them to multiply at a much faster rate.

by HARRY RUBIN

VIRUSES AND CANCER

POLIOMYELITIS AND INFLUENZA are two of the most familiar virus diseases. In both these cases, the virus produces disease symptoms by damaging or killing cells. It seems strange then that there are other viruses which not only fail to kill cells, but actually cause them to multiply at a much faster rate. This multiplication occurs in a very disorganized manner, and the result is a cancer which ultimately kills the host.

Most of these cancer-causing viruses have been found in chickens. The common leukemia of chickens is due to a virus; that is, we can make a cell-free extract from the tumor tissue which will cause a similar growth when inoculated into another chicken. This was discovered almost half a century ago. Similarly, many other chicken cancers, particularly those of connective tissue origin, are caused by viruses. One of these that has received a good deal of attention is the Rous sarcoma virus. This was discovered by Dr. Peyton Rous in 1910 at the Rockefeller Institute. He observed a large tumor in the breast muscles of a laboratory hen, and found that this could be very easily transplanted to other chickens by transferring intact cells. Then he found that cell-free extracts of the tumor, which were passed through filters of small-enough porosity to hold back the smallest bacteria, were just as efficient in transmitting the growth. More recently, it has been found that the same virus can also cause a completely different type of cancer, a carcinoma or epithelial cancer, if inoculated into the proper tissue of the chick embryo.

What distinguishes cancer viruses from ordinary viruses? In size and gross chemical composition there are no distinguishing characteristics. Yet one group causes cells to multiply malignantly, and the other group causes cells to die. This problem has been investigated in the Biology Division at Caltech. Rous sarcoma cells were removed from afflicted chickens and grown in tissue culture. In this way, the number of cells was always known, and the rate of virus production could be studied.

These cells were found to produce virus at a very slow but constant rate—approximately one virus particle per cell every day or two. Compare this with a poliomyelitis-infected cell which may produce 1000 virus particles within a few hours. This simple quantitative

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"Viruses and Cancer" has been adapted from a Friday Evening Demonstration Lecture given by Dr. Rubin at Caltech on December 9, 1955.

finding may indicate why such differences in pathological manifestation of the two groups of viruses are found.

A cell which only has to produce a single virus particle every day may have its normal metabolism upset somewhat—perhaps to the extent of being liberated from the normal regulating mechanisms of the animal and thereby becoming cancerous—but it will not be destroyed. A cell which has to produce a thousand virus particles in several hours has to divert all its metabolic machinery to this function. Not being able to carry on its own essential functions, it soon dies. Thus we have the first hint of an explanation for the distinctive pathologies.

Speculations on structure

It was once thought that cancer viruses contained normal unaltered host protein as an integral and functional part of their structure. This seemed to be a very important and exciting thing, since it suggested that these cancer viruses were very closely related to the cells which they parasitized, in contrast to the ordinary cell-killing viruses, such as polio, which have no such relation to the cells in which they multiply.

It seemed reasonable to speculate that cancer viruses originated in their host cells while the cell-killing viruses were of foreign origin. Some recent work at Caltech has indicated that, although the growth of Rous sarcoma cells is very strongly inhibited by antiserum to normal cells, there is no evidence for a relationship between cancer virus and normal cell protein of the sort that was once supposed.

Mammalian cancer viruses

Perhaps the most perplexing aspect of this problem is the ease of finding cancer viruses in chickens, contrasted with the great difficulty in demonstrating them in mammals. The first mammalian cancer virus was not isolated until 1936. In that year, John J. Bittner found that the common breast cancer of mice was ordinarily transmitted by a virus found in the milk of nursing mothers from a strain of inbred mice which had a very high incidence of breast cancer. However, to demonstrate the agent, Bittner had to infect mice within a few days after birth. Then he had to wait until these mice became mature nursing mothers themselves—a matter of almost a year—before the cancer appeared. Compare this with the Rous sarcoma virus of chickens, which can be inoculated at any age and will produce cancer in less than a week. In addition, Bittner had to have another inbred strain of mice which had a very low incidence of cancer, in order to convincingly demonstrate the effect of the virus. With chicken cancer viruses such complications did not exist.

Since 1936, only two more mammalian cancers have been shown to be of viral origin. In one of these, mouse leukemia, the difficulties in demonstrating the virus encountered with the breast cancer were multiplied. This suggests that the failure to isolate causative viruses from mammalian cancers may arise from such complications rather than from the absence of a virus. There is no evidence to suggest that causative viruses in any of the mammalian cancers are contagious in the way that polio or influenza is contagious.

Therefore the critical question—are all cancers, and particularly human cancers, caused by viruses?—must remain unanswered for the present. Certain aspects of the origin of even such thoroughly-studied viruses as those which infect bacteria are quite obscure.

Even in such well-defined systems the line between viruses as foreign invaders and as altered cell components is not clearly drawn. Speculation about the origin of human cancer, which is considerably more refractory to precise study, would therefore not be fruitful at this stage.

Viruses and human cancer

Two crowning difficulties in the study of the relation of viruses to human cancer must be kept in mind. The first is that most of the known cancer viruses are usually produced in such small quantities that they cannot be readily demonstrated by physical methods such as electron microscopy. The second is that they can generally cause cancer only in animals of the same species, and frequently, as in the case of the mouse tumors, only in very closely related strains of the same species.

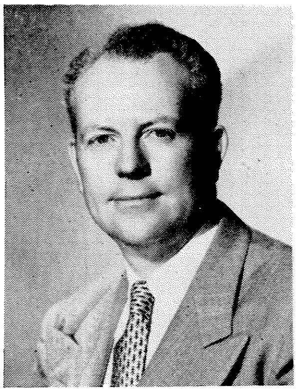
To carry this to perhaps a not too absurd extreme, demonstration of a tumor virus in humans by the methods now known could involve inoculating newborn babies with tumor extracts and waiting 30 or 40 years until maturity was reached to see if cancer developed. Even then, a large enough group would have to be included to make the results significant when compared with the normal incidence of cancer in a control group, since we have no genetically pure strains to work with.

The promise of future research

This perhaps dramatizes the difficulties. There are some bright spots on the horizon of basic research. Perhaps the most promising is the great flowering of tissue culture work—growing cells, human as well as animal, outside the body—within the last few years. An outstanding example is Dr. Renato Dulbecco's work at Caltech. The information that is bound to arise from such work will profoundly influence our understanding of this problem.

ALUMNI NEWS

Annual Meeting



VIRGIL M. PINKLEY, editor and publisher of the Los Angeles *Mirror-News* will be the dinner speaker at the annual banquet and meeting of the Caltech Alumni Association to be held at the Pasadena Elks Club, 400 West Colorado Street, on June 6.

Mr. Pinkley's talk — "Asia and the World" — will be based on a 30,000-mile trip he made recently to Southeast Asia and the Far Pacific, where he interviewed ambassadors, business men, farmers in the field and private citizens. Until he became editor and publisher of the *Mirror-News* Mr. Pinkley was general European manager and vice-president of the United Press Association.

Reunion classes at the annual banquet and meeting will include 1916, 1921, 1926, 1931, 1936, 1941, 1946 and 1951. Cocktails will be served at 6:30 p.m. and dinner will start at 7. Besides Mr. Pinkley's talk, President DuBridge will give a year-end review of developments at the Institute. Reservations should be in at the Alumni Office by June 1.

Alumni Picnic

HAVE YOU SEEN a championship western rodeo recently? No? Then here's your chance, at the annual picnic. Just load the wife and kids in the family bus on Saturday, June 23, and head for Corriganville, the world-famous movie ranch.

Enjoy a leisurely picnic (bring one or buy it there) in the shady Robin Hood Forest. In the morning and early afternoon Hollywood stunt men will reenact a daringly realistic bank hold-up and a stage coach hold-up, just as you see it in famous movie scenes.

Before the rodeo there will be time to walk through the interesting movie sets of Fort Apache (home of the TV Rin-Tin-Tin series), the Corsican Village, and Silvertown (an old frontier town). There will also be time for horseback riding, a stage coach ride, or perhaps a short hike with junior. Then at 3:30 the spectacular rodeo starts. This will keep you on the edge of your grandstand seat, with all the thrills of a championship rodeo.

Save the date—*Saturday, June 23rd.* See you and your family at Corriganville.

—*John Eaton Fleming, '46*
Chairman, Annual Picnic.

National Academy of Sciences

FOUR CALTECH ALUMNI were elected to membership in the National Academy of Sciences last month, bringing alumni membership to 26. Those elected were Walter Heinrich Munk, BS '39, MS '40; Folke Karl Skoog, BS '32, PhD '36; Charles Hard Townes, PhD '39; and William A. Fowler, PhD '39, Caltech professor of physics (see page 21).

Dr. Munk, an Austrian by birth, became an American citizen in 1939, at the same time that he got his BS from Caltech. After receiving his MS here, he went to the University of California, where he got his PhD in oceanography in 1947. Now professor of geophysics at the Scripps Institute of Oceanography, Dr. Munk has explored the spectrum of motions of the sea surface which has led to research on ocean waves as a meteorological tool. His studies of wind stress on the water, tidal movements of the ocean surface, and gravity waves in the atmosphere, reach into related astronomical and meteorological problems.

Dr. Skoog, professor of botany at the University of Wisconsin, was born in Sweden and became an American citizen in 1935. After receiving his BS and his PhD from Caltech, he became a National Research Council fellow at the University of California in Berkeley. He was an instructor and research associate at Harvard University from 1937 to 1941. Then, after three years of teaching at Johns Hopkins University, he served as a chemist and technical representative for the Office of the Quartermaster General in Europe, until he joined the staff of the University of Wisconsin in 1947.

Dr. Skoog is a leader in studies of plant growth substances. He uses a variety of techniques—physiological, chemical, microbiological and cytological—in attacking the problems of cell growth. He has contributed to our understanding of cell divisions and recently announced the isolation of a substance, kinetin, which appears to be an important regulator of this process. For his work on auxin physiology, the American Society of Plant Physiologists gave him the Stephen Hales award in 1954.

Dr. Skoog has also pioneered in research with the blue green algae which are so ruinous to fish in Wisconsin's lakes and streams. From studies of the nutritional cultivation and growth of these algae, he has created a compound which will destroy them.

Dr. Townes, professor of physics at Columbia University, is one of the pioneers and chief contributors in the field of microwave spectroscopy. A native of Greenville, South Carolina, he received his BA and BS from Furman University there, got his MA at Duke University in 1937 and his PhD from Caltech in 1939. After working in electronics for six years, he joined the Columbia University faculty in 1948.

SEMINAR DAY

THE 19TH ANNUAL Alumni Seminar, held on the campus on Saturday, April 7, turned out to be the largest on record, with 726 alumni, wives and guests in attendance.

The daytime program this year featured a series of six lectures in the morning (on earthquakes, earth satellites, Dickens and Thackeray, biology, computers and the Russians), a symposium on the stars as nuclear furnaces in the afternoon, and a talk by Paul G. Hoffman on "Free Asia in the Balance" at the banquet in the evening.

Above: Mid-morning coffee break

Left: Alumnus and son, on a campus tour, take a thoughtful look at the 200-inch telescope model on top of Robinson Hall.

Below: Catching up between lectures

THE CALTECH UNDERGRADUATE

—and What You Can Do With Him

STUDENT DISSATISFACTION and apathy are so recurrent around Caltech that they hardly need describing. For the record, though, let's mention such current manifestations as the recent editorial in the *California Tech*, asking the administration, "Why aren't you doing something for the student?"; the constantly repeated query, "What am I getting out of this place?"; the number of people becoming uninterested in science during their stay at the Institute; the increasing number of "extra-curricular" majors.

In three words: We got problems.

I don't presume to be able to solve these problems, but I would like to take a square look at them, and put forth my own views in as frank and unclouded a manner as possible.

First, I should state that I myself am unclear as to just how many fundamental problems are represented by the manifestations cited in the first paragraph. Is there really only one big problem to solve, or are there, say, two or three—or are there a whole flock of them?

Maybe not many—but major

I tend to favor the idea that we have only a few major difficulties; and I also feel that, in the past, we have been running around trying to alleviate a multitude of minor grievances without getting at the heart of the situation. In a sense, we have been trying to shore up the individual ceilings of a many-storied building, when we ought to be trying to keep the whole structure from falling on its face.

We've had physics and math clubs grow up in an effort to make students interested in physics and math. The administration has gone all-out to stimulate the faculty advisors program. The Leaders of America program has come about in an effort to acquaint students with some of the big men of our country and the big problems that they face. Student leaders initiate many new and unusual social events and then spend endless hours cooking up ingenious ways to get other students to go to them.

Now, all these things are good, and some are so unique and so worthwhile that they represent really outstanding achievements. But they don't—and by themselves, won't—solve the problem of student dissatisfaction and apathy.

One of the real big problems is Caltech's own uniqueness, and the ivory-tower regard which the general public seems to have for science. Student feeling goes something like this: "The outside world thinks that, if you go to Caltech, you're queer unless proven otherwise; but, by God, *we'll* show them."

And so the rat race starts, with the students outdoing themselves to prove that they are perfectly normal human beings. They study as little as possible, and sometimes even less than that; they have a fantastic number of social events; they have an almost unheard-of turnout for athletics; they have boundless criticism of science, the administration, and Caltech in general.

Some of these things are to be fostered, and some are a crying shame, but all, I believe, are a result of the fact that the students want to prove that they are normal human beings.

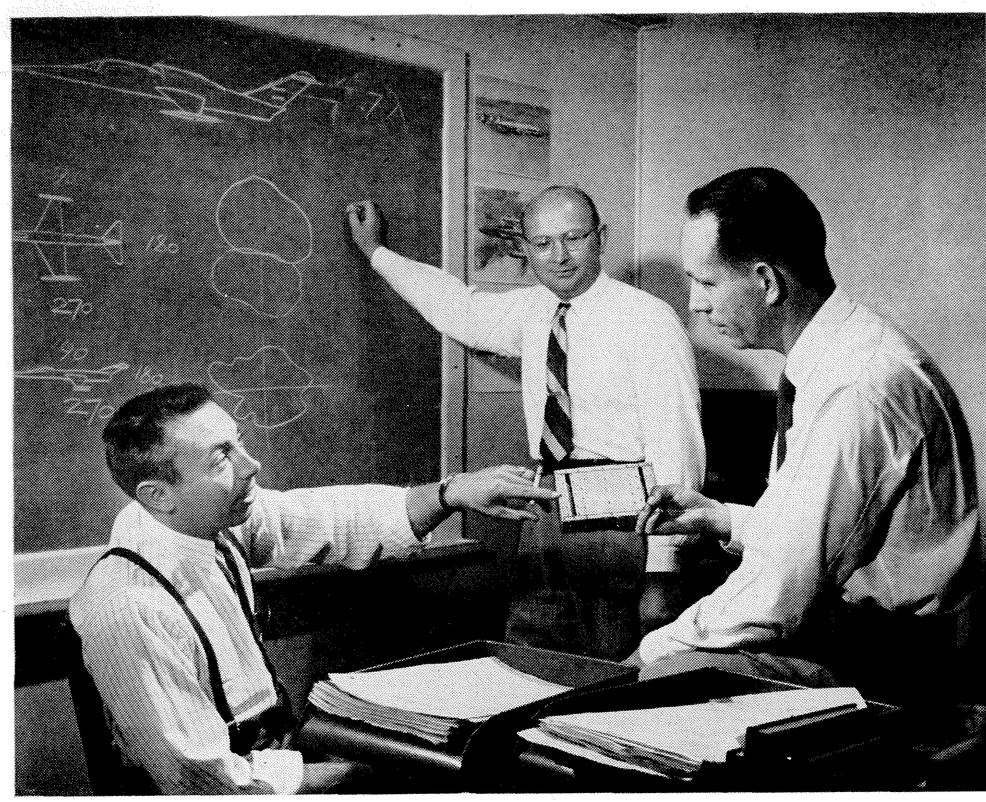
Now let us look at the other side of this picture. It is one thing to be proud of Caltech, but you don't have to be around the Institute long before you become aware of the unusually high opinion students have of themselves with regard to the fact that they are "Tech men." This seems to be an attempt to reap whatever harvest can be made off the general public regard for Caltech and its students. For example, I heard the following in a recent bull-session: "But we're engineers and we wield much more general influence than the average man in the street." I don't want to debate the validity of the statement here, but I do shudder a bit at the matter-of-fact way in which it was tossed out.

Double-reversible reactions

So we have these two somewhat ambivalent reactions arising out of the general public impression of Caltech —one of trying to disprove that impression and the other of trying to make hay while the sun shines.

The other really big problem confronting most students here can be summed up most succinctly by, "Where in hell am I going, anyway?"

This seems, quite clearly, to be a result of the fact that students don't really come to understand what science is all about, or how rewarding it can be, during their undergraduate careers. Going to school is a long hard grind, which nobody will deny; what's more, it looks as if it will get worse. Scientific education today is harder than it was for our fathers by just the factor



Research Specialist Edward Lovick (right) discusses application of experimental slot antenna in the vertical stabilizer of a high-speed aircraft with Electronics Research Engineer Irving Alne and Electronics Research Engineer Fred R. Zboril.

Lockheed antenna program offers wide range of assignments

Lockheed Sponsor for California Institute of Technology, Richard R. Heppe, Class of '47. *As the Lockheed sponsor for the California Institute of Technology, Mr. Heppe counsels students about their opportunities at Lockheed through periodic visits to the campus and through correspondence. After students join Lockheed, he maintains a close relationship with them as friend and career advisor. He now heads the Aerodynamics Department, directing aerodynamic phases of preliminary and production aircraft. He joined Lockheed in 1947.*

Airborne Antenna Design is one of the fastest-growing areas of endeavor at Lockheed. Advanced development projects include work on stub, slot, reflector-type, horn and various dipole antennas.

These diverse antenna activities reflect the full scope of Lockheed's expanding development and production program. For with 13 models of aircraft already in production and the largest development program in the company's history underway, the work of Lockheed Antenna Designers covers virtually the entire spectrum of aircraft, commercial and military.

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that describes the 25 years of scientific advancement that has taken place since they were in college. Thank God that we aren't our children; 25 years from now it's *really* going to be rugged!

Getting back to the present problem, however, I think the situation goes something like this: New students come here all fired up about science and Caltech. Their one major goal in life is to become educated scientists or engineers. The trouble is that they come here to get educated, but they don't come prepared to wage the long, nasty psychological war that goes along with it; so somewhere along the way in their Caltech career they lose interest in the thing that was once their chief aim in life! When this happens, there is no reason why they shouldn't become uninterested and apathetic about almost everything else.

Where do we go from here?

As I said, we got problems. What do we do about them? (Having stuck my neck out this far, I see no reason not to keep on going).

One of the things I think we can do is to completely deemphasize whatever outstanding academic talents our students may have. Perhaps we can't do much about how the general public feels, but we certainly can do something about the approach to students, particularly new students, taken here on the campus. The first thing I heard when I went to Freshman Camp was what a brilliant student I was. Why, my being a Caltech freshman meant that I stood in the 90-nth percentile of all students in the nation!

That kind of thing should be strictly taboo on this campus. I think that a much more fruitful general approach would be something like this:

"We certainly welcome all of you here, but we want to point out that, individually, you are all of roughly equal intelligence, and as a class you are about par for the course. Also we want to point out that Caltech is not a place where we train brilliant young men to be outstanding scientists; it is a school where normal young men can come to get an education if they want to work for it."

A new approach

The approach to students throughout their career should not be that Caltech is here to train men who are already brilliant, but rather that Caltech is here to develop men's personalities and wits through the medium of a technical education.

There are doubtless those who will hasten to point out that all this is just a denial of the truth. To these I would answer that most of the seniors that I know feel, at long last, that they don't know a damned thing! They haven't been trained for anything.

It's not a particularly uncomfortable feeling, it's just the way the world is; and the more I consider the situation, the more I feel that nobody is so bright or knows so much that he needs feel self-conscious about it or that he can afford to carry a chip on his shoulder. I know plenty of people who know next to nothing about science and who possess only a casual interest in the field, but whom I consider to be more intelligent, more productive and better adjusted than I. To pick a case in point, look at some of the men in our own Humanities Division.

A question of experience

In discussing the problem of keeping students interested in their work I should like to use an analogy. If, as has happened all too frequently in the history of warfare, a prisoner is placed on the torture rack in an attempt to extract information from him, his ability to withstand the ordeal and keep his mouth shut is a direct function of his intestinal fortitude, the stability of his personality and the strength of his convictions. You could talk patriotism to him a mile a minute and it wouldn't do one bit of good. What counts is what is already inside of him, based on his own *personal* past experience. Likewise for the student who must run the four long miles through his undergraduate career. You can stand there and preach the wonders of science to him until doomsday, but unless he has experienced them himself it won't help a bit.

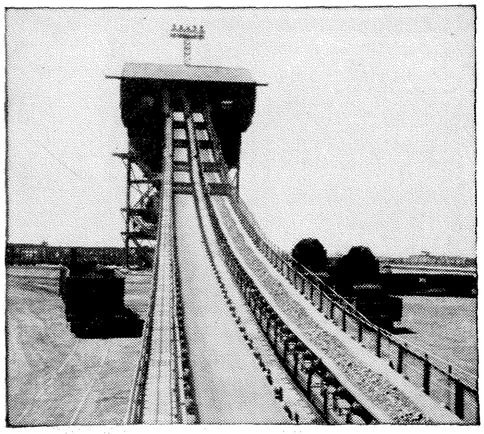
Time to get excited

What must be done is to give the student a chance to participate in some field of scientific endeavor when he is not under the strain of going to school, when he has the time to get excited about it. What I am advocating is an all-out effort on the part of the administration and faculty to assist and encourage (I almost want to say *force*) students to take summer jobs in a technical industry. It seems to me that, between the Institute and the alumni, some program of summer technical work could be set up. I know that we all like to think that students are far enough along to take care of things like summer jobs by themselves. But if the thesis of this dissertation is correct, these students need help.

In closing I should like to point out that I—at one time or another, and usually more than once—have had every one of the problems mentioned herein, and I have made an ass out of myself a good many times as a result. There will be those who don't agree with either the premises or the conclusions reached here. That's fine; let's generate some new ones. Somehow, some way, we can beat this problem, and students, faculty, administration, alumni and friends of the Institute can all lend a hand.

—*Fritz Trapnell '56*

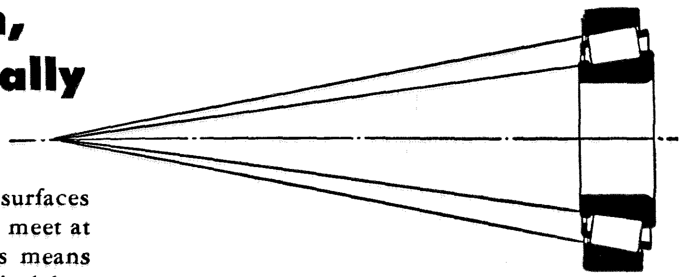
Another page for **YOUR BEARING NOTEBOOK**



How to get longer roller and belt life in a conveyor system

Engineers had to find a way to reduce costly friction and wear on rollers and idlers in designing this big conveyor system. It handles up to 3,300 tons of ore per hour on each of two 54″ belts traveling at more than 500 feet per minute. Their solution: Mounting the idlers on Timken® tapered roller bearings. Result: reduced friction, less sliding and scuffing between idlers and belts, longer roller and belt life.

True rolling motion, high precision practically eliminate friction



All lines drawn coincident with the working surfaces of the rollers and races of Timken bearings meet at a common point on the bearing axis. This means Timken bearings are designed by geometrical law to have true rolling motion. And they're manufactured with great accuracy to live up to their design. Result: Timken bearings practically eliminate friction, give longer bearing life, keep conveyors rolling smoothly.

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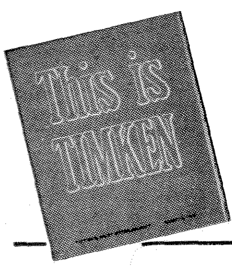

Many of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, O.

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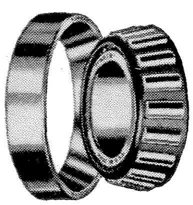

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LETTERS

Some Remarks on the Shortage of Engineers

California Institute of Technology

SIR:

Many articles have appeared recently in which it has been pointed out that the demand for engineers by industry is not adequately satisfied at present. Extrapolations have also been made as to the future prospects, and it seems that the shortage of engineers is likely to become worse, unless the present trends change rather drastically. The reasons for the present shortage and possible measures to increase the supply of engineers in the future have been discussed in detail. These problems, therefore, need not be treated here. It is only my intention to add a few remarks on the subject of using engineers efficiently—a subject related to the shortage of engineers, but one which has not been as strongly emphasized so far.

Engineers before the war

Almost up to the beginning of World War II, the engineers who were engaged in industry were concerned largely with production and construction problems. For these problems, as for any difficult assignment, ingenuity, experience, and organizational skill was required, but an intensive academic training in science and technology was usually not essential. Calculations and analyses which had to be performed were mostly of a routine type and were assigned to the junior men. The successful engineer would devote more and more of his time to managerial problems, and less to actual technical analyses.

Ever since World War II, and the rapid growth of aeronautics and electronics, industrial technology has become so complicated that engineers highly trained in the sciences are needed to cope successfully with the problems that present themselves.

Engineer—or manager?

The leaders of industry and education have recognized this need clearly. Industry in general, and particularly the aviation and electronics industry, has employed a large number of engineers. In integrating the engineer into an industrial organization, however, the older concept of the function of the engineer still largely prevails. Scientific ability is still—often unconsciously—considered of secondary importance, and the engineer's standing in his company is most often determined by his organizational and managerial aptitudes. The analysis and solution of technical problems is frequently left in the hands of the junior personnel —often with a minimum of guidance from their seniors, whose time is taken up with managerial duties.

Secondary consideration

The feeling that the technical work of an engineer is of secondary importance is indicated quite tangibly in another way. In many companies, the engineers concerned with technical problems are housed in large warehouse-like structures along with typists, file clerks and draftsmen. Some of these structures may contain several hundred people, the number being limited principally by the space taken up by the desks and file cabinets. The general atmosphere and noise level in such a building is not unlike that in the waiting room of a Greyhound Station—an atmosphere certainly not conducive to intellectual work. It seems probable that each engineer could work twice as effectively if he were given more suitable working conditions, for example a private office. Nevertheless only a few companies have felt that the necessary capital expenditure for such an arrangement would be warranted. It may be pointed out that this expenditure is not at all an enormous one, certainly not when compared with the capital expenditures which have to be made to provide the tools for a machinist.

Non-technical tasks

One other instance which illustrates the inefficient use of the engineer's time is the fact that those who are actually engaged in the technical phase of engineering are often burdened with additional non-technical tasks which could as well be performed by persons without technical training.

A subject which is related to engineers' positions in industry is that of salary. It is true, of course, that engineering salaries have increased significantly in the last few years. Taking as an example offers made to BS graduates from the California Institute of Technology, one finds that the average offer in 1951 was $305 a month and in 1955 it was $395 a month. Expressed in terms of hourly wages these salaries correspond to $1.75 and $2.78 respec-

tively. In order to obtain the proper perspective for these figures it is necessary to compare them to certain other wages and earnings. Some of these are listed in the following table:

Average Hourly Wages	**1951**	**1955**
Durable goods mfg.	1.68	2.00
Skilled labor—construction	2.66	3.25
Automobile industry	1.90	2.30
Corporation Earnings		
Av. earnings per share (Moody's 125 stock avg.)	7.44	10.90

Comparing the engineering salaries to the data in the table, one finds that engineering salaries have increased in line with the other indices. The great shortage of engineers is, however, not reflected to the extent one would expect in an economy governed by supply and demand.

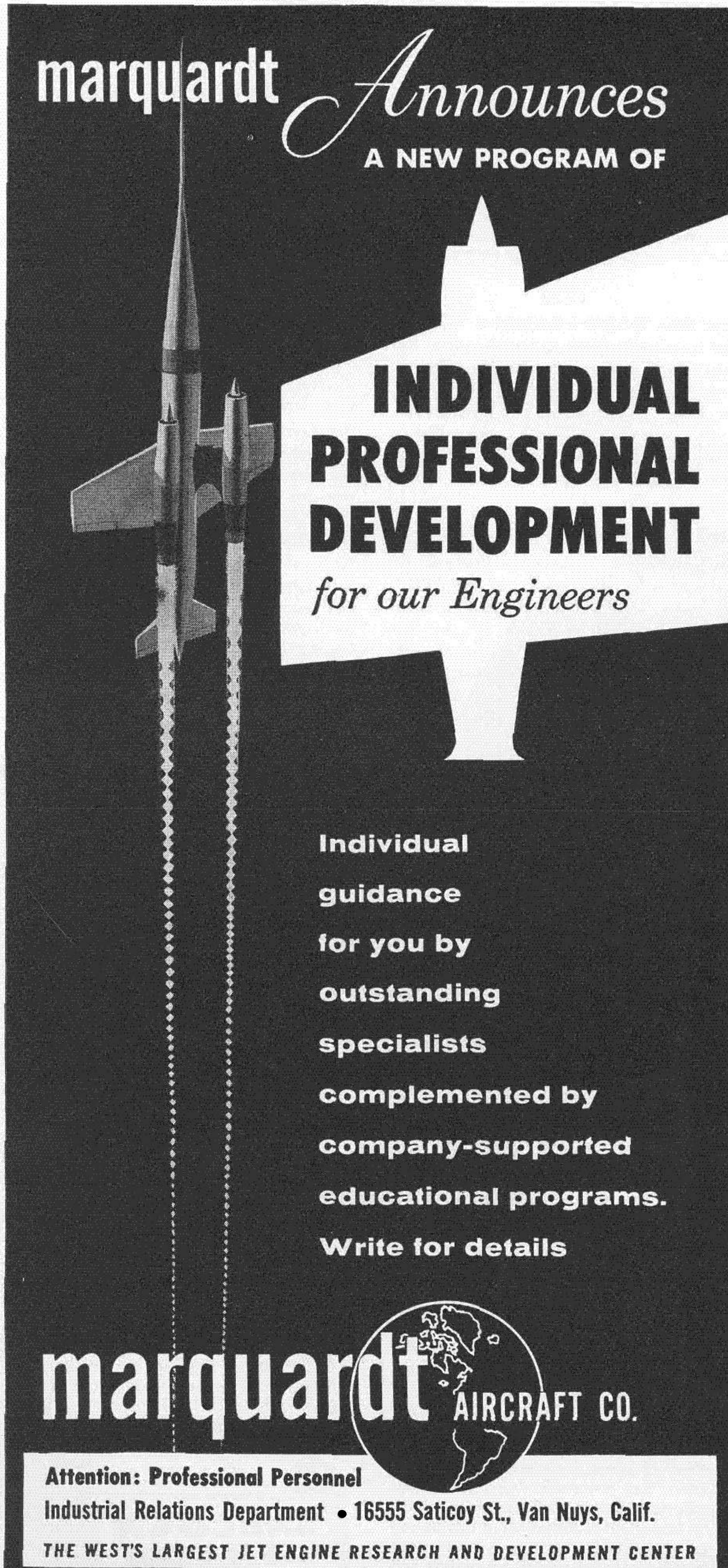
It should also be noticed that the salary for the beginning engineer is below that of some of the skilled labor groups. Although the beginning engineer is here compared to a group which is already experienced, the comparison between these two groups seems justified, since the time required for the workman to acquire his skill is probably not more than the four years spent by the beginning engineer to acquire his training.

Relieving the shortage

Looking over the foregoing brief comments, it seems that certain steps could be undertaken to relieve the engineering shortage by more effective use of the presently available talent. To this end it will be necessary for the managers of industry to regard the engineer as a trained professional person, to make full use of his specialized training, and to provide him with adequate working conditions. Salaries may have to be increased to attract the necessary number of qualified persons. If so, this should not be considered a detriment by industrial companies. On the contrary, if engineering salaries were increased significantly, companies would not be able to afford inefficient use of the engineers' time, and, as a consequence, more engineering services might actually be rendered per dollar than at present.

If industrial management will recognize engineers as professional people, it will, of course, have the right to expect performance compatible with professional standards. There is no doubt that the engineers of today will be able to meet this challenge.

Rolf Sabersky
Associate professor of mechanical engineering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PERSONALS

1919

Charles W. Hibbard, Jr., retired last year after 30 years of service with the engineering section of the Los Angeles Department of Water and Power. He's living in Pasadena.

1926

Major Orrin H. Barnes died on March 29 in Honolulu. He had been employed as a design engineer in the Public Works Division of the City and County of Honolulu and was also assistant director of the Territorial Civil Defense Agency. During the war, Orrin was Executive Officer and Post Commander of Fort Ruger in Hawaii. Surviving him are his widow and two sons—Malcolm, 10, and Bruce, 8.

1928

Nicholas A. D'Arcy, Jr., consulting mechanical engineer and manufacturer's representative in Los Angeles, was recently elected president of the Los Angeles Engineering Council, and also chairman of the AIME National Council of section delegates.

1931

Cecil E. P. Jeffreys, PhD, writes that he and his family have lived in the same house in San Marino for 20 years. His position as a consultant with the Truesdail Laboratories in Los Angeles has continued for the same period of time. His daughter is now in medical school at USC and his son in law school at UCLA.

1932

Charles W. Jones writes that his company, doing business under his name, has just moved into new engineering offices in Los Angeles. "Our present design work," he says, "is concerned with optical and radio telescopes (Tech's new Bishop radio antenna), two hydraulic dredges, a mercury mill and mine."

1937

Charles S. Milliken, MS '39, electrical staff engineer at Lockheed in Burbank, reports that he is a member of the AEEE, the IAS, and is active in AIEE as a member of two subcommittees of the Air Transportation Committee — the Systems subcommittee, and the Installation Testing subcommittee. He is also past president and a life member of the AES (Aircraft Electrical Society).

Leonard F. Schombel, who is a district geologist with the Shell Oil Company in Billings, Montana, just completed ten years with the company. He started with Shell in Bakersfield as an assistant seismologist and, before going to Billings, he was seismic party chief in Los Angeles. Leonard and his wife, the former Eunice Lambert of Live Oak, California, have three children—Linda Lou, Stephen and Trudy.

1938

Waldon R. Rhoads has been appointed director of the Georgia nuclear aircraft test laboratories in Dawsonville, a U. S. Air Force project which will be operated by Lockheed. The new research and testing program calls for laboratories and research reactors to be built on a 16-square-mile tract in the foothills of the Blue Ridge Mountains with a personnel force of about 500 scientists, engineers, technicians and service personnel. Waldon has been with Lockheed since 1941 when he began work as a project engineer. The Rhoads' have three daughters—Billie Jean, Elizabeth Ruth and Patricia Louise.

Peter Kyropoulos, MS, PhD '48, associate professor of mechanical engineering at Caltech, last month served as chairman of a seminar on "Frontiers in Auto-

motive Engineering," given by the Society of Automotive Engineers, Inc., in Los Angeles.

1939

Stephen C. Clark is now assistant professor of psychology at Los Angeles State College. He formerly taught at John Muir College in Pasadena, and is still living in Altadena.

Harry Majors, Jr., research professor in the Bureau of Engineering Research at the University of Alabama, is spending the year in India as a guest professor. Under the American Technical Cooperation Mission, he's at the Bengal Engineering College, lecturing on all phases of engineering research.

Alexis M. Eichelberger, Jr., who has been in Brazil as the representative for Geophysical Service, Incorporated, is returning to the U.S. shortly—to Santa Ana.

1940

John A. Dilworth, who has been chief of research and development at Consulair in Fort Worth, Texas, is now structural requirements division engineer with the Lockheed Aircraft Corporation in Marietta, Georgia. The Dilworths have three children.

1941

Richard M. Vaughan recently joined the technical staff of the Guided Missiles Division of the Hughes Aircraft Company in Culver City. Dick was formerly with Reynolds Industries, Inc.

Floyd George Steele, MS, is head of the Advanced Computer Research department of Litton Industries in La Jolla, California. He's well known in the electronic computer field for his special design features which first appeared commercially in Litton's portable, typewriter-size digital differential analyzer.

1942

David H. Brown, PhD '48, is now an associate professor of biological chemistry at Washington University in St. Louis.

1944

Neville S. Long, MS '48, writes from Sonora, in the heart of the Mother Lode country, to say that he began working with Tudor-Goodenough Engineers at the first of the year. He's resident engineer for the construction of the $10,000,000 Tulloch Dam on the Stanislaus River in central California, one of the three dams in the Tri-Dam project. The Longs have two boys and a girl.

Leon Trilling, PhD '48, assistant professor of aeronautical engineering at MIT, last month completed a study of Soviet aeronautics for MIT's Center for International Studies. This study is part of a complete examination of the qualitative aspects of Soviet technical education being prepared by the Center under a government contract and a grant from the Carnegie Corporation.

Leon joined the MIT staff in 1951 and has been assistant professor of aeronautical engineering since 1954.

1945

William E. Cook has been appointed assistant professor of civil engineering at Loyola University in Los Angeles. He was formerly associated with Cook and Cook, Civil Engineers, in Long Beach.

John H. Nichols writes about a skiing vacation that he and his wife, Judy, enjoyed in March at the Sierra Club's Clair Tappaan Lodge near Donner Pass. "Our three-year-old son, David, was left at home," he writes, "even though he has tried skiing several times down south. The trip was a relaxing change from petroleum engineering at the Monterey Oil Company."

1946

John P. Calligeros is now coordinator of the producing department of the Arabian American Oil Company in Saudi Arabia. He and his wife have two children—Peter, 14 months old, and Andrea, who was born on February 14. John is looking forward to a vacation next winter when the family hopes to get back to California.

Richard A. Smith, MS '47, and his wife, Marion, have announced the arrival of Lyle Richard on March 22. He joined two sisters, Cecil, 3, and Holly, 1½. The Smiths live in West Covina and Dick is a design group engineer with Consolidated Vultee.

Arthur F. Gebhart, MS, writes that, "After 8½ years away from the Caltech campus, I'm still working for Consolidated Electrodynamics in Pasadena. My wife, Natalie, and I have seen the construction of three new houses since 1951. This house is our last, we hope—especially when the pool is finished. We overlook all of Pasadena from the Kinneloa Mesa. My avocations these days consist of racing my MG in the Sports Car Club of America events and pistol target shooting."

Donald Furst, MS '48, has two new events to report: he has been transferred from Burbank to the Phoenix division of the AiResearch Manufacturing Company

where he is assistant project engineer in charge of the development of two gas turbine engines; and he has a new daughter, Cheryl, now 6 months old.

Glynn Lockwood is now chief engineer in the gyro division of G. M. Giannini & Co., Inc., in Pasadena. He was formerly with C. F. Braun and Company as a piping-design leader.

1947

Dale J. Meier, MS '48, who was formerly working as a chemist in the lubricants general department of the Shell Development Company in Emeryville, California, has now been made a research supervisor in the Company's plastics and resins department. Dale has been with Shell since 1951.

1949

John G. Kariotis, a partner in the structural engineering team of Kolesoff and Kariotis in Pasadena, was married in St. Louis on April 28.

1950

Joseph H. Birman, MS, reports that he has a second son, Daniel, born last November. Joe is chairman of the Department of Geology at Occidental College in Los Angeles.

Warren G. Whiting, who is a project engineer with the Reynolds Metal Company, has been transferred from Phoenix to Richmond, Virginia, where the company is opening a new extrusion plant.

Ralph Stone, secretary of the Caltech alumni group in Phoenix, writes that the visit of *D. S. Clark*, secretary of the Alumni Association, resulted in a fine alumni get-together last month. Ralph, who is plant manager of the Superior Honey Company, says he'd like to hear from 1950 classmates, with hopes of getting up a newsletter after six years.

Frederick H. Leinbach, Jr., MS, writes that he was married in 1953 to Ruth Eckhardt in Fairbanks, Alaska. After two years with the Army, in the Chemical Corps at Rocky Mountain Arsenal in Denver, Fred returned to the University of Alaska last January, and is now working for his doctorate there, while holding down a job with the Geophysical Institute at the same time.

1951

Thomas R. Fahy, who is working as an editor at the U. S. Naval Ordnance Test Station in Pasadena recently received a Superior Accomplishment Award (and a check for $200) from the Bureau of Ordnance for his accomplishment in two fields—technical writing and engineering.

Ronald T. Caldwell, MS '55, writes that he is a preliminary design engineer at the AiResearch Manufacturing Company in Phoenix. The Caldwells have a son, Norman, who was born on March 11.

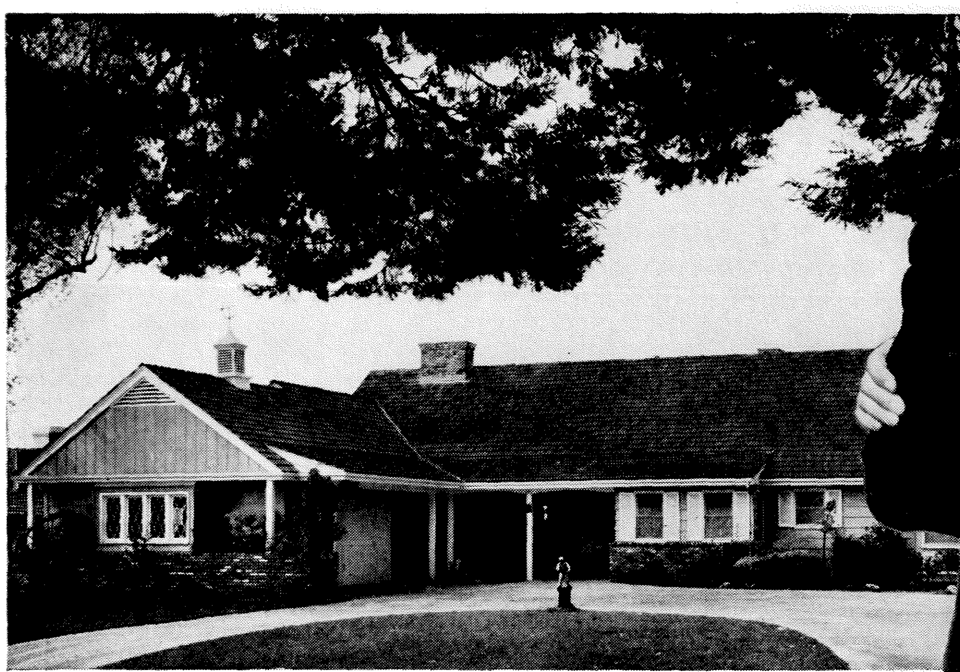
Clarence R. Gates, PhD, who has been at the Jet Propulsion Laboratory since graduation, was recently appointed chief of the Lab's Guidance Analysis Section.

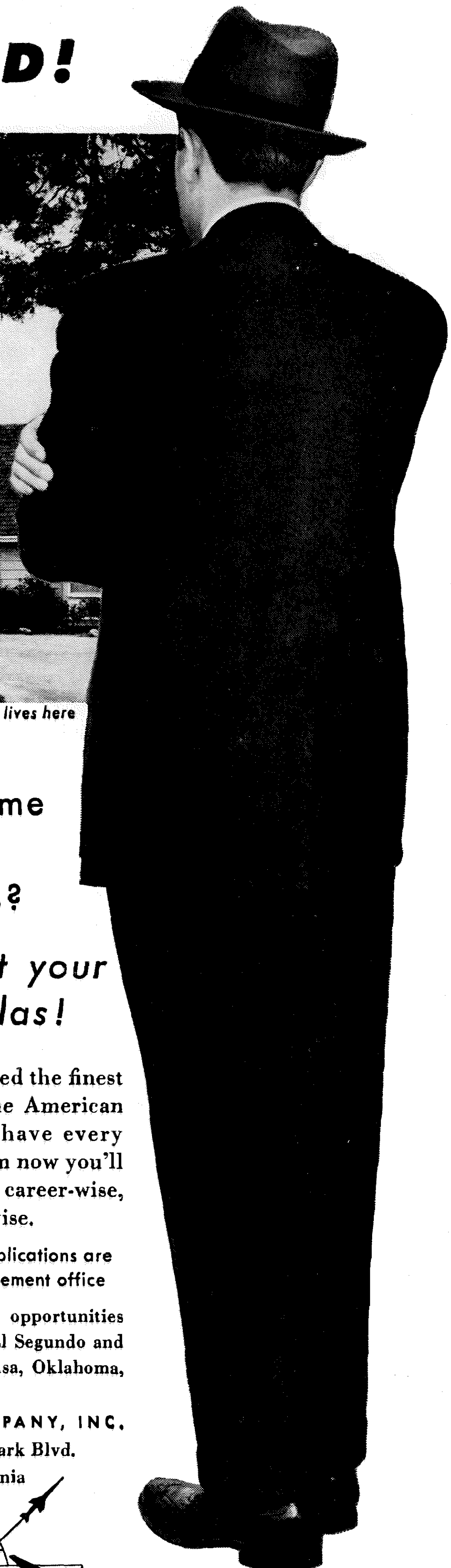
Charles McHenry Steese, Jr., graduate student in chemistry at Caltech, was found shot to death—apparently by his own hand—in his automobile, on Angeles Crest Highway, on April 2.

After graduating from Caltech, Charles got his MS at MIT in 1953. He was in the Army for two years before returning to Caltech as a graduate student.

Frederick G. Baily is now an Ensign

ENGINEERS...
LOOK TEN YEARS AHEAD!





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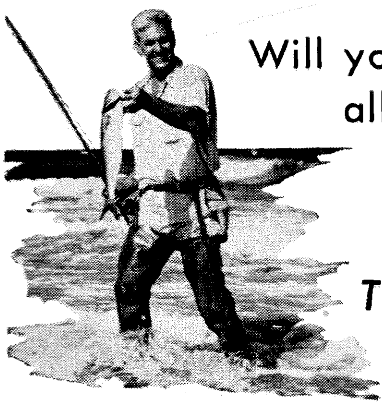

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in the U. S. Naval Reserve in San Diego. His engagement to Miss Sheelagh Hanna of San Diego was announced last month. Fred was formerly a test engineer with the General Electric Company in Burnt Hills, N.Y.

Earl Hefner, MS '52, writes that, although some of his classmates may be startled to hear it, he "left the confines of bachelorhood" last October 30 to marry Beverly Jean Shephard of San Marino. Earl is with the Holly Manufacturing Company in Pasadena as head of market research.

1952

Waheed K. Ghauri reports from Bakersfield that. "I have been working for the Shell Oil Company since graduation in 1952. I returned recently from a three-month trip to Pakistan and Europe. This was my first visit to Pakistan in seven years and I was amazed at the tremendous technological advances made in the country and also at the feelings of good will and amity toward the United States. In Europe I visited a few engineering schools (in addition to the usual tourist night and day spots, of course). I was most impressed by the Swiss Federal Institute of Technology in Zurich which I'd say comes closest to Tech in its educational aims. I'm now assigned in Bakersfield as an 'exploitation engineer.' The term is of Shell coinage and means one who exploits petroleum reservoirs—not the masses."

Alan R. Johnston, who expects to get his PhD at Caltech this year, reports that he has a son, Philip Franklin, born last October.

Dale Krause received his discharge from the U. S. Army in January and is now working for his MS in geology at the University of California at Berkeley. Dale spent his two Army years in a survey company, doing primary triangulation work from Alaska to Chile. Before that, he was in Peru working as a geologist for the Carro de Pasco Mining Company.

W. Barkley Ray, now a graduate student at Caltech, will begin new duties as an associate professor of geology at the Institute in June. Before he starts teaching, he will take charge of the summer geology camp in New Mexico.

Douglas Alverson completed a year's study of Russian at the Army Language School at Monterey and his next assignment will no doubt be in Europe as interpreter, probably close to the Russian Zone.

Wesley Caspers, MS, received his PhD in March from the University of Minnesota. He has been professor of education at Friends University in Wichita, Kansas, since he left Caltech.

1955

Paul Harrison writes from San Bernardino that he has just entered active duty as a 2nd lieutenant with the U. S. Air Force at Lackland AFB. Paul is in flight training now and his wife and daughter, Juli, will join him after their second child is born in May. Paul was formerly with Vard, Inc., in Pasadena.

Oreste W. Lombardi was married in February to Jane E. Littlefield in Albuquerque, N.M. They are both students at the New Mexico Institute of Mining and Technology at Socorro, she as a chemical engineering major and he as a graduate student in geology.

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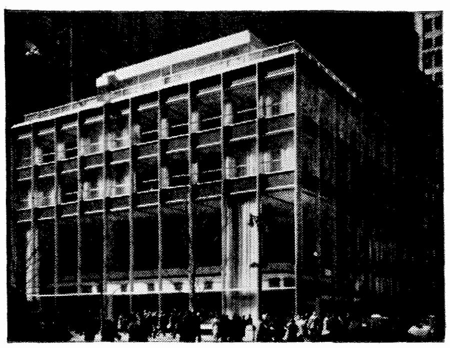

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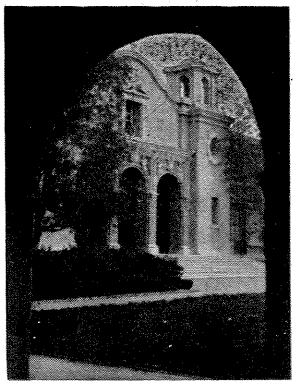

CALTECH CALENDAR

May, 1956

ALUMNI CALENDAR

June 6 ....Annual Meeting
Elks Club—Pasadena

June 23 ....Annual Picnic
Robin Hood Lake and Forest—Corriganville

ATHLETIC SCHEDULE

BASEBALL

May 12—Occidental at Caltech
May 16—Nazarenes at Caltech
May 19—Caltech at Redlands

SWIMMING

May 10—All conference at Caltech
May 11—All conference at Caltech
May 12—All conference at Caltech

TENNIS

May 11—Conference at Pomona-Claremont
May 12—Caltech at Redlands
May 18—Conference Tournament at Caltech
May 19—Conference Tournament at Caltech

GOLF

May 18—Conference Tournament at Occidental

FRIDAY EVENING DEMONSTRATION LECTURES

Lecture Hall, 201 Bridge, 7:30 P.M.

May 11—
Radio Astronomy ....Dr. John G. Bolton

May 18—
Volcanoes, Ice and Destructive Waves ....Dr. Frank Press

May 25—
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Sleek styling starts with special steel:

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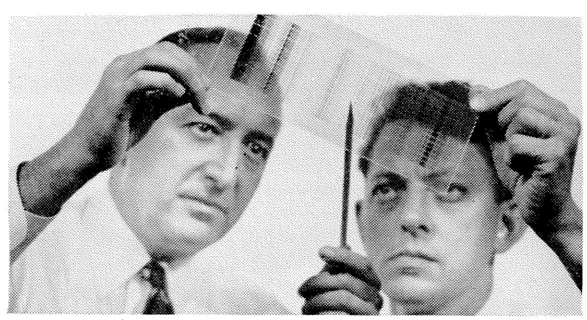
Fenders, hoods, roofs and side panels call for best quality steel—and the watchful eye of photography guards specifications and controls that quality.

Car designers' dreams come true only if steel forms well under the pressure of deep drawing operations. That takes a particularly high quality steel.

Great Lakes Steel Corporation, Detroit, Mich., unit of National Steel Corporation, makes this steel for the automobile industry. And to make sure of its high quality they use photography. For example, during production, spectrograms show chemical make-up—insure the proper minute quantities of alloying elements, and photomicrographs reveal crystalline structure.

Controlling quality is but one of the many ways photography works for modern industry. In small businesses and large it is aiding product design, simplifying production, creating sales and expediting office routine.



At Great Lakes Steel a spectrogram is readied for reading in the densitometer—one of the tests that assure quality steel.

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