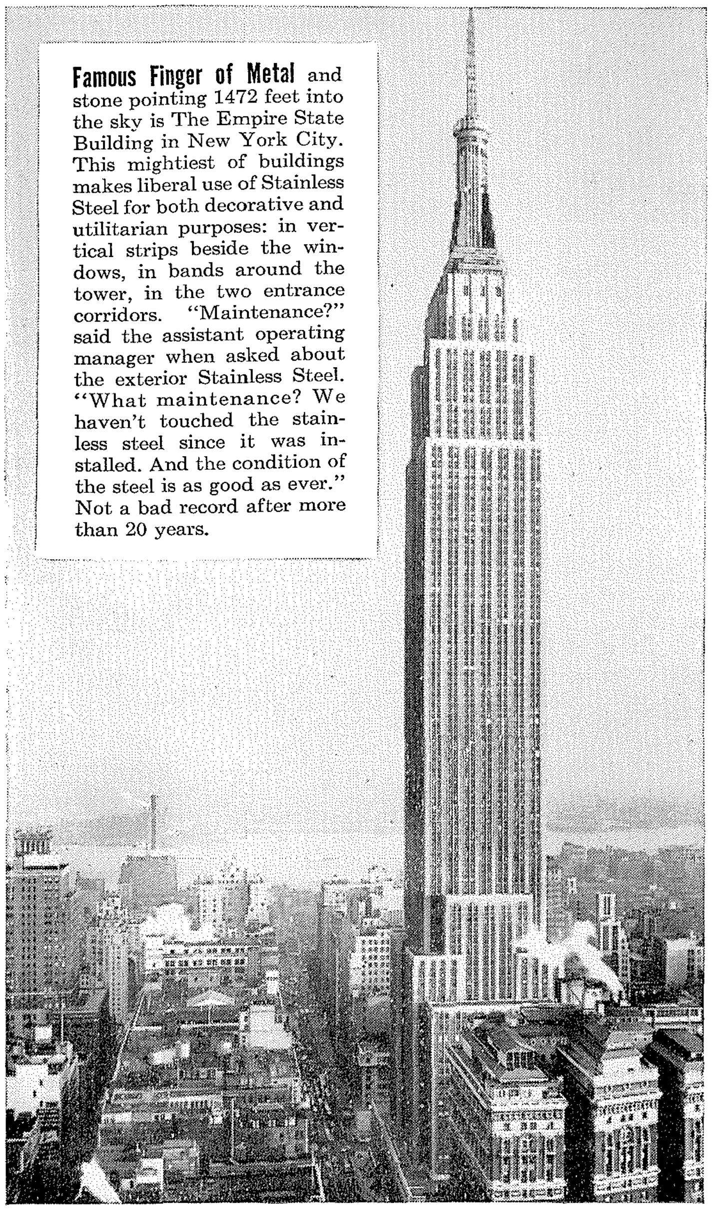
ENGINEERING | AND | SCIENCE

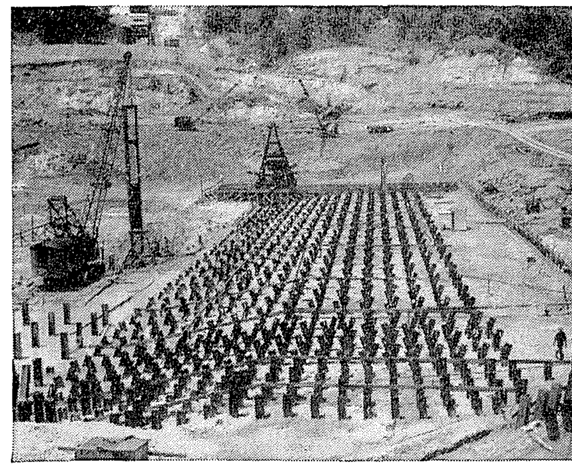
JUNE/1954

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

Only STEEL can do so many jobs so well



Famous Finger of Metal and stone pointing 1472 feet into the sky is The Empire State Building in New York City. This mightiest of buildings makes liberal use of Stainless Steel for both decorative and utilitarian purposes: in vertical strips beside the windows, in bands around the tower, in the two entrance corridors. "Maintenance?" said the assistant operating manager when asked about the exterior Stainless Steel. "What maintenance? We haven't touched the stainless steel since it was installed. And the condition of the steel is as good as ever." Not a bad record after more than 20 years.



Dragon's Teeth Sprouting? No, these are steel bearing piles in the foundation of a dam spillway. When the dam is finished, you'll never know the steel piles are there. But they'll be working just the same, for strength and safety, as enduring steel so often works unseen in buildings, highways, pipelines and power plants.

This Baby Sitter is Galvanized! In truth, a sturdy, good-looking Cyclone Fence is a dependable baby sitter. For it makes a safe home playground out of your yard. It keeps youngsters, absorbed in play, from stepping accidentally into the path of passing traffic. It prevents stray dogs from molesting your children or flowers. Cyclone Fence, made by U. S. Steel, is further evidence that only steel can do so many jobs so well.

MANUFACTURED FROM USS STEEL UNITED STATES STEEL

This trade-mark is your guide to quality steel

OPPORTUNITIES WITH U. S. STEEL

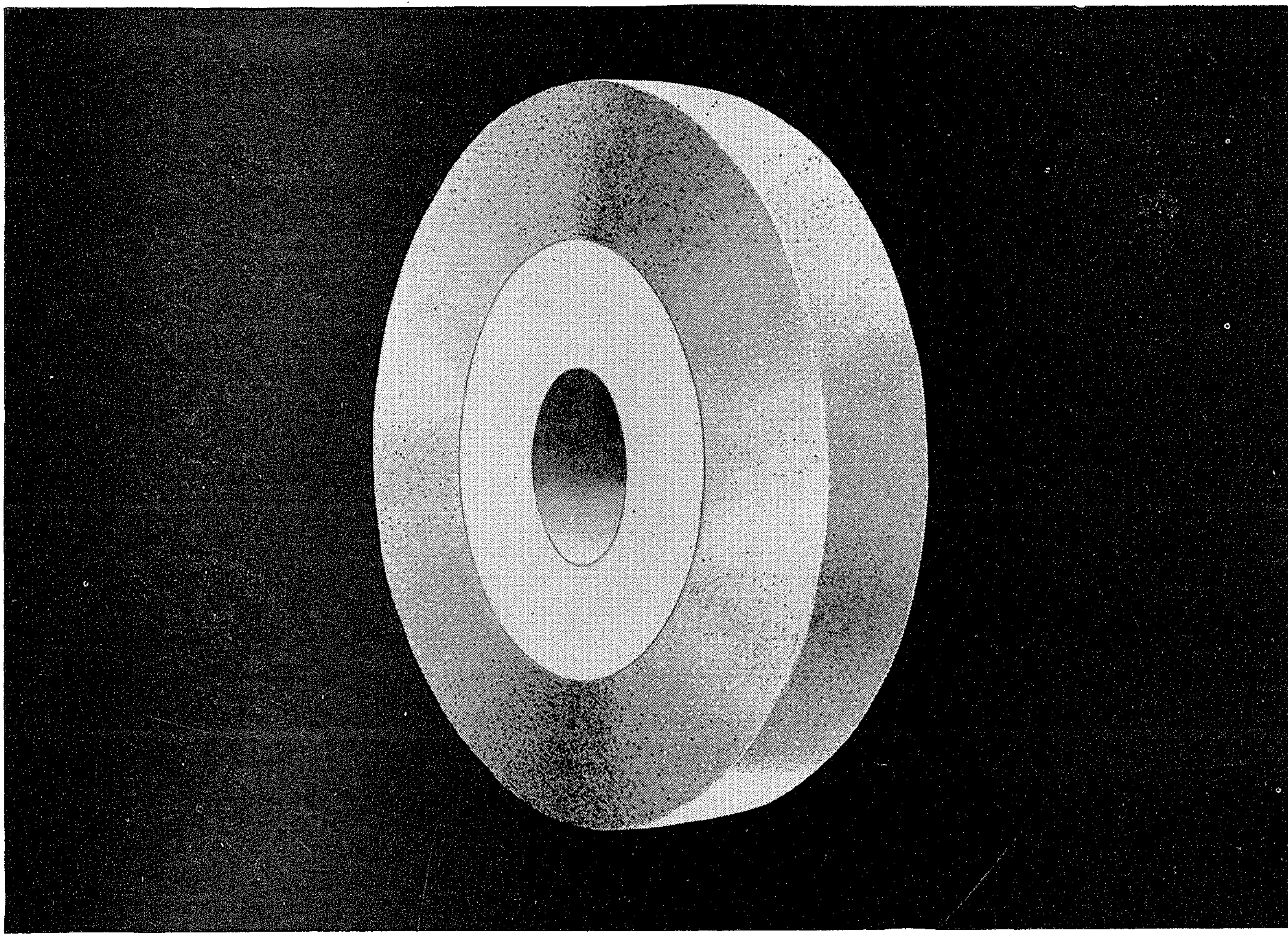
If you're thinking about what you're going to do after graduation . . . if you're interested in a challenging, rewarding position with a progressive company . . . then it will pay you to look into the opportunities with United States Steel. Your placement director can give you more details, or we'll be glad to send you the informative booklet, "Paths of Opportunity." United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

UNITED STATES STEEL

For further information on any product mentioned in this advertisement, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

AMERICAN BRIDGE . . AMERICAN STEEL & WIRE and CYCLONE FENCE . . COLUMBIA-GENEVA STEEL . . CONSOLIDATED WESTERN STEEL . . GERRARD STEEL STRAPPING . . NATIONAL TUBE
OIL WELL SUPPLY . . TENNESSEE COAL & IRON . . UNITED STATES STEEL PRODUCTS . . UNITED STATES STEEL SUPPLY . . *Divisions of* UNITED STATES STEEL CORPORATION, PITTSBURGH
UNITED STATES STEEL HOMES, INC. · UNION SUPPLY COMPANY · UNITED STATES STEEL EXPORT COMPANY · UNIVERSAL ATLAS CEMENT COMPANY

4-1074



HIDDEN HENCHMAN . . .

Early man used Nature's rocks and stones to shape and sharpen his crude tools and weapons. Today, industry has at its command abrasives that will do in seconds jobs that formerly required days of tedious toil.

Yet relatively few people know or appreciate the vital labor-saving, back-stage role which abrasives play in the production of practically all mechanically finished articles.

MAN-MADE MINERALS . . .

Through the centuries man's ceaseless search for better abrasives has paralleled progress in production. Wheel-shaped sandstones replaced rocks . . . only to give way to emery and corundum, which were sieved, sized, glued to paper and cloth or bonded in pottery mixtures to form artificial grinding wheels.

But it was by the discovery of silicon carbide and crystalline fused alumina—man-made minerals from the electric furnace—that the grinding wheel became a high speed, precision production tool.

AMERICA WORKS LIKE THAT . . .

Industry's insatiable desire to improve its products and make them available at lower cost has sparked the specialized skills and knowledge of a myriad of men . . . has led to the development of thousands of different styles and types of abrasive products for innumerable industrial applications.

America can work like that because it has an all-seeing, all-hearing and reporting Inter-Communications System.

THE AMERICAN INTER-COM SYSTEM . . .

Complete communication is the function, the unique contribution of the American business press . . . a great group of specially edited magazines devoted to the specialized work areas of men who want to manage better, design better, manufacture better, research better, sell better, buy better.

COMMUNICATION IS OUR BUSINESS . . .

Many of the textbooks in which you are now studying the fundamentals of your specialty bear the McGraw-Hill imprint. For McGraw-Hill is the world's largest publisher of scientific and technical works.

After you leave school, you will want to keep abreast of developments in your chosen profession. Then one of McGraw-Hill's many business magazines will provide current information that will help you in your job.

McGRAW-HILL PUBLISHING COMPANY, INC.

ABP 330 WEST 42nd STREET, NEW YORK 36, N. Y. ABC

McGRAW-HILL FOR BUSINESS

HEADQUARTERS FOR TECHNICAL AND BUSINESS INFORMATION

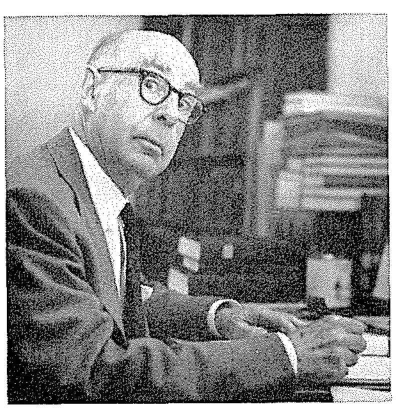
ENGINEERING | AND | SCIENCE

IN THIS ISSUE

On the cover this month, and on pages 11-13, you'll find pictures of Caltech's 60th commencement and on page 14 is the text of Dr. I. I. Rabi's fine commencement address.

This issue is not entirely given over to commencement activities, though. On page 5 there's an account of the hypersonic research now in progress at the Institute, written by James M. Kendall, graduate assistant in aeronautics — and the first entry in the E&S Science Writing Contest (which you can read more about on page 31).

George R. MacMinn, Professor of English, retires this year after 36 years of service. You'll find an impressive portrait of him on page 10. Unwilling to let it go at that, we've added the characteristic portrait below, just to remind all the students who've knocked at his door during the past 36 years of the expression that invariably greeted them after they got inside.



PICTURE CREDITS

Cover	W. W. Girdner
p. 5	Hank Hoag
pps. 6-7	James M. Kendall
pps. 10-14	W. W. Girdner

JUNE, 1954 VOLUME XVII NUMBER 8

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

CONTENTS

STAFF

Publisher..........Richard C. Armstrong '28

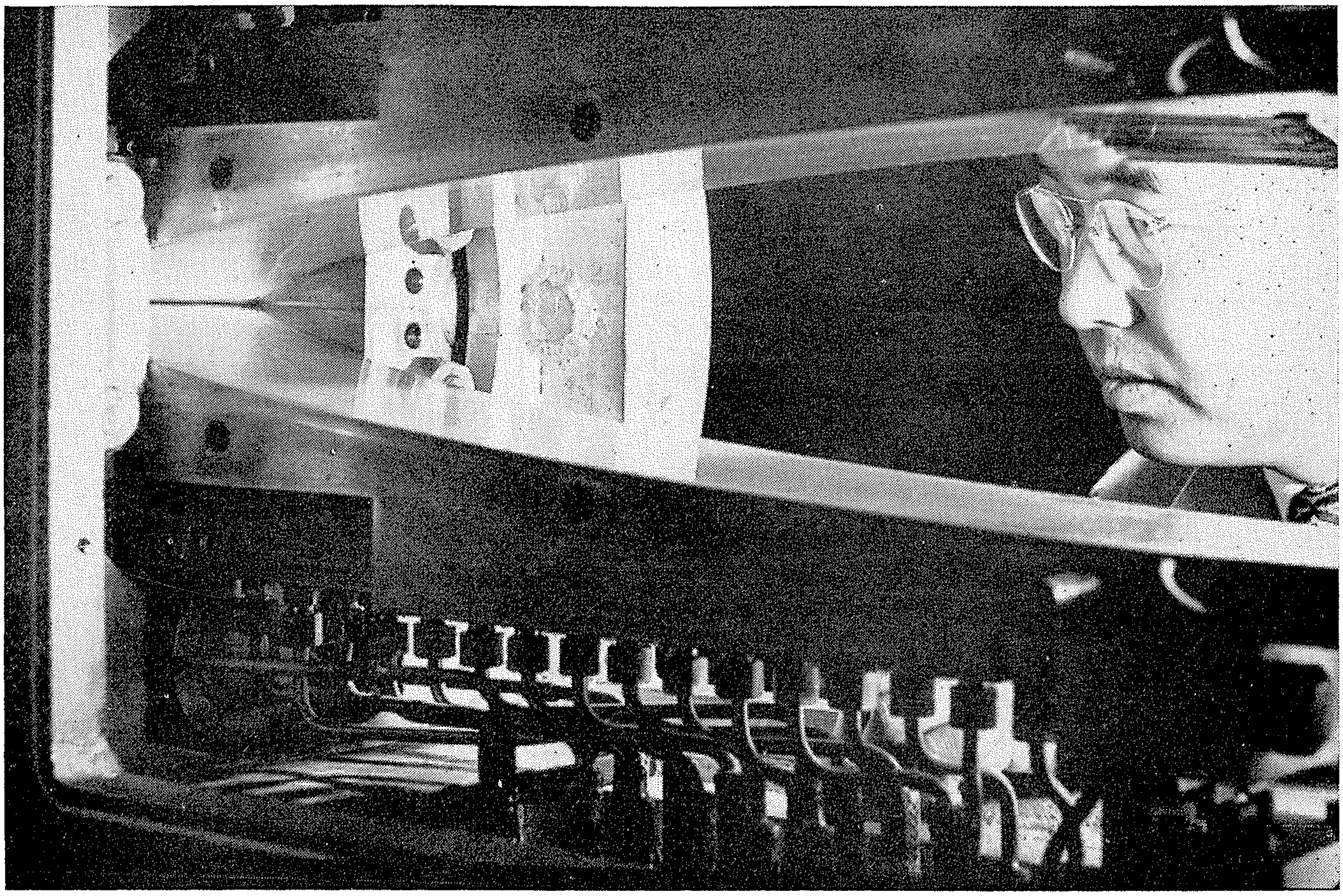
Staff Photographers..........Byron Johnson, Jr. '56
Tom Bergeman '56

Editor and Business Manager..........Edward Hutchings, Jr.

Editorial Consultant..........Professor of English George R. MacMinn

Published monthly, October through June, at the Californa Institute of Technology, 1201 East California St., Pasadena 4, Calif., for the undergraduates, graduate students and alumni of the Institute. Annual subscription $3.50, single copies 50 cents. Entered as second class matter at the Post Office at Pasadena, California, on September 6, 1939, under the act of March 3, 1879.

Manuscripts and all other editorial correspondence should be addressed to: The Editor, *Engineering and Science*, California Institute of Technology.



The principal part of a hypersonic tunnel is the set of contoured blocks of steel which comprise the nozzle.

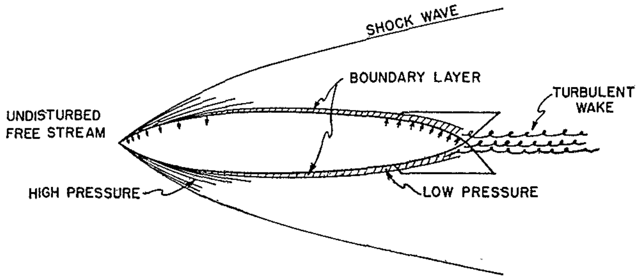
HYPERSONIC RESEARCH AT CALTECH

Studies of how air flows around a body at speeds "faster than supersonic" keep research ahead of the ever-growing needs for knowledge imposed by the high-speed flight of the future.

by JAMES M. KENDALL
Graduate Assistant in Aeronautics

PIONEERING WORK in one of the newest phases of aerodynamics is being carried forward at Caltech's Guggenheim Aeronautical Laboratory (GALCIT) by a research group under the direction of Dr. Henry T. Nagamatsu. The group is investigating, both experimentally and theoretically, how air flows around a body in the hypersonic speed regime. Literally, this means "faster than supersonic," and is arbitrarily taken to be Mach 5 and higher. The group is currently operating two hypersonic wind tunnels, one of which has recently achieved flow at Mach 11, or 11 times the speed of sound.

The reason for the extensive research program is the rapidly growing need for fundamental knowledge about hypersonic flow to be used in the design of high-speed



Shock wave pattern and growth of boundary layer on a body in hypersonic flow. The drag results from the pressures and from the boundary layers.

vehicles. The United States now has some 18 types of guided missiles, many of which are capable of very high Mach numbers. As early as the spring of 1949, a two-stage rocket consisting of a V-2 and a Bumper WAC attained a Mach number of about 7.5 during tests at White Sands. As newer missiles are designed, aerodynamic data at ever higher Mach numbers are needed. For example, a long-range ballistic rocket of 4000 miles range would require a speed corresponding to Mach 13 at the end of burning, and a rocket designed to escape from the earth would require about Mach 35 at the end of burning. But the hypersonic program at Caltech is definitely not concerned with the design of missiles or space stations. The models tested are not futuristic shapes; they are simple cones, spheres and wedges, because the information obtained from these is more basic.

Hypersonic flow differs from low-speed flow in several ways, many of which can only be regarded as disadvantageous to high-speed flight. One of these is extreme aerodynamic heating. Transfer of heat to a body surface is brought about on the region near the forward parts of the surface by rapid compression of the air as the body pierces the atmosphere. The after parts of the surface are heated by friction as the air flows over the surface, even though air is only slightly viscous. It so happens that these two processes produce nearly identical final temperatures, but the rate of heat transfer is in general widely different at different parts of the surface. The final temperature depends mostly on the Mach number of the flow.

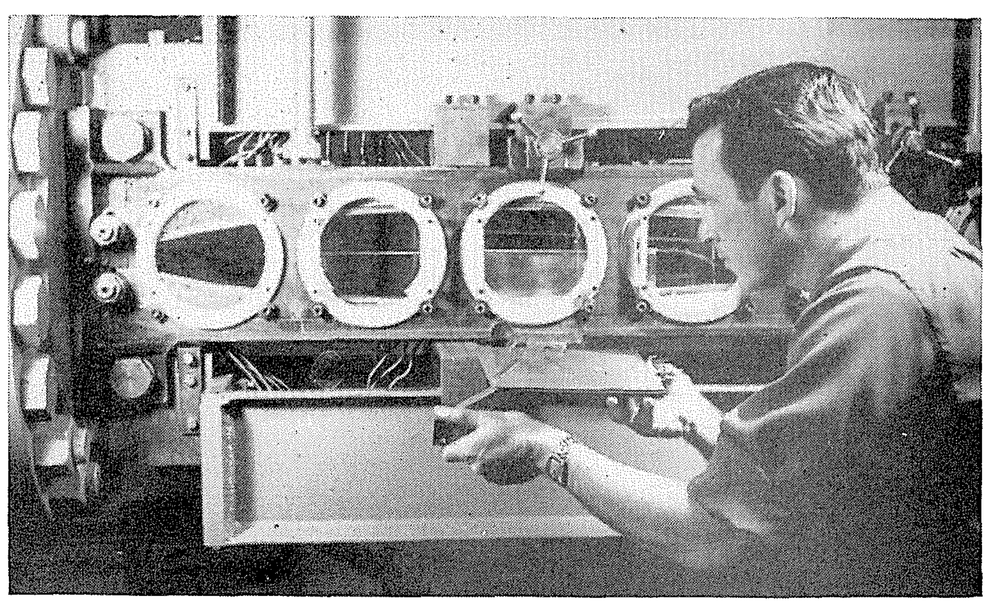
By way of illustration, two missiles sustaining flight at Mach 5 and 10 respectively, on a day when the air temperature is 70°F, are heated to 2650° F and 10,600°F. Because steel melts at about 2600°F, it is quite evident that high-speed missiles can withstand flights of only short duration so that time does not permit heating to the equilibrium temperature. Flight time decreases, however, as speed goes up, and a missile traveling vertically upward from sea level at Mach 5 would remain in the earth's atmosphere less than 10 seconds.

Pressure distribution

A second unfortunate effect is that the pressure distribution about a body in high-speed flight is highly unsymmetrical fore and aft, so that a large drag results. High pressures occur on the nose of the body as it pushes aside the air in much the same fashion as a nail penetrates wood, while parts of the surface behind the thickest section of the body experience virtual vacuum, because it is difficult for the air to accelerate sidewards fast enough to follow the surface contour.

The power used to drive the body forward against the drag force due to the pressure is converted to heat by the dissipative action of the shock waves produced—as shown in the diagram at the top of this page.

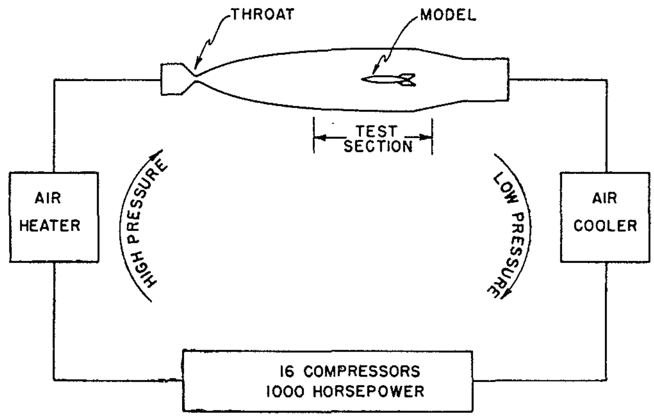
The shock waves are the interface of the lower pressures of the undisturbed free stream and the high pressures produced by the motion. These waves extend with decreasing strength to great distances from the body,



Leg 1 of the hypersonic wind tunnel. The worker here is checking a flat plate model before installing it in the tunnel for an experiment.

and their action is to deflect the air outward as the body contour passes by. It is of importance that the higher the Mach number, the closer the shock waves lie to the surface, and correspondingly the stronger they become. These changes produce subtle effects which are peculiar to hypersonic speeds.

For hypersonic studies, as with most other phases of aerodynamics, the basic instrument of experimental research is the wind tunnel. In 1885, Horatio Phillips used the first aerodynamic tunnel for experiments, and since that time tunnels have become ever more extensively used. The justification for wind-tunnel testing is usually a matter of economy in the form of reduction of design costs. At the present time, the development of a new aircraft requires a vast amount of research, the cost of which may well run into millions of dollars and take many months. The wind tunnel, wherein scale models are tested, offers a means of reducing time and costs, and offers to hypersonic research, in particular, certain ease of gathering data.



Components of a hypersonic wind tunnel system. The wind tunnel, in which scale models are tested, offers a means of reducing time and costs in the development of a new aircraft.

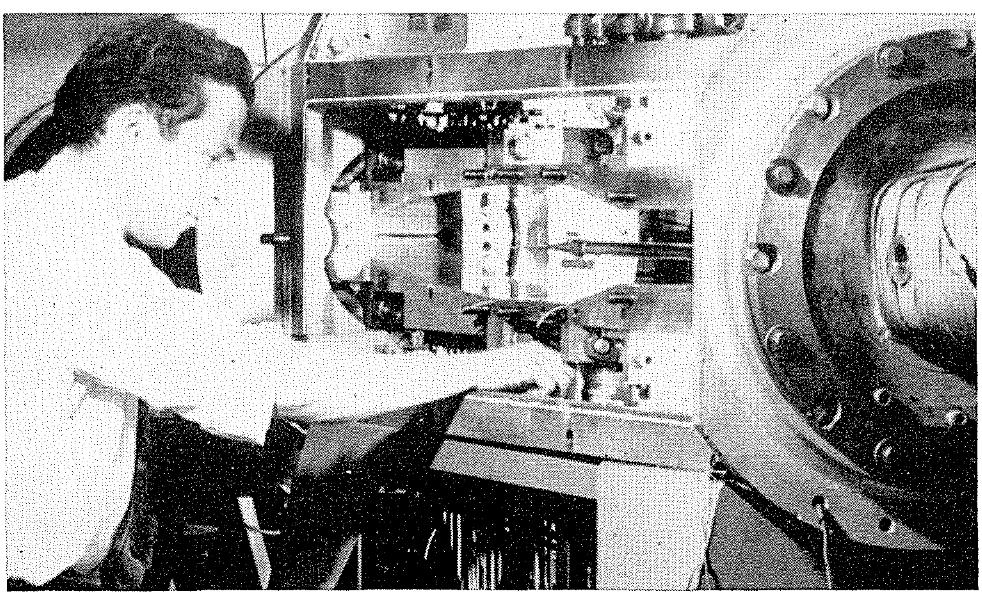
Similarity parameters

The comparison between data obtained in a tunnel and that needed for full-scale application is made on the basis of so-called similarity parameters. These are dimensionless numbers which depend on various important physical quantities, such as the density, viscosity, and speed of the air. The two most important of these parameters are the Mach number and the Reynolds number. The Mach number is the ratio of the air speed to the speed of sound. The Reynolds number depends on the viscosity, density, and speed of the air, and on the length of the body. This number, in a sense, provides a certain measure of all processes which depend on viscous effects, such as heat transfer rate and surface or skin friction.

This notion of similarity parameters is expressed by saying that the coefficient of drag of a body, for example, is a function of Mach number and Reynolds number, and if these two are adjusted to be the same in the tunnel as in the desired free-stream conditions, then the value of coefficient of drag measured is the correct one. It is on the basis of this similarity that one is able to use wind-tunnel measurements to predict full-scale performance.

The experimental facilities of the Caltech hypersonic group center around two tunnels referred to as Legs 1 and 2, both with 5-by-5-inch test sections. The principal part of a hypersonic tunnel is the set of contoured blocks of steel which comprise the nozzle. High pressure air enters the nozzle at a low Mach number, and when it gets to the narrowest part, which is known as the throat, it has attained Mach 1.

When air moves at supersonic speeds the familiar principle of "the larger the area, the slower the flow speed" is reversed. Thus the air is accelerated by a dif-



Leg 2 of the hypersonic wind tunnel. The sidewalls of the tunnel have been removed to show the 5-by-5-inch test section.

ference in pressure until it reaches a final high Mach number and a low pressure at the widest part of the nozzle, the test section.

As the air expands in going from the high to the low pressure, the temperature drops very sharply; for example, by a factor of 6 for Mach 5 and by a factor of 21 for Mach 10. Also, the speed of sound, which depends on temperature, goes down correspondingly, so that high Mach numbers may be produced with somewhat lower air speeds than might seem necessary at first thought. The actual air speed in Leg 2 operating at Mach 11 is about 3,000 miles per hour.

Heat and high Mach numbers

To prevent its temperature from dropping below the liquefaction point, the air must first be heated. It is this heating that places the limitation on producing higher Mach numbers in wind tunnels. A steam heat exchanger raises the temperature of the air supply of Leg 1 to 300°F, and 300 kilowatt electrical heater raises the temperature of the Leg 2 air supply to 1100°F, so that the temperature at the test section of either tunnel is not lower than —385°F, which is approximately the temperature of liquefaction. After the air passes the test section, a series of shock waves slows the air to low speeds, and simultaneously the temperature returns to that to which it was initially heated. The air must then be cooled by a water heat-absorber before it can be returned to the compressors.

When either tunnel is run without heating the supply air, the air becomes so cold that it condenses into tiny droplets of liquid air, which look like fog if illuminated by an intense beam of light passed into the tunnel through a window. No satisfactory comparison between data of condensed air flows and single-phase air flows has been obtained; most experiments, therefore, require the use of the air heaters.

Flow conditions

The contours of the nozzle blocks are of an exact shape which depends on the desired Mach number. The specific shape produces uniform flow conditions across the height of the tunnel at the test sections for only the one Mach number the nozzle was designed for. However, because the Mach number produced by a nozzle depends only on the height ratio of the throat and the test section, one may vary the Mach number by changing the throat height. The flow conditions across the test section height will still remain acceptably uniform for a fairly wide range of Mach numbers. The throat height for Leg 1, which normally operates at Mach 5.8, is .080 inches; for Leg 2, operating at Mach 8, it is .020 inches. Because the nozzle throat is so narrow for hypersonic flow, the rate of flow of air through it is correspondingly low, and consequently the power required to drive the compressors is not excessive. The 16 compressors, comprising 7 stages of compression, are driven by electric motors of about 1000 horsepower total.

As previously mentioned, the Mach number produced by a hypersonic tunnel depends only on the area ratio of throat to test section, and not on the pressure available. However, to keep the test section pressure at a realistic value in comparison with conditions a missile might meet, the supply air pressure is elevated. The supply pressure of both Legs 1 and 2 may be raised to 1000 pounds per square inch. In spite of this compression, the pressure falls to a hundredth of atmospheric pressure or less at the test section.

Observation of the flow over the model being tested, and the shock-wave configuration, is made possible by the use of a Schlieren apparatus. The Schlieren employs a beam of parallel rays of light from a mercury vapor arc which is passed through the test section of the tunnel, illuminating the model. The variations of air density in the regions of the model and of the shock waves refract the light, thus causing an increase or decrease of illumination in the image formed on the ground glass or photographic plate used for observation.

Operating schedules

Tunnel running time is scheduled, whenever possible, so that while one tunnel is running, the other is being instrumented and prepared to run. In this way, maximum usage of the compressor plant is obtained. Preparation takes somewhat longer in Leg 2 than in Leg 1, because the higher operating temperatures pose additional problems. For example, the plastic medical tubing used for connecting pressure probes in Leg 1 must be replaced by stainless steel hypodermic needle tubing in Leg 2. All joints made with this stainless steel tubing must be silver-soldered, because ordinary solder would melt.

There are two principal aspects of hypersonic flow that one may wish to study: the pressure distribution about a body, with its corresponding shock-wave configuration; and the viscous effects, which are known as boundary layer phenomena. However, the pressure distribution is already well understood as a result of the more classical compressible-flow theory. In fact, the shock-wave equations were deduced as early as 1870. Consequently, most hypersonic research is currently directed toward an understanding of boundary layer phenomena, which are of very great interest.

Boundary layer

The boundary layer is a layer of air that clings to a surface because of the viscosity of the air. It is responsible for both the viscous drag and the aerodynamic heating and may take two forms: laminar or turbulent. In the laminar form the air within it flows smoothly over the surface, and the speed varies in an orderly fashion between the surface and the outer edge of the boundary layer. On models in the tunnel, the laminar boundary layers get as thick as an eighth of an inch. In the turbulent form the flow in the boundary layer is highly irregular. It is not difficult to imagine that this chaotic flow produces more drag and heating than the streamlined laminar flow.

It is observed that as a surface moves through the air, a laminar layer forms at the front and extends to a rearward position which depends upon, among other things, the Reynolds number and the surface roughness. At this position, the flow in the boundary layer begins to be turbulent, and after another length, called the transition region, it is fully developed as a turbulent layer.

Turbulence, drag and heating

Among various problems recently investigated in the hypersonic tunnels is that of how much the occurrence of turbulence changes the drag and heating, and what influences affect transition. Using a flat plate model which had a small element of its surface connected to a force balance, direct measurements of skin friction were made. The boundary layer at the measuring element was normally laminar, but could be made turbulent by injecting air through a series of small holes in the plate surface located across the width of the plate near its leading edge. It was found that when transition occurred, the skin friction increased 4 or 5 times. However, it was noted that the laminar boundary layer showed much less tendency to become turbulent at hypersonic Mach numbers than at lower speeds. The result of this behavior is that a missile would have a larger laminar boundary layer region at high speeds than at low, and hence not so high a viscous drag as predicted by lower speed measurements.

Shock wave effects

Another investigation has been concerned with the effect of the closeness of the shock wave to the boundary layer at the leading edge of a flat plate. It has been found that for a short distance rearward of the leading edge, the high pressure behind the shock wave influences the manner in which the boundary layer builds up, and produces an accompanying increase of skin friction and heat transfer. While this may sound like a matter of only academic interst, it is of importance to an understanding of the high heat-transfer conditions near the nose of a missile.

An investigation soon to be made will study a method of cooling a surface exposed to hypersonic flows in an attempt to overcome the adverse effects of aerodynamic heating. The surface to be cooled will be made of a porous material, so that a coolant gas may be ejected outward through the surface by pressure. It will act, in a sense, as a heat-insulator. To be studied are the effectiveness of the method and its influence on transition.

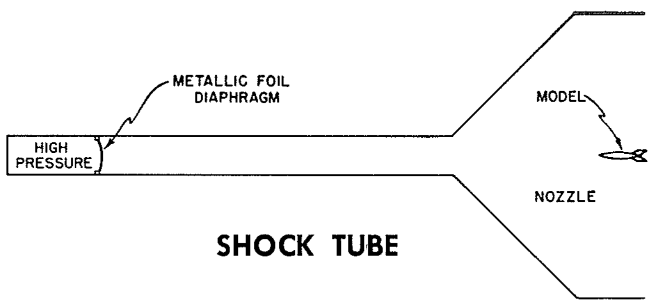
The group is developing two other means for producing high Mach number flows: a shock tube, and a helium tunnel. The shock tube (as shown in the diagram at right) essentially consists of a steel tube several feet long, closed at one end and leading into a nozzle at the other. A length of the tube near the closed end is made into a compartment by closing off with a diaphragm of metallic foil, and high pressure air is pumped into this chamber. When the diaphragm is burst by puncturing, a shock wave followed by a supersonic flow rushes down the tube until it reaches the nozzle. There it expands, just as in the wind tunnel, and produces flows of about Mach 6. The flow lasts only a few thousandths of a second, so that as it arrives at the model located in the nozzle, it must be observed by high-speed photography. The shock tube has as its advantage temperatures more nearly like those encountered in free flight conditions, rather than the temperatures of about —385°F in the wind tunnels.

Helium tunnel

The helium tunnel now undergoing testing is designed to produce flows of Mach 20. The helium tunnel, like the wind tunnel, produces high Mach numbers by expanding the gas in a nozzle. The advantage of helium over air is that its liquefaction temperature is so low that condensation does not occur, even without heating. The helium comes in steel cylinders from a commercial supplier, and although the tunnel exhausts three such cylinders in a matter of minutes, much valuable information about the shock-wave pattern and the pressure distribution on a model will be obtained.

While the projects that have been discussed are of an experimental nature, it should be realized that theoretical research receives equal emphasis. Because there is strong coordination of the two types of work, experiments are frequently suggested by analytical studies, and theory always modifies experiment when possible. Conversely, theoretical work many times depends upon experiment to guide it in the formulation of the problem.

The hypersonic program at GALCIT, sponsored by Army Ordnance and the Air Force, is part of a long-range program designed to put research ahead of the ever growing needs for knowledge imposed by the high-speed flight of the future.



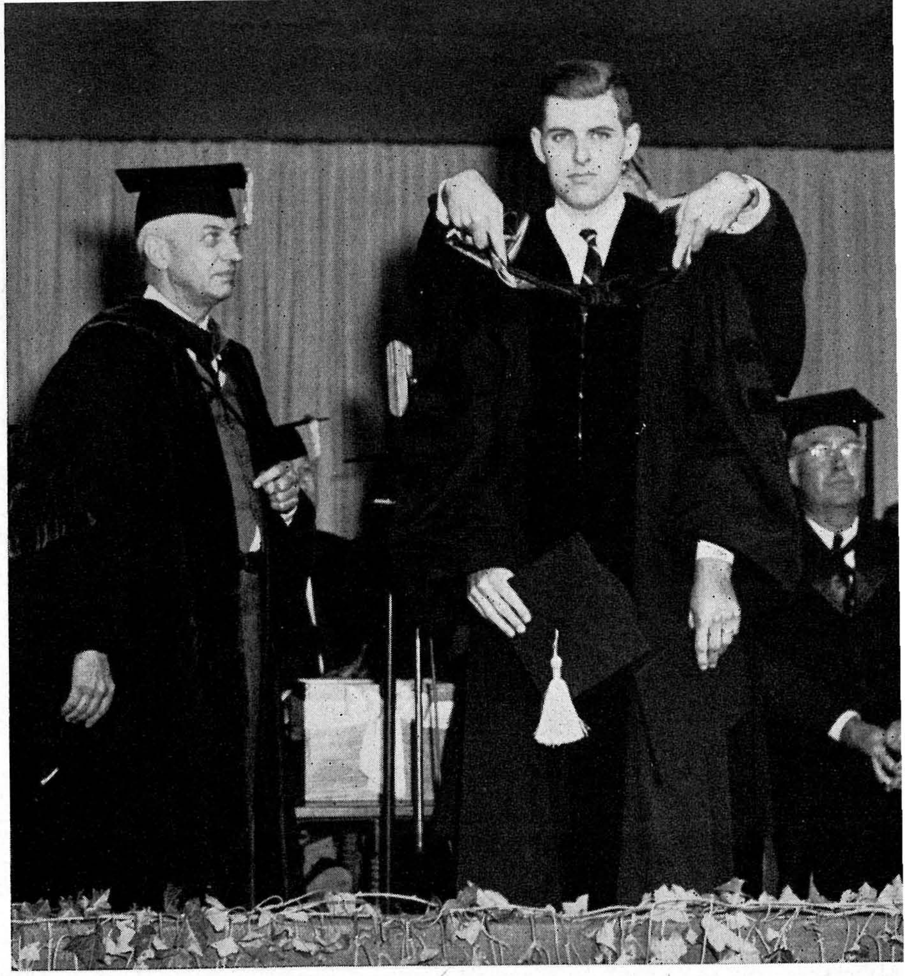
The shock tube is also a means for producing high Mach number flows. It is a steel tube, closed at one end and leading into a nozzle at the other. A diaphragm closes off the end of the tube, and high pressure air is pumped into this chamber. When the diaphragm is broken by puncturing, the nozzle produces high temperature flows at about Mach 6.

GEORGE RUPERT MACMINN, Professor of English, retires this month after 36 years at Caltech. Born in Moorestown, N. J., in 1884, he received his AB from Brown University in 1905. After teaching at Brown, Iowa State, and the University of California, he came to the Institute as Associate Professor of English in 1918. He has been a full professor since 1945.

George MacMinn specialized in American literature, the literature of the Bible, and technical report writing. He was faculty advisor to the *California Tech*, the student newspaper, from the beginning, and he has been editorial consultant to *Engineering and Science* for many years. He organized a Caltech Press Club to cultivate interest in journalism and contemporary literature, and he also organized the first Dramatic Club to give modern plays at Caltech.

He is co-editor, with Harvey Eagleson, of *College Readings in the Modern Short Story*, published in 1931, and author of *The Theater of the Golden Era in California*, the pioneer book in its field, published in 1941.

CALTECH'S 60TH COMMENCEMENT



A TOTAL OF 286 STUDENTS received degrees from the Institute at the 60th annual commencement on June 11. Bachelor of Science degrees went to 104 men. Fifty-one received the BS in Science—18 of them with honors; and 53 received the BS in Engineering—6 with honors.

Of the 29 men graduating with honor, 5 coupled this distinction with "exceptionally effective participation in extracurricular activities", for which they were awarded Student Body Honor Keys. They are Samuel W. Autrey, James C. Crosby, George L. Johnston, John T. Lloyd, and John K. Wall. Honor Keys were awarded to 9 seniors in all.

Master of Science degrees went to 97 men. 36 men were given the MS in Science and 61 received the MS in Engineering. Nineteen men were awarded Engineer's degrees—11 of these graduates being officers in the armed forces who were assigned to Caltech for advanced work in aeronautics.

Sixty-seven men received the PhD degree. Of these, Thomas K. Caughey, of Rutherglen, Scotland, is the first recipient of the Caltech doctorate with the major option of Engineering Science.

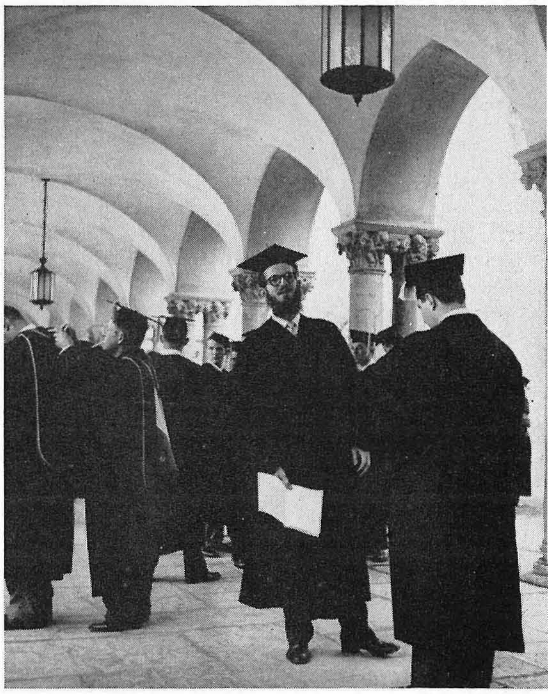
James R. Page, chairman of the Board of Trustees, presided at the commencement ceremonies. Commencement chaplain was the Reverend Curtis Beach, pastor of the Neighborhood Church of Pasadena. Degrees were conferred by President DuBridge, who also delivered the charge to the graduating class.

The commencement speaker was Dr. I. I. Rabi of Columbia University. His talk, "Man's Right To Knowledge and the Free Use Thereof," appears on page 14 of this issue. A nuclear physicist and Nobel Laureate, Dr. Rabi has long been a key figure in American science, and active in military research and development.

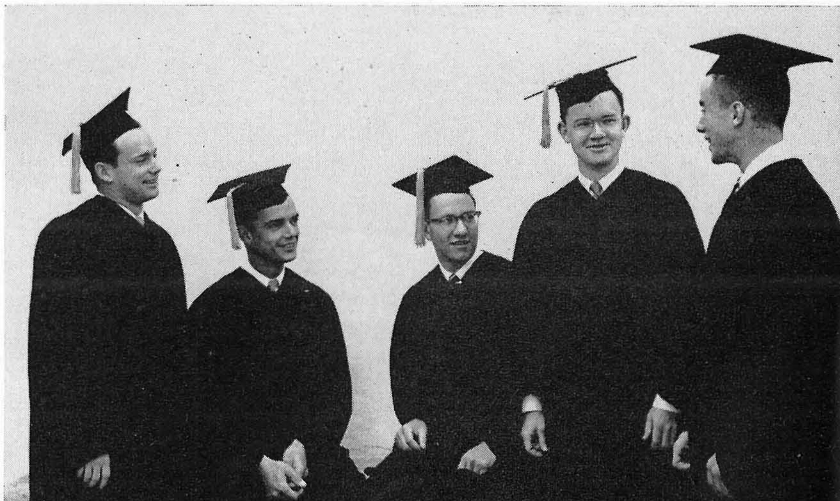
During World War II Dr. Rabi was a consultant to the atomic bomb project and was Associate Director of the Radiation Laboratory at the Massachusetts Institute of Technology—the government laboratory, directed by Dr. DuBridge, which was the U.S. radar research facility.

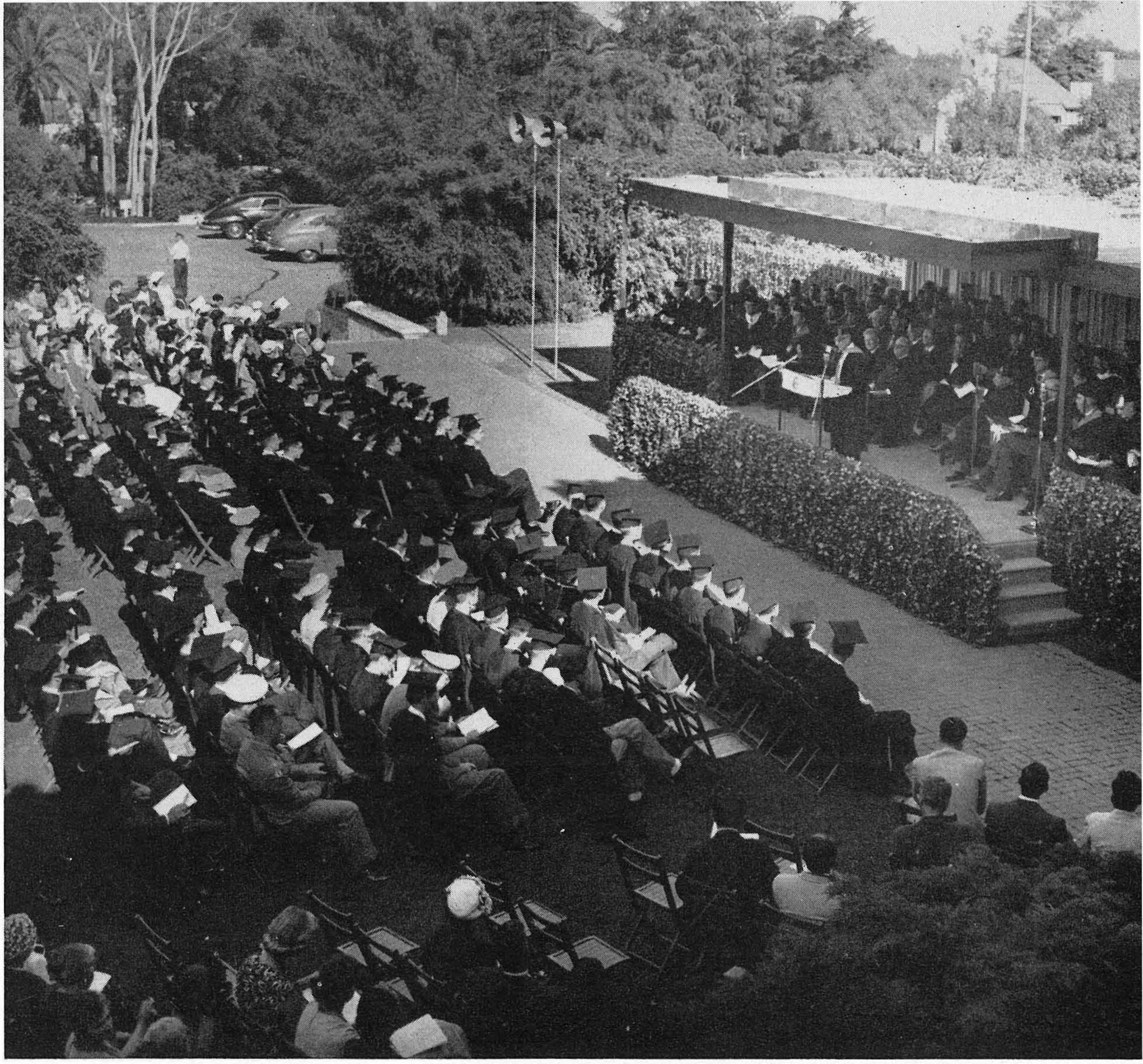
He is presently serving on the Office of Defense Mobilization's Science Advisory Committee, headed by Dr. DuBridge, and is chairman of the General Advisory Committee of the Atomic Energy Commission. He is also an advisor to the Aberdeen Proving Ground.

Highlights of the 60th commencement are pictured on this and the following pages.

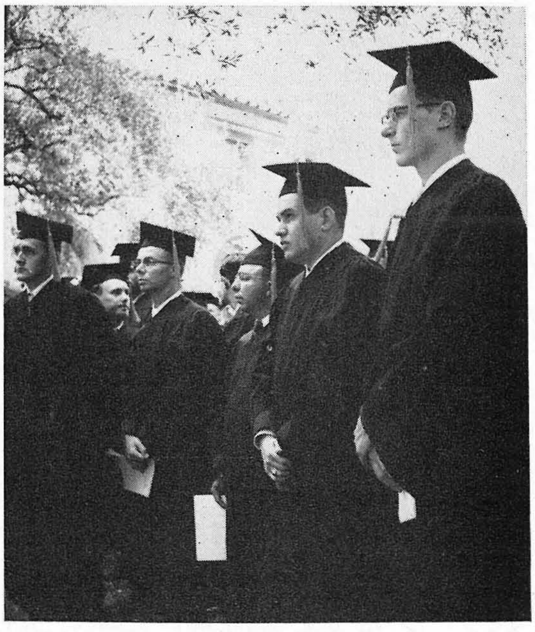


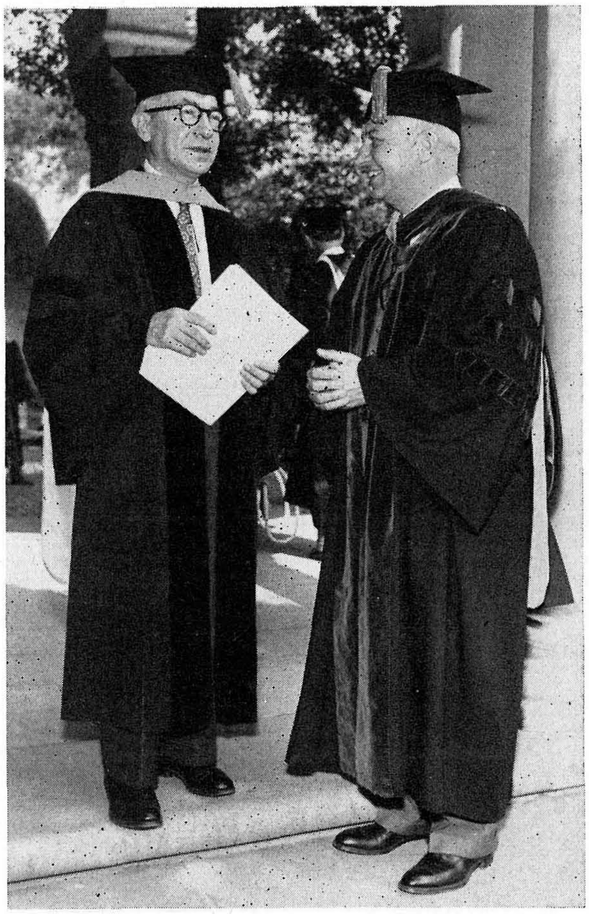
Above, left, Hal Musselman briefs graduates on commencement etiquette; Right, a practicing Beaver; Below, left, Trustee John Barber, President DuBridge and Chairman of the Board James Page; Right, graduates with honor, as well as Honor Keys—Lloyd, Autrey, Wall, Crosby and Johnston.





Above, Dr. Rabi giving the commencement address; Below, a faculty member collects his academic costume; Right, some men of the Class of '54





I. I. Rabi and L. A. DuBridge

MAN'S RIGHT TO KNOWLEDGE

and the free use thereof"

by I. I. RABI

I AM HAPPY TO BE ABLE to bring you the greetings of Columbia University, now beginning the third century of her life, and her thanks for your joining us in our Bicentennial Celebration on the theme, "Man's right to knowledge and the free use thereof."

In our United States we are born free, but we cannot be born wise. Man's right to knowledge is not the same as his right to the air he breathes. Knowledge has to be attained, it has to be learned, it has to be discovered. Even learning is a form of discovery. Therefore, man's right to knowledge can only mean his right to the opportunity to learn and to discover.

Man's right to knowledge then becomes an assertion of a right to education for all who have the ability to learn and the will to knowledge. Even more, since knowledge is always bounded by the unknown, we assert the right and even the duty to press forward the boundaries of knowledge. It is our faith that knowledge is a good to be sought even for its own sake alone, that new knowledge transforms the old, making it more beautiful, more meaningful, and more useful to mankind.

In our democratic society these propositions meet with wide acceptance. It was not always so. The struggle for universal elementary education was long and arduous and is not completely over even in our own day. As for higher education, the almost unique position which your own institution holds in this field shows how far we still have to go before higher education of the first quality is available to all who can profit thereby.

Our assertion of man's right to knowledge is then only a prelude to a large program. It is not a statement of existing fact, but an ideal which can be achieved only after generations of persistent and devoted effort. Even though our country leads the world in providing educational opportunity for our population, the greater part of the program still remains to be fulfilled.

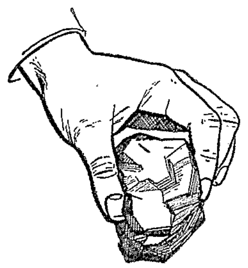
We must not forget that in other parts of the world, notably in the Soviet Union, another and different educational effort of vast dimensions is being pressed forward. Their ideology does not carry the banner of "Man's Right to Knowledge." Individual rights are meaningless or abhorrent to that ideology. Their educational program is to train the citizen to the service of the state, to be a cog in a vast machine, to operate and think only in complete conformity to principles laid down from above.

Subversive as this effort may be to true education, it is not wholly unsuccessful in its appeal. There are people even in our own country who are attracted to this perversion of knowledge and education, this denial of intellectual and spiritual ends. This shallow but facile doctrine is very persuasive to those who look upon the individual as only a means to an end, although the end on close examination turns out to be ignoble and degrading.

These people, tired of thinking, incapable of learning, need the reassurance of a mass. They are more than

QUARTZ CRYSTALS

How a 1¼ hour "gem-cutting" operation became an 8-minute mechanized job



PROBLEM: Preparing quartz crystals for use as electronic frequency controls calls for the highest degree of precision. So much so, in fact, that prior to World War II skilled gem-cutters were employed to do the job.

But during the war, there were not enough gem-cutters to keep up with the demand for crystals in radar, military communications and other applications.

Western Electric tackled the job of building into machines the skill and precision that had previously called for the most highly skilled operators.

SOLUTION: Here is how quartz crystals are made now—by semi-skilled labor in a fraction of the time formerly required:

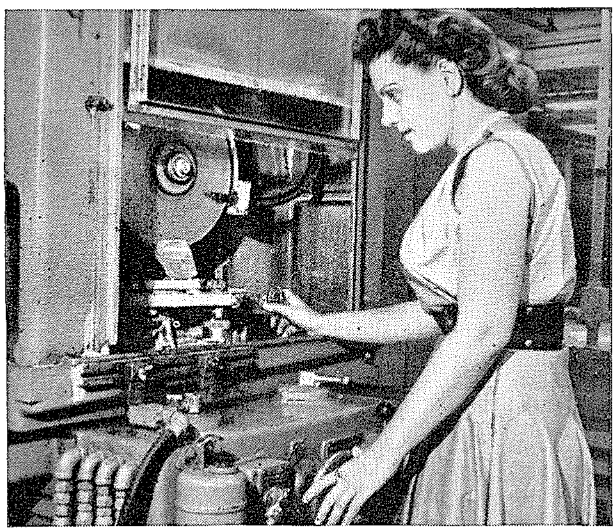
A quartz stone is sliced into wafers on a reciprocating diamond-edged saw, after determination of optical and electrical axes by means of an oil bath and an X-ray machine. Hairline accuracy is assured by an orienting fixture.

The wafers are cut into rectangles on machines equipped with diamond saws. The human element is practically eliminated by means of adjustable stops and other semi-automatic features.

The quartz rectangles are lapped automatically to a thickness tolerance of plus or minus .0001″. A timer prevents overlapping. Finally, edges are ground to specific length and width dimensions on machines with fully automatic microfeed systems.

Most of these machines were either completely or largely designed and developed by Western Electric engineers.

RESULTS: With skill built into the machines—with costly hand operations eliminated—this Western Electric mechanization program raised production of quartz crystals from a few thousand a year to nearly a million a month during the war years. This is just one of the many unusual jobs undertaken and solved by Western Electric engineers.



Quartz stones are cut into wafers on this diamond-edged saw, with orientation to optical axis controlled by fixture. This is just one of several types of machines designed and developed by Western Electric engineers to mechanize quartz cutting.

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

Manufacturing plants in Chicago, Ill.; Kearny, N. J.; Baltimore, Md.; Indianapolis, Ind.; Allentown and Laureldale, Pa.; Burlington, Greensboro and Winston-Salem, N. C.; Buffalo, N. Y.; Haverhill and Lawrence, Mass.; Lincoln, Neb.; St. Paul and Duluth, Minn. Distributing Centers in 29 cities and Installation headquarters in 15 cities. Company headquarters, 195 Broadway, New York City.

ready to surrender their individual wills to a leader, to be submerged in a herd where all one has to do is to keep step with the man ahead. Their drives come not from spiritual resources within, but from the pressure of the mass without. Their motivation is hate and envy. Always their great hatred is directed at freedom, at schools that are free to teach objectively, at libraries where the individual has freedom of access to all knowledge and all doctrines, but their greatest hatred is for the individual who undermines their security by daring to think differently.

The mechanism which maintains the domination of absolute conformity is terror. We have seen its effects in Russia, in Germany, Italy, Japan, and most recently in China. When fear is in the saddle, enthusiasm takes the place of thought, hypocrisy takes the place of genuine patriotism, cant takes the place of reasoned doctrine, and a noble record of achievement can become a source of calumny and suspicion.

Ultimately, and the signs are already visible even in our own country, this drive for conformity will be directed at science, the stronghold of reason and objectivity, and we must prepare for the attack.

Science is perhaps the most important of the driving forces which give our culture its pervasive power and aggressive virility. If our science is fettered by intimidation and outside control, as it is in the Soviet Union, the principles on which this country was founded will cease to have a living validity.

The influence of science

Our science is a massive and beautiful intellectual structure which has been erected piece by piece over centuries of effort by devoted men from many lands. It cannot be successfully challenged except in its own terms, since it is solidly based on detailed experiment and exact observation. In response to its universal appeal, an increasing portion of the more gifted young people in every country of the world are attracted to study and to contributing to the growth of scientific knowledge. It is then no wonder that even the ancient cultures of the East, which have kept their own integrity for many centuries, are now being transformed in our own generation because they are unable to resist the influence of scientific thought.

Likewise, within the universities, science has through the last century played an increasingly important role. The university is no longer an institution which is chiefly concerned with the preservation and dissemination of knowledge. With the growth of science, the university is now equally concerned with the more dynamic activity of discovering new knowledge and educating young men and women to carry on this task in the future.

The modern university is therefore no longer an ivory tower, with windows turned only toward the past; the present and the future are now equally our concern. When new materials are needed in industry, when new healing agents are needed in medicine or when new weapons are required for defense, or even when our political and economic arrangements require revision, people now look to the university for help, guidance, and inspiration.

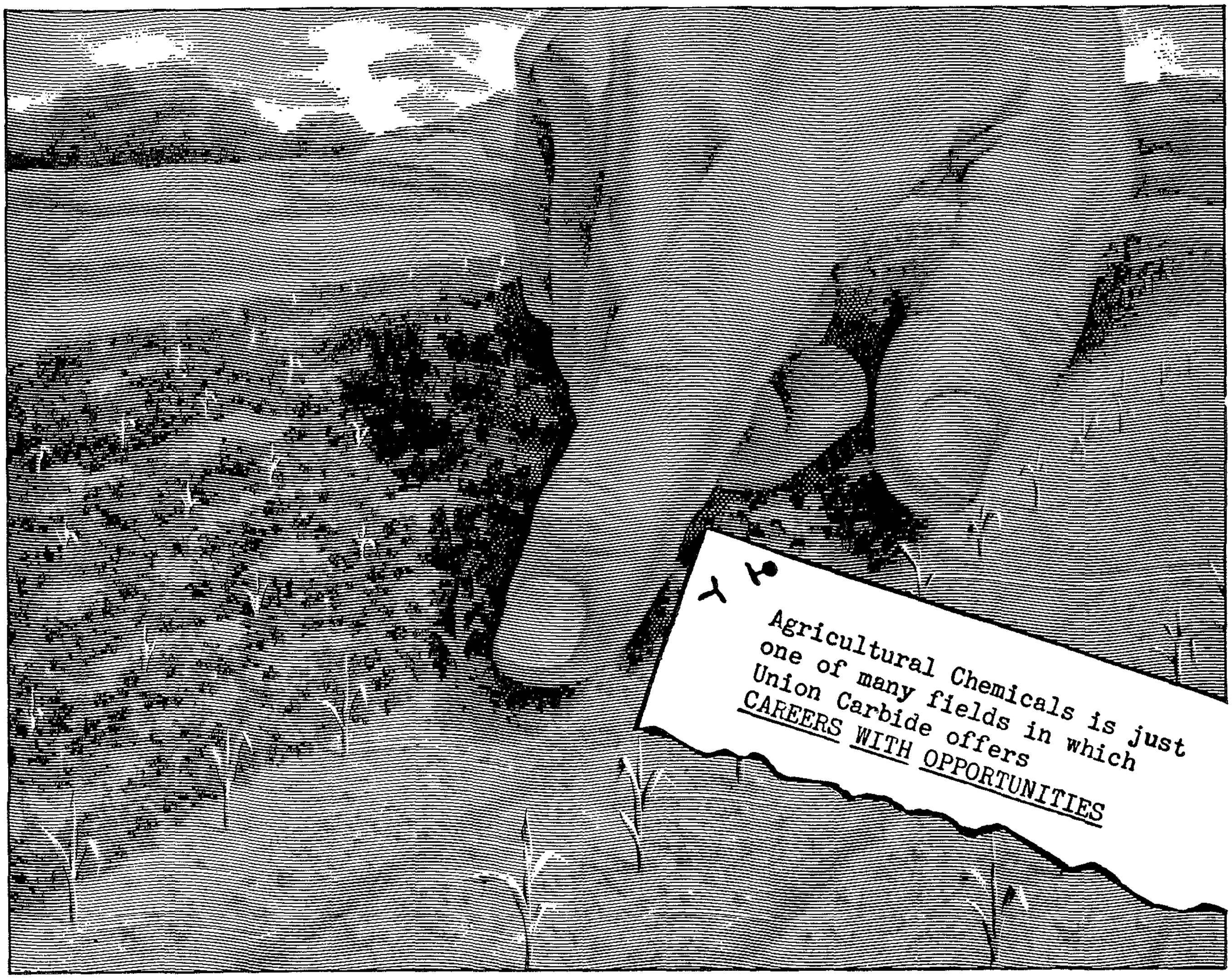
Nevertheless, so great is the capacity of the human mind to hold two contradictory views at the same time, the university professor is still regarded as an unworldly person, out of contact with reality, unable to conduct the affairs of his university without the intervention of politicians.

The tradition of science

Science is the greatest uncentralized, undirected cooperative effort of all time, not only among people of the same culture but also among peoples of the most diverse origins and customs. Furthermore, the traditions of science provide us with a set of values and an ethic which are rational and therefore accessible to all men. The universal respect in which science is held by people who differ extremely in other matters indicates that the scientific tradition can become a means to bring the nations of the world together for peace and cooperation.

In this day of thermonuclear bombs many here will find my statements optimistic to the point of naiveté. When civilized mankind is cowering before the shadow of extinction, the blessings of science and technology are hardly obvious. But we must ask ourselves from where does this threat come? Surely not from some malevolent spirit alien to ourselves. It comes from other men like ourselves who must also feel this threat, and therefore there is hope that this menace can be overcome by wisdom and insight and by the very knowledge which produced the menace in the first place. We surely cannot give up our science to live the mean, benighted, fear-and-disease-ridden lives of our remote ancestors. Our powers for good and evil have always been the two sides of the same coin. There is no turning back on the path which humanity has taken. The solution, if any, of the problems of mankind lies in deeper understanding, more penetrating insights, greater capacities, more science and not less.

This path was recognized by the President of the United States in his stirring address before the United Nations Assembly in December of last year, when he called upon the nations to form a pool of uranium, plutonium, and other fissionable material to be used for the common good under the United Nations. This proposal, as the President made clear, is only the first step on the road which we have to travel if our civilization is to survive. No one should have any illusion that this


Agricultural Chemicals is just
one of many fields in which
Union Carbide offers
CAREERS WITH OPPORTUNITIES

path will be an easy one. The history of the past decade is enough evidence to the contrary. Nevertheless, it is the direction which we must pursue with firmness and sincerity. If our new weapons are ever brought to the test of war, the result can only be universal disaster.

Up to the present day the Soviet Union, blind to the interests of her own safety and deaf to the anguished cries of humanity, has blocked our every effort to achieve a peaceful and harmonious world. Fruitless as our efforts have been so far, we must not be discouraged. We must not permit ourselves to be thrown back to a policy which depends solely on a Maginot Line of secrecy backed by atomic and thermonuclear retaliation. While building up the offensive and defensive strength of our country, we must continue to retain the initiative in offering to the peoples of the world positive proposals, imbued with moral purpose, to relieve the fears and tensions of our time. This, President Eisenhower, who is schooled in war but a lover of peace, will not cease from doing.

Expensive research

As our science becomes more highlv developed, scientific research becomes increasingly expensive, not only in medicine but also in the physical and biological sciences. This development, inevitable in any case, was greatly accelerated in recent years by the invention of important and necessary, but expensive instruments such as the large cyclotrons, the electron microscope, fast calculating machines, and by the recognition of the tremendous power and utility of electronic instruments in general for many fields of research.

These developments which have so greatly advanced scientific techniques and which have led to discoveries of the first importance, have nevertheless placed serious problems before university administrations in finding funds to support these expensive undertakings. At present, the larger fraction of the support for scientific research comes either from the Federal Government or from special foundations. This kind of support, although very stimulating and timely, brings with it a whole series of problems which are both novel and perplexing. But, no matter how difficult the problems, scientific research in the university must proceed with full vigor. If private support fails, we must continue to seek public funds with all the problems which they entail.

It would be a great loss amounting to a national disaster if the universities were to lose their leadership in basic science to specialized research institutes. The universities would become schools where the results of others were taught, but where the teachers themselves played but a minor role in this creative activity. The importance, the standing, and the vigor of our intellectual life in the university would immediately sink. The professors would become, so to speak, retailers of the work of others, reporters of events rather than the active pioneers at the forefront of knowledge.

Such an atmosphere can hardly inspire the young and vigorous minds of the future generation of scientists. Bold and imaginative thinking cannot be communicated at second hand.

There is a most important practical national interest in maintaining scientific research in the university at full vigor. This point was not well understood before the war, but has now become very clear, and accounts to a large extent for the great interest of various departments of the Federal Government in the support of University research.

A professor actively pursuing his researches, surrounded by his students, in the laboratories of the universities produces not only new and valuable knowledge but also new scientists, able, skilled, and imbued with his enthusiasm. University research is always young and vigorous. Although the professor ages with time, the students remain timelessly young. The university is a producer of men as well as ideas, of inspiration as well as new knowledge and discovery.

Moreover, university scientists are uncommitted scientists. In a time of national emergency, as during the last war, students and professors could, with little or no delay, turn from their researches to the problems of the national emergency. In our universities we have, so to speak, a standing army of thousands of capable scientists who are equally useful in peace and war.

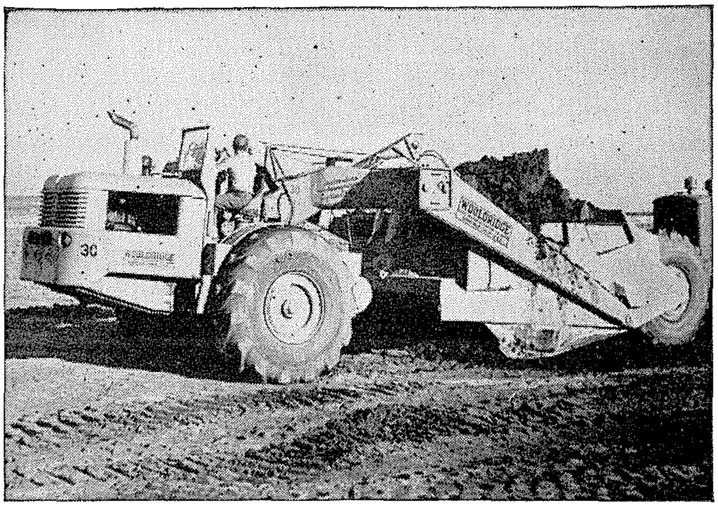
The university and government

The value of this mobile standing army was fully demonstrated in the last war; the development of the atomic bomb was only one of a long list of great accomplishments which greatly shortened the war and saved the world from even greater misery. The cordial relations and mutual respect between our university scientists and our defense forces which were developed during the war remain unbroken to this day, and are one of the important elements in our national defense.

This cooperation between the university and government does not, by any means, represent a militarization of our scientists or of our universities. It is, rather, a symbol of maturity in our science and our universities, a symbol of the assumption of a public responsibility which was always present but not fully recognized until this decade. It is to be hoped that these lessons from our war effort will not be forgotten by the universities, by Congress, and by the Administration.

The value of the standing army of scientists is greatest when they come from an atmosphere of freedom and independence where no avenue is closed to questioning, where a bold new idea is a value in itself; in short, an

Another page for **YOUR BEARING NOTEBOOK**



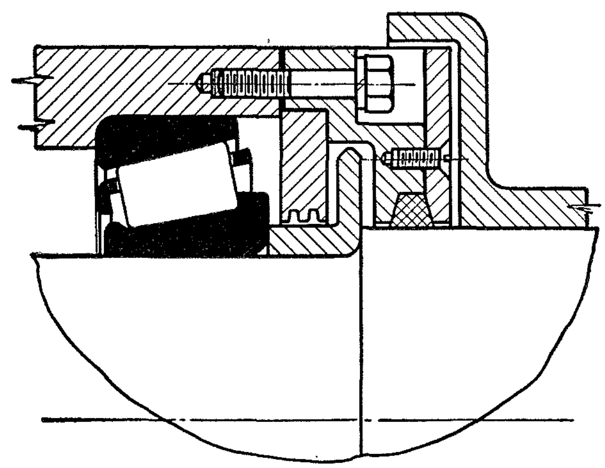
How to help prevent breakdowns in a scraper's wheels

The wheel bearings of this scraper really have to take it. They have to carry the weight of 18.0 cubic yards of earth. And they have to handle this load while the scraper jolts over uneven ground at speeds up to 35 mph. To eliminate practically any chance of breakdowns, company engineers specified Timken® tapered roller bearings.

The tapered construction of Timken bearings enables them to take any combination of radial and thrust loads that result from uneven ground. And line contact between rollers and races gives Timken bearings load-carrying capacity to spare. What's more, Timken bearings help keep damaging dirt out.

How TIMKEN® bearings help keep dirt out—lubricant in

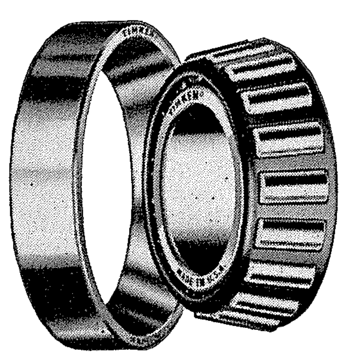
Timken bearings make closures more effective because they hold housings and shafts concentric. As a result, dirt can't get in—lubricant can't get out. Maintenance is minimized. Continuous, trouble-free operation is assured.



TIMKEN

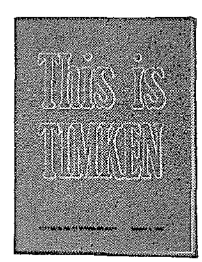
TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



Want to learn more about bearings or job opportunities?

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, Ohio.



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION

atmosphere of the utmost academic freedom. Any attempt to undermine the independence of university research through government control is an attempt to destroy the very qualities which make the scientist of value, to the country and to civilization.

This far I have dealt chiefly with the first part of our theme, "Man's right to knowledge." I will now turn to the even more challenging second part of our bicentennial theme, "Man's right to knowledge and the free use thereof." Clearly, the right to free use of knowledge cannot be as absolute as man's right to knowledge. In the first place, there are stringent but necessary laws regulating many uses of knowledge. They range from the Biblical commandment, "Thou shalt not kill," to the well-enforced traffic regulations of your Pasadena, California. Nevertheless, we do not feel that these laws violate our free use of knowledge, because we know these laws to be wise.

Knowledge and wisdom

The free use of knowledge is acceptable only when guided by wisdom. Knowledge without wisdom can be dangerous and perverse, but wisdom without knowledge is meaningless, since a man who is wise but ignorant can only be silent.

Wisdom is inseparable from knowledge; it is knowledge plus a quality which is within the individual human being. Without it knowledge is dry, almost unfit for human consumption, and dangerous in application. Its absence is clearly noticeable; the learned fool and educated bore have been figures since the beginnings of recorded history. Wisdom adds flavor, order and measure to knowledge. Wisdom makes itself most manifest in the application of knowledge to human benefit.

In its highest aspect, especially when applied to national affairs, the highest wisdom must be joined to the broadest knowledge. With knowledge as extensive as it has become in modern times, wisdom can hardly be achieved except through a communion of many minds. Indeed, it has always been so since Socrates sought wisdom by questioning his fellow men.

I would like to devote the remaining minutes of my discourse to wisdom and education.

Our colleges and universities are well organized to dispense knowledge thoroughly and efficiently, but since they tend to become a collection of schools and departments rather than a community of scholars, the saving grace of wisdom is too often omitted. Wisdom is by its nature an inter-disciplinary quality, and not the product of a collection of specialists. There can be no course in wisdom.

We do, indeed, try to mold the student toward a certain ideal of the educated man of the twentieth century, but it is too often a broad education administered by specialists. The approximate counterpart to this ideal, embodied in a living man, is a rare being on any campus except here at Caltech.

In fact, in most universities, the student is the only really active connecting link between the different departments of the university. In a certain paradoxical and limited sense the students are the only broadly educated body in the university community. It might be equally as instructive and useful to have the faculty examined by the students from time to time, as to have the students examined by the faculty, according to immemorial custom.

Our American colleges and universities, since they are fairly recent foundations, have not settled into complacency. They are always ready to experiment with the curriculum to achieve desired ends. The ultimate end of education is knowledge embedded in wisdom. Our experimental methods have taught us how to impart the most diverse forms of knowledge, but the quality of wisdom has been more elusive.

Harking back to a past which now looks so bright in retrospect, to a knowledge and wisdom which now looks simple and clear, many educators all over the land have raised a banner with the inscription "Back to the humanities." This slogan has never been well defined. It does not mean a study of Latin, Greek and Hebrew writings in their original tongues; in practice it has usually come to mean less real, solid science, and more of everything else. I do not believe that this path will lead to wisdom or salvation in this generation any more than it did in previous generations when the humanities were in flower.

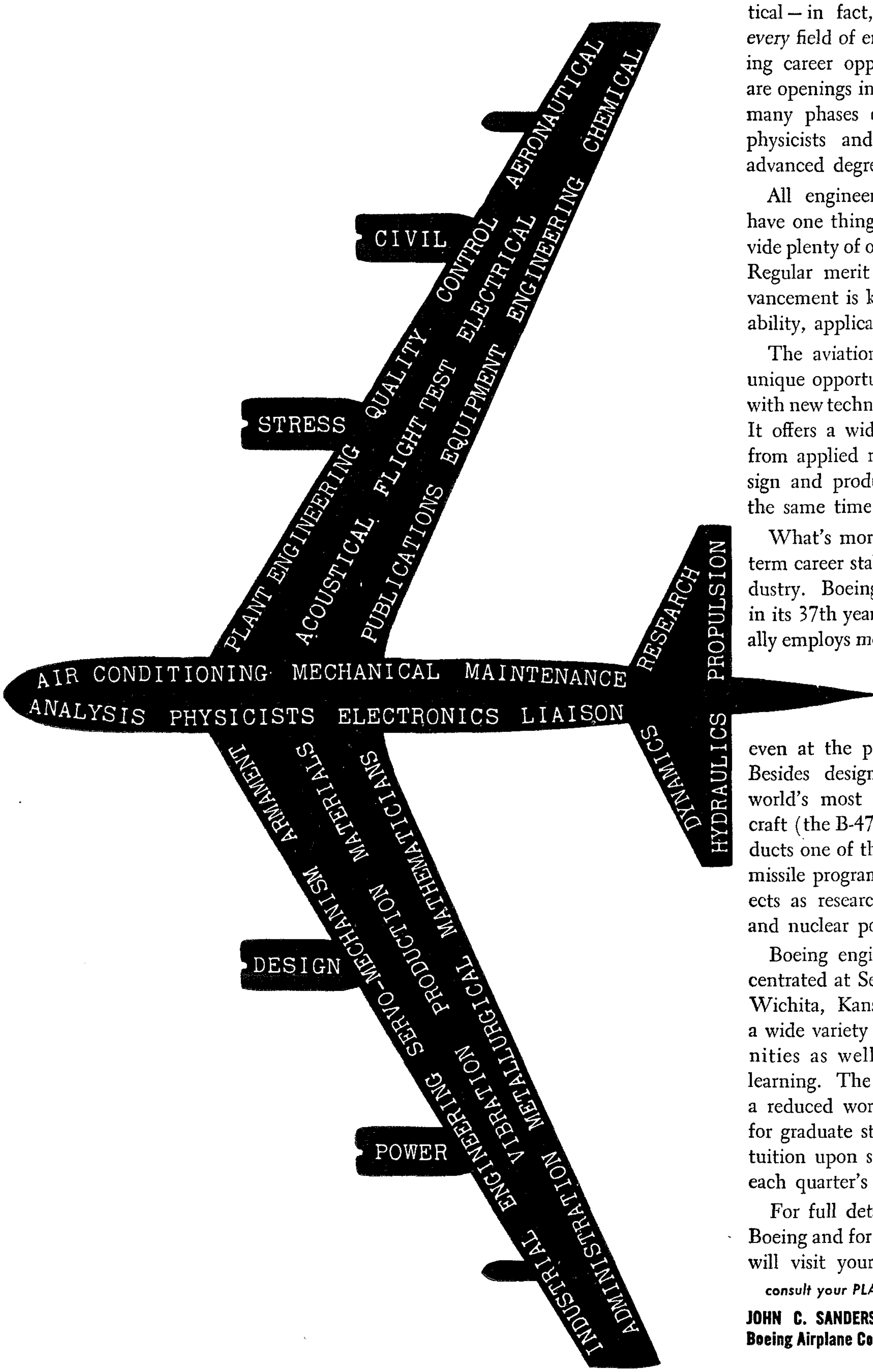
Knowledge and change

Every generation of mankind has to remake its culture, its values, and its goals. Changing circumstances make older habits and customs valueless or obsolete. New knowledge exposes the limitations and the contingent nature of older philosophies and former guides to action. When change is slow, the new is gradually assimilated, and only after a number of generations is it noticeable that a great change has been brought about.

We do not live in such a period of history. In this century, enormous changes in the circumstances of our lives and in our knowledge have occurred, not in every generation but in every decade. It is therefore not at all surprising that our intellectual, our social and political processes have largely failed to keep abreast with contemporary problems. It is not surprising that we became confused in the choice of our goals and the paths we must take to reach them.

Our modern university, which takes all knowledge as its province, is the only instrumentality we possess which has the capacity of bringing order out of this chaos.

Engineers of virtually EVERY type are needed on the Boeing team



Mechanical, electrical, civil, aeronautical – in fact, graduates in virtually *every* field of engineering–find rewarding career opportunities here. There are openings in design, research, in the many phases of production, and for physicists and mathematicians with advanced degrees.

All engineering careers at Boeing have one thing in common: they provide plenty of opportunity to get ahead. Regular merit reviews are held. Advancement is keyed to your individual ability, application and initiative.

The aviation industry offers you a unique opportunity to gain experience with new techniques and new materials. It offers a wide range of application, from applied research, to product design and production, all going on at the same time.

What's more, you can expect long-term career stability in the aviation industry. Boeing, for instance, is now in its 37th year of operation, and actually employs more engineers today than even at the peak of World War II. Besides designing and building the world's most advanced multi-jet aircraft (the B-47 and B-52), Boeing conducts one of the nation's major guided missile programs, and such other projects as research on supersonic flight, and nuclear power for aircraft.

Boeing engineering activity is concentrated at Seattle, Washington, and Wichita, Kansas – communities with a wide variety of recreational opportunities as well as schools of higher learning. The Company will arrange a reduced work week to permit time for graduate study and will reimburse tuition upon successful completion of each quarter's work.

For full details on opportunities at Boeing and for dates when interviewers will visit your campus,

consult your PLACEMENT OFFICE, or write:

JOHN C. SANDERS, Staff Engineer – Personnel
Boeing Airplane Company, Seattle 14, Washington

BOEING

Moreover, society has laid this obligation upon us since it is our task to teach the youth of our country, to give them the knowledge and guidance which will enable them to meet the problems of their generation. We must not only transmit to them the wisdom of the past, but we must arm them for the future.

This task cannot be adequately performed unless the teachers become clearer in their individual minds, and as a university community, about our values and our goals in our own times. We cannot achieve this goal unless we make a conscious effort toward the ideal of a university as a place where learned men of different disciplines really communicate with one another to achieve wisdom.

Here we come to the problems raised by science.

Understanding science

The least assimilated portion of modern knowledge, and yet the part which is most responsible for our changing world, is our science. Nevertheless, in this period of history, in this most scientific of all ages, the cultivation and understanding of science has become a specialized function of professionals in which neither the educated public nor the general university community plays an active role. In fact, with many otherwise estimable people, ignorance of scientific thought has become a matter of pride rather than regret.

How can one hope to attain wisdom, the wisdom which is meaningful in our own time, without the knowledge of the profound forces which shape our destiny? How can our leaders in government, in industry, and in education make wise decisions, now in the middle of the twentieth century, without a deep understanding of scientific thought and feeling for scientific tradition?

These anguished thoughts have impelled many scientists, to their own personal peril, to concern themselves with matters which in the past were the exclusive domain of statesmen and military leaders. They have tried to advise, importune, and even cajole our leaders to include the scientific factor in our fateful policy decisions. More often than one would expect, they have been successful. The greatest difficulty which stands in the way of a meeting of the minds of the scientist and the non-scientist is the difficulty of communication, a difficulty which I believe stems from a serious defect in education.

The mature scientist can listen with pleasure and understanding to the philosopher, the historian, the literary man, and even the art expert. There is no difficulty of communication from that side, because the scientist has been educated in our general culture.

Unfortunately this channel of communication is a one-way street. The non-scientist cannot listen to the scientist with pleasure and understanding. Despite its universal outlook and its unifying principles, science seems to be no longer communicable to the great majority of educated laymen. They simply do not possess the background of the science of the day and the intellectual tools to know what it is doing to them and their world. To his colleagues in the university the scientist tends to seem more and more as a man from another planet, a creature uttering profound but incomprehensible truths, or a technician scattering antibiotics with one hand and atomic bombs with the other.

The solution to this problem of the integration of scientific thought into our general culture can lie only in education. We must somehow find the way to integrate the scientific tradition and scientific thought with the rest of the general culture of our time. This cannot be done by giving the student a smattering of scientific ideas any more than a knowledge of French which suffices to order ham and eggs will give one the key to the beauties of French literature. A thoroughgoing revision of the curriculum in our secondary schools and colleges will be required to make the scientific mind and tradition an integral part of our culture.

We must bridge the ever-widening rift that has opened between science and what goes by the name of "the humanities" by achieving the understanding that both science and the humanities are creations of the human spirit. Only by the fusion of the two can we reach the wisdom appropriate to our day and generation. To this end we must learn to teach science in the spirit of wisdom and in the light of the history of human thought, and human effort, rather than as the geography of a universe uninhabited by mankind. Our colleagues in the non-scientific faculties must understand that if their teachings ignore the great scientific tradition of modern times, however eloquent and elegant their words, they will be meaningless in this generation and barren of fruit.

A united effort

What the world needs is a fusion of the sciences and the humanities. The humanities express the symbolic, poetic, and prophetic qualities of the human spirit. Without them we would not be conscious of our history; we would lose our aspirations and the graces of expression that move men's hearts. The sciences express the creative urge in man to construct a universe which is comprehensible in terms of the human intellect. Without them, mankind would find itself bewildered in a world of natural forces beyond comprehension, victims of ignorance, superstition and fear.

With a united effort of the sciences and the humanities, we may succeed in discovering a community of thought which will transcend the boundaries of state and nation and help bring the peaceful world which we all desire with all our hearts.

THE MONTH AT CALTECH

Young Scientists

SIX OF THE 20 MEN selected in a *Fortune* magazine poll as top young scientists in U. S. universities and industry are either staff members or alumni of Caltech.

Of the 10 top young scientists in American universities listed in the current issue of the magazine, four are Caltech staff members:

Drs. Harrison Brown, 36, professor of geochemistry, noted for his work on meteorites, geological dating and distribution of the elements in nature; Richard P. Feynman, 36, professor of theoretical physics, for his quantum theory of electrodynamics; Allan R. Sandage, 28, Mount Wilson and Palomar Observatories astronomer, for his work on cosmic distances and structure; and James D. Watson, 26, senior research fellow in biology, for his part in developing a theory of structure for an important nucleic acid.

Two of the 10 top young scientists in industry as listed by *Fortune* are Caltech alumni: W. Conyers Herring, 39, Bell Telephone Laboratories theoretical physicist and authority on solid state quantum mechanics, who spent 1933-34 at Caltech as a graduate student in physics; and Calvin A. Gongwer, 37, manager of the Aerojet-General Corporation under-water engineering division, a hydrodynamicist, designer of underwater engines, co-inventor of the Minisub, and basic research worker, who received his MS in mechanical engineering from Caltech in 1939.

Sigma Xi Award

ARMIN DALE KAISER, graduate student in biology, has been awarded the first Caltech Sigma Xi prize for research work of exceptional quality.

The $200 prize was established last month by the Caltech Chapter of the scientific research fraternity to recognize and encourage outstanding graduate students whose careers will be in pure and applied research. It will rotate each year to a different one of the Institute's five science and engineering divisions.

Kaiser, who expects to receive his PhD in 1955, has been at Caltech since 1950, when he began work under Prof. Max Delbruck.

A native of Piqua, Ohio, he was graduated in 1945 from Piqua High School, then entered the Army and was sent to the Philippines with the Signal Corps. After his discharge he entered Purdue University, majoring in general sciences, and received the BS degree with distinction in 1950. He held a graduate assistantship at Caltech in 1950-51, and since then has held a National Foundation for Infantile Paralysis Predoctoral Fellowship.

ALUMNI NEWS

Annual Meeting

AT THE ANNUAL ALUMNI BANQUET held June 9, President DuBridge announced the gift of a $15,000 scholarship fund, presented to the Institute by the Alumni Association.

Income from the fund will be used to provide a four-year tuition scholarship for able and worthy undergraduate students at Caltech. The first scholarship is to be awarded to a freshman entering the Institute next fall.

Establishment of the fund was undertaken after the alumni contributed $168,000 for the Alumni Swimming Pool and Locker Rooms as part of the new Caltech athletic center being constructed in Tournament Park. The alumni plan to make annual additions to the fund for the next three years to provide four Alumni Scholarships, one in each undergraduate class.

Announcement of the Alumni Scholarships was one of the highlights of Dr. DuBridge's report to alumni on Institute developments during the past year. Speaker of the evening was Laughlin E. Waters, who talked on "Justice Is Your Business". Mr. Waters is U. S. attorney for southern California.

Also announced at the banquet was the election of Kenneth F. Russell, '29, as Alumni Association president for the coming year. New vice-president is Charles V. Newton, '34. Professor Donald S. Clark, '29, as secretary, and George B. Holmes, '38, as treasurer, were re-elected.

Newly-elected members of the Alumni Board of Directors for two-year terms are Hugh C. Carter '49, Philip Cravitz '29, William F. Nash, Jr. '38, and Charles P. Strickland, Jr. '43. Reunion classes this year included 1914, 1919, 1924, 1929, 1934, 1939, 1944 and 1949. Reports from most of these classes are presented below.

1924

The class of '24 spent two evenings celebrating their 30th reunion. On Tuesday, June 8th, 18 members attended a class dinner at the Hotel Green in Pasadena, and the following evening 12 were present for the Annual Banquet.

Attending at least one or the other of these functions were Kenneth Anderson, Dale Barcus, Sid Duncan, Carlton Eckermann, Harold Gandy, Morry Goldsmith, Larry Hall, Bob Hastings, Bill Holladay, Grant Jenkins, Oiver Kilham, Ed Lownes, Cliff Maltby, Roy Miller, Holly Moyse, Lyall Pardee, and Frank Pine.

—E. Harold Gandy

Richard J. Conway, Lehigh '51, selects Manufacturing Engineering at Worthington

RICHARD CONWAY checks cutting tool with machinist before milling a pump casing.

After completing his general training which brought him in contact with all departments, Richard J. Conway decided that manufacturing engineering was his field. He says, "I chose the Manufacturing Engineering Department after completing my general training at Worthington because as a graduate in Industrial Engineering I can learn the practical aspects of my field while applying theory I learned in college.

"The personnel of this department work together as a team toward the solution of the numerous problems which arise daily. We have the cooperation of all other departments in the corporation in getting the necessary facts pertinent to the solution of these problems. In the course of our day it may be necessary for us to meet the Plant Manager, Chief Engineer, Comptroller, several department heads, clerks, foremen, machinists and many others throughout the company.

"I have contributed to the solution of many problems handled by this department including metal spraying, machining procedures, purchasing new equipment and designating proper dimensions to obtain desired fits between mating parts.

"I enjoy my work because I'm doing the work I want and my formal education is being supplemented with practical knowledge gained from the tremendous wealth of knowledge available to me at Worthington. I know from personal contact with many other departments in the Corporation that Worthington can and will find their young engineers a spot which will give them the same opportunities as have been afforded me."

When you're thinking of a good job, think *high*—think *Worthington.*

FOR ADDITIONAL INFORMATION, see your College Placement Bureau or write to the Personnel and Training Department, Worthington Corporation, Harrison, N. J.

WORTHINGTON

The Sign of Value Around the World

1929

The 25th anniversary reunion of the class of '29 was held at the Van Nuys home of Philip Cravitz, who generously offered the use of his home and spacious patio for a pleasant late afternoon and early evening celebration.

1944

The reunion of the class of '44 was held at the Pasadena Athletic Club on Saturday, June 12th.

1934

With half of the class of '34 still living in southern California, 24 members found it possible to attend the Alumni Banquet in celebration of the 20th anniversary of their graduation from Caltech. This group, the largest reunion group in attendance, included the following: Bob Boykin, Bob Brown, Don Cleveland, John Cortelyou, Willis Donahue, Duncan Douglas, George Downs, Roland Escherich, Bill Everett, Jim Gregory, Lawrence Hallanger, Tom Holtom, Garth Nicolson, Dick Parker, Pat Patton, Al Ramoli, George Rucker, Bob Sharp, John Sherborne, Darrel Sluder, Al Switzer, Nick Ugrin and Bill Wilson.

—Don Cleveland

1949

The class of '49—dissipated both physically and geographically—celebrated its first quinquennial reunion with a rather shabby turnout of 21 stalwarts.

Those present at the dinner were Allinder, Andres, Baron, Bulkley, Carter, Fasola, Gift, Herzig, Hirshberg, Hylton, Long, Mones, Patterson, Petzar, Saltman, Seitz, Sellick, Simons, Terriere, Vreeland, and Waters.

Some, unable to attend in person, were still able to wield a pen for their Alma Mater and fellow classmates. A few even waxed poetic. Messages of love and devotion were received from Carus, Gardiner, Heggland, Byron Karzas, Nobles, Pond, Peterson, and Stewart.

In the line of accomplishments, special attention should be directed to Hugh Carter's rise to power within the Alumni Association. Hugh begins his first year on the Executive Board of the Association. Most disappointing was the absence of our permanent class secretary, Chuck Forrester. His neglect resulted in the revivification, under protest, of one of the worst literary hacks of the class to write this column.

—Paul Saltman

PERSONALS

1920

Roscoe R. Rockafield, living in West Allis, Wisconsin, is still with Allis-Chalmers as chief engineer in charge of the processing machinery department. His two sons are married and he has a grandson and a granddaughter. Roscoe advises all other alumni that Wisconsin is "a wonderful vacationland in summer for Californians."

Harry P. St. Clair was recently promoted to the position of "Planning and Operating Engineering Manager" for the American Gas & Electric Service Corporation in New York. Harry has been doing some interesting work with the development of some 1300 circuit miles of 330,000-volt transmission, part of which included the Ohio Valley Electric Corporation system. Harry's three children are grown now, and the oldest, named after his father, is employed in the same company—public relations dept. Son Sheldon is now in the Far East after graduating from the Army Language School, and daughter Dorothy recently made Harry a grandpa for the second time.

1921

Alfred J. Stamm, a specialist in wood chemistry, is working with the U. S. Forest Products Laboratory in Madison, Wisconsin. As a renowned specialist in this field, Al was recently asked to contribute two chapters to "Wood Chemistry," which is considered the bible of this particular field. Currently he is chairman of the Cellulose Division of the American Chemical Society. Al has four daughters and a son. Of the three in school, one is a junior in the University, one a junior in high school, and one in junior high. Al adds a prideful note—"How's that for scientific precision?"

1924

William C. Dreyer writes from Houston that he will have rounded out thirty years with Westinghouse this summer, and that he "seems to get busier all the time." This year Bill and his group are supervising the installation of over 800,000 kw in turbo-generators in Texas, in addition to the electrical equipment in numerous plants and mills.

V. A. Kalichevsky, consulting chemical engineer in the refining division of the Magnolia Petroleum Co., Beaumont, Texas, has been mighty busy doing some recent writing. The Italian translation of his book *From Oil Well to Engine* appeared in 1953, and his paper titled *Development of the New Dualayer Gasoline Treating Process* (co-author C. A. Duval) was announced in March at the Western Petroleum Refiner's Association Annual Meeting held at San Antonio, Texas. Another paper, *New Distillate Fuel Oil Treating Process* (co-authors C. A. Duval and R. T. Malin) was presented at the American Petroleum Institute's mid-year meeting in Houston, Texas, last month.

Robert E. Foss moved to Tulsa last year, to continue working for the Sunray Oil Corp., as vice-president and manager of the production department. Bob, his wife and two boys, 14 and 13 years old, had previously lived in Los Angeles.

1925

William Aggeler, associate professor of French and chairman of the department of foreign languages at the University of California, Santa Barbara College, has translated and edited a new edition of Baudelaire's poetical work, "The Flowers of Evil." The book is the result of three years of work, begun during Dr. Aggeler's year of sabbatical leave in Paris, in 1951.

Dr. Aggeler majored in electrical engineering here at Caltech, and after graduation he continued in this field for five years. He then went to Paris and studied French literature, art and history at the Sorbonne, which convinced him that this was his real interest. He took his MA and PhD at UC in Berkeley.

1926

Robert C. Burt, PhD, and wife have taken off on an extended trip "down under"—Australia, the Barrier Reef, south to Tasmania, over to New Zealand, and south again to the shores of the Antarctic. Sounds like a trip that has just about everything, including exploring the Fiji Islands, and rambling around Australia in a new Australian-built General Motors car. If any envious classmates want to write, Bob's address—until February, 1955—will be c/o The American Consulate General, 7 Wynyard Street, Sydney, Australia.

1929

Charles A. Bosserman sends in a short note regarding his family. His oldest son is married and has just finished a two-year stretch as an Army MP. The second son is a physics-math major at St. Martin's College, Olympia, Wisconsin, and his daughter is a senior in high school. Last we heard, Charlie was still a test engineer at Boeing Aircraft in Seattle.

1930

Donald S. Barnes, MS, is currently serving a two year term in Rangoon, Burma, as technical adviser to the Prime Minister's Economic and Social Board, a Burmese cabinet group charged with responsibilities for action on various work projects.

Don, a former editor of *Civil Engineering* magazine, was ordered to duty with the Secretary of the Air Force shortly after the outbreak of the Korean War, and he participated in special studies of Air Force installations in the United Kingdom. Later, as colonel, he served as Director of the Ground Defense for the 3rd Air Force, and Director of Security, 7th Air Division.

1931

John R. McMillan has been elected President of the Fullerton Oil Company in Tulsa, Oklahoma. He has been with Fullerton since 1943.

1932

Robert W. St. Clair is president of the new Asco Sintering Company, the first integrated powdered metal bearing plant west of the Mississippi. They've just moved the plant to a new location, and to avoid the customary delay in obtaining specialized production equipment, a complete eastern factory was purchased and shipped to Los Angeles! Bob, an active powder metallurgy sales engineer in the Los Angeles area for over 20 years, organized the firm in 1945 under the name of Powdered Metal Products.

1934

Jan G. Schaafsma, MS, was recently promoted to the post of assistant manager for General Petroleum's Laboratories department in Los Angeles. Jan joined General Petroleum after graduation from Caltech, and has been in laboratory work since that time. A registered chemical engineer, he has invented a patented treating process for petroleum.

1936

Frank W. Davis, formerly assistant to Convair's vice president, engineering, has been named chief engineer of Convair's Fort Worth division. Frank has been in aeronautics ever since graduation, and joined Convair's Vultee Field division in 1940 as an engineering test pilot. He holds the distinction of being the first pilot in this country to fly a turbo prop plane—the Convair XP81 experimental escort fighter developed for the Air Force in 1945.

1937

Thomas S. Harper is in private practice in psychiatry at White Plains, N. Y. A wife and two children complete the family picture.

Robert L. Wells, MS, writes from Swarthmore, Pa., that he has been made assistant chief engineer of the Aviation Gas Turbine Division of Westinghouse, and is moving this summer with their jet engine division from Philadelphia to Kansas City. More important to this family man, though, is the recent addition of James Weir Wells—which makes three now, with sister Heidi, 5, and Charles, 3½.

Ernest Chilton, MS, has been promoted to development supervisor in the mechanical and electrical engineering department of the Shell Development Co. at the Emeryville Research Center, Calif., where he has been since 1947.

1938

Norman B. Dewees, MS, has just completed a satisfactory first year as advisory engineer in the reactor department of the Westinghouse atomic power division in Pittsburgh, Pa. *Ted Fahrner*, '36 and *Bill Minkler*, '27, are also in the same division. Norman writes: "Sally and I, the 13-year-old twins Donald and Mary Kay, and Richard, 10, have become strong boosters for the Pittsburgh area. It is no longer the smoky city, but is aggressive in its smoke abatement, slum clearance and civic planning program. Our residential suburb of Mt. Lebanon is a beautiful place to live."

Howard Seifert, PhD '38, resigned from Caltech's Jet Propulsion Lab May 10 to become assistant research director of Ramo-Wooldridge Company, the new Los Angeles guided-missile development laboratory.

1940

V. C. Rideout, MS, is going to spend an interesting summer in India. Professor of electrical engineering at the University of Wisconsin, he has been appointed visiting professor of communication engineering at the Indian Institute of Science in Bangalore, India. Vince, wife, three sons, and assorted paraphernalia will leave this month. He is one of nine engineering professors selected to work under the Technical Cooperation Administration of the U. S. Foreign Operations in India during the coming academic year.

1941

Max T. Rodgers, PhD, was one of seven Caltech alumni awarded Fellowship grants by the Guggenheim Foundation last month. Other alumni on the award list were *Berni J. Alder*, PhD '52, *William N. Lipscomb, Jr.*, PhD '46, and *M. Kent Wilson*, PhD '49, all chemists; *Chia-Chiao Lin*, PhD '44, and *Milton D. Van Dyke*, MS '47, Fellowships in engineering mathematics, and *Sedat Serdengecti*, MS '52, mechanical engineering.

1942

Edward F. Kelley, MS, is working with the Corps of Engineers at Ft. Belvoir, developing mobile, industrial gas generators and liquid oxygens—and living "on 20 acres of Virginia brush."

Arlo F. Johnson, MS, now has three sons —(he writes that they arrive every other April). Arlo is teaching ME at the University of Utah, and building a home in his spare time.

PERSONALS . . . CONTINUED

Tom Kirtley, MS, is now service supervisor at the Hopewell, Virginia, cellulose plant of Hercules Powder Company. Tom and his wife Jean are the parents of two boys: Tommy, 8, and Frank, 5.

1944

Frank C. Smith, Jr. will be back in familiar territory in August, when he attends the Western Electronics Convention in Los Angeles, to present a paper. Frank is sales manager of the Southwestern Industrial Electronics Co. of Houston, Texas. The Smiths have a boy, F. C. Smith III, and are hoping for a daughter when the new baby arrives this month.

Willard R. Scott, Jr. holds the title of Vice President and Director of Research of the Crest Research Laboratories, located in Seattle. Crest is a privately-owned industrial consulting and research organization serving the Pacific Coast area.

James R. Freeman is now a staff member of the Digital Computer Laboratory at the Massachusetts Institute of Technology.

1946

R. A. Montgomery, PhD, is working as a senior group engineer in the Pilotless Aircraft Division of Boeing Aircraft in Seattle. In his work he is responsible for ground guidance equipment design. The Montgomerys have three children—all boys.

Lyman Bonner, PhD, technical director of the rocket development department at the Hercules Powder Company's Allegheny Ballistics Laboratory, gave a talk in March on rockets, missiles and space ships at the monthly meeting of the American Society of Civil Engineers, Delaware section.

Dr. George Humphrey, MS, became the proud parent of daughter Gail, born in April.

Ed Dolan is still working as an electrical engineer for the Bonneville Power Administration in Ampere, Wash. He has been teaching night school at Multnomah College which, as he notes, "curtails any opportunities I might have for getting into trouble. I did find time to try out my power saw on the fingers of my left hand—and the resulting severe injuries leave no doubt in my mind that I am no superman. Still a happy, carefree bachelor without any prospects of being tied down."

1947

George L. Bate, MS, was one of five Caltech alumni receiving National Science Foundation post-doctoral fellowships for the 1954-55 academic year. Also included were *James B. Hendrickson*, '50, *Bruce B. Stowe*, '50, *Milton Van Dyke*, PhD '49, and *James A. Ibers*, '51. The fellowships are awarded for advanced study and research in the natural sciences, on the basis of academic and research records, and recommendations by a panel of scientists.

J. A. Tvedt, Air Officer on the U.S.S. Valley Forge, U.S. Navy, is wearing another gold stripe on his sleeve—having just been promoted to Commander.

1948

Wakefield Dort Jr., MS, was married on May 8 to Joanne Church at South River, New Jersey. He is now assistant professor of geology at Penn State College.

Jack Keuffel, PhD, another prof from the class of '48, has recently been appointed associate professor of Physics at the University of Utah, where he is busy building up a cosmic ray group. The group will be studying the new unstable particles by using scintillation counters. In addition to cosmic rays, Jack is finding time to enjoy some of Utah's good skiing and riding trails.

1949

Andrew V. Harris of Seattle has an eight-month-old son, Andrew Jr., now occupying a lot of his time, when he's not busy as Jr. engineer at Boeing Aircraft.

William C. A. Woods is in Richland, Washington, working in the research and development department of General Electric. The work is affiliated with the production of atomic materials, and keeps Bill

Caltech Alumni Association

ANNUAL FAMILY PICNIC

Saturday, June 19

Police Academy, 1880 N. Boylston St., Los Angeles

putting in a fair amount of overtime.

1950

Harold C. Martin, PhD, is now professor of aeronautical engineering at the University of Washington, Seattle, and works summers and one day a week throughout the academic year with the structural dynamics unit at Boeing Aircraft. Some of the results of this work were reported before the Institute of Aero Sciences in New York last January.

James Briggs Hendrickson, due to get his doctorate at Harvard this month, was recently awarded a National Research Council Post-doctoral Fellowship in the Natural Sciences for the academic year 1954-55. An organic chemist, Jim will spend the year in research at Birbeck College, University of London.

1951

Harry T. Brackett is still working as an experimental test pilot for Chance Vought Aircraft in Dallas. He recently finished up a test pilot training course at USNATC, graduating first in a class of 38. Currently Harry is performing structural demonstrations on the FW-3 Cutlass, and is looking forward to flying Chance-Vought's new fighter, the XF8U sometime next year.

Fred Eisen hopes to receive his PhD from Princeton next year—and plans to marry Carol Whittingham of Trenton, New Jersey, next fall.

Capt. Robert H. Ahlers, MS, returned from Korea in 1952 and is now stationed at Ft. Belvoir, Virginia. Bob adds a note with news of other '51 grads: *Col. John Jannarone*, MS, is believed still assigned to the Corps of Engineers in Oklahoma, *Lt. Col. William Watkins*, Ms, is at the Command & General Staff College in Fort Leavenworth, Kansas.

1952

James K. LaFleur and Carolyn Gannon, who were married on April 23rd, took a 5,000 mile honeymoon in Jim's MG. They were in Idaho, Wyoming, Colorado, and other states. (Where'd they put the luggage?) Now back on the job, Jim was promoted to development engineer on the Advanced Gas Turbine Project at AiResearch Mfg. Co. in Inglewood.

Bernard J. O'Neill, Jr., MS, resident geologist for the New Jersey Zinc Company in charge of their Littleton, New Hampshire office, is feeling extra happy these days about the new addition to the family. The O'Neills have adopted a little girl, Mary Ann.

John C. Thompson, MS, has been leading a rather eventful life so far this year. Not only was he recently promoted to the position of sales manager and asst. general manager of both Peerless Mfg. Co. and Sillers Engineering Co. in Dallas, but he has also received an LLB degree from Southern Methodist University and was admitted to the Texas state bar!

1953

Richard Ham has just completed his first year of graduate work at the University of Texas, where he has also been employed as a part-time research scientist in the bio-chemical institute. Summer plans for Dick include full-time research work at the University, plus baby sitting. Paul Edward Ham arrived on May 9th, and Dick comments: "He was born needing a haircut, just like his father's usual state!"

William D. Gardner is planning on a New England summer, working for the U. S. Coast & Geodetic survey in Maine, returning later to Norfolk. *Morgan Ogilvie* is also with the USCGS, taking weekly cruises around Chesapeake Bay with the good ship *Cowie*.

William D. McCormick is doing graduate work at Duke University, Durham, North Carolina, and although he doesn't exactly want to devote *all* his hours to research work in low temperature physics, there's apparently little alternative. "So far as I've been able to determine," says Bill, "Southern belles have been considerably overrated."

Andrew C. Bousch assisted Dr. James Noble in Canada during the summer of '53. He is now a graduate student at USC, awating those greetings from the Army.

SCIENCE WRITERS

From May 1, 1954 to May 1, 1955 **Engineering and Science** will pay for all acceptable articles by Caltech undergraduates and graduate students at the rate of $10 per published text page—or roughly a cent a word.

E&S articles should be based on some phase of scientific or engineering research, or some individual, connected with Caltech. They may run from 1,000 to 5,000 words. They should be typed, double-space.

But we are not just looking for more **E&S** articles. Our real aim is to encourage more science writing by the people who are in many ways best equipped to write it.

So—all articles submitted to us by Caltech undergraduates and graduate students —whether they are accepted for publication in **E&S** or not—will be entered in a Science Writing Contest.

On May 1, 1955 these articles will be sent to the editors of **Scientific American**, who will choose a $100 first-prizewinner, and a $50 second-prizewinner.

For further information, to register your topic—or even your interest—check the **E&S** office, 400 Throop.

ALUMNI ASSOCIATION OFFICERS

PRESIDENT
Kenneth F. Russell '29

VICE-PRESIDENT
C. Vernon Newton '34

SECRETARY
Donald S. Clark '29

TREASURER
George B. Holmes '38

BOARD OF DIRECTORS
Willard E. Baier '29
Robert R. Bennett '45
Hugh C. Carter '49
Philip Cravitz '29
Douglas G. Kingman '28
William F. Nash, Jr. '38
Charles P. Strickland '43

ALUMNI CHAPTER OFFICERS

New York Chapter:

PRESIDENT S. Kendall Gold '42
California-Texas Oil Co., Ltd., 380 Madison Ave., N. Y.

VICE-PRESIDENT G. William Boutelle '48
Bulova Watch Co., Bulova Park, Flushing

SECRETARY-TREASURER Frank F. Scheck '48
Attorney, 247 Park Ave., New York

Washington, D. C. Chapter:

PRESIDENT Charles R. Cutler '45
800 World Center Bldg., Wash. 6

SECRETARY-TREASURER Clarence A. Burmister '25
U.S.C. & G.S., RadioSonic Laboratory, Wash. 25

San Francisco Chapter:

PRESIDENT Arnold Grossberg '42
California Research Corp., 576 Standard Ave., Richmond

VICE-PRESIDENT Robert C. Heitz '36
Dow Chemical Co., Pittsburg, California

SECRETARY-TREASURER Tom Tracy '48
Minn. Honeywell Reg. Co., 1136 Howard St., San Francisco

Chicago Chapter:

PRESIDENT LeVan Griffis '37
American Machine & Foundry Co., 188 W. Randolph St.

VICE-PRESIDENT Eben Vey '41
Illinois Institute of Technology, 3300 S. Federal St.

SECRETARY-TREASURER Harrison Lingle '43
Signode Steel Strapping Co., 2600 N. Western Ave.

Sacramento Chapter:

PRESIDENT Mervin A. Schuhart '32
State Division of Highways, 1120 "N" Street

VICE-PRESIDENT Luther J. Eastman '28
California Board of Equalization

SECRETARY-TREASURER Harris K. Mauzy '30
California Division of Highways, Bridge Department

San Diego Chapter:

CHAIRMAN W. L. Bryant '25
U. S. Navy Electronics Lab., San Diego 52

PROGRAM CHAIRMAN Maurice B. Ross '24
San Diego City Schools, 22nd and J Sts.

SECRETARY Frank John Dore, Jr. '45
Consolidated Vultee Aircraft Corp.

Photography took a look

and a harvester got a stronger set of teeth

John Deere engineers, building a new beet harvester, wanted spring-tooth disposal wheels with long life. High-speed movies showed the way.

The disposal wheels on the new John Deere beet harvester moved faster than the eye could see.

So the engineers studied them in action, slowed down by the high-speed motion picture camera. A small difference in design resulted in extra-long life for the spring teeth.

Slowing down fast action is but one way photography helps product design and manufacture. With x-rays it searches out hidden faults in castings, welds, and assemblies. And by photographing cathode ray traces, it discloses the causes of improper operation. These are but a few of the ways photography saves time, reduces error, cuts costs and improves production.

Graduates in the physical sciences and in engineering find photography an increasingly valuable tool in their new occupations. Its expanding use has also created many challenging opportunities at Kodak, especially in the development of large-scale chemical processes and the design of complex precision mechanical-electronic equipment. If you are interested in these opportunities, write to Business & Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

Eastman Kodak Company
Rochester 4, N. Y.

With the high-speed motion picture camera, John Deere engineers took pictures of their spring-tooth wheels in action at 3000 a second. Projected at the standard 16 frames a second, the motion was studied, slowed down to almost 1/200 of its actual speed.

Kodak
TRADE-MARK

Return Postage Guaranteed
Engineering & Science
Calif. Inst. of Technology
Pasadena, Calif.