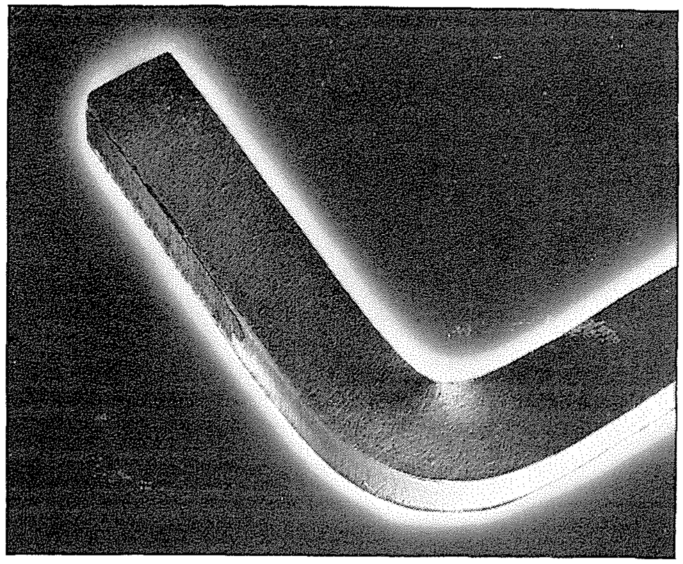
ENGINEERING AND SCIENCE

FEBRUARY/1953

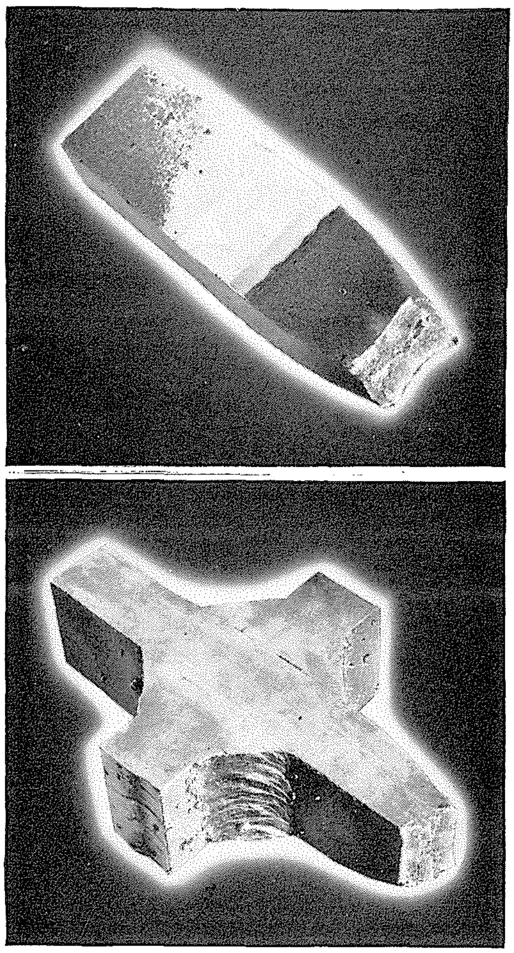
Fertility and Floods . . . page 16

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY



90° BEND AT 98 BELOW! This sample, flame-cut from 1" CARILLOY T-1 plate, was chilled to −98°F., and then bent to a full 90° angle. Even though the raw, flame-cut edge made up the outer radius of the bend, there was no sign of failure!

New steel has yield strength of over 90,000 psi yet remains ductile at 70°F. below zero even after welding or flame-cutting



100% WELD STRENGTH—Tensile tests on T-Steel specimens like these were made to determine the strength of the welds. These welds develop the full strength of the parent metal. Note that breaks occur outside the heat-affected zone, showing that the heat of welding has not harmed the strength of the material. No special pre-heating or post-heating treatments are required beyond those used with ordinary structural steels.

THIS remarkable steel, U·S·S CARILLOY T-1, offers great promise to those who need a super-strong steel that can be welded, flame-cut or cold-formed.

CARILLOY T-1 is unique. It differs from all other very strong steels in important respects: Its yield strength of over 90,000 psi is *not* lowered by welding or flame-cutting. In these operations, no pre-heating or stress-relieving is required. As a result, CARILLOY T-1 can be readily field welded.

Usually, welded steels of such high strength level suffer a loss of ductility at low temperatures unless elaborate precautions are taken in the welding operation. In striking contrast, notched bend weldability tests show that T-1 steel will remain ductile and tough down to the lowest atmospheric temperatures. As a matter of fact, T-1 steel, after flame-cutting, has been bent to a full 90° angle at temperatures as low as −100°F., without any sign of cracking.

Service tests show that CARILLOY T-1 is well suited for extremely abusive service, and the fact that it can be field welded should greatly lower the difficulties and cost of major repairs. In applications in which tension is the principal stress, thicknesses can often be reduced to one-third of those required with ordinary structural steels.

CARILLOY T-1 steel is another result of United States Steel's active research program which has enabled manufacturers to improve their production methods and make better products, too. All over the country, trained U. S. Steel engineers and metallurgists are constantly at work on problems like this, finding better ways to make and use steel. United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

USS

UNITED STATES STEEL

BOOKS

NATURE AND NEEDS OF HIGHER EDUCATION

The Report of the Commission on Financing Higher Education
Columbia University Press $2.50

Reviewed by Albert B. Ruddock
Member of the Board of Trustees

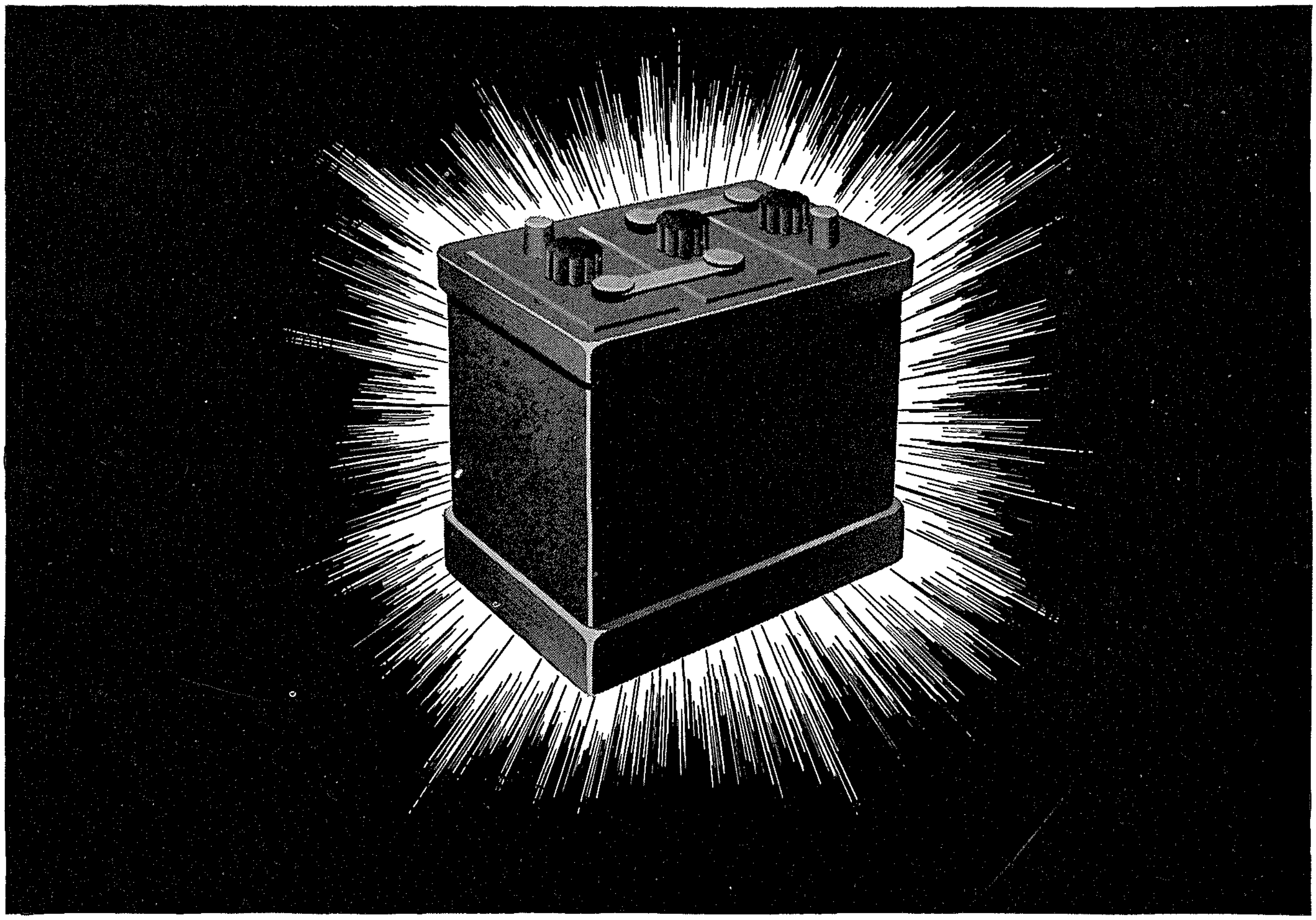
FINANCED BY THE ever-helpful Rockefeller and Carnegie groups, a Commission composed of some first-run educational and corporation executives and board members has devoted more than spare time over the past four years to a consideration of the basic problems of higher education in this country. Geographical coverage was assured which, incidentally, resulted in C. I. T.'s being well represented on the roster; and statistical adequacy was provided through ample and pertinent supporting data.

The Commission's conclusions can hardly strike a reader as novel or unexpected: to wit, higher education is a bulwark of our country; its roots are firmly planted in freedom; its fruits serve not only the spirit of the individual and the nourishment of the professions but the defense mechanics of the nation; higher education has always been difficult to finance, and, today, because of the impact of inflation, re-armament, taxes, other calls for individual gifts, such as health, it is even more difficult to finance than ever; this is especially so for the privately supported institution, but the state supported universities are also not without their financial problems; and so forth.

But while it did not require the appointment of such a commission to catalog the history and financial dilemma of higher education, the Commission's creation and work are well justified because of the clarity, vigor and authoritativeness of its presentation of the rather well-known facts. Its very caliber lends keen awareness of the facts and arguments to those who read the report, and must, when it expresses criticism and conveys warnings to those within as well as without the educational family circle, command respectful attention.

The crux of the report and its most difficult aspect, as its authors are specific enough to state, is its attitude toward further Federal support of higher education, including scholarship aid. On this point, the Commission members unanimously—all points are reached unanimously—align themselves emphatically with the position of the clergyman in regard to sin: they are agin' it. That way, declares the Commission, lies the undermining of freedom. To this, the admiring reader can only offer a loud huzzah. But, as the Commission eloquently points out, it is one thing to stage a declaration of independence and another to fill in from other sources the financial voids left by the spurned Federal gifts. Those sources are listed, especially the corporation gift; the pitifully small percentage of the national income devoted to higher education is pointed out, and the challenge is laid down.

Oyez! Oyez! May those who appreciate the value of higher education, and they should be legion, come into the court of public opinion, listen to and be moved by the eloquent arguments ably set forth by these skilled and experienced advocates, and produce some needed results!



PICKLED AMPERES...

That was the term used to describe the first storage batteries. For a score of years they were considered laboratory playthings, for they were crude, undependable, and required months or years to charge.

Their counterpart today is a reliable source of electrical energy . . . to start cars . . . to operate submarines, mine cars, materials handling equipment . . . and to perform over 200 other regular and emergency functions on land, sea and in the air.

CELLS—BRAIN AND BATTERY...

Storage batteries were conceived in France and England . . . but grew up in America. For Americans foresaw their commercial usefulness. Scientists performed experiment after experiment—thousands of them—to find the elements and chemicals with the best electro-chemical behavior . . . investors helped get production started . . . industry developed new applications . . . and today they build batteries by the millions.

AMERICA WORKS THAT WAY...

Each spark of genius electrifies dreamers, designers, engineers, executives, producers and purchasers. And the power behind our progress is America's 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...

The McGraw-Hill publications are a part of this American Inter-Communications System.

As publishers, we know the consuming insistence of editors on analyzing, interpreting and reporting worthwhile ideas.

We know that businessmen, in order to keep abreast of their jobs, subscribe to—pay for—McGraw-Hill magazines edited for their specific business interests . . . for the editorial pages tell "how" and the advertising pages tell "with what."

McGRAW-HILL PUBLISHING COMPANY, INC.

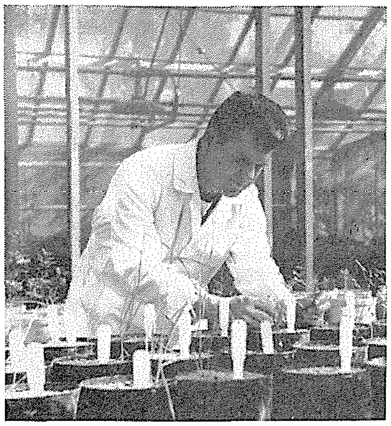
ABP 330 WEST 42nd STREET, NEW YORK 36, N. Y. ABC

HEADQUARTERS FOR BUSINESS INFORMATION

McGRAW-HILL FOR BUSINESS

ENGINEERING AND SCIENCE

IN THIS ISSUE



This month's cover shows Henry Hellmers, a research fellow at the Institute, at work in the Orlando Greenhouse. More specifically, he is checking the progress made by various native plants in varying types of mountain soils. Dr. Hellmers is a plant physiologist with the California Forest and Range Experiment Station of the U. S. Forest Service, which is cooperating with Caltech in a program of research to improve the sparse plant cover on critical areas in the rugged San Gabriel Mountains. The story of that program, and some of its accomplishments, can be found on page 16 of this issue.

Fred Hoyle's article on page 11 and President DuBridge's article on page 18 of this issue are, in a sense, complementary. The Hoyle article is called "The Place of Technology in Civilization," and the DuBridge one is called "Industry's Stake in Scientific Research." Hoyle discusses the importance of science and technology to civilization in general; DuBridge discusses the importance of science and technology to today's industry in particlar. Though the subjects of the two articles are, to this extent, similar, the reactions to them are almost certain to be varied. Depending on your point of view, you'll find the Hoyle article controversial, the DuBridge one incontrovertible—or, very possibly, vice versa.

Incidentally, if you're not familiar with Mr. Hoyle, who is presently serving as Visiting Professor of Astrophysics at the Institute, you'll find some biographical notes on him on page 15.

PICTURE CREDITS

Cover, pps. 15, 16 — George S. Stranahan '53

FEBRUARY 1953 VOLUME XVI NUMBER 5

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

CONTENTS

STAFF

Publisher......Richard C. Armstrong '28
Editor and Business Manager......Edward Hutchings, Jr.
Student News......Al Haber '53
Staff Photographer......William V. Wright
Editorial Consultant......Professor of English George R. MacMinn

Published monthly, October through June, at the California 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.

to the

ELECTRICAL ENGINEER

or

PHYSICIST

with an interest in

RADAR

or

ELECTRONICS

Hughes Research and Development Laboratories, one of the nation's leading electronics organizations, are now creating a number of new openings in an important phase of their operation.

Here is what one of these positions offers you:

THE COMPANY

Hughes Research and Development Laboratories, located in Southern California, are presently engaged in the development and production of advanced radar systems, electronic computers and guided missiles.

THE NEW OPENINGS

The positions are for men who will serve as technical advisors to government agencies and companies purchasing Hughes equipment—also as technical consultants with engineers of other companies working on associated equipment. Your specific job would be essentially to help insure successful operation of Hughes equipment in the field.

THE TRAINING

On joining our organization, you will work in the Laboratories for several months to become thoroughly familiar with the equipment which you will later help users to understand and properly employ. If you have already had radar or electronics experience, you will find this knowledge helpful in your new work with us.

WHERE YOU WORK

After your period of training—at full pay—you may (1) remain with the Laboratories in Southern California in an instructive or administrative capacity, (2) become the Hughes representative at a company where our equipment is being installed, or (3) be the Hughes representative at a military base in this country—or overseas (single men only). Compensation is made for traveling and moving household effects, and married men keep their families with them at all times.

YOUR FUTURE

In one of these positions you will gain all-around experience that will increase your value to our organization as it further expands in the field of electronics. The next few years are certain to see large-scale commercial employment of electronic systems. Your training in and familiarity with the most advanced electronic techniques now will qualify you for even more important future positions.

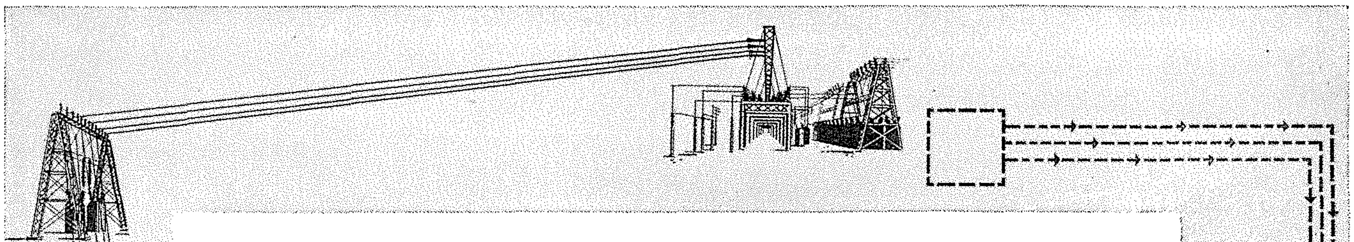
How to apply:

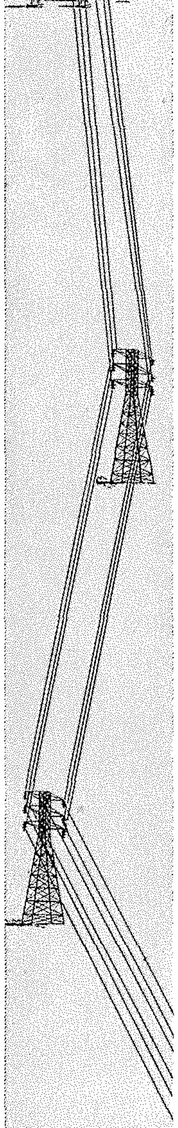
HUGHES

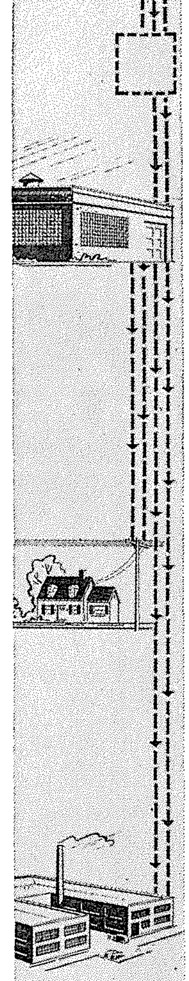
RESEARCH AND DEVELOPMENT LABORATORIES

Engineering Personnel Department
Culver City, Los Angeles County, California

See your Placement Office for appointment with members of our Engineering Staff who will visit your campus. Or address your resumé to the Laboratories.







The Importance of Cable Engineering and Design

Cable engineering is concerned with the design and use of wires and cables to direct the flow of electrical energy from its source to the point of utilization. It is generally more economical to generate electric power in relatively large blocks at strategically located power plants and to transmit it over relatively long distances than to generate in small quantities where it is used.

There are, therefore, two general types of wires and cables used in the electrical industry:

(a) those used for power transmission, usually at voltages above 22 kilovolts,

(b) those used for power distribution at lower voltages.

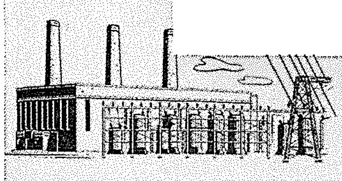
Cables used for power transmission are generally single conductors with no insulation. They are supported on insulators above ground at such separations or spacings that the air provides the required insulation. For power distribution, on the other hand, where the space occupied by the power line is important, insulated cables are used. This discussion deals with the design and use of insulated wires and cables for power distribution systems.

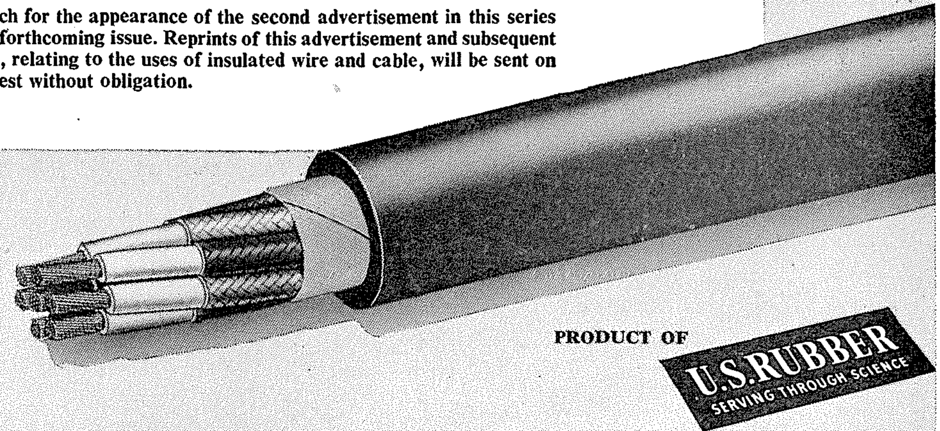
Insulated distribution cables carry power from the transformer stations along the transmission lines to its point of ultimate utilization. The voltages at which power is distributed vary from about 15 kilovolts to 115 volts used in individual homes. The higher voltages are used for the distribution of relatively large amounts of power from the transformer stations to substations nearer the points of utilization, such as industrial plants, where it is transformed to low or utilization voltages, either alternating or direct current. Large quantities of electric power are distributed in this way and the value of the distribution equipment required is great. The value of the insulated conductors, including those for both portable or stationary installations, probably exceeds that of any other single item used in power distribution.

The design and operation of insulated conductors and distribution systems are of great public and commercial importance. The primary function of insulated cable engineering and design is to provide safe, adequate, reliable and pleasant appearing distribution systems. Electric power is so extensively used in modern life that interruptions to it are serious. The failure of electrical power in an industrial plant throws people out of work and reduces production.

The appearance or sightliness of cables installed overhead in a community is important and is attained chiefly by installing such cables with a small and uniform sag from pole to pole.

Watch for the appearance of the second advertisement in this series in a forthcoming issue. Reprints of this advertisement and subsequent ones, relating to the uses of insulated wire and cable, will be sent on request without obligation.





PRODUCT OF U.S. RUBBER SERVING THROUGH SCIENCE

UNITED STATES RUBBER COMPANY

ELECTRICAL WIRE AND CABLE DEPARTMENT • ROCKEFELLER CENTER, NEW YORK 20, NEW YORK

Austin Bush, Rensselaer, '50, Helps Develop New Pump

AUSTIN BUSH, inspecting stuffing box assembly on boiler feed pump.

Reports interesting project engineering assignments at Worthington

"Despite its size as the leading manufacturer in its field," says Austin Bush, "I have found Worthington pays considerable attention to the interests of the individual. The company's excellent training program consists of several months of working with the various types of equipment manufactured, augmented by technical lectures, and talks on the organization of the corporation.

"Following this training, I was given an opportunity to choose the department in which I wanted to work—engineering, sales, or manufacturing. My choice was the engineering department where I have already been assigned to several interesting projects.

"In addition to the training program, the members of our engineering department hold monthly seminars at which engineering topics of general interest are discussed.

"Opportunities for advancement are good, and pleasant associates make Worthington a fine place to work."

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, New Jersey.

WORTHINGTON

The Sign of Value
Around the World

2.54X

Graduate Engineers!

ENJOY GOOD SALARY FROM THE FIRST DAY... INTERESTING CHALLENGES RIGHT AWAY!

At Sperry you can apply your knowledge immediately and keep on learning—with pay—in research, product development, or field work. Salary increases come as you progress.

You enjoy the advantages of working with the leaders in their fields. You are expected to use originality and a fresh approach. Every project is a creative challenge to the brain-work and the team-work of the Sperry engineering staff.

VARIETY OF OPENINGS

There are opportunities for aeronautical, electrical, electronic, mechanical engineers — physicists — technical writers and field engineers for applied engineering.

ATTRACTIVE LOCATIONS
GOOD WORKING CONDITIONS

Long Island—In pleasant suburban atmosphere but convenient to New York. Modern plant. Well equipped laboratories. Excellent working facilities.

In the Field—There are excellent applied engineering opportunities in various sections of the United States and abroad.

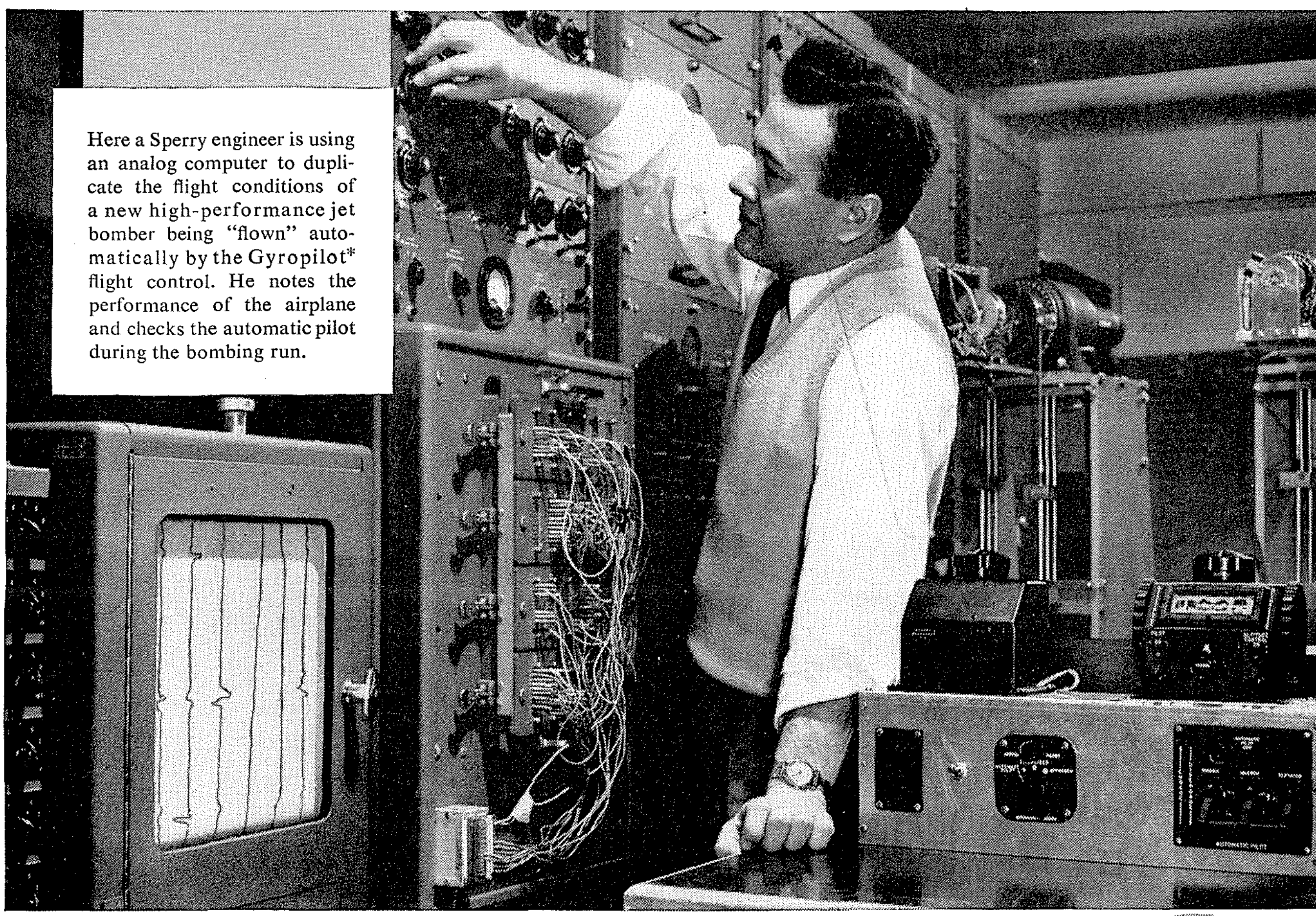
In All Locations—The way is clear for steady advancement. You are encouraged to continue your education while you earn. And liberal employee benefits are provided for all.

RESEARCH LEADERSHIP...
A FORTY-YEAR TRADITION

Today Sperry is the recognized leader in developing automatic controls for navigation. From Sperry's work in gyroscopics and electronics have come the Gyropilot* flight controller, Zero Reader* flight director, radar, servomechanisms, computing mechanisms and communications equipment.

Sperry sponsored the development of the klystron tube—the first practical source of microwave energy. From Sperry pioneering has come a complete line of Microline* instruments for precision measurement in the entire microwave field.

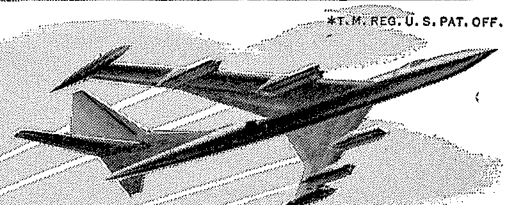
CHECK YOUR PLACEMENT OFFICE FOR DATES WHEN SPERRY REPRESENTATIVES WILL VISIT YOUR SCHOOL...OR WRITE SPERRY EMPLOYMENT SECTION 1A5.



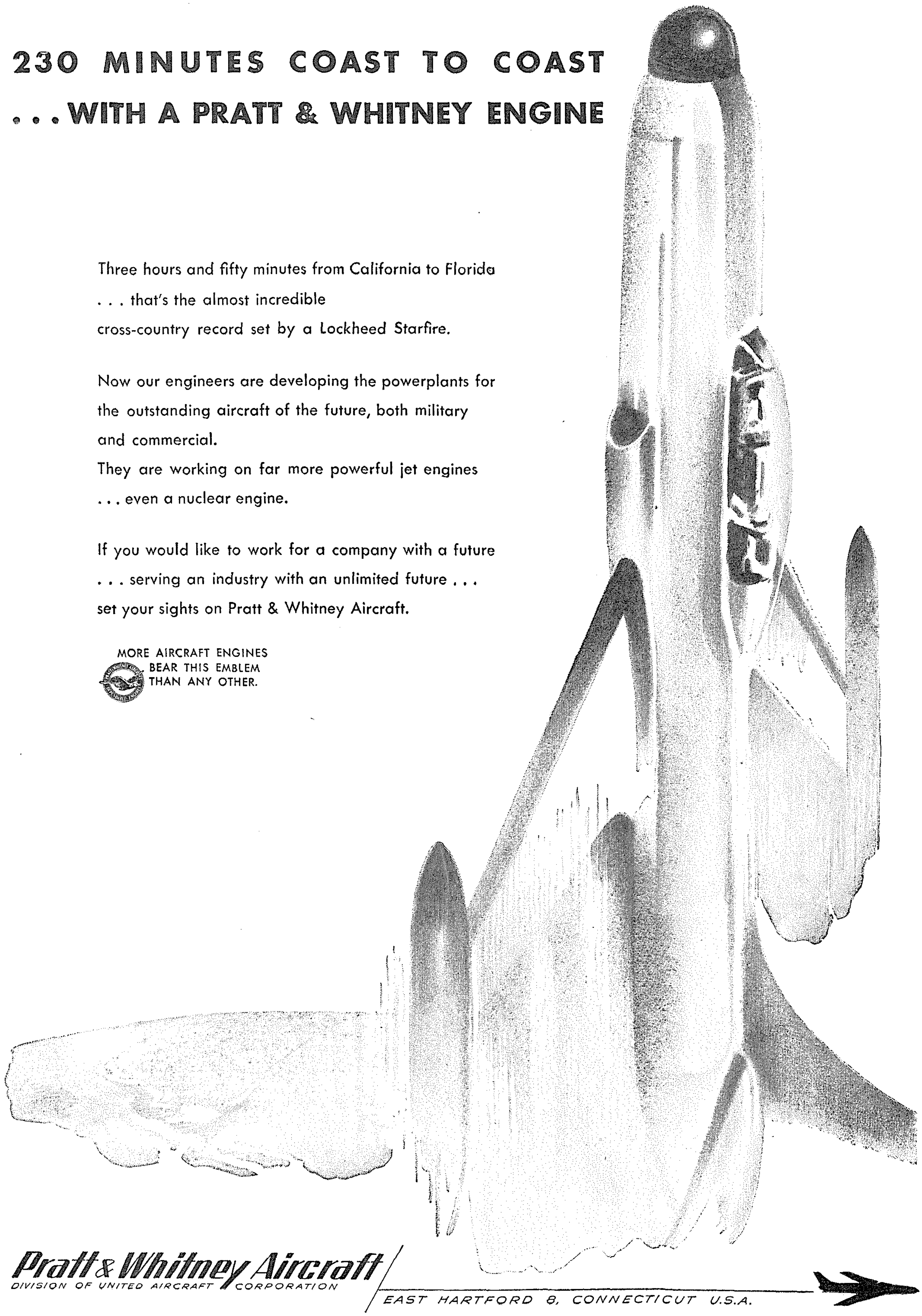
Here a Sperry engineer is using an analog computer to duplicate the flight conditions of a new high-performance jet bomber being "flown" automatically by the Gyropilot* flight control. He notes the performance of the airplane and checks the automatic pilot during the bombing run.

*T. M. REG. U. S. PAT. OFF.

SPERRY GYROSCOPE COMPANY
DIVISION OF THE SPERRY CORPORATION



GREAT NECK, NEW YORK · CLEVELAND · NEW ORLEANS · BROOKLYN · LOS ANGELES · SAN FRANCISCO · SEATTLE
IN CANADA — SPERRY GYROSCOPE COMPANY OF CANADA, LIMITED, MONTREAL, QUEBEC


230 MINUTES COAST TO COAST
. . . WITH A PRATT & WHITNEY ENGINE
Three hours and fifty minutes from California to Florida . . . that's the almost incredible cross-country record set by a Lockheed Starfire.
Now our engineers are developing the powerplants for the outstanding aircraft of the future, both military and commercial.
They are working on far more powerful jet engines . . . even a nuclear engine.
If you would like to work for a company with a future . . . serving an industry with an unlimited future . . . set your sights on Pratt & Whitney Aircraft.
MORE AIRCRAFT ENGINES BEAR THIS EMBLEM THAN ANY OTHER.
Pratt & Whitney Aircraft
DIVISION OF UNITED AIRCRAFT CORPORATION
EAST HARTFORD 8, CONNECTICUT U.S.A.

THE PLACE OF TECHNOLOGY IN CIVILIZATION

By FRED HOYLE

"Technology controls civilization . . . the details and variations in social organizations are relatively unimportant . . ."

ONE OF THE THINGS that I have found over the years, in discussing matters with my colleagues in humanities, is a profound difference of viewpoint between the scientist and the humanist concerning the organization of society. I've noticed that after discussions into human problems, the humanities side usually ends by saying, "Well, all of these problems are really very complicated; a very large number of factors are involved—and *we* think that you scientists are always looking for explanations that are too simple."

On the other hand, reflecting the scientific point of view, I have maintained what I think is the standard belief, in science, that no matter how complicated a problem one has to deal with, a solution can always be found. Some of our scientific problems are indeed complex, but it is curious how often one finds the things that seemed impossible of solution at one time turn out to have a perfectly straightforward and understandable answer. I have felt for some years that the situation with human affairs may be much the same.

Perhaps I should extend this a little. When our friends in the humanities say that ordinary social affairs are very complicated, there is a sense in which they are perfectly right; human affairs are complicated in the

This article has been adapted from a talk given by Dr. Hoyle at Town Hall, Los Angeles, January 13 sense that many factors are involved. But this does not really impress a scientist, because, in science, problems with many factors are often quite as easy to deal with as problems with only a few factors. Let me give an example.

Think about the air in this room. We know that the air is composed of a swarm of tiny particles—there are nearly thirty billion billion particles to the cubic centimeter—so you see that the total number is very large. It would be possible to argue that the whole problem of tracing the properties of all these particles is enormously complicated. They are all jostling each other, colliding with each other, and evidently a detailed tracing of their individual motions would be a problem of surpassing complexity. But that is not how the scientist goes about the matter. Instead of worrying about individuals, he tackles the problem of finding how the particles behave *on the average*. And a calculation of the average situation turns out to be simplified, not made more difficult, by the very complexity of the situation. In a word, the very complexity allows us to adopt the powerful methods of statistics.

The individual and society

This analogy comes close, I think, to the human situation. If one is concerned to describe the fate of a particular individual, or of a comparatively small group of individuals, then certainly one has a very complex problem on one's hands that probably cannot readily be solved. But if one is concerned to speak of the evolution of human society as a whole, then, just as with the gas problem, matters become comparatively simple. A great deal of what happens in our daily lives averages out when taken statistically. There are only a few factors happening at any given time that are going to have outstanding effects on the future.

To give you a simple example from history, take the case of Napoleon. Apparently, he produced enormous disturbances in his day, and everybody thought that the things he did were very important. But by now we can see that present-day society would hardly be any different if Napoleon had never lived. The political and military disturbances that he produced were transitory and did not have a lasting effect. They have averaged out to zero.

Simplicity in complexity

Well, that is the main background for what I am going to say: that, while on the surface human affairs are complex, underneath, on the large scale, things are really quite simple.

Perhaps next I ought to say what factors of the human problem I think to be important, and what factors I believe to be unimportant. First then, what are the things that don't matter? Here are a few of them: The constant striving of one community against another; war; the particular social organizations adopted by different communities. These are the things that we spend a great deal of time on, and these are the things that average out to zero. By contrast, the things that do matter are the making of technological discoveries, and this brings me to the case that I wish to make—that technology controls civilization, and that the details and variations in social organizations are relatively unimportant, except where the social organization in some degree affects technology itself.

Now, shall we look at the evidence for this view? One can readily see the importance of technology by comparing our present situation here today with the position of Stone Age man. Stone Age man had the same earth, he had the same resources as we have today, but he could do little with them. Why? Because he did not have the "know-how." He did not have the technology. Notice that Stone Age man was not lacking in brains. (We have pretty fair indication from certain activities of Stone Age people that their mental stature was not much inferior to ours, if it was at all inferior.) He was lacking in knowledge.

So we can certainly say that technological discoveries make an enormous difference, because, if we didn't have the "know-how," we would be back—right now, at this minute—in the Stone Age. I often think that the best reply to anyone who affects to despise technology would be: "You despise technology? All right then, back you go to the Stone Age!"

Technology in the Stone Age

Even to the Stone Age people themselves, technology was a very important matter. The Stone Age, which I am speaking of rather loosely now, lasted from about 200,000 years ago to about 6,000 years ago. Over that period there were important changes and great inventions. Man had very little 200,000 years ago. He didn't know how to clothe himself; he didn't even know much about how to provide shelter. His tools—his equipment for dealing with situations that might arise in hunting, for example—were no better than odd bits of stones that he had managed to pick up off the ground. Then, over the millennia, people discovered that one could make better tools, not by picking up stones in their natural state, but by shaping them.

It is rather curious that two independent methods of shaping were discovered. In one case people took stones and chipped bits off until the required shape was left. The other technique was to take larger stones and to make tools out of the chippings. In one case it was the core that was wanted, and in the other case it was the bits that were chipped off that were wanted.

A fighting matter

The surprising thing is that great areas in Europe and Asia would use one system almost uniformly, and other areas would use the other system. I have no doubt that, when the two groups came in contact with each other, they fought fiercely over which way was best to cut up stones.

Then, men learned how to make more refined tools—axes, spears, the harpoon, and the bow and arrow. Bone needles were used in the making of clothes, and tents were made out of the hides of animals.

Even these crude developments made it possible to provide for more and more people on the earth. But the really great discovery that enabled man to increase enormously in number was, of course, agriculture. Without the invention of agriculture, made some seven or eight thousand years ago—without the deliberate sowing of seeds and the reaping of crops—no large-scale social organization would have been possible at all.

The origin of civilization

Agriculture made it profitable for people in certain regions to live together in farly large numbers, particularly in river valleys, where it was possible to use irrigation methods. In Mesopotamia, for example, productivity was so much increased that a large concentration of population arose. This was the beginning of the type of social organization that we call civilization. So the origin of civilization itself was made possible by a technological discovery—namely, the discovery of agriculture. (You will realize from this remark that I am using the world "technology" in a very wide sense; to cover both the acquisition and the application of knowledge. This includes the activity that we normally call "science.")

The greater number of people that could be supported by the discovery of agriculture led to further discoveries, of which the most important was the discovery of methods of working metals; in particular, of copper and its alloys. Also, because of people coming to live together in increasing numbers, it became important that methods of writing things down should be available, to tell where a man's land started and where it ended, how many cattle he had, and things of that sort. In this way, came the beginnings of the intellectual inventions of writing, and of numbers, and the beginning of calculation.

Achievements of ancient civilizations

So we see the technology of agriculture leading to civilization, and, following that, civilization itself producing several far-reaching discoveries. That really, however, is the sum total of what the ancient civilizations achieved, insofar as their achievements have effect on us today. It is true that they formed their different communities, that they had their social organizations, and they fought with each other in a never-ending series of wars—but by now those activities count not a jot. It is only the things they discovered that are of any importance.

When the next important discovery was made, it did not come from civilized people at all; centuries of disturbance and fighting so befuddled the wits of civilized man that he became incapable of making further discoveries. The next discovery, coming from a barbarian tribe, was the discovery of how to smelt iron; an enormous discovery, because iron is a cheap metal as well as a very strong one. Because of its cheapness it became possible for the common people to possess iron tools, in a degree that had not been possible when copper and bronze were the main metals. This meant that farmers no longer had to till the ground with crude stone ploughs, or hack away at it with stone axes. From then on they were able to have iron tools for farming.

Civilization swings West

This had a great effect in swinging civilization away from its origins in the East. It was no longer necessary for men to be congested in the river valleys. The greater territories around the Mediterranean Basin and in Western Europe became available, once iron tools for breaking up the earth were available. So we see the swing of civilization to the Mediterranean Basin. This change was aided by a gradual change of climate that had been going on for several thousand years, which was making the territories occupied by the older civilizations somewhat too arid.

Now I would like to say just a little about the Mediterranean civilizations, and about the Roman civilization in particular, because it was the Roman civilization that led into our own. The Roman society was in essence anti-democratic. It evolved into an aristocracy that controlled everything. The ordinary people were given practically nothing, and they got increasingly less as the civilization went on. Indeed, the aristocracy reached a stage where it could see little point in keeping large numbers of poor people alive, and the condition of the ordinary people was so depressed that the population began to fall, simply because the poorer people were not able to get enough to eat. As time went on, the population declined until the aristocracy even reached the stage where it was not willing to support the Roman army. It was this that caused the collapse of the Roman Empire.

Now the importance of this anti-democratic society, from our point of view, is that it continued on in Europe in the form of the feudal system. Under the feudal system, society moved along on a very low population level. The leaders took most of the productivity and allowed very little for the support of the ordinary people.

A shortage of people

In such a condition, about a thousand years ago, something rather curious happened. Devastating plagues began to sweep across Europe. In these plagues a very large proportion of the population died; a third or sometimes a half of the people might be wiped out in a matter of a few months. Now, in a population which was already down to a very low level, such a plague was a far more serious matter than it would have been to the overflowing populations of the earlier civilizations.

The effects of the plagues turned a low population into a real shortage of people.

This had two important effects; one was the search for machines that would take over the work for humans, so that human muscle-power was no longer required. Thus, we find a tremendous spurt of invention, starting about a thousand years ago. This was the start of modern technology, which has accelerated as the centuries have gone by.

The second effect was a reversal of moral values. The shortage of people led to the basis of our modern ideas of the value of the individual. What had started under the Romans as stark anti-democracy evolved into the most democratic society that the world has ever seen. Our present sense of values, our ideas of liberty, our bills of rights, are a product of Roman anti-democracy—a curious reflection.

The average share

This brings me to the last part of my talk. I would like to pin my conclusions down to a sharp form, and then to examine very briefly their implications. Technology decides how much we can produce. If we take the productivity of a community and divide the productivity by the population, then we arrive at what can be described as the average share. The average share decides in a very large measure the evolution of a community.

I would regard the general spirit of activity which is present here in the United States as in a large measure due to the fact that the average share is increasing and has been increasing for some time. In contrast, if we take the opposite case, where the average share decreases, then we have ample historical evidence to show that decadence and collapse is likely to ensue.

I think that the issue of whether a civilization rises or falls is really as simple as this—a rise if the average share is increasing, a fall if the average share is decreasing. If, indeed, I am at all correct in imagining that this is a basic feature of human organization, then we can reach very firm conclusions in regard to the future. We can see that the way into the future is to plan that the average share increases rather than decreases.

Now this is a matter that raises very important questions, because our productivity is something that is not guaranteed to us. It is true that, in a large measure, the earth will continue to yield its agricultural productivity so long as we have the machines with which to deal with our agricultural problems. But if we were suddenly reduced to using stone tools, then, of course, our agricultural productivity would decline enormously. So it is obviously vital that we maintain our industrial technology. The maintenance of our industrial technology is dependent largely on whether we can maintain a large supply of power and of essential metals.

As regards power, the position is not immediately serious. We now derive most of our power from coal and from oil. It is true that supplies are limited—one might say limited to about 500 years—but even if we imagine that we reach the stage where coal and oil become exhausted, then, even so, there remains the possibility of using either atomic power or solar energy.

Speaking personally, I don't think that atomic power is going to be able to take over in the long run from coal and oil. I think it will become a useful addition, but it is hardly an ultimate solution. On the other hand, plenty of energy is falling on the earth's surface every day, being radiated from the sun. Plants manage to use some of this energy. Indeed it is this energy that keeps us going physically; when we eat, we are in effect using the energy supplied to us by the sun. Eventually we shall probably be forced to use the sun's radiation in order to run industrial machinery. This would have the great advantage that effectively no limit exists to the length of time that the sun will make its radiation available. It will remain available for some thousands of millions of years, and that is as long as most of us wish to look ahead.

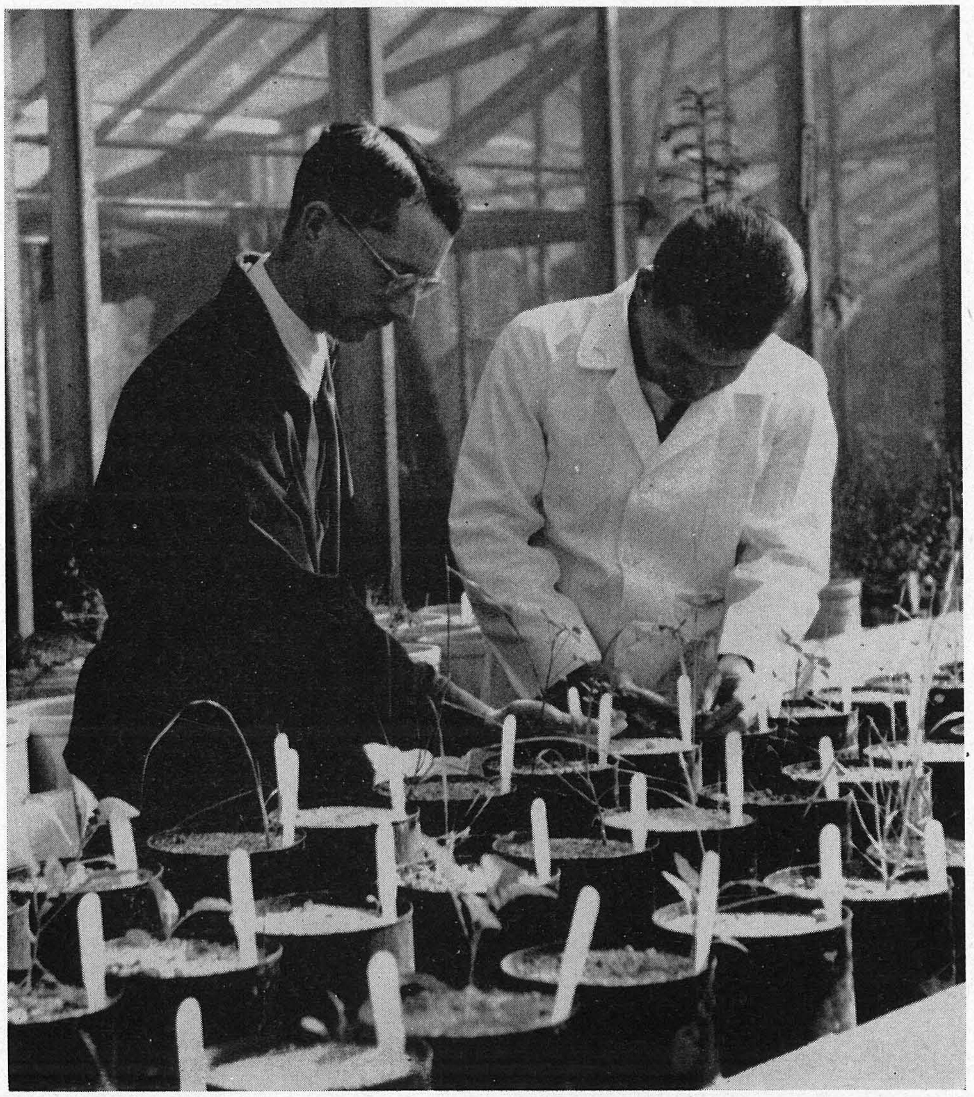
When we come to metals, the position is more serious, however. Already the lifetime of worked mineral deposits is of the order of fifty years for many metals. It is true that new discoveries may extend this a little, but we can see ahead of us, possibly not in our own lifetime but at least in the lifetime of our children, the day when metal deposits, in the concentration that we now regard as economically useful, will become exhausted.

The problems ahead of us

This doesn't, of course, mean that the total supply of metals will be exhausted, because we can always go to lower and lower grades of ore. But when one goes to lower grades of ore, new processes are required to enable the ore to be smelted in an economical way; that is, by the expenditure of a reasonable amount of energy. Unless such processes can be found the consequences will be serious. If it should become extremely troublesome, for instance, to smelt a very low grade of copper ore, then effectively we shall have lost our supply of copper, which means that we shall have lost the most effective material for use in our electrical machines. So, for this reason, I would say that anyone who discovers how to smelt very low grade ores in an economical way will have a far greater effect on the future of humanity than any of our other apparently more important political activities.

The case of copper is illustrative of the problems that lie before us. Our present technology certainly is not going to be enough. New and important developments will be necessary—and in the not very distant future—if civilization is to avoid running into a period where the average share begins to decline disastrously. And I say again that the time when this problem will overtake us is really not very far away. The time is short, but if we realize the importance of what we are doing, of technological processes, of industrial know-how, then although the time is short, I think it is perhaps sufficient.

Fred Hoyle, fellow of St. John's College, Cambridge, and Professor of Mathematics at Cambridge University, is now serving as Visiting Professor of Astrophysics at Caltech. A mathematical astronomer, he is one of the authors of the New Cosmology, which theorizes that "the universe was not created in 'one big bang' in the remote past, but that it is continually being created and will go on being created in the infinite future." An expert popularizer of science, he explained the New Cosmology in a highly successful book, *The Nature of the Universe*, published in 1951.



William C. Ashby and Henry Hellmers, plant physiologists with the California Forest and Range Experiment Station, study the development of plant cover in Caltech's Orlando Greenhouse.

FERTILITY AND FLOODS

Caltech and the U. S. Forest Service cooperate on a program of research to help cut soil erosion and flood damage in California's San Gabriel Mountains

RESEARCH NOW IN PROGRESS at the California Institute of Technology has shown that the proper fertilizer can increase the growth of native vegetation on our semi-arid mountains. Less erosion, reduced flood dangers, and improved water supply may result.

Most investigators had assumed that little or nothing could be done to increase plant cover in the near-desert mountain regions of southern California. It is true that lack of water limits plant growth in the dry seasons, but Institute biologists discovered that low soil fertility becomes the limiting factor when water *is* available.

They found this in a cooperative research program being conducted with the California Forest and Range Experiment Station of the U. S. Forest Service. Co-workers are Drs. James Bonner, Professor of Biology, and Henry Hellmers and William C. Ashby, Research Fellows, who are Forest Experiment Station plant physiologists.

The Forest Service is seeking ways to improve the sparse plant cover on critical areas in the rugged San Gabriel Mountains. The belief is that better cover would help cut the high rates of soil erosion and the flood peaks that occur during winter storms. Debris-laden floods sometimes cause severe damage. The silt they carry reduces the capacity and efficiency of reservoirs and stream channels. Lives may be endangered and improvements destroyed on the outwash plants not protected by flood control structures.

Experiments with native plants

The initial experiments were carried out in the Orlando Greenhouse near the Caltech campus with five plants native to the San Gabriel Range: Coulter pine, big-cone spruce, mountain oak, mountain lilac, and chamise (greasewood). Dr. Hellmers planted seeds in potted samples of each of the three major soils of the range: Wilson diorite, Lowe granodiorite, and anorthosite. He left some samples unfertilized and applied chemical fertilizers to others. One fertilizer—ammonium nitrate—was rich in nitrogen, others in calcium, potassium, phosphorus, sulphur, or a combination of magnesium, boron, zinc, copper, and molybdenum.

Plants grew well and thrived in the soils treated with ammonium nitrate, but this was the only fertilizer that consistently produced a significant response. Soils treated with the other compounds grew plants as scrubby as those in unfertilized soils. The scientists therefore concluded that lack of nitrogen limits the development of plant cover in the San Gabriel Range.

This finding is not universally applicable, they caution, because soils elsewhere might be deficient in one or more of the other elements affecting plant growth. But a knowledge of specific local deficiencies, they feel, may enable scientists to improve plant cover in other semi-arid regions where erosion is a serious hazard.

In the field

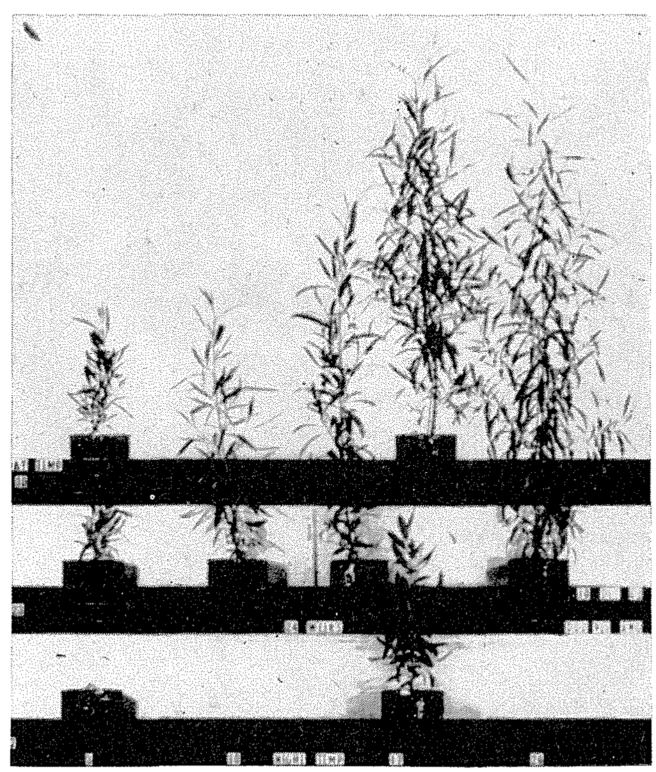
The plant scientists moved their experiments into the field after demonstrating the nitrogen deficiency in the greenhouse. They set up 14 large plots throughout the mountainous part of the Los Angeles River watershed, at altitudes of 1,000 to about 5,000 feet. Part of each plot was treated with a standard commercial nitrogen fertilizer—ammonium sulfate—because it was cheaper than ammonium nitrate. In just one year the treated areas produced twice as much new plant growth as adjoining untreated areas, and this growth has persisted through two growing seasons without more fertilization.

A good plant cover is considered to be useful in flood control in several ways: The vegetation, and the leaves and needles it sheds, protect the soil and also make it porous; the roots help hold the soil in place. Rainwater can percolate through the porous soil and fractured rock and so reduce surface runoff and erosion. Where no cover grows, the impact of raindrops loosens particles of soil and rock, and rainwater flushes this silt downhill to join many freshets and mushroom into a destructive mass of water, mud and rock.

Such silt-packed water cannot be diverted directly to community use. Nor can it be allowed to collect in and clog the spreading grounds through which mountain runoffs trickle into underground basins. Silty water must be shunted onward to the sea, lost to a water-hungry area. If plant cover could be grown on bare mountainsides, less silt would come down the slopes and the rainwater might be used for community supplies. Too, more water would seep gently through the soil during rainy seasons to raise the level of underground basins.

Search for nitrogen-fixing plants

The biologists point out that fertilizing mountain soils, perhaps by dusting from an airplane or helicopter, would be extremely expensive, even if the work was concentrated only on critical areas. They are now searching for nitrogen-fixing plants which can grow in the mountains. This is primarily the concern of Dr. Ashby. In the Earhart Plant Research Laboratory at Caltech, where any desired climate can be duplicated under controlled conditions, he is trying to find a leguminous plant that will grow in the San Gabriel Range. The legumes—clover, beans, and their allies—can collect nitrogen from the air and fix it in the soil for their own use and that of other plants in the vicinity. If a suitable legume can be found, fertilization would not be necessary.



Experiments with Hopbush, native of Arizona and other warm regions of the world, show an increase in growth with an increase in temperature, day or night. This limits it to low elevation sites that have ground water available in the summer.

INDUSTRY'S STAKE IN SCIENTIFIC RESEARCH

By L. A. DuBRIDGE

THREE YEARS AGO this week I addressed the American Management Association meeting in San Francisco on the same subject I am dealing with here. The basic ideas I set forth then are still good today, and I should like to review them briefly.

The first idea I tried to expound in 1950 was the idea of change. The conditions under which human beings live have been changing for the last 100,000 years. They will be changing for the next 100,000 years. And the chief instrument of change is new knowledge. Men do things differently today, compared to yesterday, because something new has been learned. Sometimes new knowledge gives rise to changes that are welcome. Sometimes these changes cause hardship and distress. But there is always going to be change. Hence we should be ready for it—even invite it—and be ready to guide it in such a way as to cause the greatest good and the least harm.

A second point I stressed three years ago was that the rate at which change occurs continually increases. The reason for this is simply that we have learned how to increase greatly the rate at which we acquire knowledge. Modern methods of research in science and technology result in both the rapid acquisition of knowledge and the rapid application of knowledge to new things. Thus every phase of modern life is continually reeling from the impact of change. This is the great fact—the great challenge and the great opportunity—which faces the management of American business and industry.

The third major point of my previous talk was that, since the rate of change and direction of the changes which will occur will depend largely on the nature of our progress in science and technology, American industry can, to a large extent, determine the rate and much of the direction of this future change, through the way in which it supports and carries on research in pure and applied science, and the way in which it uses the products of such research.

All of this means that American industry has an important stake in scientific research, and my thesis today is simply that the management of American industry has a two-fold responsibility:

1. To understand something about the nature of scientific research—its possibilities and limitations.
2. To formulate and carry out a policy concerning industry's relationship to research—how it will foster it and how use its results.

This is a large order. And I know that many an industry representative will at this point smile indulgently at the naiveté of a college professor.

Understand science? Develop a policy relating to research? How in the world can a company official do that? With all his worries about taxes and government controls, about markets and advertising, prices, dividends, labor relations, wages, pension systems, production, raw materials, new models, what his new competitor is going to do, what the new Congress and the new

This article has been adapted from a speech delivered by President DuBridge before the annual midwinter conference of the American Management Association in Los Angeles, January 15, 1953

Whether a company is still in existence and making a profit 10 or 20 years from now is more likely to be determined by what happens in the laboratory than in the accounting office, in the sales office, or even in Congress or the White House.

President are going to do—with all these inescapable worries, how is the management of a business going to give any attention to science?

Well, frankly, I don't know. That's your problem. All I say is that whether a company is still in existence and making a profit 10 or 20 years from now—or what kind of a product it will be making or selling then—is more likely to be determined by what happens in the laboratory than in the accounting office, in the sales office, or even in Congress or the White House.

If you don't believe me, think back 50 years. The changes that occur in the next 25 years will be every bit as great as those of the last 50. How many companies of today even existed 50 years ago? And of those that do date back to 1903, how many were then making products or using methods which were the same as those of today? And how many companies of 1903 have gone out of existence because they stuck to a product which became obsolete?

Yes, in 50 years we have gone from wagons and kerosene lamps to airplanes and television. And whence came all these changes? Did anyone in Washington invent radar or television? Did the political actions of Theodore Roosevelt or Woodrow Wilson create the radio industry or the oil industry?

No, the really great changes of the past—as of the future—stem from the creative ideas of men and women working in the laboratory, in the drafting room, and in the shop. And the management that ignores what goes on there is doing nothing more or less than ignoring the things that will really affect the future.

The first thing on which we must be clear is the nature of the complex process that goes on which gives rise to scientific discovery, and its eventual translation into products or techniques which are of use to human beings. Obviously, if we are going to participate in and, indeed, encourage the progress of technological change, it is important that we understand the nature of the process. Otherwise we may well be doing things which are ineffective, possibly harmful, and certainly expensive. Our disappointment will then make it more difficult for us to spend money for the right things in the future.

This process of scientific discovery and technological development, followed by large-scale use, is often grossly oversimplified. I suppose no one really believes that a basic discovery made one day can lead to a product in mass production the following day. However, there are those who seem to think that if there are more than a few months' delay, someone is responsible for negligence. But the real fact is that in the past there has quite commonly been an interval of something like 50 years between a basic new discovery in science and its practical realization in the form of a new device or technique.

Fifty years sounds like a long time in these days of "high power" research. But let us take some examples. It was in 1896 that Becquerel observed that compounds of uranium gave off radiation that could penetrate black paper and then metal sheets, and affect a photographic plate. This so-called radioactivity of uranium has only an *indirect relation to the fact* that 49 years later uranium was first used in an atomic bomb. But Becquerel's observation was nevertheless the discovery which ushered in the science of nuclear physics.

In 1896 no one had any idea of the meaning of the phenomenon of radioactivity. The idea that atoms even had a nucleus had not then been developed. And yet, looking back, we can see the inevitable march of discovery from Becquerel to Pierre and Madame Curie, to Rutherford, to Bohr, Cockcroft, Chadwick, Lawrence, Fermi—to many others, and then—to Los Alamos. It took 49 years and 4 months.

Radar—after 50 years

Or take the case of radar. For its beginning we must go back to 1887, to some experiments conducted by one Heinrich Herz, whose aim was to test some new theories of electricity and light which had been proposed by James Clerk Maxwell. Herz was the first to produce radio waves. He showed that they could be reflected and refracted, that they traveled in straight lines like light waves—and moved with the same velocity. Again, from that discovery, it was a direct series of developments over almost exactly 50 years to the first radar set.

I could give many more examples—all illustrating the single fact that wresting knowledge from nature is not an easy job. Fact upon fact, theory on theory, experiment on experiment, knowledge grows slowly and with great effort. It is like building an enormous structure of brick and stone. Each brick must be painstakingly laid; and as each one goes in, a place for a new brick is created. Every now and then a great keystone is fitted in, and the structure suddenly takes on new form and new beauty. But always must continue the process of placing one small brick upon the other.

There are many more workers on the structure now than a few years ago; they have discovered new techniques for laying bricks more rapidly. But on the other hand the structure has grown enormously more complex. It is no longer so easy to see how each new fact—each new piece of stone—is best fitted into the whole structure. Hence many false starts are made and we must more frequently tear down and rebuild.

Scientist and layman

I suppose it will always be impossible for a scientist to explain clearly to a layman just what this process of building the structure of science—or as we call it, carrying on scientific research—is really like. I have tried many times, and—with all due respect to the intelligence of my audience—all I get is a blank stare. It's like explaining falling in love; you just can't get it across to someone who has never done it! How can one explain how endless days and nights of drudgery can be exciting? How can a perpetual chain of apparently trivial things add up to something terribly important? How can one explain the indescribable patience of men who, year after year, generation after generation, spend their lives trying to understand the structure of a protein molecule, or of an atomic nucleus, when each apparent step forward leads only to new and more puzzling mysteries?

This is the process through which new knowledge in science is acquired—the slow process of finding facts, fitting facts to the theory, altering the theory, predicting new facts, testing the predictions. This process of research, first discovered in the 17th Century, is the single intellectual discovery which has transformed the world of 1600 into the world of 1953—and will continue to transform it into the still different world of 1973, of 2053.

From Becquerel to Alamogordo

As I have suggested, however, the discovery of a single new fact or principle does not lead directly or immediately to the manufacture of a new product. Why was it 49 years and 4 months from Becquerel to Alamogordo? The chief reason is that a new product usually depends not on a single scientific discovery but on the development of a whole science. Becquerel initiated studies in a new area of science. But it was really not until 1940, after years of work by hundreds of physicists—including men like Einstein, Rutherford, Bohr, Fermi and the others—that the science of nuclear physics had reached the stage where a nuclear explosion was even thinkable.

No single discovery led to the atomic bomb, though many brilliant ones were made during the chain of events that led to it: The atomic bomb was possible because there was a science of nuclear physics, painstakingly built by hundreds of workers over several decades.

Incidentally, this is one reason why there is so much confusion in discussions of the so-called "atomic secrets." There were no secrets in nuclear physics before 1940. It was a growing new science to which contributions were made by scientists all over the world—American, British, French, German, Italian, Russian, Japanese. And when some British and American scientists finally, in 1940, sat down together to discuss the development of an atomic weapon, they were familiar with and used the whole of nuclear physics. And it was clear to them that any other group of competent scientists in the world could design such a weapon just as well as they could. I repeat, there were no secrets then. It never occurred to anyone that there was any reason for a secret. The only secrets which later developed were the particular design tricks which made the bomb an efficient, practical device.

The basic objective

The point I am seeking to make, however, is this: the new things of the future will arise not so much from isolated spectacular discoveries or inventions as from the growing knowledge of science. The first objective of people interested in material progress, then, is to insure the future growth of science. This basic simple step is the one which we in America seem most likely to neglect or forget.

A second stage in this process of change—in this transition from discovery to use—is the stage of what we might call "applied science" or "technology." Modern radar and radio and television were, of course, impossible before Herz discovered radio waves and J. J. Thompson discovered the electron; before R. A. Millikan had measured the electron and identified it as the basic unit of electricity, before these and many other workers had created the science of electron physics. But to know all about the nature and behavior of the electron—though this was necessary—was not sufficient. Someone familiar with electron physics had to use this knowledge and develop an electron tube. Fleming and DeForest did this. And then many physicists, engineers, and inventors had to develop practical, versatile tubes, and useful and ingenious methods for using them.

Electron physics and electronics

The science of electron physics was thus followed by the technology of electronics. The electron, as it turned out, was the most extraordinarily versatile particle. Hence, there is a bewildering and ever-growing array of electronic devices—radio tubes, television tubes, amplifiers, oscillators, rectifiers, magnetrons, klystrons, travelling wave tubes, and so on.

And so it is in every field. Upon the *science of mechanics* there have grown several technologies: the technology of structures (which we usually call civil engineering); the technology of machines, or mechanical engineering; the technology of fluid dynamics, of which one part is aeronautical engineering. The science of sound leads to the technology of acoustics; the science of light to the technology of optics, of optometry and illumination.

In the same way, the various branches of the science of chemistry lead to a whole array of technologies covering various fields of chemical engineering, such as industrial chemistry, petroleum chemistry, high polymer chemistry. So, too, upon the science of plant biology we build the technology of agriculture, and on the science of animal biology, the technology of medicine.

Science, technology and change

A strong science and a strong technology; these are the elements that make for rapid and constructive change. It is the growth of these two realms of human activity, and the growth of the relation between them during the past 200 years—and especially during the past 50 years—that has led to the profound changes that have occurred in our way of living. It is the strength of science and technology which guarantees change for the future.

It seems to me, therefore, relatively obvious that industry in America should be aware of these elementary facts. And, I submit, they are not very complicated facts. Yet the consequences of being alert to them are both profound and far reaching. Let us examine these consequences. Let us proceed to the second question which I raised at the beginning: What policies must American industry adopt as it faces the future?

It would be presumptuous for me to attempt a general and complete statement of policy which would be adequate to insure the future of any or all industries. But I would like to suggest four elements which a complete policy must certainly contain. In the language of the mathematician, my four elements are *necessary* but probably not *sufficient* conditions for a promising future. I will state them in the form of propositions.

For a promising future

Number One is simple and obvious—one of those truisms which bears daily repetition: "No industry can be stronger than the community of which it is a part."

If I emphasize that the word "community" is to be interpreted broadly, the proposition is, as you see, a truism. It means simply that the welfare of your industry depends utterly on the welfare of your city, your state, your country—and upon the free world of which your country is a part. No one is isolated any more. Obscure events in far places may affect your future. This does not mean that every company manager must take on his shoulders the burden of assuring the welfare of the whole world. But it does mean that each company owes a responsibility to its local community and to the nation. It does mean that it is good business to contribute something to the welfare of the community and the nation. It means that it was inevitable that the leaders of American business and industry should do precisely what they have done in recent years; namely, take a broad and not a narrow view of their responsibilities.

The broad view

It is obviously not appropriate here to expound further on this first proposition. It was however necessary to state it as an axiom. For unless it is accepted, my other propositions become meaningless. Unless management takes a broad and not a narrow view, it will not be interested in science and technology at all.

Proposition Number Two is a little more definite—and equally a truism: "Progress depends upon people."

Of course every manager knows that. Doesn't he spend a good share of his time finding and assigning the right people to the right places? And it doesn't help any if I qualify the statement by making it read "key people" or "top people." They are all the harder to find. Exactly! And this leads me to my point—where do top people come from? In industry, in business, in science and technology, in the life of the community and the nation we grow ever more dependent on competent, high-minded and well-educated men and women. And where does one look for the source of such people? To the colleges and universities.

The problem of educating men and women for future leadership becomes especially critical if we look at the case of scientists and engineers. Modern civilization is truly one which depends heavily on such people. There are 20 times as many scientists and 5 times as many engineers per million of population in the United States now as there were in 1900. And the need has continually outrun the supply.

Sir Ewart Smith, Director of the Imperial Chemical Industries of England has recently stated flatly that the fact that United States productivity per worker is 2½ times greater than the British is directly attributable to the fact that there is a 2½ times greater supply of United States scientists and engineers per million of population. Clearly it is important to maintain our source of supply.

The managers of the future

Furthermore, as you probably know, the managers of American industry are more and more coming from the ranks of the scientists and engineers. In a representative group of American managers, about 40 percent began their careers in science or engineering. This figure is rapidly growing and the chances are that most of the managers of the future will be men now on your research or engineering staffs.

All of this leads to a simple consequence. Because industry leans so heavily on college-trained men, especially on scientists and engineers, it will be to the advantage of industry and the country if you make it a matter of policy to assist colleges and universities to survive and to keep flowing the supply of competent educated young people.

Proposition Number Three: "Knowledge Is Power."

After what I have said I don't need to explain this idea any further. *Knowledge is the difference* between today and yesterday; between today and tomorrow. The search for knowledge is one of the great and exciting endeavors in which human beings engage. It will be to your advantage to encourage and support those engaged in this adventure—seeking new knowledge in many fields.

There are many people these days who, knowingly or unknowingly, are discouraging rather than encouraging this search for new knowledge. They ignore or even deride those in scholarly pursuits; they derogate the intellectual; they point the finger of suspicion at new ideas; they persecute those who express unconventional opinions; they foster misguided notions about scientific "secrets," and thus impair the freedom of communication which is the life-blood of science and of the search for truth in any field.

You, the industrial leaders of the nation, have the obligation—for the sake of the future of your business, your community, your country, and free men everywhere—to stand out in favor of intellectual adventure. You, the trustees of free enterprise, know full well how the road to success and progress is strewn with risk, with dangers of trodding untried paths. Free enterprise is precious in the intellectual world too—and the road to new knowledge is also a dangerous road to tread. But tread it we must, and the pioneers who lead the way must be given encouragement and support, even if they make mistakes—as they surely sometimes will.

Where is the search for truth primarily pursued? You know the answer. The universities of the world have always been the primary homes of those who sought the truth. What can business and industry do to help? Here let me quote a few excerpts from a recent talk by the head of one of the country's largest corporations, C. F. Greenewalt, president of DuPont. Said he: "Our prospects for the future depend on a proper and harmonious blending of fundamental and applied research . . . We must at all times have a steady flow of basic knowledge . . . For this we must rely primarily upon our universities, for only in the academic environment can fundamental research in its true sense really flourish . . . It is unfortunate that financial necessities of some of our universities appear to have driven them more and more into the field of sponsored and applied research. This is a disquieting trend and I think it is one of industry's prime responsibilities to do what it can to reverse it."

DuPont has a very practical way of helping on this—cash; grants-in-aid for basic research. Your company may be able to find a better way—but it won't be easy. But the conclusion from Proposition Three is this: Encourage and support basic research in the universities.

My final proposition is simply a gratuitous piece of advice: "Support your own research organization."

It is not my intention to give you a long essay on how industrial research laboratories pay off and how every company should have them. You have all, no doubt, been exposed to the argument many times, and your companies have made their decisions one way or the other. But I need only point out that, as the university is the source of new knowledge, industry is the source of new technology.

A window to the world of science

For those companies who have research organizations I only wish to suggest that they be regarded by management not only as organizations for grinding out new products and processes but that the research and development staff be looked upon as a window to the outside world of science and technology. No one wishes to be left behind in the march of technological progress. One of the key functions of a research and development organization, even if it consists of only one person, is to keep the company alert to new developments and to keep the management informed as to their significance and potential impact upon the company. No speeches or articles or books can keep management informed of new developments which might affect it, but an understanding and alert group of trained scientists and engineers will give you a chance, at least, of staying in the running.

THE BATEMAN PROJECT

"This work is dedicated to the memory of Harry Bateman as a tribute to the imagination which led him to undertake a project of this magnitude, and the scholarly dedication which inspired him to carry it so far toward completion."

THESE WORDS INTRODUCE a monumental work on mathematics conceived by Dr. Harry Bateman, who at his death seven years ago at the age of 63 was Professor of Mathematics, Theoretical Physics, and Aeronautics at the California Institute of Technology. Carrying forward the work he began, an international team of mathematicians directed by Professor A. Erdélyi has dedicated some 15 man-years of their efforts to complete it.

These efforts have resulted in a three-volume series called *Higher Transcendental Functions.* Volume I is scheduled for publication this month. *Tables of Integral Transforms,* in two volumes, will follow.

This work is the outgrowth of the Bateman Manuscript Project which was sponsored at Caltech by the U. S. Office of Naval Research. It is expected to become indispensable to pure and applied mathematicians, theoretical physicists, some electrical engineers and others for whom special mathematical functions are almost a daily tool of their research. It will be a standard reference, useful whenever special functions are needed to solve problems.

A mathematical function expresses the relation between two or more variable quantities. Simple examples are $y=x+2$ and $y=\cos x$. The higher transcendental functions are considerably more involved than these algebraic and trigonometric functions. They are used to describe more complex relationships and to solve more difficult problems than those involving simple quantities or relationships of angles.

Virtually all special functions originally were mathematical inventions, but many have been found to be valid representations of natural phenomena. A few examples are Bessel functions, which can be used to describe the motion of water waves spreading from the point where a rock fell onto a smooth surface; Legendre functions, the electromagnetic radiations from a radar antenna; and confluent hypergeometric functions, the waves scattered from an atomic nucleus by an electron.

The books carry out Bateman's objective of compiling an encyclopedic reference work in which the contributions to mathematical analysis of hundreds of mathematicians, living and dead, would be available. They describe the properties and interrelations of special functions and bring together information now scattered widely through many journals and books. Without them, a scientist wanting the properties of a specific function might have to seek out a dozen or more different sources, some in rare periodicals. With them, many scientists will save days or weeks of search.

Bateman had a unique and impressive combination of interests and knowledge. An adroit and skillful analyst, he made contributions to aerodynamics, hydrodynamics, geophysics, thermodynamics, electromagnetic theory, and a host of other fields. He came close, in fact, to anticipating Einstein's general theory of relativity.

He looked far ahead of technical development. During the first World War, for example, he published a paper on the stability of helicopters, which came into wide use only during the second World War. A key man on a National Research Council Committee on Hydrodynamics, he wrote most of its definitive 600-page report. He was a member of both the U. S. National Academy of Sciences and the Royal Society of London. He almost invariably replied to requests for solution of problems by return mail. He documented these solutions with extensive bibliographies, many of them supplied from memory.

He planned a work in which he would lay down all the mathematical analysis he used in these endeavors, to make it easily accessible to all. Then, at his untimely death, he left notes scattered through his three offices. At least ten thousand pages were filed, but not indexed, in many places—including dozens of shoe boxes.

After a preliminary survey by Dr. A. D. Michal of Caltech, the research team was brought together in 1948: Drs. Erdélyi, University of Edinburgh, now of Caltech; Wilhelm Magnus, University of Göttingen, now of New York University; Fritz Oberhettinger, University of Mainz, now of the American University, Washington; Francesco G. Tricomi, University of Turin; and several younger mathematicians and assistants.

They had to select judiciously from Bateman's voluminous legacy if their job was to be done in a reasonable period. They added a good deal from their knowledge of the literature and their own research.

The Bateman work is unique in that no other exists on a similar scale. It provides all the information commonly needed on special functions. It stands as a permanent monument, available for daily reference by scientists in the many fields to which Bateman contributed.

THE MONTH AT CALTECH

Church Laboratory

A BEQUEST OF THE late Norman W. Church of Los Angeles to the California Institute of Technology, together with gifts he made to the Institute a few months before his death on January 7, will make possible construction of a $1,500,000 chemical biology laboratory on the campus.

The Norman W. Church Laboratory of Chemical Biology will be located in the northwest corner of the campus, at the intersection of San Pasqual Street and Wilson Avenue. It will be joined to the present Crellin Laboratory of Chemistry, and also, eventually, to the Kerckhoff Laboratories of the Biological Sciences.

"The building," Dr. DuBridge explains, "will house important research work in the area where chemistry and biology come together, work which has developed rapidly at the Institute during the past few years under the joint leadership of Professors Linus Pauling, Chairman of the Division of Chemistry and Chemical Engineering, and George Beadle, Chairman of the Division of Biology.

"Completion of this laboratory will fulfill hopes and plans which were initiated more than five years ago. At that time the combined chemistry and biology program of the California Institute was visualized and initiated. The program was given assurance of support through a grant from the Rockefeller Foundation of $700,000, available for use over a seven-year period. At the time this new program was announced, Mr. Church expressed a keen interest in it and informed Institute officials of his hope that he could help to provide a building to house the work."

These plans materialized last summer when Mr. Church gave $750,000 to the Institute to provide for the initial phase of construction. He asked that no announcement of his gift be made until the beginning of construction, now scheduled for the spring of 1953.

At Mr. Church's request, Stiles and Robert Clements of Los Angeles were asked to serve as architects for the proposed building. They have been collaborating with Caltech staff members in drawing up plans during recent months.

Preliminary plans for the Church Laboratory call for a structure three stories high above ground, plus two floors below ground. The laboratory will have an overall length of 305 feet along San Pasqual Street and a width of 52 feet. It will join the Crellin Laboratory at the east end, and, if funds permit, a connecting wing will be built to the Kerckhoff Laboratories to the south.

In making his $750,000 gift last summer, Mr. Church had promised that he would provide additional funds at a later date for the laboratory. His will has now been filed for probate and provides a specific bequest of $300,000 to complete the building. The will also provides that after other specific bequests, the residue of Mr. Church's fortune be used by Caltech to establish the Norman W. Church Fund for research in chemical biology.

Conservation Award

DR. JOHN P. BUWALDA, Professor of Geology, last month received an Honor Award from the California Conservation Council for his effective work for the conservation of natural resources.

Dr. Buwalda has worked continuously for the past 25 years with the National Park Service for the better use of national parks. A member of the board of expert advisers to the National Park Service, he later served on the Yosemite Advisory Committee. Dr. Buwalda has also been active in water supply conservation in connection with work on the Colorado River Aqueduct and construction of dams in California. During the last war he worked to increase water supplies for army camps and military hospitals, and his World War I activities were directed toward increasing the strategic mineral supply.

Professor Buwalda was Chairman of the Division of Geological Sciences at Caltech from 1925-47. For the past two years he has been president of the Seismological Society of America.

Bowie Medal

DR. BENO GUTENBERG, Professor of Geophysics and Director of the Seismological Laboratory, has been selected as the 1953 recipient of the William Bowie

CONTINUED ON PAGE 28

Medal presented by the American Geophysical Union.

He will be given the award at the organization's annual meeting, to be held May 4-6 in Washington, D. C. Walter D. Lambert, award committee chairman, informed Dr. Gutenberg of his selection by unanimous vote. The medal is given annually "for distinguished attainment and outstanding contribution to the advancement of cooperative research in fundamental geophysics."

Barrett Scholarship

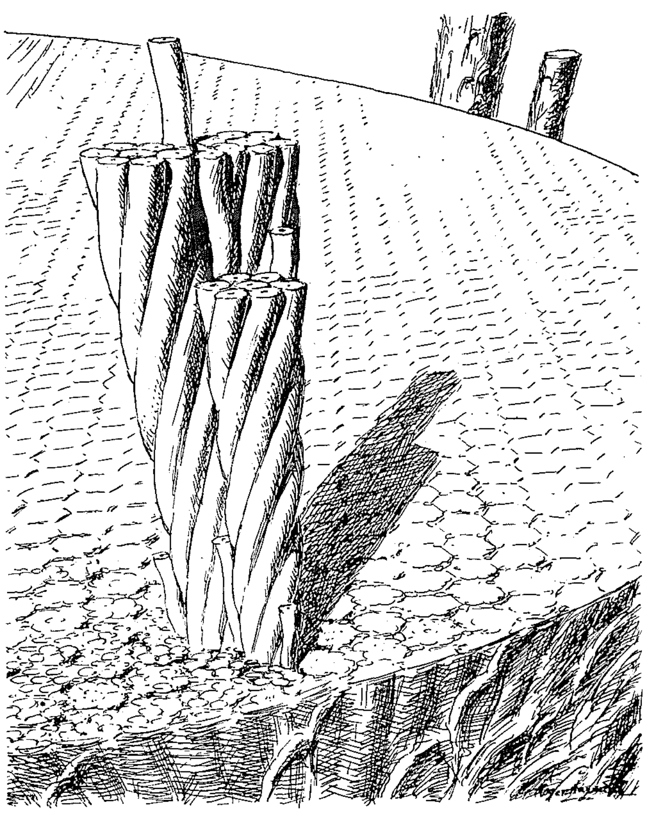
ANNOUNCEMENT OF THE Edward C. Barrett Memorial Scholarship Fund was made this month, in a letter sent to Mr. Barrett's friends on the Caltech staff, among the alumni, and in the community.

"In the death of Edward C. Barrett last spring," the letter reads, "the California Institute lost a devoted servant who had been intimately involved in every phase of the Institute's growth and development since 1910, when it began operations in Throop Hall on the the present campus with only thirty-five students. Mr. Barrett's friends on the staff, among the alumni, and in the community feel very strongly that some permanent memorial should be established in recognition of this service.

"Since he always had, throughout his years at Caltech, a particularly warm and sympathetic interest in the welfare of the students, it seems that the most appropriate memorial to him would be an undergraduate scholarship awarded annually in an amount to cover tuition.

"A substantial sum has already been made available as the nucleus of the Edward C. Barrett Memorial Scholarship Fund, and it is hoped that additional contributions will make possible the maintenance of this scholarship on a permanent basis. Checks should be made payable to the Barrett Scholarship Fund, California Institute of Technology, and sent to Mr. H. H. G. Nash, Secretary, Room 108A Throop Hall, California Institute, Pasadena. We will be happy to answer any questions which you may care to direct to us."

Donald S. Clark	*Wesley Hertenstein*
Margaret Fleming	*William Huse*
William A. Fowler	*George R. MacMinn*
Ray Gerhart	*Robert A. Millikan*
Abe J. Hay	*H. H. G. Nash*



Artist's conception of the molecular structure of hair, suggested by studies of Drs. Pauling and Corey.

Protein Structure

LINUS PAULING, Chairman of the Division of Chemistry and Chemical Engineering at the Institute, and Robert B. Corey, Professor of Chemistry, have discovered evidence that muscle, hair, fingernail and other body proteins contain molecules twisted into the shape of ropes and cables.

In 1951, after 15 years' work on the problem, Drs. Pauling and Corey announced the discovery of the molecular structure of some proteins (E&S—October 1951). They found then that the *individual* molecules in muscle, hair, fingernail, and many other proteins consist of a series of atoms of carbon, hydrogen, nitrogen, oxygen and sometimes other elements which are coiled into spirals or helixes.

Now they have found that seven of these coiled molecules can be twisted into a cable, and they believe that these cables are present in hair and some other proteins. Each cable consists of a central molecule, coiled into a spiral, and six other molecules, also coiled into spirals, which are themselves coiled around the central molecule to form a seven-strand cable.

This coiling closely resembles that of a rope, in which the individual strands are coiled in one direction, and then the strands themselves are coiled around one another in the opposite direction. This prevents the rope from unraveling when it is stretched or when a piece is cut from it.

In their investigations—sponsored by the United States Public Health Service, the Office of Naval Research, and the Rockefeller Foundation—Pauling and Corey have found evidence that hair and similar proteins contain three different kinds of protein molecules (keratin A, B, and C). These are: (A) the coiled molecule forming the center of the cable, (B) the six coiled molecules twisted about this central one, and (C) two additional molecules filling in the spaces between the cables.

CONTINUED ON PAGE 30

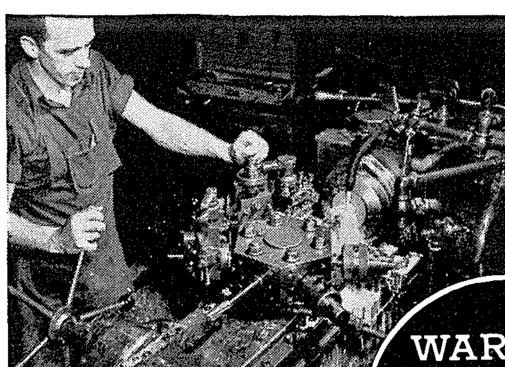
Somebody ought to speak sharply to Nature

THERE's a lot of loose talk these days about profits, attacking them as though they were evil.

The very existence of the world depends on profits; the *improvement* of the world depends on *big* profits. A farmer plants one potato and usually gets back 15. Even allowing for all his costs, that's more than 1000% profit! He plants one pound of corn and gets back 336 pounds—that's 33,600% profit. These are big profits. Is that bad?

Should the farmer be scorned as anti-social? Should his "excess" profit (whatever that is) be taken away from him? Should he be told that from now on he must limit his "profit" to, say, 6%?

To legislate against profits is as silly as to legislate against things growing.



Warner & Swasey is always interested in talking future opportunities to young men of ability and character. Write Charles Ufford.

WARNER & SWASEY
Cleveland
Machine Tools
Textile
Machinery

YOU CAN MACHINE IT BETTER, FASTER, FOR LESS WITH WARNER & SWASEY TURRET LATHES, AUTOMATICS AND TAPPING MACHINES

The researchers believe it should be possible to separate the different kinds of molecules from one another chemically.

The principal protein of muscle—actomyosin—was separated into two distinct proteins—myosin and actin—a decade ago by Dr. Albert Szent-Gyorgyi, Hungarian Nobel Laureate, who is now associated with the Marine Biological Laboratory at Woods Hole, Massachusetts.

Professors Pauling and Corey suggest that in muscle the molecules of myosin are seven-strand cables and that the molecules of actin are coils filling up the spaces between the cables in actomyosin. They predict that it should be possible to separate myosin further into two distinct proteins: the one found in the central coil and the one consisting of the molecules twisted around it.

This new knowledge about the structure of proteins has been obtained by the study of X-ray diffraction patterns of the amino acids which make up proteins, and also of the X-ray patterns of the proteins themselves. In 1915, three years after Dr. Max von Laue of Germany discovered that X-rays were diffracted by crystals, Caltech scientists set out to determine the structure of some crystals by using X-rays. The technique has continued since then to be one of the more important fields of research in the Caltech chemistry division.

The Caltech investigators now believe that the X-ray diffraction method should provide significant information about the structure of abnormal proteins involved in disease and that it may soon become a powerful tool in fundamental medical research.

Turkey and China

Two more representatives of the American Universities Field Staff will visit the Institute this month. Last month Richard H. Nolte and Lawrence W. Witt of the AUFS reported, respectively, on the Middle East and Brazil to the Caltech faculty, students and friends. On February 9 Richard H. Robinson arrives to report on Turkey, and on February 26 A. Doak Barnett will be here to discuss current conditions in China.

Mr. Robinson was born in Yakima, Washington, in 1921. He was graduated from the University of Washington in 1942 and received an M.B.A. degree from the Harvard Graduate School of Business Administration in 1943.

He enlisted in the Army in 1943, was shortly commissioned, and taught for a time in a Transportation Corps School. Later training in military government and Far Eastern studies led to his assignment at the end of the war to the Headquarters of the Military Government of South Korea, where he was placed in charge of the Office of Public Opinion and made responsible for assessment of Korean reactions to the American administration.

He left the Army in 1946 and became a civilian War Department historian of Soviet-American relations in Korea. In July 1947 his employment by the Government ended and he and his wife travelled around the southern fringe of Asia to Turkey.

For the past five years Mr. Robinson has concentrated on Turkish affairs. He studied and taught for a few months at Robert College, Istanbul. Later, as an Associate of the Institute of Current World Affairs, he lived and studied provincial life in central Anatolia for nearly a year. More recently he and his family have lived in Ankara. Among the fields he has investigated are religious trends, political movements, labor organization, farm mechanization, and the effectiveness of American aid to Turkey.

Mr. Barnett was born in 1921 in Shanghai, China, the son of an American Y.M.C.A. official, and lived there until 1936. He was graduated from Yale *summa cum laude* in 1942. After wartime service as a Marine officer, he returned to Yale and took an M.A. in international relations.

He joined the Institute of Current World Affairs in 1947 and en route to China made brief visits in India, Singapore, Indonesia and Thailand. In China his program of field studies brought him into contact with such issues as the Nationalist elections and National Assembly meetings, rural and urban economic problems, labor organization in Shanghai, attitudes and activities of intellectuals, and the problems of racial minorities in border provinces.

During 1948-49 he observed the communist military siege and takeover of Peking and studied communist propaganda, policies, and actions on the spot. He then made further studies of conditions in Nationalist-controlled Yunnan and Kweichow provinces and on Hainan, Hong Kong and Formosa.

In 1950-51, back in the United States, Mr. Barnett was a consultant to the Far East Program Division, Economic Cooperation Administration. He then went to Hong Kong, and until June 1952 served there as Evaluation Officer (with rank of Consul) of the U. S. Information Service. He has now again taken up his private studies.

Chemistry Teaching

Caltech is one of 32 American colleges and universities which will benefit from a new program announced by the DuPont Company, to assist and advance the teaching of chemistry. The program goes into operation next fall. To 19 four-year private colleges DuPont has made grants to help the schools maintain their outstanding performance in the training of students majoring in chemistry. To 13 universities—including Caltech—the company has awarded postgraduate fellowships to improve the teaching of chemistry to undergraduates. The new plans broaden the company's present program of support for postgraduate study and fundamental research in universities, which will total $600,000 for the academic year of 1953-54.

CONTINUED ON PAGE 32

The DuPont postgraduate teaching fellowships, which amount to a maximum of $3500 for married fellows, are to be awarded to outstanding graduate students who have had two years' experience as half-time teaching assistants.

"Teaching is a field which merits industrial support," said Crawford H. Greenewalt, president of DuPont, in announcing the new program. "The maintenance and encouragement of high-quality teaching is vital to the future supply and quality of scientists and consequently research."

Cancer Research

THE INSTITUTE last month received a $10,000 grant for cancer research from the Damon Runyon Memorial Fund. This was a renewal of a grant made last year.

Part of the grant, presented to Dr. George W. Beadle, Chairman of the Division of Biology, will be used for studies of growth-regulating mechanisms and part for studies of some naturally occurring carcinogenic substances.

The studies of growth-regulation will be conducted on the bread mold *Neurospora* by Dr. Sterling Emerson, Professor of Genetics. These have been undertaken, Dr. Beadle says, because changes from normal to tumorous growth appear to result from alterations of body processes which regulate growth. The funds allocated to the Division of Biology will also help support the continued research of Dr. J. W. Dubnoff on enzymes and transmethylation processes.

In the Division of Chemistry and Chemical Engineering, Dr. L. Zechmeister, Professor of Organic Chemistry, and Dr. B. K. Koe have isolated some carcinogenic substances from barnacles. These substances are not inherent in the barnacles, according to the investigators, but enter them with small floating particles from the ocean. They may originate from either natural tars or artificial tar products.

SOME NOTES ON STUDENT LIFE

Out of Season

IN SPITE OF THE fact that it is now mid-season in basketball, football has held the interest of the conversationalists in the houses lately. The NCAA ruling, which effectively eliminates the two-platoon system that has been in effect since 1941, has been the subject of much debate. Though some have adopted the attitude of "I don't believe it," the general consensus seems to be "It can't be done." But Caltech men, invariably optimistic, are going to try; and the valiant attempt of footballers to change their styles is capturing the hearts of all Techmen.

The defensive specialist is gone forever, it seems, and defensive ends are forcing themselves to learn to catch passes. By the same token the offensive specialist is gone, too, and Tech quarterbacks are learning how to stop plays as well as start them. With football season over, it would seem a little strange, under normal circumstances, to see the gridiron giants practicing; so in order to allay any suspicion of 'snaking' football they have turned to more subtle ways of practicing.

Who would suspect that under the guise of a water fight with a rival house the grid star is practicing his football lessons? Who would believe that he is throwing that water-filled balloon for practice in passing alone? Who would be able to tell that his dashing through a hail of oranges is merely to develop a sure-footed running attack? Who would think that the fevered battles for the Ricketts brakedrum are merely trial runs for a new and smashing gridiron defense? A great football team is obviously in the making!

Each Caltech man can thank his lucky stars that the Institute is placed in such a favored spot as southern California, where water is cheap and the oranges grow on trees (as, in fact, they do in most parts of the globe) so that such heated off-season football practice can exist.

Preliminary Event

AS A PRELIMINARY to the main event, the Freshmen elected a new set of officers last month. After much parliamentary haggling, amendments to the amendments, the reversal of precedence, and the bringing up of questions which even Robert's Rules of Order did not touch upon, a slate of candidates was picked.

Hurried conferences of political bigwigs pondered election strategy, and, in spite of their inexperience with this type of campaign (most of the candidates and their backers had come from schools where the fickle women's vote was all important) the political czars seemed pleased with the slate of candidates. Petty differences discounted, everybody seemed pleased with the new Freshmen officers, too.

It was truly heart-rending to hear many of the candidates decline nomination for offices, professing rare tropical maladies and mental inability. It was quite evident, however, that these maladies and inabilities would undoubtedly disappear come time for ASCIT elections the middle of this month. —*Bill Barlow, '56*

ALUMNI NEWS

San Francisco Chapter

President DuBridge will address members of the San Francisco Chapter of the Alumni Association at a dinner meeting to be held on February 12 at the Leopard Cafe in San Francisco. Wives and guests are welcome, and reservations may be made through any of the San Francisco Chapter officers, whose names, addresses and phone numbers are listed on page 47 of this issue.

John Clark Lewis

John Clark Lewis '20, brother of Howard B. Lewis '23 and uncle of Howard B. Lewis, Jr. '48, died January 10 from injuries suffered in an automobile accident. John was born in Riverside, California in 1895. He graduated from the Riverside High School in 1913 and entered Pomona College the same year. Interruptions for work and Army service in World War I delayed completion of his college work till the spring of 1920.

He worked as Assistant City Engineer in South Pasadena till 1924, then went to Riverside to the County Surveyor's office, and later to the County Assessor's office, where he served until 1942. In 1942 he joined the Lewis-Larson Company in Los Angeles and since January 1948 had served as Manager of the Co-Jay Corporation, an affiliate of Lewis-Larson. In the last few months he had completed a new plant for the Co-Jay Corporation in Costa Mesa, California, and had moved there with his family.

John married Isabel McEuen in Riverside in 1927. She and her daughter, Mrs. Guy T. Edgcomb, are establishing in his memory a fund at Caltech to assist worthy undergraduate students, and have suggested that those wishing to join them in this tribute to him do so.

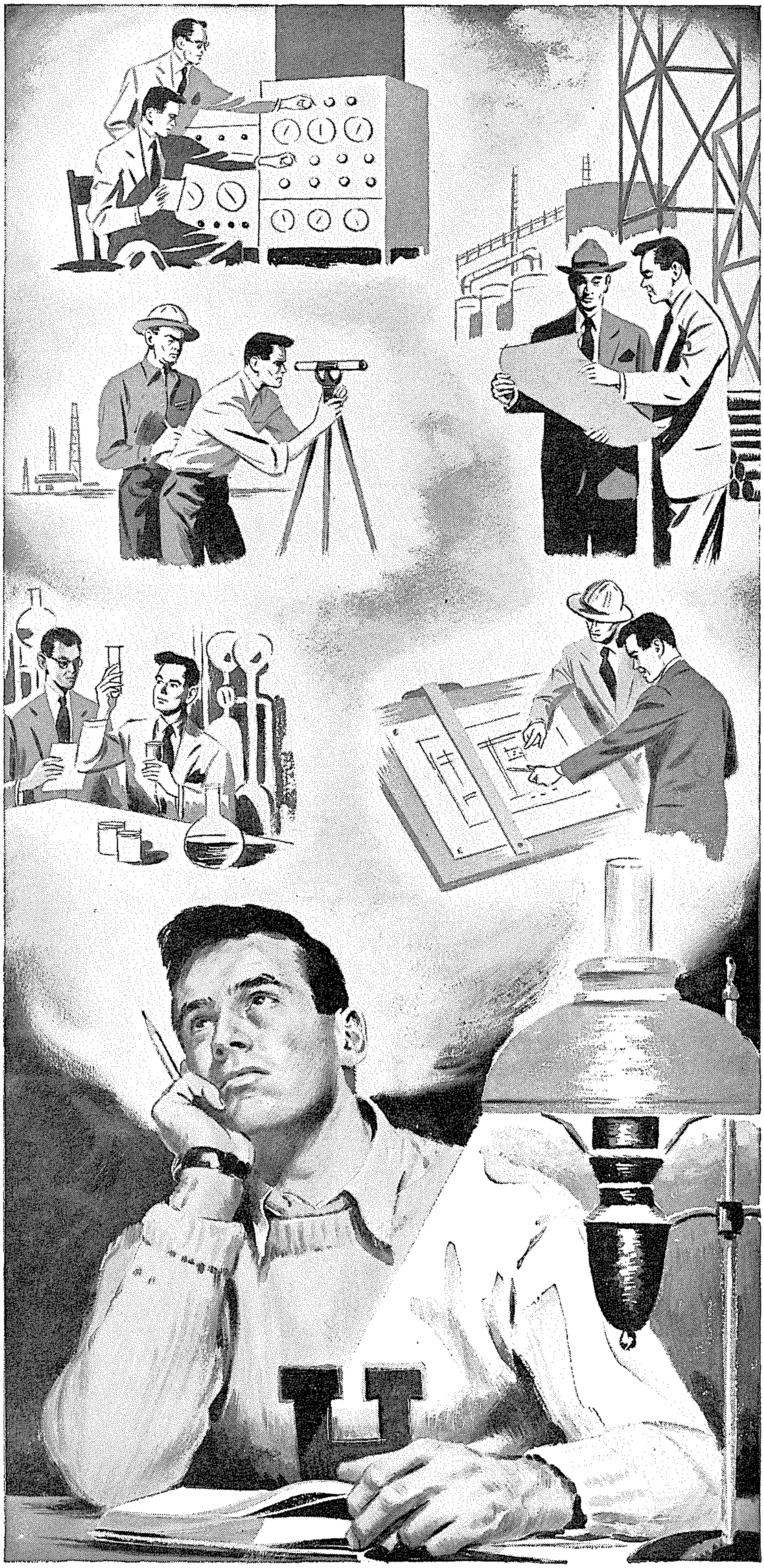
Alumni Fund Report

The Caltech Alumni Fund was conceived on March 28, 1946, and is now in its seventh year. On December 15, 1952, the Fund totaled $138,301.02. This year should produce the first tangible evidence of the outstanding success which the Fund is proving to be. The hopes of being able to start construction of a swimming pool and locker room last year, as the first phase of the gymnasium program, were doomed to disappointment because of the steel strike and resultant inability to obtain the necessary steel. However, steel will be made available during the first quarter of 1953, and there is every expectation that actual construction can start by April first of this year.

Plans and specifications are being prepared by the Institute staff for a regulation-size heated outdoor swim-

CONTINUED ON PAGE 36

What Can Phillips Offer the Technical Graduate?



ming pool, with adjoining dressing rooms, lockers and showers. In selecting the site and layout for the pool, consideration is also being given to integration of this unit with the projected gymnasium and other athletic facilities. The best available estimate on cost of the swimming pool and locker room is $150,000, with every expectation that the Fund will exceed that figure this year.

In keeping with the original concept of the Alumni Fund, it will be continued in future years, with the proceeds being made available to the Institute for those projects which the Alumni Association and Institute agree to be worth while. The solicitation for the Fund is conducted each year by direct mail to all those men who have received undergraduate or graduate degrees from Caltech. The expense of conducting this campaign is handled as an item in the budget of the Alumni Association, so that all of the contributions made to the Fund are available for the intended purpose. Contributions to the Alumni Fund are deductible from income for tax purposes, within the usual limitations on such contributions.

The Alumni Fund is rapidly becoming one of the major activities of the Alumni Association. The Fund's activities are guided by the Board of Directors of the Alumni Association, with two directors being specifically assigned to this function. They have been:

1947-48 H. B. Lewis and J. W. Lewis
1948-49 J. W. Lewis and R. F. Mettler
1949-50 R. F. Mettler and R. J. Hare
1950-51 D. C. Tillman and E. J. Macartney
1951-52 D. C. Tillman and K. E. Kingman
1952-53 K. E. Kingman and A. A. Ray

Assistance in the Fund's activities is also given by the Vice Chairmen, who currently are as follows:

1898—'23 G. A. Alles
1924—'32 Phillip Cravitz
1933—'40 Holley B. Dickinson
1941—'46 Frederick H. Felberg
1947—'51 Wm. A. Freed

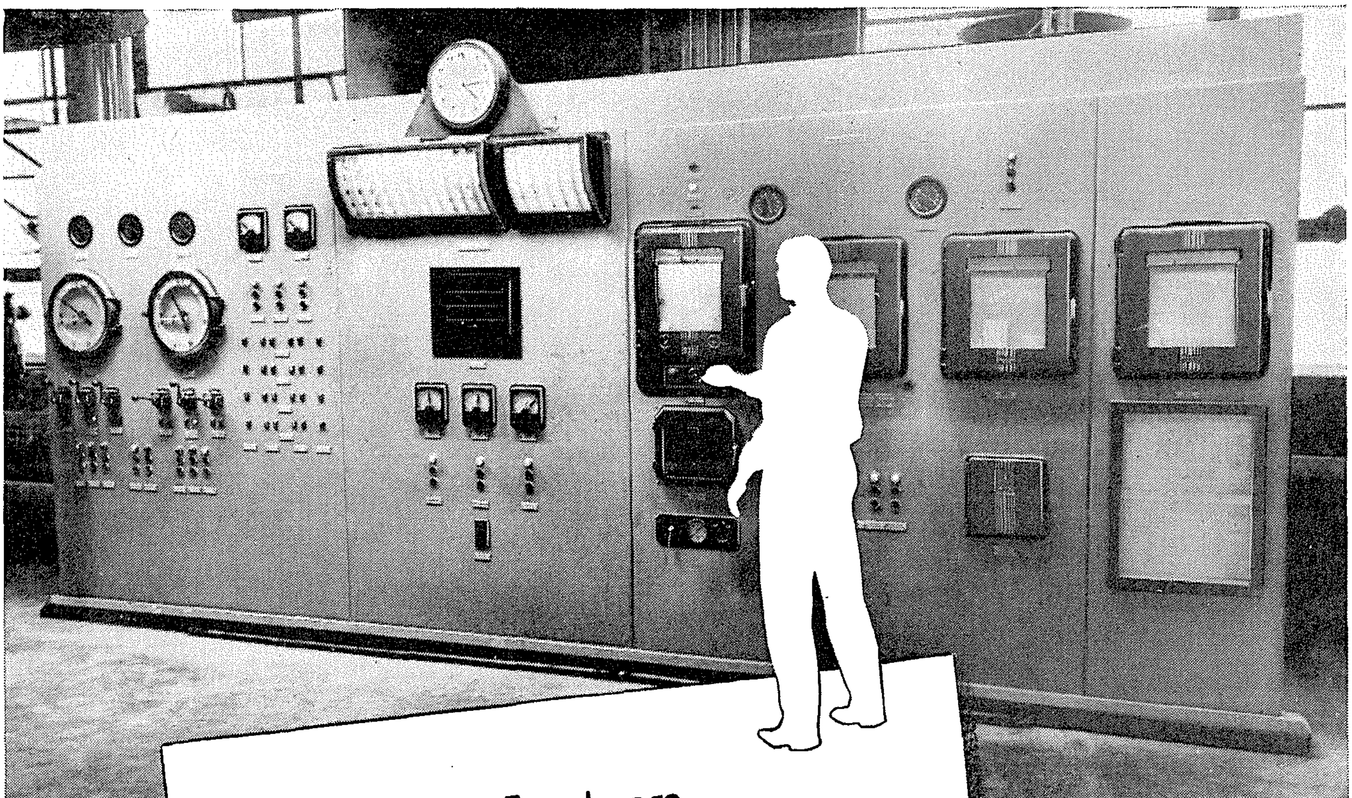
The Secretaries of the graduating classes, as well as the Presidents of the various Alumni Chapters, also assist in the solicitation efforts.

—K. E. Kingman '29

Seminar Coming Up

THE SIXTEENTH ANNUAL ALUMNI SEMINAR is beginning to take form under the general supervision of Kenneth F. Russell '29, member of the Board of Directors. Ken is general manager of the Vortox Manufacturing Company. The detailed planning for the event, to be held on April 11, is in the hands of an able committee led by C. Vernon Newton '34. Newton is production manager for the California Walnut Growers Association and

CONTINUED ON PAGE 40



Meet an Engineer-Businessman… Class of '50

● One of the interesting angles of L&N Field Engineering is that you get into it *soon*. You're not rushed—you get full training, and what's more, you're trained as an individual, with full recognition of your present strengths. But, even so, it's only a few months before you're ready for the polishing of field service work, and that in turn swiftly fits you for a business day something like this:

You start off with a visit to, say, a bolt-making plant. There you gather the instrument-engineering facts about a new heat-treating furnace, and make a date to bring in your recommendations for temperature-control equipment . . . You didn't solicit this sales call; the firm is an old L&N friend, and you've been given the responsibility of meeting their present and future requirements.

After lunch you're in another plant, checking instruments. You find one of the instrument relays pretty well shot, and promise to bring in and install a new one.

You're especially happy about your next stop, because they got their first L&N instrument when the manager "bought" your analysis and recommendation for control of a galvanizing kettle-furnace . . . Now, he wants to know how you'd improve the control of a malleableizing furnace.

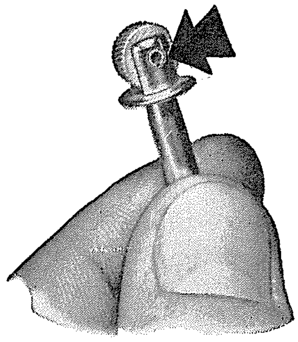
Back at the office, you talk things over with another sales engineer, who supervises your work. He verifies your ideas about both the controls you discussed with customers; suggests you check one of them with the district manager, in case that new accessory from the home office should be included . . . And he has a request that you call at an aircraft plant tomorrow or the next day.

And so, almost before you know it, you're on the ladder and climbing. This big, long-established firm is helping you develop your talents as engineer-business man, and can use them in your well-paid present and attractive future. Why not make an L&N date through your placement bureau?

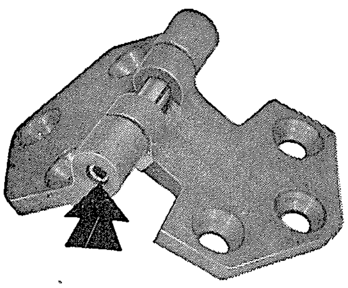
LEEDS NORTHRUP
instruments *automatic controls • furnaces*

Atlanta	Cincinnati	Houston	San Francisco
Boston	Cleveland	Los Angeles	Seattle
Buffalo	Detroit	New York	St. Louis
Chicago	Hartford	Pittsburgh	Tulsa

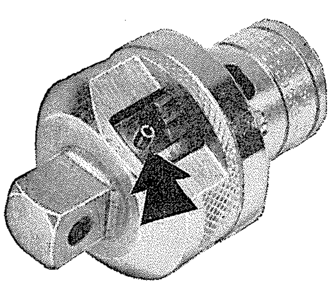
Jrl Ad ENT-560(2)



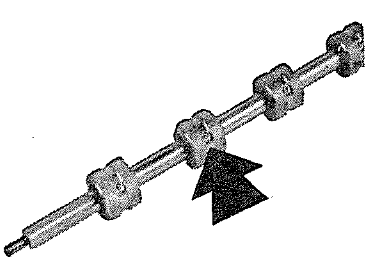
Replacing a rivet



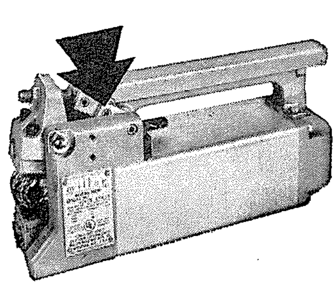
. . . a hinge pin



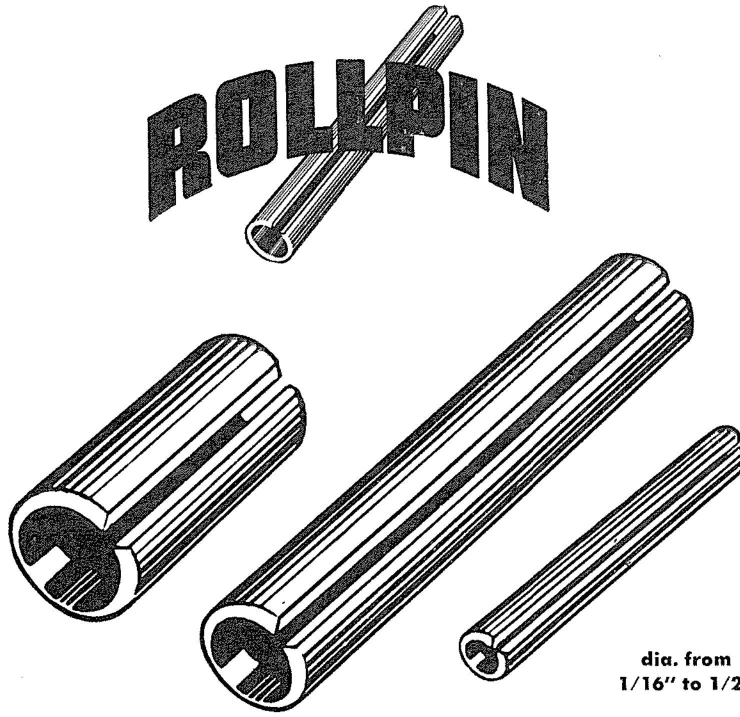
. . . a stop pin



. . . a set screw



. . . a bolt and nut



. . . a modern fastener that saves time and money on thousands of applications

Rollpin is a hollow, split, cylindrically formed pin with chamfered ends. It is simply driven into holes drilled to normal production tolerances. Because Rollpin is slightly larger than standard sized holes, it compresses as inserted. It is self-locking—and vibration-proof—because of the constant pressure it exerts against hole walls. Its shear strength exceeds that of a cold rolled pin of the same diameter. Rollpin is readily removed with a drift or pin punch—and can be reused.

Because of its versatility—and the production economies it makes possible—Rollpin is finding wide usage in almost every phase of manufacturing activity. Write for design information on the Rollpin. It will enable you to cut costs for many applications where use of rivets, set screws, dowels, and straight, serrated or cotter type pins create installation or performance problems.

ELASTIC STOP NUT CORPORATION OF AMERICA

2330 Vauxhall Road, Union, New Jersey

Elastic Stop Nuts with the famous red collar are another ESNA product

ESNA

has had previous experience in preparing for an Alumni Seminar.

Arrangement of the program is being handled by Hugh C. Carter '49, Wesley M. Dynes '47, Willis R. Donahue, Jr. '34, and Emmett M. Irwin '24. Hugh Carter, who is with the Bechtel Corporation, is chairman of the Program Committee and promises an excellent session this year. Wesley Dynes, while spending his days as sales engineer for Ingersoll-Rand Company, is working over the faculty to unearth hidden material for the program. Willis Donahue, employed by General Petroleum Corporation as assistant manager of the Gas Department, is new material for the Program Committee. Emmett Irwin, the owner of Induflux Testing Service, represents the view of the older classes on the Committee.

One of the most important items of the Seminar is food, consisting of midmorning coffee, lunch in the Student Houses, and dinner at the Elks Club in Pasadena. John E. Fleming '46, production planner with Clary Multiplier Corporation, and Ray E. Kidd '34, sales engineer with General Electric Company in Los Angeles, are shouldered with the responsibility of seeing that alumni and their guests are properly fed.

The job of getting the announcements about the Seminar to the alumni, and getting all the material printed, is the responsibility of George F. Weismann '29. George is manager of industrial sales with General Petroleum Corporation. The registration of those who attend this Seminar is in the hands of John R. Fee '51. John is an engineer with James M. Montgomery Consulting Engineers. He was treasurer of ASCIT while a student, and it is appropriate for a man with his name to be in charge of registration.

In planning and operating a seminar, the cooperation of Institute administration and faculty is necessary. Someone must be on location well in advance to arrange for rooms, signs, public address facilities, custodians, etc. The man for this job is Ernest B. Hugg '29, assistant superintendent of Buildings and Grounds for the Institute.

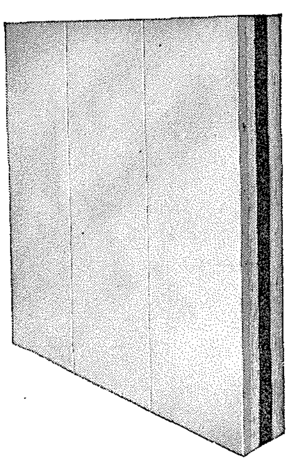
A lot of work goes into the planning, organizing, and operating the Seminar, and these men are doing a real job to provide the alumni with an outstanding program. Remember, save Saturday, April 11; get your baby sitter arranged for; give your wife a treat for a day by bringing her along; and, of course, bring some friends. Watch for the notice that will be mailed to all alumni in southern California. Alumni in other areas who expect to be in southern California on the 11th of April should write in for reservations.

What's Happening at CRUCIBLE

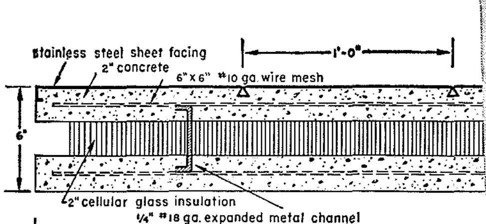
about stainless curtain walls

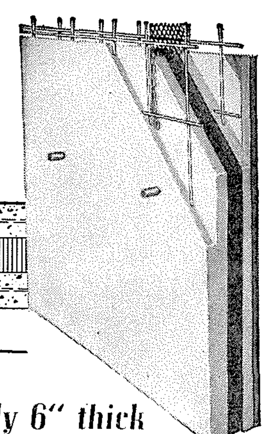
Modern construction methods have changed walls from the self-supporting type to a mere covering which does not support its own weight for more than one or two stories. Hence the definition of "curtain wall":—the facing or enclosure of the structural steel frame. This frame supports the entire weight of modern buildings.

The need has existed for a covering that would not only clothe the building, but be lightweight, economical and space saving. Because these requirements are more than adequately met with stainless steel curtain wall construction, this method is becoming increasingly popular with cost and space conscious owners, builders and architects.



the CRUCIBLE "sandwich"





the CRUCIBLE "sandwich"—only 6" thick

(can be less)

Crucible stainless steel curtain wall panels are in the form of 6-inch thick "sandwiches". The facing consists of flanged, light-gauge stainless steel sheets with a factory, or site-fabricated, sandwich consisting of cellular glass insulation between two layers of concrete with connecting reinforcing. Crucible 18-8 stainless as the outside face offers excellent resistance to weather and fire while providing eternal beauty with a minimum of maintenance; the inside face can be finished or painted to suit the requirements of modern building interiors. Since 18-8 is restricted in use, a good substitute material, type 430 stainless, now government decontrolled, offers the same benefits as 18-8 stainless.

moisture penetration

The unique characteristics of the cellular glass insulation stop moisture vapor migration from one face of the panel to the other. The cellular insulation properly designed and installed assures that condensation will not take place *anywhere* within the sandwich.

insulation

Although less than half as thick as the usual wall construction, this Crucible stainless steel panel construction has more than twice the insulating value. The "U" value (overall thermal conductivity) is approximately 0.15 BTU Hr./Sq.Ft./°F.

fire resistance

The Crucible sandwich met the requirements of a standard 4-hour fire test conducted in the testing laboratories of the National Bureau of Standards. This meets all old building codes and is double, or better, the requirements of modern enlightened building codes.

erection and fabrication

Since a building frame is not precision built, the attachment of the panel walls to the frame is done with fastening devices that provide necessary 3-dimensional adjustment. Panels can be made at the building site, and a 24-hour casting-to-fastening cycle is possible.

technical service available

Though the use of some stainless steel is now restricted, Crucible metallurgists and development personnel are continuing to investigate improved methods of curtain wall and other construction so that better buildings can be built when stainless is more freely available. For more information write: CRUCIBLE STEEL COMPANY OF AMERICA, General Sales and Operating Offices, Oliver Building, Pittsburgh, Penna.

CRUCIBLE first name in special purpose steels

52 *years of Fine steelmaking*

Midland Works, Midland, Pa. • Spaulding Works, Harrison, N. J. • Park Works, Pittsburgh, Pa. • Spring Works, Pittsburgh, Pa. National Drawn Works, East Liverpool, Ohio • Sanderson-Halcomb Works, Syracuse, N. Y. • Trent Tube Company, East Troy, Wisconsin

PERSONALS

1917

Harry T. Meyer died on November 15, 1952 of arteriosclerosis. Harry was one of our early electrical engineering graduates, and after leaving Tech went to work for General Electric in Schenectady. He was born in 1893 in Tempe, Arizona, and spent much of his life there as an operating engineer for the Central Arizona Light and Power Company. He is survived by his wife, Matty.

1922

Charles F. Ritchie joined the Mallinckrodt Chemical Works in St. Louis, Missouri, in January, 1945. Shortly after, he says he was dumped into "The Project"—meaning the refining of uranium ores to molecular-weight purity salts and metal on a large-scale basis. He rates as something like Assistant Technical Director now, and finds the work interesting, but can't let out much detailed data. Charlie was married to Elinor Close Cashman after the death of his first wife in 1943.

Howard G. Vesper was recently elected vice-president of Standard Oil Company of California. Howard, who is president of California Research Corporation, Standard's research subsidiary, joined the oil company in 1922. Following service in research and development at Standard's El Segundo refinery, Howard worked as a salesman in foreign trade operations in New York City and then returned to Standard's manufacturing department. He was manager of gasoline and fuel oil marketing when he became president of Cal Research in 1946.

1924

Eugene W. Smith is the new president of Cogswell Polytechnical College. Gene, who was formerly vice-president and dean of men, first joined the Cogswell staff in 1930 as an instructor in mechanical engineering. He began his career in the engineering department of the Union Oil Company of California.

1928

Nicholas A. D'Arcy, Jr., Ex., has recently been made chairman of the Southern California Section of the AIMME.

1929

Duane Roller, Ph.D., received the honorary degree of Doctor of Science at Hamline University, St. Paul, Minnesota, in connection with the dedication of a new natural science building. Duane is at present a special consultant to the Director of Hughes Aircraft Research and Development Laboratories in Culver City.

1930

Jack Sturgess, his wife, Mary Jane, and two children (Jane, 4, and John, 2) are living in San Gabriel. Jack has recently been on assignment by the Union Oil Company of California to Washington, D. C., and is now in inventory work for Union Oil at Los Angeles.

Francis Dashwood Bode, M.S. '31, formerly an instructor in the Geology Division, and for the past ten years with the California Division of the Texas Company, has now been made Chief Geologist of the Rocky Mountain Division of the Texas Company. The Rocky Mountain District is the second largest of the Texas Company's several divisions.

1934

Thomas P. Thayer, Ph.D., is still with the Mineral Deposits Branch of the U. S. Geological Survey, and says he spent most of the year pushing papers on the Defense Mineral program. He spent seven weeks in Liberia recently, examining iron deposits in the Eastern Province and logging 1300 feet of new drill cores at Bomi Hill. While there, Tom received a decoration as Commander, Order of the Star of Africa, from the Liberian Government (*E&S*—Oct. '52).

Norman L. Hallanger, M.S. '36, after 16 years with the airlines, has joined the Ralph M. Parsons Company on a research project, and is temporarily located in Minneapolis, Minn. His children, Larry, 13, and Ann, 11, are enjoying the ice skating, sledding, skiing, etc., but they are all looking forward to returning to California.

1936

Robert G. Parker, Ex., has been promoted to production manager for Continental Oil Company's central region, with headquarters in Oklahoma City, Oklahoma. Bob joined Continental as a driller in 1939, and in 1948 was moved to Conoco's production offices at Wichita Falls, Texas. In 1950 he became area production manager at Fort Worth, and two years later was promoted to assistant production manager for the company's southwestern region.

1938

Henry S. Hopkins, Engr., is at present assigned as technical representative to the U.S.A.F.'s Military Air Transport Service Headquarters at Andrews Air Force Base in Maryland. The Hopkins' have a family of three children: two sons—Robert Alan and Edward Brian; and a daughter—Christine Melinda, born last May.

Frank Jewett was promoted last summer

from Director of Development and Business Administration in General Mills' Research Department to Vice President in charge of Industrial Development and Marketing in the G. M. Mechanical Division. He also bought a farm in partnership, in the Borrego Valley. So far, he says, it's been all outgo—no income. The Jewetts' fourth child, a girl, was born in May, making it now an even two to two ratio. Frank is now Alumni Trustee of the Labor Academy.

Peter Kyropoulos, M.S., Ph.D. '48, has been named Regional Councilor of the Office of Ordnance Research, set up in 1951 by the Ordnance Department to "plan, sponsor and encourage basic scientific research in fields of knowledge fundamental to ordnance techniques." Kyro's position with OOR will be largely that of advisor and coordinator. He'll be working closely with J. B. Edson, western representative for OOR, with offices in the Vista Del Arroyo Hotel in Pasadena.

Newman A. Hall, Ph.D., has been made Director of the Engineering Sciences Division of the Office of Ordnance Research. Newman will keep his job as Chairman of the Mechanical Engineering Department at the University of Minnesota, but he'll now be spending three weeks out of every month at OOR headquarters, at Duke University, Durham, North Carolina.

1939

Col. T. Hills, M.S., is a student at the Industrial College of the Armed Forces at Fort Lesley J. McNair in Washington, D. C.. until June, '53.

Willard M. Snyder is still busy flying for the Bureau of Reclamation and has gotten in some aerial photography work along with other assignments. The Snyders have been in their home in Billings, Montana, which they designed and built themselves, for two years now. He says he doesn't miss the California climate as much as you'd think, and finds even their below-zero temperatures fairly bearable. Besides, they are in one of the last hunters' and fishers' paradises and would be glad to see any hardy alumni who might venture that far into the wilds.

1941

Fred W. Billmeyer, Jr., is working as a research chemist at E. I. duPont de Nemours & Co. at the Experimental Station in Wilmington, Delaware, on the molecular structure of high polymers. He is also a lecturer in high polymers for the University of Delaware. Fred was married in August, 1951, and has a daughter (Eleanor Ann) born December 2, 1952. He expects to participate in the Spring ACS meeting to be held in Los Angeles in March.

Jerry Jones is working with the Georgia Division of Lockheed Aircraft Co. as Materials and Process Group Engineer. He was married February 14, 1952. Other Caltech alumni at Lockheed in Georgia include *Harry Davis* '39 and *Herb Ellis* '38.

1942

Lt. Kenneth H. Beers is completing his tour of active duty with the U. S. Navy, and is due for release in May of this year. He's looking forward to being a civilian again, though he has no definite plans for the future. He admits to having developed a deep hatred of the smog in southern California, even though he's a native—due to living in what he considers the superior atmosphere of Key West, Florida.

Jack L. Alford, Ph.D. '50, formerly a Research Fellow here at Caltech, is now Head of the Structural Mechanics Branch, Underwater Ordnance Department, of the U.S. Naval Ordnance Test Station in Pasadena.

1944

Willis A. Bussard resigned last December from the DuPont Company after six years of production work in nylon and dacron. He is now with Industrial Models, Inc. of Delaware, a small, young company which makes scale models of new industrial plants. These models are being used by designers of chemical plants as a design tool, as well as by construction groups to expedite work and avoid delays, and as operator training aids. The Bussards now live in Arden, Delaware.

1946

John C. Nickerson, Jr., M.S., writes that he is in the atomic energy section of the research and development division, G-4, of the Army General Staff. He and his family, which consists of wife, Carol, and Jeanne (10), Charles (9), and Dan (1), live in Fairfax, Virginia. John transferred to the Ordnance Corps in November, 1952.

Dansy T. Williams, M.S., has been employed for several years by the U. S. Weather Bureau, and for the past two years has been Field Manager of the Tornado and Squall Line Project with headquarters in Kansas City. As such, he supervises the operation of the project and also conducts some of the research studies.

William W. Butler, M.S., is a project supervisor for Engineering Research Associates, a division of Remington Rand Corp. The Butlers had their fourth son last year.

1947

Elmer E. Hall, M.S., was released from the USMC and spent last summer in Eureka as resident engineer and rock revetment for a new Pacific Gas and Electric Company plant. He and his wife and two children have now settled in Auburn, where Elmer is a resident engineer for miscellaneous hydro construction.

Robert Ilfeld, M.S., reports the arrival of his third child (second daughter), just a few weeks before the family moved into their new house in Jackson, Michigan. The Ilfelds also have another reason to cele-

PERSONALS . . . CONTINUED

brate; Bob has been appointed Executive Vice-President and General Manager of Quick Industries. Caltech alumni passing through Jackson are invited to stop in and see the Ilfelds at 755 Bloomfield Blvd.

Richard C. Gerke, M.S., is now president of the Junior Forum, Los Angeles Section, of the American Society of Civil Engineers. Dick is a sales engineer at the Bethlehem Pacific Coast Steel Corporation.

1948

Jeff Williamson, M.S. '49, is currently with Sverdrup & Parcel, Inc., Consulting Engineers in St. Louis, working as an aerodynamicist on the design of a ram jet test facility for the Arnold Engineering Development Center in Tullahoma, Tennessee. Jeff says he's still a bachelor, due to the demands imposed upon his time and attention in maintaining the cleanest MG in St. Louis in the manner to which it is accustomed. (You don't just buy a sports car, says Jeff; you practically marry it.) His non-automotive hobby at present is the collection of vintage wines—a project which has now attained considerable dimensions.

Hugo Schwartz, M.S., has been in Israel for four years now, and is managing director of a plant manufacturing brake linings, moulds for the plastic industry and dies for the sheet metal industry. He's married, but has no family as yet. This report comes from *H. Darwin Kirschman* '18, who spent a day with Hugo and visited his father's plastic factory in Tel Aviv. To all alumni, old and new, Hugo says, "Look me up when in Israel."

Harold Mooney, M.S., Ph.D. '50, is Assistant Professor of Geophysics at the University of Minnesota. He has been working for two years on a study of the magnetic properties of rocks throughout Minnesota, but plans to spend next summer in the Southwest. Harold has two daughters now, born in March, 1951, and July, 1952.

1949

W. N. Harris, M.S. '50, has been transferred by the California Research and Development Co. from the Livermore Research Laboratory to the Argonne National Laboratory in Chicago for study and work on atomic power reactors.

Charles H. Arrington, Jr., Ph.D., was made supervisor of physical chemistry research at the DuPont Experimental Laboratory in Wilmington, Delaware, last February.

Ensign Keith Kohnen worked for the Ingersoll-Rand Company (in the gas engine department) in New York City for two years, before joining the Coast Guard. He says he's thoroughly enjoyed assignments as Assistant Engineer Officer on Cutters out of first Long Beach and then Honolulu. At present, Keith is undergoing treatment at the Marine hospital in San Francisco, and looking forward to becoming a civilian again next summer.

Donald W. Peterson is now working as a geologist with the Mineral Deposits Branch of the U. S. Geological Survey and is living in Globe, Arizona.

1950

Edwin Reinecke is living in La Crescenta and is in business with his two brothers. The company, FEBCO, Inc., of which Ed is president, manufactures valves and automatic lawn sprinkler controls.

John K. Inman is still working for his Ph.D. in biochemistry at Harvard. He's in his third year there, doing research in the physical chemistry of proteins at the Medical School. He is also teaching at Harvard and at Wellesley College.

J. B. Alexander, M.S., writes from Batu Gaja, Perak, that he has been promoted to principal geologist in the Malayan Division of the British Colonial Geological Survey. The Malayan Survey is expanding and planning new headquarters buildings, which, along with his regular Survey duties, keeps him very busy. He still found time, last year, to complete the work for and receive the Ph.D. degree from the University of London; and to marry Rosa Sum Ching Yeuk, daughter of the late Governor of Canton.

Bill Lansdown is still in Kansas City, working for the Midwest Research Institution on electronic instrumentation to measure pressure, temperature, strain, and time. Bill keeps busy with church and Sunday school work, and spent his vacation as counsellor at the Kansas Bible Camp last August.

1951

Donald E. Sanderson, who is working on his Ph.D. in math at the University of Wisconsin, received a $1050 fellowship in math and education this year. The Sandersons had an addition to their family last February 28—a son, Robert Charles.

Rich Smyth and his wife Emilie report the arrival of a daughter, Gretl Suzanne, on January 11. Rich changed jobs on January 5 and is now working for North American Instruments, Inc. in North Hollywood. He works for *Gene Bollay*, M.S. '36.

Kent Stratton is in New York, still convalescing from his auto accident last September.

John Moss was married last December and is still in Houston, Texas.

1952

Henry Keswick is now with the Arabian American Oil Company (Aramco), stationed in Saudi Arabia. He has signed a contract for two years, and is working as a mechanical engineer.

Gilbert E. Stegall, M.S., is the Meteorologist in Charge of the Weather Bureau's records processing center in Kansas City, Missouri.

ALUMNI ASSOCIATION OFFICERS

PRESIDENT
John E. Sherborne '34

VICE-PRESIDENT
Gerald P. Foster '40

SECRETARY
Donald S. Clark '29

TREASURER
George B. Holmes '38

BOARD OF DIRECTORS
K. E. Kingman '29
Fred H. Felberg '42
Francis M. Greenhalgh '41
Kenneth F. Russell '29
Hallan N. Marsh '22
Allen A. Ray '35
Richard W. Stenzel '21

ALUMNI CHAPTER OFFICERS

New York Chapter:

PRESIDENT Howard E. Baker '30
Underwriters Labs., Inc., 161 Sixth Ave.

VICE-PRESIDENT Erwin Baumgarten '40
Calco Division, American Cyanide Co., Bound Brook, N. J.

SECRETARY-TREASURER S. Kendall Gold '42
California-Texas Oil Co. Ltd., 551 Fifth Ave., N. Y. 17

San Francisco Chapter:

PRESIDENT Robert R. Bowles '41
California Research Corp., 576 Standard Ave., Richmond

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

SECRETARY-TREASURER Robert G. Heitz '36
Dow Chemical Company, Pittsburg, California

The San Francisco Chapter meets for lunch at the Fraternity Club, 345 Bush St., every Thursday.

Washington, D. C., Chapter:

PRESIDENT F. Miles Day '46
8704 Barron St., Takoma Park, Md.

SECRETARY-TREASURER Howard Goodhue '24
3618 N. Potomac St., Arlington 13, Va.

Sacramento Chapter:

PRESIDENT Fred Groat '24
California Division of Water Resources,
Public Works Building

SECRETARY-TREASURER Richard Silberstein '41
Arthur A. Sauer, Consulting Structural Engineer,
2203 13th St.

Chicago Chapter:

PRESIDENT LeVan Griffis '37
Armour Research Foundation, 35 W. 33rd 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.

CALTECH CALENDAR

February 1953

ALUMNI ACTIVITIES

February 7	Dinner Dance
March 4	Dinner Meeting Los Angeles area
April 11	Annual Seminar
June 10	Annual Dinner Meeting
June	Annual Family Picnic

ATHLETIC SCHEDULE

VARSITY BASKETBALL

Feb. 10, 4:30 p.m.
Nazarenes at Caltech
Feb. 14, 9:00 p.m.
Pomona at Caltech
Feb. 17, 4:30 p.m.
Chapman at Caltech
Feb. 21, 8:00 p.m.
Caltech at L.A. State
Feb. 24, 8:15 p.m.
Occidental at Caltech
Feb. 28, 7:15 p.m.
Redlands at Caltech

FROSH BASKETBALL

Feb. 10, 4:30 p.m.
Nazarenes at Nazarene College
Feb. 13, 9:00 p.m.
Pomona at Occidental
Feb. 25, 6:45 p.m.
Occidental at Caltech
Feb. 27, 7:15 p.m.
Redlands at Occidental

DEMONSTRATION LECTURES

Friday Evenings

7:30 p.m.—201 Bridge

Feb. 13 "Viruses," by Prof. Renato Dulbecco

Feb. 20 "Liquid Air," by Prof. E. C. Watson

Feb. 27 "The Beginnings of Experimental Chemistry in America," by Prof. Henry Dan Piper

Mar. 6 "The Structure of Metals and Alloys," by Prof. Gunnar Bergman

All kinds of engineering jobs call for photography

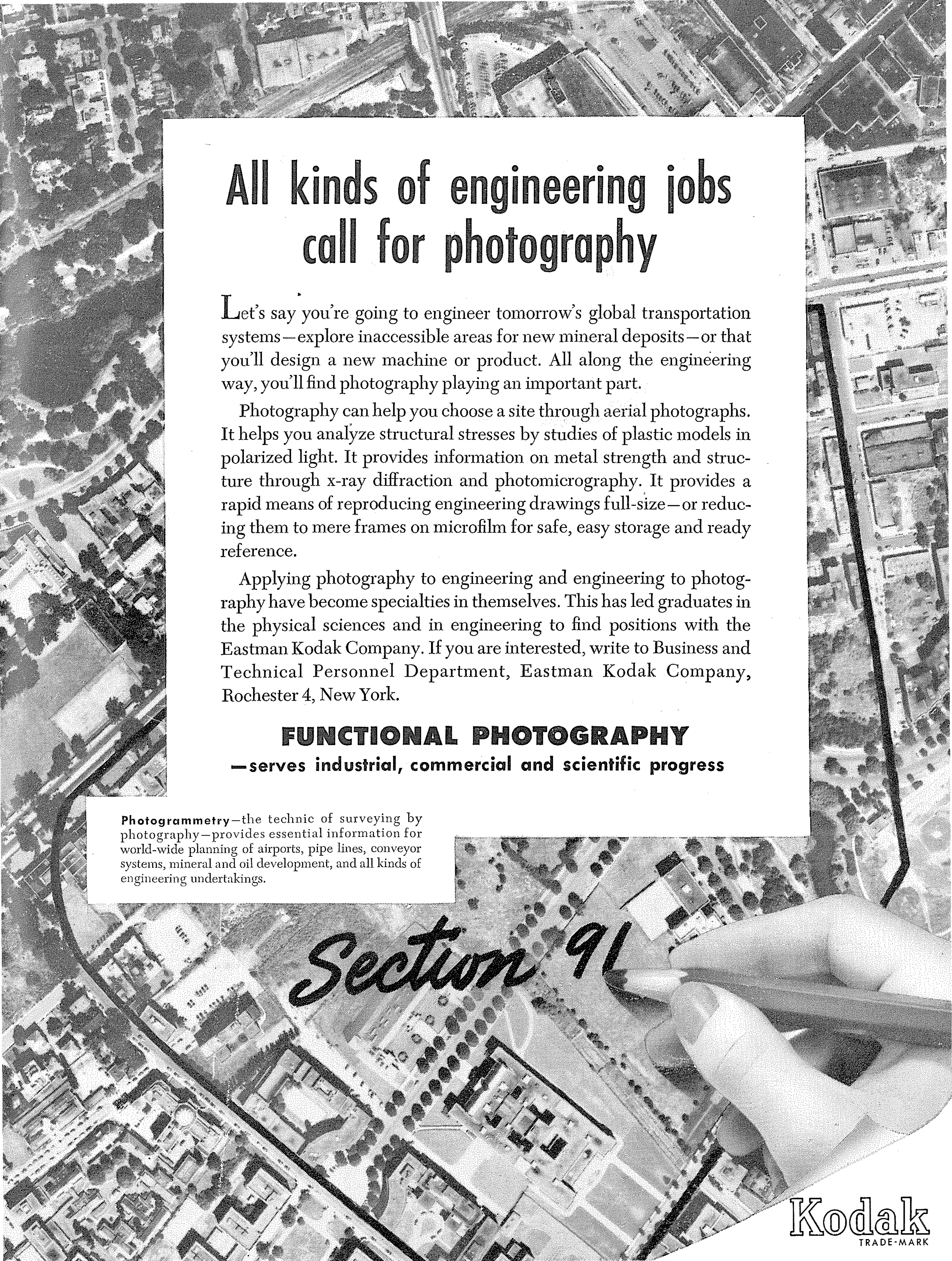
Let's say you're going to engineer tomorrow's global transportation systems—explore inaccessible areas for new mineral deposits—or that you'll design a new machine or product. All along the engineering way, you'll find photography playing an important part.

Photography can help you choose a site through aerial photographs. It helps you analyze structural stresses by studies of plastic models in polarized light. It provides information on metal strength and structure through x-ray diffraction and photomicrography. It provides a rapid means of reproducing engineering drawings full-size—or reducing them to mere frames on microfilm for safe, easy storage and ready reference.

Applying photography to engineering and engineering to photography have become specialties in themselves. This has led graduates in the physical sciences and in engineering to find positions with the Eastman Kodak Company. If you are interested, write to Business and Technical Personnel Department, Eastman Kodak Company, Rochester 4, New York.

FUNCTIONAL PHOTOGRAPHY

—serves industrial, commercial and scientific progress



Photogrammetry—the technic of surveying by photography—provides essential information for world-wide planning of airports, pipe lines, conveyor systems, mineral and oil development, and all kinds of engineering undertakings.

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