ENGINEERING | AND | SCIENCE

DECEMBER / 1950

Students' Day . . . page 14

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

CARGO: Big Business for Little Businessmen!

YOUR Mobilgas dealer has a stake in this tanker—and in *all* facilities we own or charter. So do 46,400 dealers and jobbers like him!

For fine quality product, efficiently supplied, competitive in price, is the very life-blood of "little" business, any business.

Here, in effect, our tanker is a cost-cutting tool for "little business"—helping to keep gas and oil prices down, business volume up.

The same thing is true of Socony-Vacuum's modern laboratories—the advanced refining methods and equipment with which we work to produce the *most* product of *highest* quality at *lowest* cost.

In short, your Mobilgas dealer—an independent local businessman—can offer the quality, price and other benefits you want—because of the efficient, integrated structure that supplies him.

YOUR NATION depends on strong industries . . .

YOUR INDUSTRIES are only as strong as your Companies

YOUR COMPANIES are only as strong as their ability to give you

Your Biggest Money's-Worth!

SOCONY-VACUUM

The Sign the Nation Knows . . . Builds as the Nation Grows!

SOCONY-VACUUM OIL COMPANY, INC., and Affiliates: MAGNOLIA PETROLEUM COMPANY, GENERAL PETROLEUM CORPORATION

Why they put a glass pipe line underneath Buttermilk Channel

If you've ever driven through a long tunnel, you know how hard the lights are on your eyes.

The reason is you pass under a succession of bright spots of light which are apt to take your attention from the road. And you're made uncomfortable by the reflection of these bright spots from the top of the car ahead.

But New York's new 9117-foot Brooklyn-Battery Tunnel—America's longest, built and operated by the Triborough Bridge and Tunnel Authority—has an amazingly different and better kind of tunnel lighting.

Instead of the disturbing flicker of lights placed at regular intervals, motorists enjoy bright and even illumination—practically daylight—every foot of the way beneath Buttermilk Channel and New York Harbor.

The pipe line for this flood of light is built of 3000 twelve-foot sections of Corning's Pyrex brand glass tubing. Each length of pipe is a self-contained light cartridge, with two slim fluorescent lamps inside.

Should one of the lamps die out, that cartridge is replaced with another, assembled and kept ready on a repair truck. And replacement is made as easily as you'd pop a new bulb into a light fixture in your home.

The twelve-foot sections of Pyrex pipe are only two inches in diameter, with walls only a quarter of an inch thick. But despite their slimness, they're so strong they can withstand washing with a high-pressure hose. They're so sturdy they're not injured by truck tarpaulins which sometimes work loose and slap against them.

Designers of this new tunnel lighting system had no trouble finding a material needed to make it work because, years ago, Corning developed heat-resistant Pyrex pipe for industrial use.

Throughout industry, *Corning means research in glass*—research that has helped make glass a material of practically limitless uses.

So, when you're out of college and busy planning new products or processes, or improvements in existing ones, it will pay you to keep glass in mind. Then we hope you will call on Corning before your planning reaches the blueprint stage. *Corning Glass Works, Corning, New York.*

CORNING
means research in glass

BOOKS

AIR POWER: KEY TO SURVIVAL
by Alexander P. de Seversky

Simon and Schuster, New York, $3.50, cloth; $1, paper

Reviewed by George K. Tanham, Instructor of History

AIR POWER: KEY TO SURVIVAL might well be termed a repeat performance, with some slight modifications made by the eight years that have gone by since Seversky's previous book. The thesis is the same one he advocated in *Victory Through Air Power* in 1942—that "air power alone can impose surrender on an enemy."

A common misunderstanding is that by this Seversky means strategic bombing of the enemy. He does not; he means "conquest of the air," and then bombing as an incidental procedure until the enemy seeks peace. He feels that once an opponent is stripped of his air power—just as in previous times when his army was wiped out—he will seek peace.

Two factors have added strength to the already persuasive nature of this thesis. In the first place World War II demonstrated the great value of air power, especially in the final defeat of Japan. Vannevar Bush, in his *Modern Arms and Free Men*, admits that, without friendly control of the air, land and sea forces are practically useless. Even opponents of air power concede that without air superiority other military operations are extremely difficult, if not impossible. In a sense this is encouraging to Seversky, but he claims that by clinging to the idea of the need for land and naval forces as *equal* partners in a future war, these thinkers have weakened the concept of air power and unnecessarily divided our defense effort. Since the war will be won by planes based in the United States, there will be no need for overseas bases or the army or navy.

A second factor strengthening the theory is that in the present cold war with Russia the United States is inferior in numbers and materials, and only in a technological sense does it have a real superiority. As this seems to be reasonably true, we must utilize our strength and wage war on our terms—not fight on Russia's terms of masses of men and material.

Since many Americans have recognized these facts, the Seversky theory becomes all the more appealing. He does not, however, foresee a twenty-four hour victory, but feels that there will be bitter and perhaps drawn-out fighting for air control. So it is no cheap or easy means of victory.

The weakness in this book seems to be the failure of the author to objectively appraise the defense. Since the offensive was dominant in the last war, he assumes that it always has been and always will be, though lessons of World War I would seem to indicate that at given periods of history the defense can be nearly impregnable.

Seversky claims that in air warfare all the instruments and methods used by the defense may be used by the bombers to combat the defensive forces. This may be true, but he fails to recognize the fact that the technique of ground installations (radar, etc.) and ground control have been and will probably remain superior to those utilized in a bomber.

Defensive aspects of battle

Two illustrations may be used to show Seversky's neglect of the defensive aspects of battle. In the first plan he states that escort planes will no longer be small one-seaters, but as large as bombers and equipped with all the latest scientific devices for air combat. He fails to point out that the defensive fighters may be of the same type.

Secondly, after he has admitted that homing devices and proximity fuses may be used by the defense, he then states that the same measures may be used by the bombers to explode the missiles aimed at them by the opposing ground defense. He neglects to say that if these devices are so perfected they might be used by the defending air forces against enemy bombers and fighters, and even to explode dropped bombs before they reach the target.

Even though Seversky relegates bombing to a minor role, it would seem that, if the war-producing capacity of a nation was not destroyed, the ability to continue the war would still exist. Therefore bombing would seem to be essential. While denying this, he gives great space to strategic bombing. Here again he assumes that precision bombing will be infallible and completely effective, though there is considerable evidence that during World War II bombers at times not only could not locate their targets, but also were ineffective against them. Vannevar Bush even goes so far as to say that the days of mass bombings are over, not only because of improved defenses, but because of the difficulty of hitting the targets.

While Major Seversky marshalls many facts, thinks clearly, and argues persuasively for his theory, it still seems a large gamble.

PLANT BIOCHEMISTRY
by James Bonner

Academic Press, New York, $6.80

FOR TWELVE YEARS Biology Professor James Bonner has been giving a course in plant biochemistry at the Institute. In the absence of any appropriate text the course has been conducted by lectures and readings in the original literature.

In this book, based on his course, Dr. Bonner has brought together the scattered work on general biochemistry as it applies to plants, and summarized those fields of biochemistry pertaining to the plant. As the only modern book in this field it is a valuable reference work for advanced students in the plant sciences, as well as a valuable text for courses in plant or agricultural biochemistry on the senior and early graduate level.

CHANCE AND CHOICE
by Lancelot Hogben

Chanticleer Press, New York, $9.50

Reviewed by Robert P. Dilworth, Assoc. Professor of Mathematics

AS STATED in the foreword to this book, Professor Hogben, author of *Mathematics for the Million* and *Science for the Citizen*, has here set himself the task of presenting the rationale of modern statistical methods to readers having a moderate mathematical background.

In order to accomplish this he has made extensive use of charts, diagrams and other visual aids. Thus many combinatorial theorems are given diagrammatic as well as formal proofs, and most of the illustrations are taken from situations which can conveniently be represented visually by cardpack or urn schemes. Furthermore, assuming a familiarity with the elements of the calculus, the book contains quite complete deriva-

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Build Confidence ON BROAD EXPERIENCE

by ARCH COOPER
Manager, Empire Region
ALLIS-CHALMERS MANUFACTURING COMPANY
(*Graduate Training Course—1909*)

ARCH COOPER

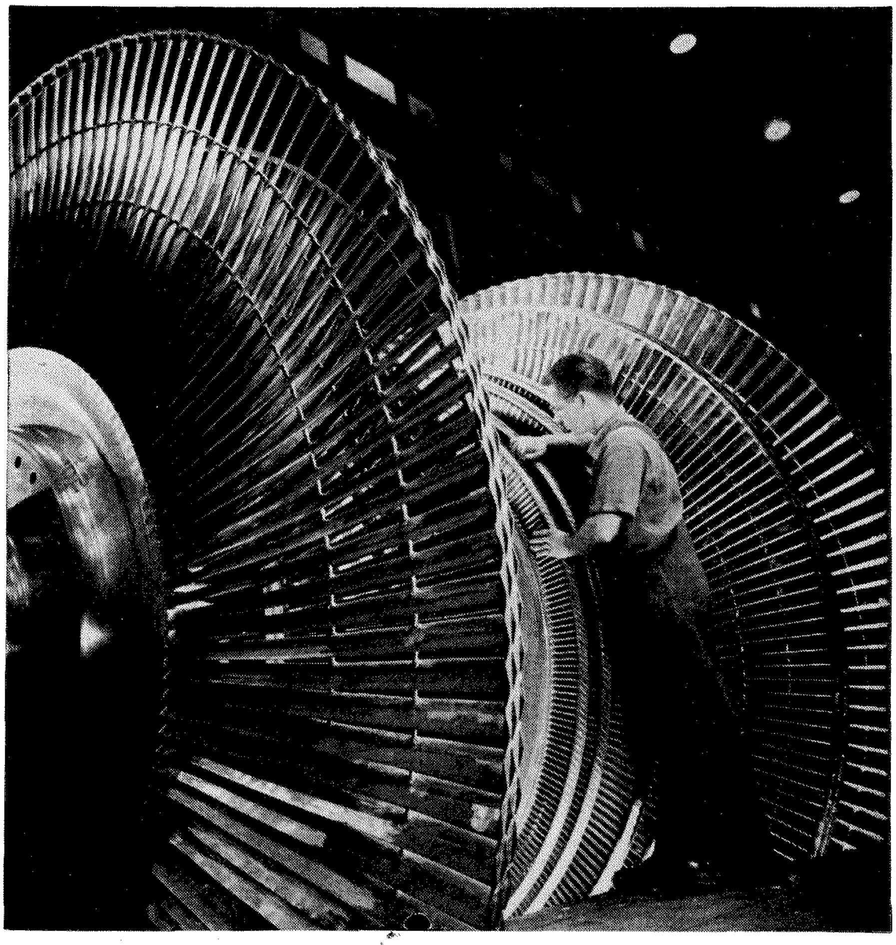
YOU NEED the confidence that comes from wide experience, whether you intend to be a salesman, designer, researcher, or production man. Confidence based on knowledge is one of the greatest assets an engineer can have. Here is what I mean.

You may visit a mine with the idea of talking about crushing equipment, but find that their engineers have an electrical problem. Or you may visit a utility to talk about electrical equipment and find that they're all excited about a pump break-down.

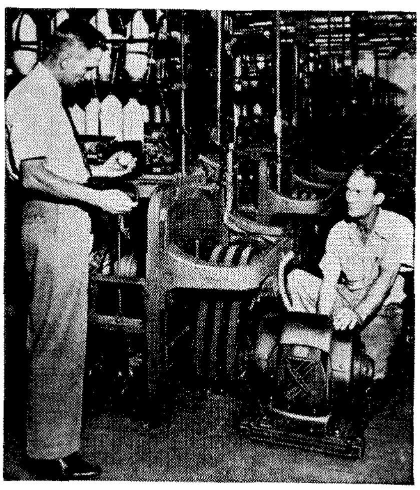
Offer All-Around Help

Can you help them? Or are you just another peddler who is taking their time when they have problems on their minds. In my work I call on electric utilities, cement plants, machinery builders, textile mills, paper mills, shoe factories and many other types of plants. In each of them, I try to help the engineers and mechanics I call on.

It's a good credo for salesmen, but it takes broad experience to carry it out. It's the kind of experience you must deliberately set about acquiring as early as possible. I had heard of Allis-Chalmers equipment, seen A-C's giant Corliss engines in Australia's biggest power plant and decided to study design at Allis-Chalmers. It looked like the best place in the world to get a broad engineering background.



High temperatures and speeds raise tough design and production problems on giant steam turbine spindles like these.



Textile mills are getting adjustable speed at lower cost by using new automatic Vari-Pitch sheaves on spinning frames as shown.

I joined the Allis-Chalmers Graduate Training Course after graduation from Sydney Technical College in 1908 . . . worked on steam turbines, wound coils of all types, performed tests for the electrical department. After that there were field trips to erect electrical equipment. It was soon apparent that I wasn't a designer at heart, and my sales career started.

Broad Opportunity

Forty-one years later, Allis-Chalmers still offers the same opportunity for broad experience. A-C still builds equipment for electric power, mining and ore reduction, cement making, public works, pulp and wood processing, and flour milling.

And the Allis-Chalmers Graduate Training Course is still flexible. Students help plan their own courses. They can switch to design, manufacturing, research, application, sales, or advertising—divide their time between shops and offices—and can earn advanced degrees in engineering at the same time.

Men at Allis-Chalmers get a close-up of the basic industries. No matter what path they take in the industrial world, experience gained with this broad organization lays a foundation for the confidence that comes with all-around knowledge.

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin

 CONTINUED FROM PAGE 2

tions of all of the necessary mathematical results.

Though quite self-contained mathematically, the book will not be easily read by anyone of limited mathematical facility. Indeed, the mathematical limitations frequently lead to cumbersome and inelegant proofs. Also, the author's attempt to make the basic ideas precise by introducing new terms for standard statistical concepts is, at the very best, confusing. It seems likely that the reader for whom the book is intended would do better to first devote a little time to the necessary mathematical techniques and then consult one of the standard treatises on the subject.

THE LOS ANGELES BOOK
Photographs by Max Yavno
Text by Lee Shippey
Houghton Mifflin, Boston, $5

THE LOS ANGELES BOOK is not solely a picture book, through Max Yavno's striking photographs do capture all your attention when you first open it. Actually the book is almost 40% text.

This has been written by Lee Shippey, columnist ("The Lee Side of L.A.") for the Los Angeles Times. In his 40% of the book Mr. Shippey packs in an astonishing number of little-known facts about L.A. (Some samples: The city of Chicago could be contained in the San Fernando Valley area. The first public building in L.A., in 1781, was the jail. There are 430 public schools in L.A. today, and the minimum campus of a high school here is 20 acres—though one school in the San Fernando Valley uses 400. Los Angeles has a Buddhist Temple, as well as five different kinds of Russian churches. In fact, there are more Russian-born here than either English-born, German-born or Italian-born residents. L.A. has Chinese, Japanese, Yugoslav and Dutch communities, and it's said there are more Mexicans here than in any other city except Mexico City).

Mr. Shippey's text is refreshingly objective, and free from back-slapping, chest-swelling or Chamber-of-Commerce adjectives.

Max Yavno's photographs, which range all the way from Muscle Beach to a Hollywood "preemeer" to Angels Flight, Pershing Square, the new freeway and the oil fields, are in a variety of styles as well—a nice mixture of scenic, art, documentary, candid and character studies.

All in all, it's about as good a book on Los Angeles as you can find—and a natural, of course, for Christmas.

BLACK BONANZA
by Frank J. Taylor and Earl M. Welty
McGraw Hill, New York, $4.00

SUBTITLED "How an Oil Hunt Grew Into the Union Oil Company of California," *Black Bonanza* attempts to describe the fantastic growth of "the industry that furnishes the lifeblood of modern living" by describing the growth of one oil company from a wildcatting operation in the late nineteenth century to one of the "Big Twenty" today.

Union Oil serves as an excellent case study in this endeavor. It bridges the complete life span of the oil business; big as it is, it's still classified as an independent; and it can take credit for an impressive list of "firsts": building the first tanker on the Pacific Coast, for instance; laying the first pipeline from the oil fields to tidewater; first spanning the Isthmus of Panama with a pipeline from the Pacific to the Atlantic; and perfecting the first oil burner—to mention just a few.

The authors, both professional writers, find little to criticize—and a great deal to praise—in the history of Union Oil, and have managed to make a fairly lively story out of a mass of research material and old records. For good measure, the book contains nearly 200 photographs.

ADVENTURE INTO THE UNKNOWN
The First 50 Years of the General Electric Research Laboratory
by Laurence A. Hawkins
William Morrow, N.Y., $3.50

THIS DOESN'T pretend to be a full-scale history of the 50-year-old General Electric Research Laboratory; it's merely a quick survey of some of the prominent men who have worked in the lab, and some of the valuable developments which have come out of it.

The book is intended for popular consumption, and, aside from an occasional passage of purely intramural interest (the author was with the Research Laboratory for 38 years—having retired as its business manager in 1948) should appeal to most science-minded laymen.

Adventure Into the Unknown concentrates chiefly on the contributions of the three directors of the Research Laboratory — Willis R. Whitney (1900-32), W. D. Coolidge (1932-45), and the present director, C. G. Suits—as well as those of the laboratory's most distinguished scientist, Irving Langmuir. Other men and their contributions are mentioned briefly and the work of the laboratory in general reviewed and brought up to date with a description of the plant and program of the new Knolls Atomic Power Laboratory.

MAN THE MAKER
by R. J. Forbes
Henry Schuman, New York, $4.00
Reviewed by R. L. Daugherty, Professor of Mechanical Engineering

THIS BOOK TRACES the development of man from the pre-dawn of history down to the present day, not so much through the growth of his brain and increase in culture as by unfolding for us his achievements in inventing, making, and improving tools and machines from their crudest beginnings.

The story starts with the Stone Age and traces the developments in irrigation, spinning and weaving, pottery making, working stone, metallurgy, and communication. It goes on to the works of the peoples in the empires of the Near East; the contributions of the Greeks and the Romans, such as the building of roads, aqueducts, bridges, and war machines; the rise of the medieval engineer, the use of the water wheel and windmill, the production of cast iron and of paper, and the beginning of the art of printing.

A chapter headed "Steam Comes of Age" describes the various early types of steam engines and the industrial revolution brought into being by this new source of power.

Another chapter, on "The Conquest of Distance," describes the growth of highway systems with good paving and the evolution of the railroad, streetcar, bicycle, automobile, and airplane.

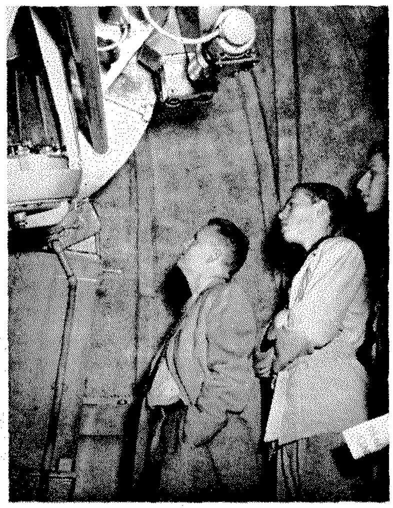
The closing chapter, entitled "Steel and Electricity," covers the development of the modern steel industry on which so much of our present day civilization is based; the electric power industry, together with radio and television; and finally some phases of modern chemical engineering.

The author—a chemical engineer, formerly on the staff of the Shell Oil Company, and now professor of the history of science and technology at the Amsterdam Municipal University in the Netherlands—has condensed a vast amount of material, both in time and in content, into this book. But he has done a skillful job and the book is not highly technical, so it can be read with interest and profit by anyone.

ENGINEERING AND SCIENCE

DECEMBER 1950 VOLUME XIV NUMBER 3
PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

IN THIS ISSUE



ON THE COVER

This month's cover picture shows some of the visitors to the Institute campus on Students' Day, Saturday December 2, looking over the 20-inch telescope on the roof of Robinson Hall, the astrophysics building.

Students' Day was the first open house to be held at the Institute since before the war—and a highly successful one too. Instead of holding a wide-open-house this time, the Institute limited attendance to prospective students. Some 750 Southern California high school seniors, with their teachers, were therefore invited to tour the campus on Students' Day. The function was a joint effort of Caltech students, faculty and other participating groups, including alumni.

You'll find some pictures of Students' Day activities on pages 14 and 15—a couple of pages, by the way, which we held up until the last minute, so we could get these pictures in this issue.

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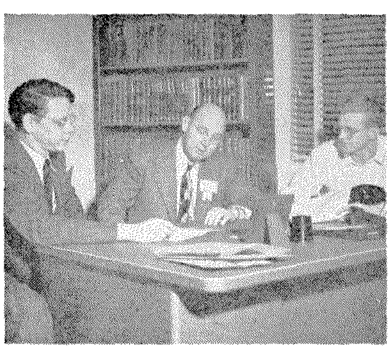

Committee in charge of Students' Day—Hildebrand, Varney, Tautz

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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 $3.00, single copies 35 cents. Entered as second class matter at the Post Office at Pasadena, California, on September 6, 1939, under the act of March 3, 1879.

The Main Line

DECEMBER, 1950

Here it is, winter again. And unless this year turns out different from all the years that have gone before, winter means that the whole countryside is going to be slopped up with rain, mud, sleet, snow, fog, wind and what have you?

Except, of course, down in the South and Southwest. Around Palm Springs, Phoenix, Tucson, etc. the sun is now spending the winter. You can do all the shirt-sleeve loafing you like there. We recommend it.

How're You Going?

There are, of course, many ways to get to the Southwest resort and guest ranch country. For example, you *could* walk. (You'd probably encounter some interesting bone formations from people who found this method over-tiring.)

Another possibility is to drive your own car. On the off chance that you may be considering this method, we have prepared a special presentation of the scenery you can expect to encounter en route.

In the crowded, metropolitan areas, where traffic creeps along bumper to bumper, if you dare take your eyes off the car ahead for a moment, chances are you'll receive a by-then untimely suggestion like this:

Farther along, where the highways are narrow, winding and slippery when wet, you'll more than likely see this:

And then, before you get there, about the time you're wondering why you undertook the project at all, you'll probably get another cheery greeting like the one at the top of the adjoining column.

Having thus eliminated the unreasonable ways to go, that brings us to the one best way to travel. In short, as it says on the signs . . .

Next Time, Try The Train

We have fine, fast, streamlined trains to take you to winter sunshine. Our new *Sunset Limited* and *Golden State* streamliners directly serve the heart of the winter resort country.

And what a way to go!

You relax in complete, air-conditioned comfort, while the engineer does the driving. Sleep (if you're sleepy) in luxurious private Pullman rooms. Or, if you're traveling on a budget, doze in super-comfortable "Sleepy-Hollow" chair car seats.

Good food travels with you in dining and coffee shop cars. You eat when you want to on S. P. trains—not when you happen to pass a place that looks suitable. And you'll find all the companionship—or all the privacy—you want. Baggage allowance is generous, too—probably more than you can lift.

Snow-bound?

Of course, some people aren't sun worshippers. So if you believe there's no fun like snow fun—or if you have some other reason for heading north—we have some very sweet streamliners headed thataway.

From Los Angeles to San Francisco, you can go by *Daylights*, *Starlight* or *Lark*. From San Francisco to Portland, take the *Shasta Daylight* or the *Cascade*. And if your spirits need a Reno-vation, go there over the High Sierra on the *City of San Francisco*.

Happy Holiday

The nearly 90,000 men and women who are Southern Pacific join in wishing you a very merry Christmas and a happy, prosperous and peaceful New Year.

S•P The friendly Southern Pacific

IN THIS ISSUE CONTINUED

Students' Day visitors listen to an address by President DuBridge

SMOG

On page 7 of this issue you'll find an article by Dr. A. J. Haagen-Smit on "The Air Pollution Problem in Los Angeles." It's the most informative, most straightforward, most unemotional article on smog we've seen. And, as far as we're concerned, it couldn't have come at a better time.

The long succession of smoggy days in the Los Angeles area last month not only got everybody fighting mad; it routed out every crackpot, headline-hunter and sure-cure expert in the area. Now that we've heard from all of *them*, it is even more interesting to turn to a consideration of some of the *facts* about smog which are given in Dr. Haagen-Smit's article.

Dr. Haagen-Smit, Professor of Bio-organic Chemistry at the Institute is *on leave this year to conduct research on smog for the Los Angeles Air Pollution Control District.*

RADIATION DETECTORS

On pages 16-18 C. M. Stearns tells about two interesting machines which have been developed recently at the Institute—both radiation detectors. One, Dr. Eugene Cowan's nonstop cloud chamber is proving useful in cosmic ray studies in Physics; the other, Dr. Geoffrey Keighley's nonstop Geiger counter is working on protein synthesis studies in Biology.

Work on the Cowan cloud chamber, incidentally, was in part supported by funds granted by the office of Naval Research and the Atomic Energy Commission.

PICTURE CREDITS

Cover	Charles Davies
pps. 5-6	Charles Davies
p. 7	Max Yavno
p. 11	Charles Davies
pps. 14-15	Charles Davies
pps. 16, 18, 22	Charles Davies
p. 24	Morgan Ogilvie

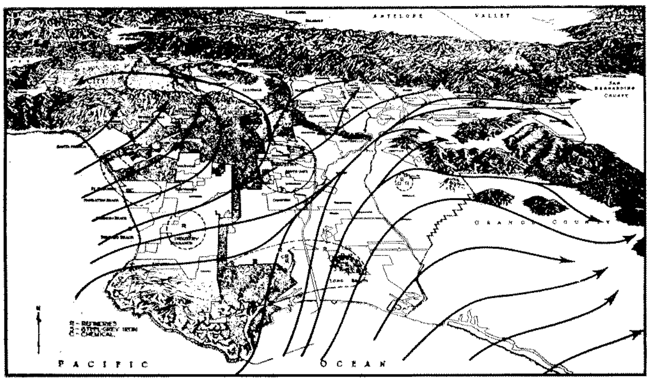
Max Yavno photograph from The Los Angeles Book

THE AIR POLLUTION PROBLEM IN LOS ANGELES

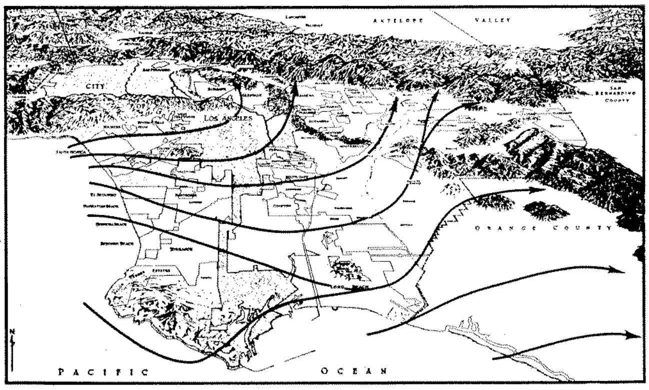
by A. J. Haagen-Smit

AIR POLLUTION IS NOT a unique problem of our machine age. In about 1300 A.D. a royal decree by the King of England forbade the use of a certain type of coal because it produced vapors damaging to the health. A committee of investigation was set up to punish the infringers by fines and demolish their ovens in case of repetition. One unfortunate individual was condemned to death because he had infringed the smoke rules three times.

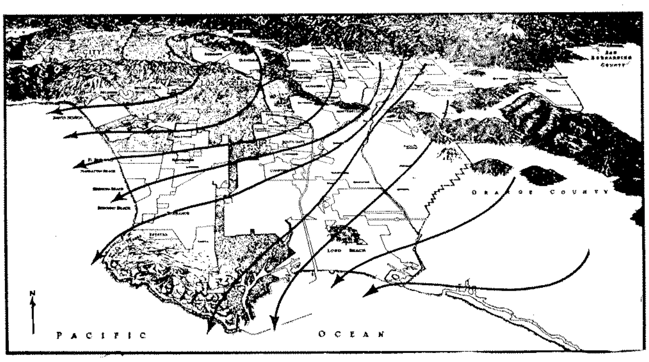
I felt greatly relieved when I read in a recent issue of the Pasadena *Star-News* that a kiln operator in Los Angeles had just received his 54th notice of violation of the anti-smog laws and was fined $1,000 and sentenced to five days in jail—a sentence which his lawyer promptly appealed. This comparison shows, among other things, that after 650 years air pollution is still with us. Some of the problems are very much the same as then, except



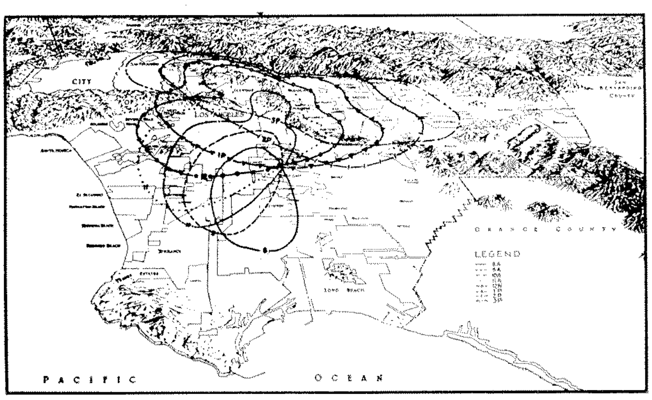
Wind direction in Los Angeles County
Summer—9 a.m. to Noon



Wind direction in Los Angeles County
Summer—Noon to Midnight
Winter— Noon to 4 p.m.



Wind direction in Los Angeles County
Summer—Midnight to 7 a.m.
Winter— 7 p.m. to 10 a.m.



Position of area of eye irritation at various times of day in Los Angeles County—8 a.m. to 3 p.m.

Charts from Industrial and Engineering Chemistry, November '49

that the magnitude of the pollution is many times greater.

Usually we consider the air as an unlimited reservoir for our refuse. However, in densely populated areas we soon find out that this is not true, and at present we are sadly aware that there are limits to the amounts of material which we can send up into the air without creating a nuisance and even health hazards. This is especially true when geological and meteorological conditions favor the accumulation of air pollutants.

A favorable situation

Such a situation exists in the Los Angeles area, where a half-circle of mountains prevents the free movement of the air. Early in the morning a slow sea wind of a few miles per hour carries the exhausts of the great city up to the high mountain barrier in the north. In the evening the wind turns, and the pollutants move seaward. Usually the speed of this land breeze is too slow to be very effective in cleaning the area.

While the air is hampered in its free movement in a horizontal direction by the mountain barrier, meteorological conditions limit the movement in a vertical direction. Meteorologists have observed that during a large part of the year the lower layers of the air over the Los Angeles area have a lower temperature than the higher ones. The colder air, because of its higher density, is not able to rise, and it is just this layer that contains the gases, smokes and fumes released in this area.

This so-called temperature inversion is quite frequent, though the height of the layer is very different on different days, and may range from several hundred to several thousand feet. Complaints about smog are usually received when the base of the inversion layer is from 600 to 1200 feet.

A limited reservoir of air

Under these conditions the unlimited reservoir of air has shrunk considerably; however, it is still of enormous size. When we look at a map of this area on which has been plotted the movement of the cloud of eye irritants, we notice a gradual displacement and spreading towards the San Fernando Valley in the northwestern direction and towards San Bernardino in the eastern direction.

When such an area, of approximately 25 by 25 miles, is covered uniformly with a smog layer which we will assume to be about 1000 feet thick, we can calculate that approximately 500,000,000,000 cubic meters of air have been polluted. Since one cubic meter weighs about 1.3 kilograms, the actual weight of this smog-containing layer is about 650,000,000 tons. This enormous tonnage is often overlooked in "quick cures" for smog, when proposals are made to place fans on the mountains or drill tunnels through the mountains to drive away the smog.

Knowing the volume of air involved gives us a basis for a calculation of the quantities of materials which are polluting our atmosphere. If a substance gives irritation in a concentration of one part per million, we need in this area 650 tons of material to show this effect. When only one tenth of a part per million is necessary for irritation, we need 65 tons; and for one hundredth of a part per million 6.5 tons must be released.

It is interesting to compare these values with a list of the threshold concentrations of some of the most potent war gases, all of which have threshold concentrations above one hundredth of a part per million. For one of the most potent tear gases, chloro-acetophenone, we need 150 tons to cover an area such as we are dealing with, to give eye irritation. For the war gases Lewisite and mustard gas, we need hundreds of tons to make life rather unpleasant. Further assurance that we are not in immediate danger comes from the column in the table below, showing the enormous tonnage which is necessary for lethal action.

WEIGHT IN TONS TO CAUSE IRRITATION IN 625 SQ. MILES INVERSION BASE 1000 FT.
VOLUME OF AIR 500.000.000.000 M^3
WEIGHT 650.000.000 TONS

	SMELL	IRRITATION	TEARS	LETHAL IN 10 MIN.
ETHYL MERCAPTAN	0.02(20 Kg.)			
SYNTH. MUSK	0.005 (5 Kg.)			
SKATOL	0.0002 (0.2 Kg.)			
ACROLEIN		80	3500	180.000
FORMALDEHYDE		—	400	—
CHLORO ACETOPHENONE		—	150	400.000
CHLORINE		185	—	3.000.000
LEWISITE		—	400	60.000
SULFUR DIOXIDE		—	30.000	3.000.000

Our sense of smell usually responds to much smaller quantities of material than those necessary for irritation. One thousandth of a milligram of ethyl mercaptan (a relative of the skunk smell) released in a small auditorium can be readily detected by smell. If we extrapolate this example to the 25 by 25 mile area, we find that 20 kilograms (about 46 pounds) of ethyl mercaptan released at the City Hall in Los Angeles would be noticed in Pasadena. For a similar experiment with musk or skatol (one of the constituents of feces), the quantities necessary would be only about six pounds and a half a pound, respectively. These exceedingly low threshold values for odor perception are in accord with the common observation that the smell of smog is noticed long before there is any complaint of irritation.

Sources of pollution

We have seen that the quantities involved in irritation over such a large area run into hundreds of tons. These large quantities can be released by industries handling a large tonnage of material, or by numerous small offenders. At one end of the scale we find the petroleum industry, where a few refineries are handling many thousands of tons of material every day. But the half million automobiles driving around in Los Angeles contribute their share to air pollution, too. Together they burn approximately 12,000 tons of gasoline daily. Even if the combustion were 99 percent complete, which it certainly is not, 120 tons of unburned gasoline would be released. Another example of this type of pollution is the private incinerator, where the large number compensates for the small quantity released by the individual.

The analysis of air contaminants has some special features, due to the minute amounts present in a large volume of air. The state in which these pollutants are present—as gases, liquids and solid particles of greatly different sizes—presents additional difficulties. The small particles of less than one micron diameter do not settle out, but are in a stable suspension and form so-called aerosols.

Collecting air contaminants

The analytical chemist has devoted a great deal of effort to devising methods for the collection of this heterogeneous material. Most of these methods are based on the principle that the particles are given enough speed to collide with each other or with collecting surfaces. In the impactor, the air is drawn through a small slit, thus attaining a velocity close to that of sound. The particles in the air colliding with a glass slide are deposited on the slide and can be observed microscopically. A sample of Los Angeles' air shows numerous oily droplets of a size smaller than 0.5 micron, as well as crystalline deposits of metals and salts.

In a thermal precipitator the same principle is applied by passing the air over a heated wire which is placed between cooled surfaces. The particles move from the hot wire to the cooler surface, and are there deposited. Other instruments cause agglomeration of the smog particles by accelerating the particles with ultra sound waves, or through the application of a strong electric field. Many of these different techniques are used in industry to remove aerosols from waste material, and are known as Venturi scrubbers, sonic and electric precipitators.

Material collected from an electric precipitator was shown to consist of approximately one half inorganic material such as silica, traces of lead, zinc, copper, iron and a variety of other metals; their oxides; and salts such as sulfates, nitrates, nitrites and ammonium salts. The other half of the collected material consisted of organic material, which is partly soluble in fat solvents, and which contains hydrocarbons, aldehydes and organic acids. The insoluble organic material contains fibrous material, carbon and salts of organic acids.

Although the electric precipitator allows the processing of large quantities of air, a disadvantage of this method is the possibility that, under the influence of the corona discharge in a precipitator, secondary reactions would modify the organic materials. Therefore, the study of organic pollution has been conducted mainly on material collected on filters, or obtained from scrubbers. When air is passed through a filter paper, the paper takes on a grey appearance, and extraction with organic solvents gives an oily material. Subsequent extraction with water removes salts of organic, as well as inorganic acids.

However, this method too has disadvantages, since most of the volatile material is lost. For this reason, extensive use has been made of traps held at very low temperature. Mass spectrographic studies on the collected dilute aqueous solutions have been useful in the analysis of the hydrocarbons present in the atmosphere.

For the isolation of special groups of substances, scrubber techniques are often useful. In our studies on the organic acids present in the air, scrubbers with sodium hydroxide were used. However, the most common organic acid in the air, carbon dioxide, occurs in quantities several hundred times greater than those of the air pollutants. It is therefore necessary to start with a large quantity of concentrated sodium hydroxide to be able to collect sizable quantities of the organic acids.

In our experiments we started with several liters of ten percent sodium hydroxide and, in a run of several days, made a very expensive sodium carbonate from 30,000 cu. ft. of air. However, after careful acidification and ether extraction, several tenths of a gram of organic acids could be extracted.

The identification of these acids can be made by converting them into derivatives which have characteristic melting points. Before this can be done, they must be separated from each other. Such separations, with small quantities involved, can be accomplished with chromatographic procedures. We have used a method whereby the acids are converted into the phenylphenacyl esters, which have the advantage of fluorescing in ultraviolet light.

Identifying acids in the air

When the mixture of derivatives is passed through a column of silica, a number of fluorescent bands appear, each representing a simple compound or a mixture of closely related acids. In this way we obtained fifteen of these bands, illustrating the complexity of the acid mixture present in the air. Some of these acids are normal and branched-chain ones; others contain, in addition to the carboxyl group, keto- and hydroxyl groups.

For a routine analysis of the air when no detailed separation of the collected material is intended, we rely on the specificity of the reagents. When, for example, a solution of sulfanilic acid and alpha naphthylamine turns pink when air is bubbled through, we are reasonably certain of the presence of nitric oxide.

The difficulty comes when we use less specific reactions or determine groups of substances on the basis of their oxidation, reduction power or acidity. For example, if we wish to determine the oxidizing material in the air, the amount of iodine liberated from potassium iodide solution can be used as a measure of this activity through titration with sodium thiosulfate or electrometric titration.

This total oxidizing capacity does not allow the making of any prediction as to the specific nature of the compounds present, and the results are further complicated by the possible presence of reducing substances which act in the opposite way. The iodine liberation is a balance of the two effects, and separate determinations for a number of compounds such as hydrogen peroxide, nitrogen oxide and reducing substances are necessary to enable us to explain this liberation quantitatively.

In the Los Angeles area it was found by several independent investigators that the liberation of iodine from potassium iodide was relatively high, and exceeded by several times the amount which could reasonably be expected as a result of the presence of ozone. With reagents more specific than potassium iodide, such as the dye, indigo-sulfonic acid, it is found that the ozone content cannot exceed a few parts per hundred million. But even these reagents are not fully specific, and scrubbing the air with a solution of ferric chloride and postassium ferric cyanide, which does not react with ozone, reduces the apparent ozone content still further. Semiquantitative experiments on rubber-cracking support these lower figures for the ozone content in this area.

High oxidizing powers of L.A. air

It is clear that the determination of the oxidizing compounds needs a great deal more study, and at the present time we are faced with the difficulty of finding an explanation for the high overall oxidizing power of the Los Angeles air. Since none of the inorganic pollutants gives an answer to this problem, it is only natural to look for the presence of organic material which may liberate iodine from potassium iodide solutions.

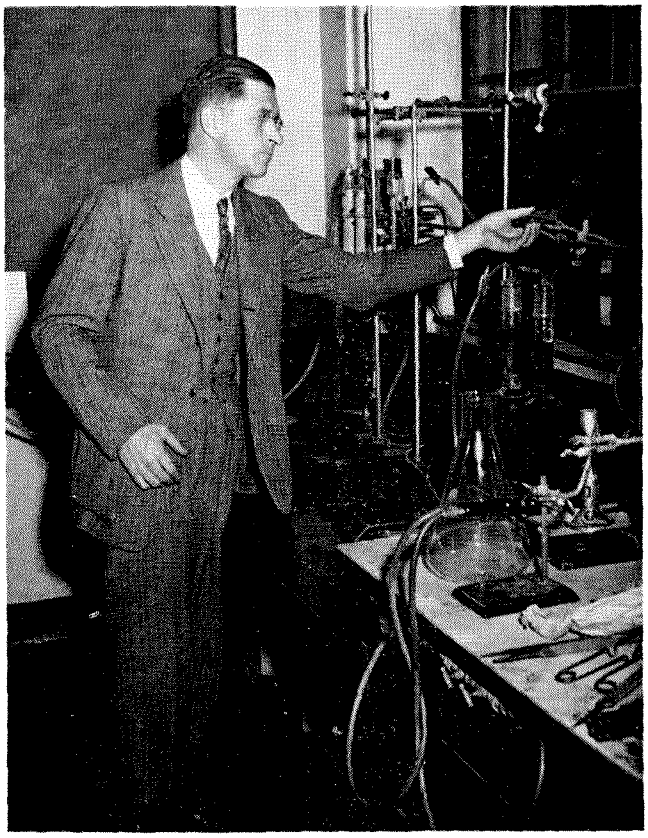
The organic substances in the air are of manifold origin and are subjected to sunlight, air and water; and as a result a rather complicated mixture can be expected. It is, therefore, of advantage to consider first what the sources of organic material are, and to what degree we can hope to analyze for these compounds.

The volatile material released into the air consists of hydrocarbons, saturated and unsaturated, originating from products derived from the petroleum industry and industries using solvents of different kinds. This includes all the material lost at the oil fields, refineries, filling stations, automobiles, etc.

Products of incomplete combustion

Then we have to consider the products of incomplete combustion from fuel as well as garbage of all kinds. In the literature we find detailed analyses for a few of these products. For a representative petroleum, the National Bureau of Standards published the identification of approximately 90 hydrocarbons. These are mostly saturated, whereas in the cracked gasoline extensively used nowadays there is a large amount of unsaturated hydrocarbons.

The products from the combustion of fuels have not been studied very thoroughly. Some of these products are carbon monoxide, methane, formaldehyde, acrolein and phenols. Similar unsatisfactory data are available on the combustion products of garbage. Its major components are of plant and animal origin, and it contains a high percentage of wood and paper. The



Dr. A. J. Haagen-Smit, Caltech Professor of Bio-organic Chemistry now on leave to work for the L.A. County Air Pollution Control District, manufactures smog in his laboratory above. Indistinguishable from the real thing, it's known, to his colleagues, as "Haagen-Smog."

combustion will be a partial oxidation which in many cases will approach a dry distillation when, as is often the case, not too much attention is paid to a sufficient supply of oxygen.

For one of the garbage materials, wood, we possess a thorough analysis of the distillation products. It has been shown that saturated acids—mostly acetic acid—are formed, accompanied by a few unsaturated acids and one with a furane ring. Also formed are alcohols, ketones, aldehydes, phenols and phenol ethers, ammonia derivatives and hydrocarbons of the benzene and furane series. In total, more than a hundred compounds were identified in these distillates.

These examples, incomplete as they are, suffice to show the complexity of the material released into the air. When these products are released and exposed to sun, air and water, drastic changes in the molecules take place, such as oxidation and polymerization.

This fact can easily be shown in the laboratory by exposing unsaturated hydrocarbons to the sunlight. Peroxides are formed, and iodine is liberated from potassium iodide solution which has been added to the oxidized hydrocarbons. This behavior is not limited to hydrocarbons. It has been shown to occur with a large number of organic compounds—alcohols, aldehydes and acids. These peroxides in turn are decomposed and smaller aldehydes and acids are formed. The purifying action of the air will eventually break most of these compounds down to carbon dioxide.

An interesting experiment on the oxidation of unsaturated hydrocarbons can be performed by mixing two streams, one of dilute ozone and the other of small amounts of pure, unsaturated hydrocarbons or mixtures such as cracked gasolines. Where the two streams meet, a dense aerosol is formed. This shows some similarities to that observed in the Los Angeles area—as, for example, its oxidizing capacity, eye irritating effect, and its nearly neutral character.

This experiment presents a convenient way of preparing a type of aerosol quite different from that obtained with sulfur trioxide, and can be of help in the study of collecting techniques and analytical methods in this field. It also illustrates the possibility of a continuous chemical change of the products which one tries to determine. As soon as the ozonides are formed, the relatively unstable peroxides begin to decompose with the formation of more stable peroxides and the formation of acids and aldehydes. At the same time a considerable amount of polymerization takes place—probably the main canse of the formation of the dense aerosol. Also, the interaction of the products formed has been established, and we may therefore expect a rather complicated mixture in samples collected from air when unsaturated hydrocarbons have been released.

In such a case, the interpretation of the analytical results should be made with caution, and should take into consideration the possibility of conversions of the original products as well as the interaction of the components.

On the basis of the analytical work, the conclusion was reached that the oxidation of organic material—under the influence of sunlight and ozone, and possibly other air contaminants such as nitrogen oxides—plays an important role in the pollution of the atmosphere. In these reactions, aerosols are formed which have eye irritating properties and which, because of the small size of their particles, are able to decrease the visibility.

Support of these conclusions came in an unexpected way when the action of smog on plants was investigated. It had been observed that crops such as spinach, beets and grasses are often badly damaged when grown in this area. The symptoms are not identical with any observed in other areas, and are certainly different from sulfur dioxide damage.

Effect of smog on plants

In a project combining the efforts of the L. A. County Air Pollution Control District (LACAPCD), the University of California Agricultural Experiment Station at Riverside, and the California Institute of Technology an attempt was made to study the effect of smog and of individual air pollutants on plants.

It is fortunate (although not accidental) that the facilities at the Institute's Earhart Plant Laboratory are

Smog damage to vegetables is studied at the Institute's Earhart Plant Research Laboratory. Smoggy air coming down the tunnel at the left, above, ruins plants. But the plants on the right keep healthy, since they're grown in air from which smog is removed by carbon filters.

ideally suited for studies of this kind. In this laboratory, rooms are available where the effect of gases on plants can be studied under closely controlled temperature and light conditions. Chemicals can be dispersed in these rooms either in gaseous form or as aerosols. The large turnover of air, amounting to 9,000 liters per minute, and proper distribution of the incoming and outgoing air make it possible to carry out quantitative determinations on chemical plant damage with considerable accuracy. Gas outlets provided in the doors permit the determination of the concentration of the gases used in the fumigation. The effect of a number of possible air pollutants was studied on a series of plants which were known to be susceptible to smog.

The smog indicator plants include spinach, sugar beet, endive, alfalfa and oats. The symptoms on the first three species are mainly silvering or bronzing of the underside of the leaf, whereas alfalfa and oats show bleaching effects. Some fifty compounds possibly present in the air were tested on their ability to cause smog damage—without success. However, when the reaction products of ozone with unsaturated hydrocarbons were tried, typical smog damage resulted.

The ozonization was carried out in vapor phase by bringing the vapors of the hydrocarbons into contact with the ozone. When the two streams meet, a dense aerosol is formed which, through the adequate turbulence, is readily and evenly distributed in the room. As a source of the hydrocarbons ten-degree fractions of a cracked gasoline were used. (All gasoline now available is cracked, and contains 20 percent of olefins, or unsaturated hydrocarbons. The straight-run gasoline formerly used contained no more than 1 percent of olefins). It was found that the maximum of typical plant damage occurred with the oxidation products of low-boiling hydrocarbons.

After these encouraging results a series of pure olefins was tried in the ozone fumigation experiments. Maximum damage was found to occur with olefins of a chain length of five to six carbon atoms with the double bond in the end position.

Active agents in causing smog damage

During these oxidations a series of products are formed, with aldehydes and acids as end products. Fumigation experiments with these show that they are not responsible for the typical damage. We concluded, therefore, that the series of peroxides formed by the addition of ozone to the double bond are the active agents in causing the typical smog damage. Threshold determinations carried out on 1-n-hexene showed that oxidation of this hydrocarbon with a concentration of ozone as low as 0.05 parts per million still caused slight, but typical smog damage.

It is reasonable to assume that in our atmosphere where olefins are available, the ozone which occurs in unpolluted air in concentrations of 0.05-0.08 parts per million combines with hydrocarbons released in the area to produce material causing crop damage. However, the extent of the damage experienced when a smog wave hits the plants leads one to suspect that there are additional means by which oxidized hydrocarbons could be formed.

It has been shown that oil fractions acquire weed-killing properties when exposed to the action of sunlight and oxygen. Saturated as well as unsaturated hydrocarbons are thereby oxidized, yielding peroxides and their conversion products, aldehydes and acids.

Oxidizing the hydrocarbons

A third way of oxidizing the hydrocarbons was found in the plant experiments when oxides of nitrogen were used together with olefins. These oxides add to the double bond of the hydrocarbon and form nitrosates and nitrosites. Fumes are produced which can be eye-irritating when the reaction is taking place too violently, as in the case of butadiene, through the formation of nitro olefins. While the nitrosates and nitrosites are not causing plant damage at concentrations lower than one part per million, one of the nitro olefins, nitroethylene (a very efficient lachrymator) did produce smog symptoms at concentrations of 0.1 part per million. The presence of this compound in the air has not been established, although there is evidence that some of the higher nitro olefins do occur, since we found small amounts of their polymers in the filter-paper extracts.

Since it was known that the nitrogen oxides may function as oxidation catalysts under the influence of light, plant fumigations were also carried out with nitrogen dioxide and the olefins under ultraviolet light. Typical smog damage was produced on the plants with both gasoline and 1-n-hexene. These symptoms can be produced readily in sunlight since, from chemical evidence, it is known that the upper limit of the photocatalytic action of nitrogen dioxide is at approximately 4300 A, a wavelength of light within the range of wavelengths received from the sun at the earth's surface. Under the influence of the light the reaction $NO_2 \rightarrow NO + O$ furnishes atomic oxygen which is available for the oxidation of the hydrocarbons.

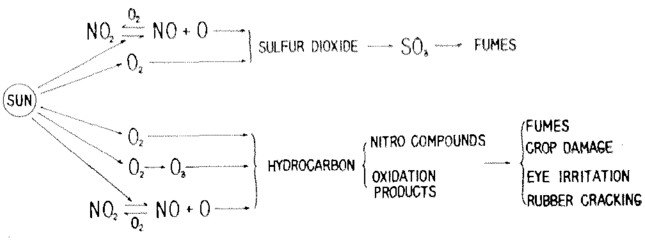
Smog effects on rubber

Supporting evidence for this NO_2 catalyzed oxidation came from a totally different aspect of the smog problem. Tire manufacturers had observed that rubber deteriorates faster in this area than in other parts of the country. The effects observed are rapid cracking when the rubber is stretched or bent during the exposure to the atmosphere. This effect was initially attributed to the ozone in the atmosphere. However, since it was shown that the high oxidizing value of the air was not due to the action of ozone, but to that of peroxidized organic material, it was necessary to find another explanation for this phenomenon. Dr. C. E. Bradley developed a technique to study rubber cracking by placing bent rubber strips in a measured stream of air. Under the conditions of the test, it takes half an hour to one hour to produce cracking on a non-smog day. When the smog is at a maximum, the cracking is visible after only seven minutes. This cracking effect can be compared with that caused by ozone. While, for example, on a normal day the concentration of "ozone" calculated in this way is 2-3 parts per hundred million, on a smog day calculations show that there should be 10 parts per hundred million of "ozone" in the air to give similar damage.

As in the plant experiments, many substances were tried without producing the typical cracking, and when it was found that the action of sunlight on hydrocarbons and nitrogen oxide gave plant damage, bent rubber samples were exposed to a similar action. The results of these tests showed that cracking of rubber similar to that caused by ozone could be produced. In this case, the rubber, being an olefin, functioned as did the lighter unsaturated hydrocarbons in the plant experiments, as acceptor of the oxygen.

The evidence from these different lines of research all points to the presence of peroxidized compounds, and a direct demonstration of their presence can be made when enzymatic reactions are used. Peroxidase is able to oxidize a number of amines and phenols to colored compounds only when hydrogen peroxide or alkyl peroxides are present. This reaction is readily given by condensates collected from the air in traps cooled with liquid oxygen. This peroxidase reaction and the coloring of the reagent is prevented by poisoning the enzyme with hydrogen cyanide, thereby establishing that the color is not due to a non-specific oxidation, but to the enzymatic action of the peroxidase.

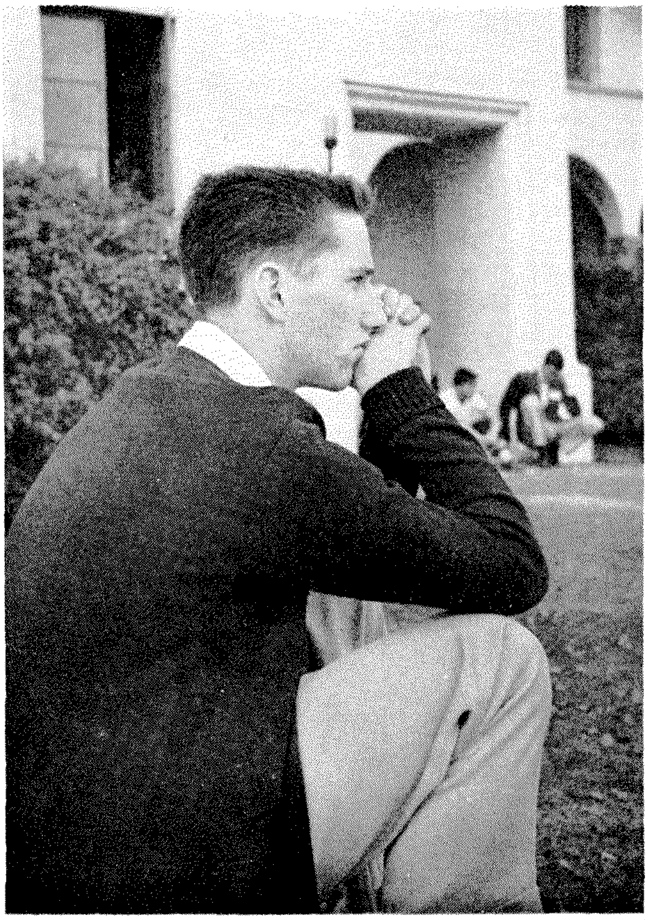
As a result of this work we have come to the conclusion that the organic material, mostly hydrocarbons, released into the air is oxidized by the ozone initially present; by the action of oxygen and sunlight; and by the catalytic action of the NO_2 and NO cycle releasing atomic oxygen under the influence of the sunlight. These oxidations produce peroxides, aldehydes and acids, and aerosols are formed which decrease visibility and would be a source of eye irritation. In addition, side reactions such as the addition of the nitrogen oxides to the double bonds might occur, giving rise to aerosols, as well as eye irritants. These reactions are incorporated in the following scheme:



For a total picture of the air pollution problem, the presence of inorganic materials cannot be neglected. Such a contribution we find in the SO_2, which through its oxidation with sunlight and oxygen will decrease the visibility. Undoubtedly the catalytic action of the NO_2 with light plays an important role, as in the case of the oxidation of the organic material. Through the combined efforts of the enforcement agencies as well as industry, this source of pollution has been greatly reduced, as has that of metallic dusts.

Where we go from here

With these ideas on the causes of the smog nuisance, the smog elimination has entered a new phase. Careful studies have to be made of the amounts and nature of the organic material released into the air. In this way we can hope to make up a balance sheet on which all the deposits of the contributors are listed. Only in this unemotional way can we hope to bring relief to this area.



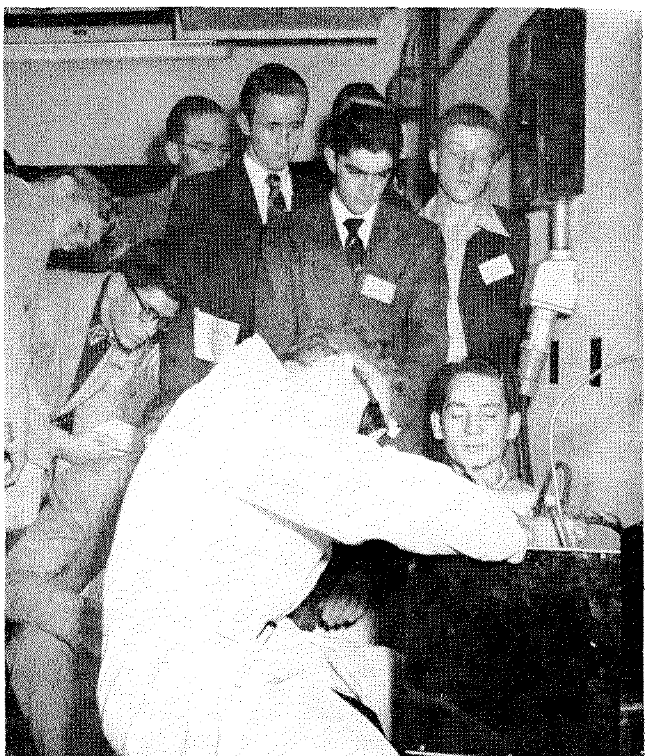
A thoughtful visitor listens to President DuBridge's address on college students and military service.

STUDENTS' DAY

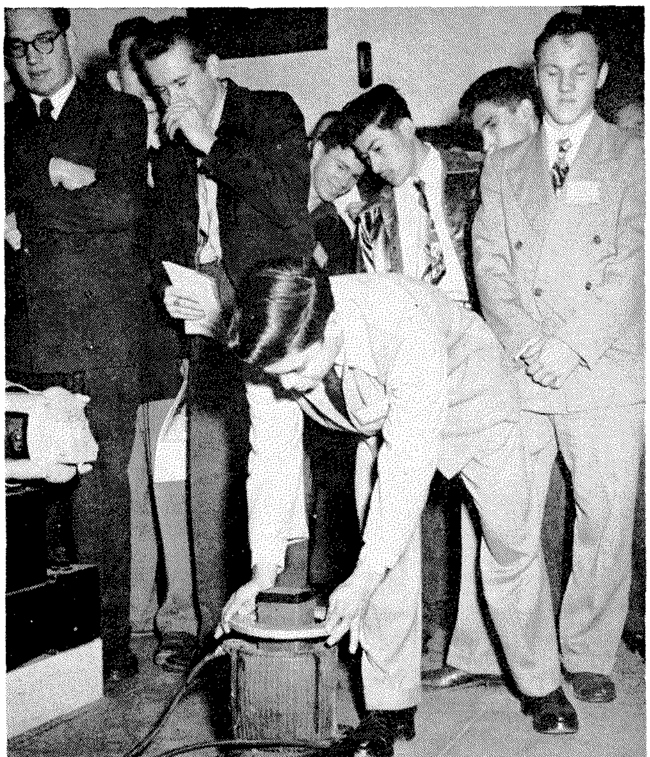
BEFORE THE WAR the Institute used to hold an annual open house for the public. The popularity of this affair finally reached the point where some 20,000 citizens stormed the Institute on Exhibit Day and all but brought its normal operation to a standstill. The war finally caused the abandonment of this function.

This month the Institute held its first post-war open house. It was open only to prospective students this time, and about 750 seniors from southern California high schools were selected, by their respective principals and science teachers, to visit the Institute on Students' Day, Saturday December 2.

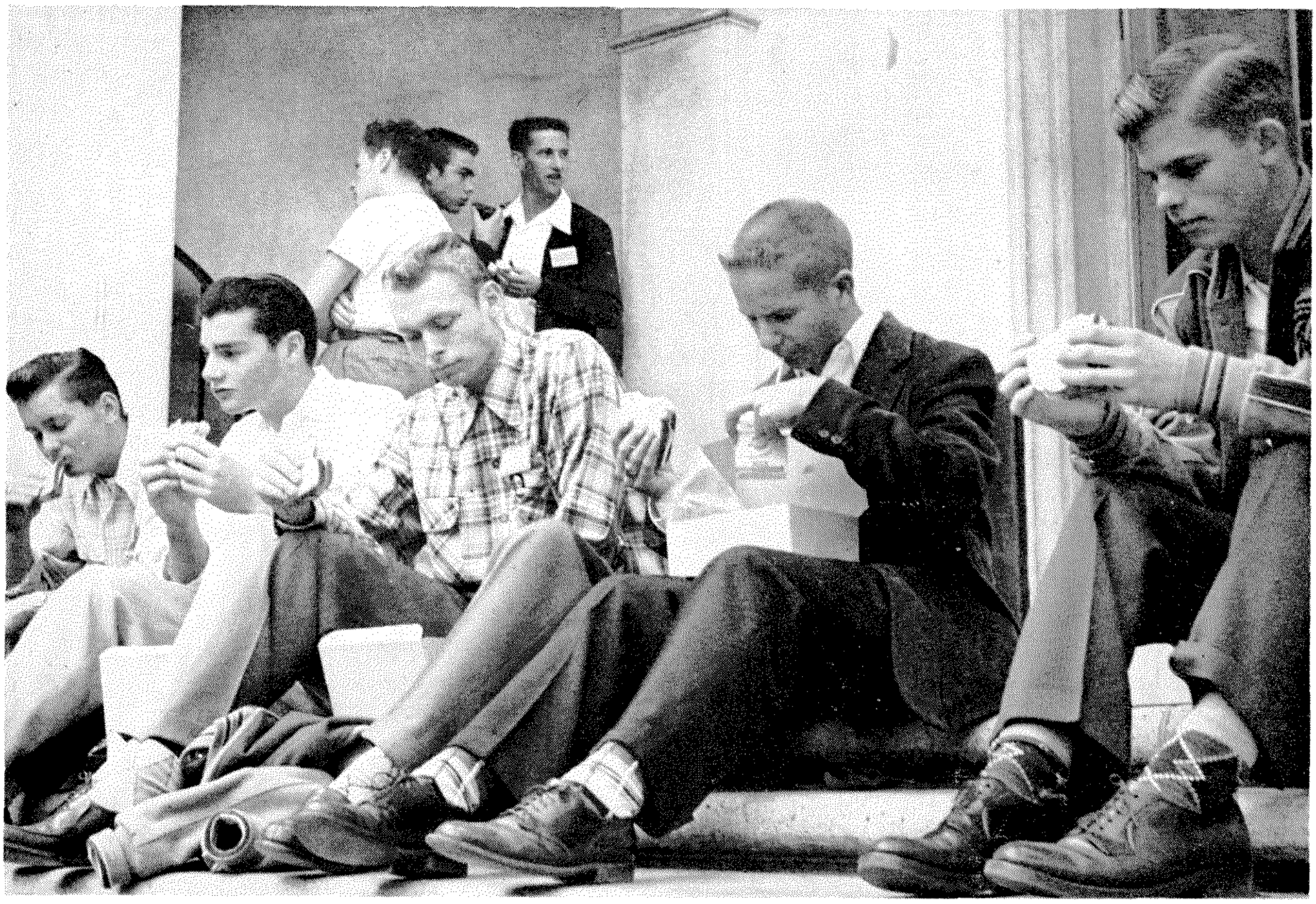
Accompanied by their teachers, the high school students spent the morning touring the 40-odd exhibits which were set up and operated by Tech students in all the major departments. After a box lunch in the student houses, and a talk by President DuBridge, the students attended demonstration lectures in the afternoon. Some of the things they saw and did are shown on these pages.



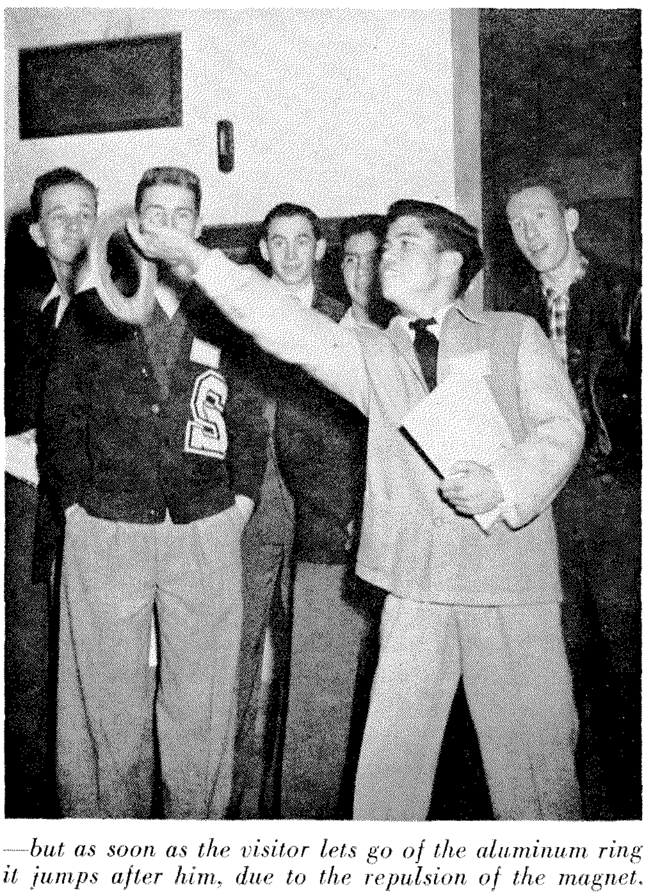
In the new Engineering building Bill Wright '51 demonstrates arc melting of titanium in helium atmosphere.



Visitor holds down metal ring against the force of an a.c. magnet in electrical engineering demonstration—



High school students ate a box lunch at noon, in and around the Institute's student houses. The visitors came from schools in 60 southern California cities, from as far north as Santa Barbara and as far south as San Diego.



—but as soon as the visitor lets go of the aluminum ring it jumps after him, due to the repulsion of the magnet.

A shot in the dark at the ever-popular high voltage demonstration reveals a variety of representative reactions.

Cowan

TWO NEW RADIATION DETECTORS

Institute researchers develop a nonstop cloud chamber and a nonstop Geiger counter

by C. M. STEARNS

1. NONSTOP CLOUD CHAMBER

EUGENE W. COWAN, Assistant Professor of Physics working in Carl Anderson's group, has succeeded in making cosmic-ray tracks visible on a 24-hour basis. The standard "cloud chambers" that physicists use to make the tracks of subatomic particles visible are good for one set of tracks every few minutes; but the chamber has to have a rest between sets. Cowan's "continuously sensitive diffusion cloud chamber," on the other hand, can catch particle tracks one after another for considerable lengths of time without pause. Furthermore, Cowan's cloud chamber is small, inexpensive and simple (and this is a good thing, since it is at present more of a cosmic-ray demonstration device than a precision research instrument for which anyone would care to spend a large sum of money). It is so simple, in fact, that anyone with a reasonable amount of perseverance and a small supply of dry ice can set one up at home.

The new detector makes visible, as a thin line of cloud, the path of every electrically-charged subatomic particle that passes through it with sufficient energy. Such a particle may come from radioactive material, such as the radium on a watch dial; it may come from a particle accelerator, such as a cyclotron; or it may be a cosmic ray—either in the primary form of a particle coming in from outer space, or in the secondary form of a particle set in motion by the primary ray in a collision with some atom in the earth's atmosphere.

The particles that make up cosmic rays are the ones that most cloud chambers, including the new one, are designed to study. Dr. Cowan's new cloud chamber not only makes the tracks of such cosmic-ray particles continuously visible; but also "holds" each track long enough for easy visual inspection.

The new cloud chamber, in one form, is little more than a box, with transparent sides, sitting on a cake of ordinary "dry ice." The box is covered with a pad which has been soaked with slightly heated alcohol. The heated alcohol vaporizes and, under the temperature conditions that the heated top and cold bottom of the box dictate, diffuses downward inside the box. At this stage, since the alcohol vapor is an invisible gas, nothing can be seen inside the box.

If, now, a charged cosmic-ray particle such as an electron passes through the box, it disrupts the atoms in its path and leaves a trail of electrically-charged fragments behind it. The alcohol vapor condenses on these fragments to make visible droplets. The end result is a cloud trail—a thin thread of droplets, easily visible in a strong light, that marks the path taken by the cosmic ray.

Other cloud chambers rely on the same basic phenomenon—the condensation of vapor on the charged ions left in the wake of a speeding particle. But, to achieve the conditions that must exist for such condensation to occur, they require a sudden, large drop in pressure in the chamber; and this in turn requires, besides some fairly complex mechanical apparatus, a rest period ranging from one to several minutes between operations. Only the tracks of particles that pass through at or about the time of the pressure drop are made visible, and these tracks remain visible for only about one-tenth of a second. The continuous cloud chamber requires neither moving parts nor rest periods, and the tracks that appear in it remain visible for several seconds.

In its laboratory form, the continuous cloud chamber has many refinements. Electric elements heat its top, which supports a pad automatically supplied with methyl alcohol. The inert gas argon fills its interior. An electric field, energized briefly from time to time, pulls to the top or bottom the charged fragments that the passing rays have left, leaving the chamber more receptive to the next rays to come along.

But in its crudest form — one that can be set up with ease in any physics classroom and without much difficulty in any home — the continuous cloud chamber is a large glass jar filled with ordinary air, sitting on dry ice, in a strong light, with a pad soaked with pre-heated alcohol as its cover.

From the standpoint of cosmic-ray research, the continuous cloud chamber has (particularly in its present early stage of development) certain disadvantages. Some uses for it have already developed, however. One model will be tried out in the stream of electrons ejected by the billion-volt synchrotron now under construction on the Institute campus. The chamber has some promise in the field of investigation of "electron showers," cascades of thousands of high-speed electrons that cosmic rays sometimes produce. Other uses will undoubtedly be discovered to take advantage of the continuous operation of which the chamber is capable.

At present, the best use of the continuous cloud chamber is found in teaching and demonstration. It can, at a fraction of the cost of a classic cloud chamber, make available for study the tracks of many of the 20-odd cosmic-ray particles that strike every foot of ground at sea level every second, and thus provide an excellent and convincing demonstration of radiation otherwise completely invisible.

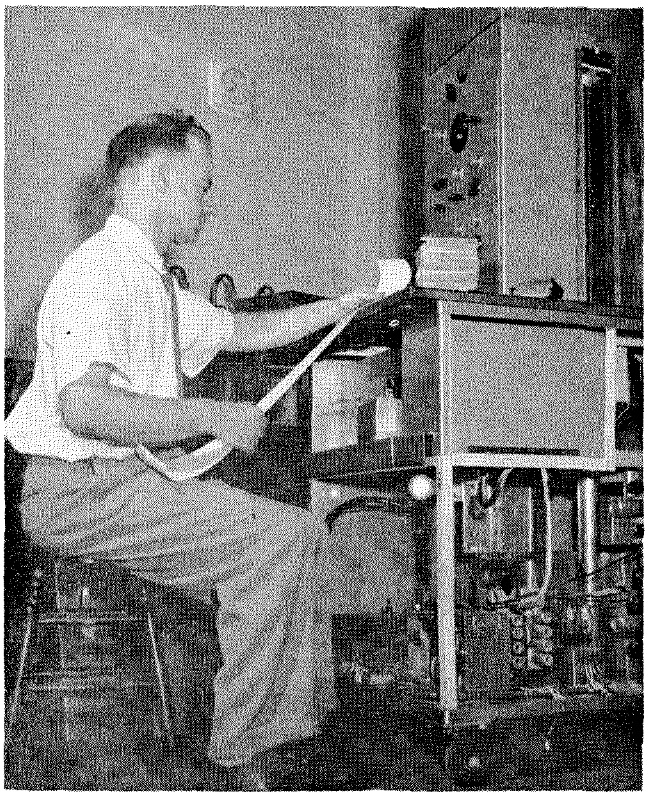
2. NONSTOP GEIGER COUNTER

While the Institute's Physics Division was busy making a nonstop cloud chamber, the better to watch one kind of radiation, the Biology Division was building a nonstop Geiger counter to measure another kind.

Dr. Geoffrey Keighley, concerned over the tedious hours spent by lab assistants in measuring the minute radiation emitted by the various materials resulting from "tagged atom" research, has finished an automatic counter that does most of the work without human assistance. It takes as many as 100 radioactive samples, examines the radioactivity of each for any preselected time between five minutes and one hour, and prints its findings on a paper tape. Though it is not the only device of its kind in existence, Keighley's counter has certain advantages over the few others that have been built; and its ability to work nights and weekends without supervision is of no mean value to Caltech's Biology laboratories, whose lights burn late enough as it is.

In biological research that relies on "tagged" atoms, or radioactive tracers, sample-counting is the final headache. It is difficult to incorporate radioactive atoms into the compounds that must be followed through a specific biological process. It is also difficult to obtain samples of the particular materials produced in the process that can reveal how far the tagged atoms have moved, chemically speaking. But these problems are fundamental problems of biology and chemistry. The "counting," on the other hand — the careful measurement of radioactivity that tells how many radioactive atoms have moved into various individual samples — is neither chemistry *nor* biology, but a tiresome and time-consuming chore.

Usually this "counting" involves putting each sample in a Geiger counter that measures, by responding to the particles ejected by each radioactive atom as it disintegrates, the number of radioactive atoms present in the sample. Then the operator must wait perhaps 30 minutes (but not 29 or 31) for the counter's report, note accurately the "count" (and often several hundred thousand atomic disintegrations are involved, even in a half-thimbleful of material), remove the sample, reset



Dr. Geoffrey Keighley's automatic counter measures minute radiation emitted by various materials resulting from "tagged atom" research. Samples move beneath a counting tube, which records reactions. These are transferred to a paper tape which can be read by the operator. The machine is currently being used to "count" radioactive samples obtained in a study of protein synthesis in the Institute's Biology Division.

the counter, put in another sample, and so on. Since many experiments produce fifty or more samples, it is easy to see why a machine to do this job automatically is welcomed by the Institute biologists.

The automatic counter itself is a combination of the mechanical and electrical improvisations that appear in any laboratory. An elevator raises samples (set in three-by-six-inch aluminum plates) on one side, receives and lowers them on the other; a conveyor slides them across the top of the machine beneath the counting tube itself. A dial, preset, determines the length of time that each sample remains under the tube. The tube's reactions are fed into a fairly complex assembly, called a scaler, which converts these reactions into numbers illuminated by small neon bulbs. A photocell reads off the illuminated numbers and operates the printing mechanism that puts the readings, suitably coded, onto a tape that the operator can read when the machine has finished its work.

If it is ever necessary, the counter can make one-hour counts of 100 samples, operating unattended for over four days and turning itself off at the end of the job. Since a 30-minute counting time is usually long enough, and since there are rarely as many as a full 100 samples, the machine will probably never take on a job that long; but a day or two of work may be expected from time to time.

So far, Keighley's counter has spent most of its time "counting" radioactive samples obtained in a study of protein synthesis. It has been known for many years that living systems somehow take a selection of the 24 complex chemical compounds known as amino acids and out of them make proteins — muscle, nerve, blood, germ-cell, bacteria, virus, depending on what system is doing the making. No one knows how the living systems do it. A most promising attack on this problem, an attack also being made in other laboratories all over the world, is to incorporate radioactive atoms (usually atoms of carbon, in their radioactive form of carbon 14 are used) into the various amino acids to see what the living systems do with each acid. The automatic counter, after the experiments have been run and samples obtained, provides the results for the scientists who are working on the protein-synthesis problem at the Institute.

A money saver too

Besides saving many tedious man-hours, the automatic counter should save money. Radioactive carbon 14 is obtained, in quantities adequate for research of this sort, only from the Oak Ridge nuclear reactor of the Atomic Energy Commission, and is expensive even though the A.E.C. provides it at as low a cost as is possible. Building carbon 14 into amino acids is an extremely complex, and therefore expensive, process. Yet, the less carbon 14 that is used in a given experiment, the longer each sample has to be counted—the less the radioactivity or the smaller the sample, the longer the time necessary to get a scientifically acceptable count. When men and women are doing the counting, this is important; when the automatic counter is doing it, time is no longer so important, and less of the expensive carbon 14 and carbon 14 compounds need be used.

SCIENCE IN ART

A Display of the Arts and Sciences in 1698

by E. C. WATSON

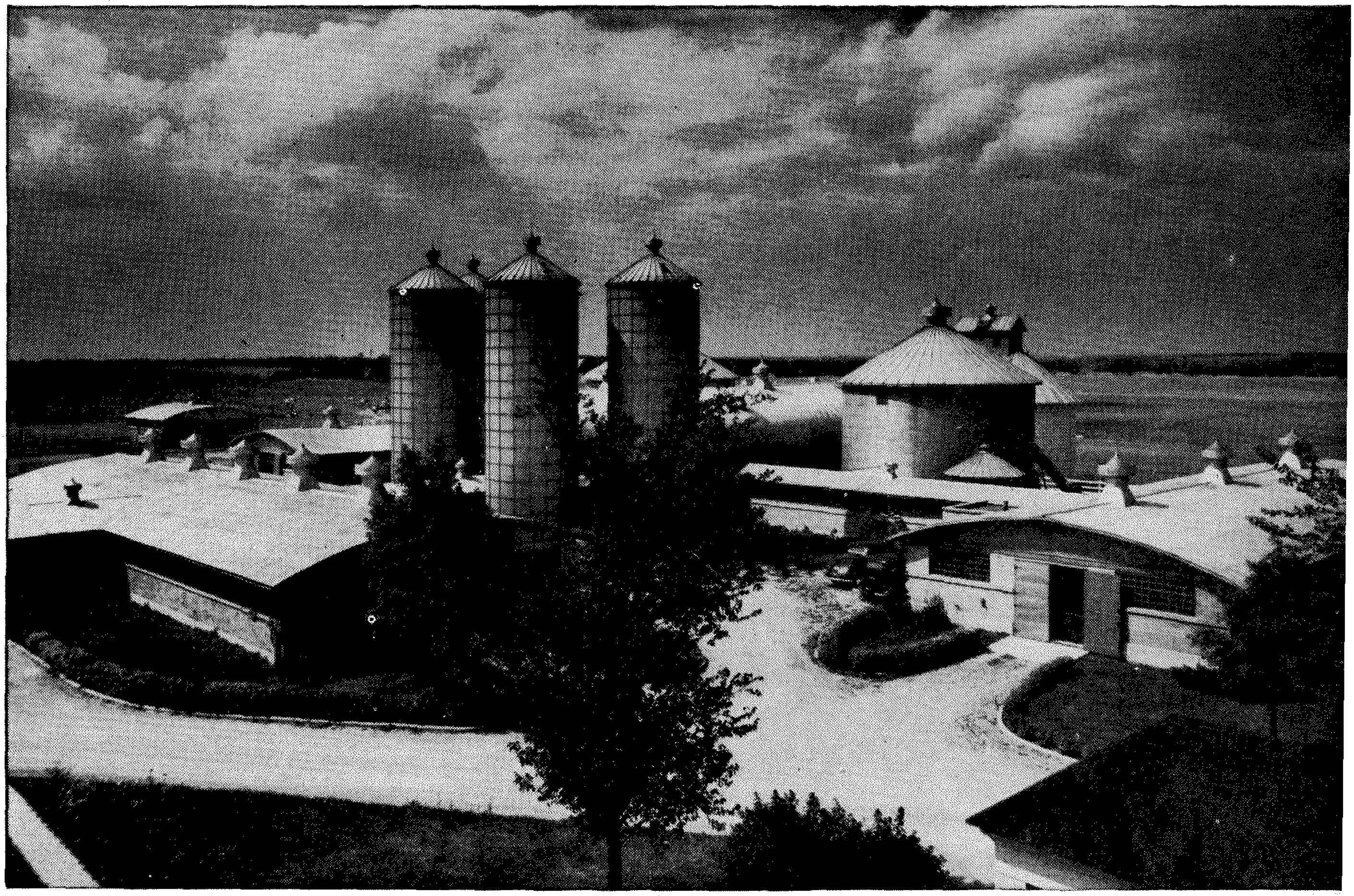
As ENGRAVER TO Louis XIV, Sebastien Le Clerc (1637-714) illustrated most of the early publications of the Académie des Sciences, and his engravings constitute a contemporary pictorial record of the Academy's personnel, apparatus, meetings and proceedings from 1670 to 714 that is not only unique but also remarkable in its mount and in its accuracy.

Trained and practiced as an engineer as well as an ngraver, a lifelong student of physics, geometry and perspective, a minutely painstaking and precise draughtsman, Le Clerc was able to depict the work of the Academy and its various scientific instruments with the reatest fidelity and understanding. His work affords n excellent example of the effective use of scientific material by the artist, as well as of the values of art in recording and humanizing scientific achievements.

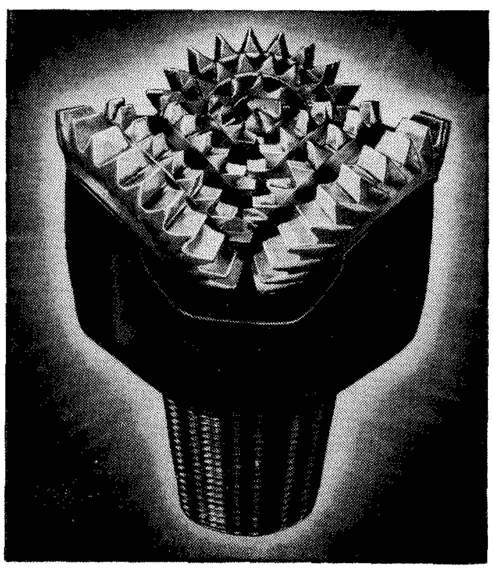
The engraving reproduced on this page was executed by Le Clerc in 1698, at the time when the Académie was being reorganized and was moving its collection of apparatus and its equipment to new quarters in the Louvre. It is considered to be Le Clerc's best work and is notable not only for the accuracy and fidelity with which the various scientific instruments are delineated, but also for the number and variety of the subjects, their distribution and grouping, the handling of the composition. As an engraving showing the state of scientific technic at the close of an epoch it has probably never been surpassed.

One of a series of articles devoted to reproductions of prints, drawings and paintings of interest in the history of science—drawn from the famous collection of E. C. Watson, Professor of Physics and Dean of the Faculty of the California Institute.

Only STEEL can do so many jobs

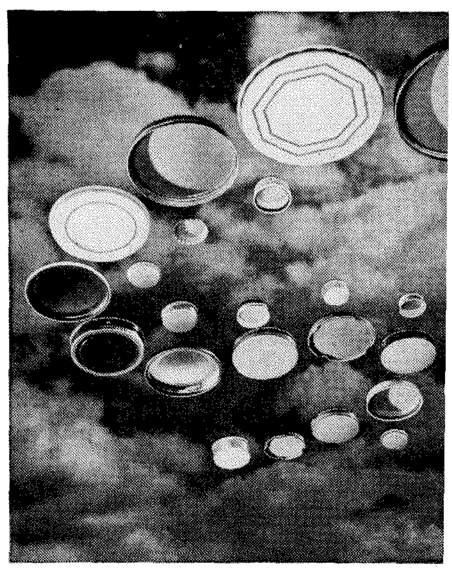


PRELUDE TO A SQUARE MEAL. Today, about 12½% of our population works on farms and ranches, supplying food for America and the world. And steel, more than any other material, has helped to make their work easier, their production greater, their lives pleasanter. For steel not only gives them strong, weather-proof roofing and siding for farm buildings like these, (U·S·S Stormseal and U·S·S Tenneseal are famous names in rural areas) but helps to bring them modern farm machinery and equipment, the blessings of electricity, fast transportation and scores of other benefits.



THE CAP IS THE CLIMAX. Many of the things we need to keep us healthy and happy these days come to us in handy, closed containers. And the caps, or closures, of these containers are actually the climax to a painstaking effort on the manufacturer's part to keep the container's contents pure and safe. Last year, 53,592,563,699 of these closures were used in America—many of them made from U·S·S Tin Plate . . . steel with a very thin coating of tin.

KEY TO BURIED TREASURE. This is a rock bit, the steel drilling tool that chews its way down through the earth to tap our deeply-buried treasures of oil and gas. For such bits, U·S·S Alloy Steels supply the super-strength, the extra toughness, the high resistance to impact, shock and abrasion needed for drilling to great depths.



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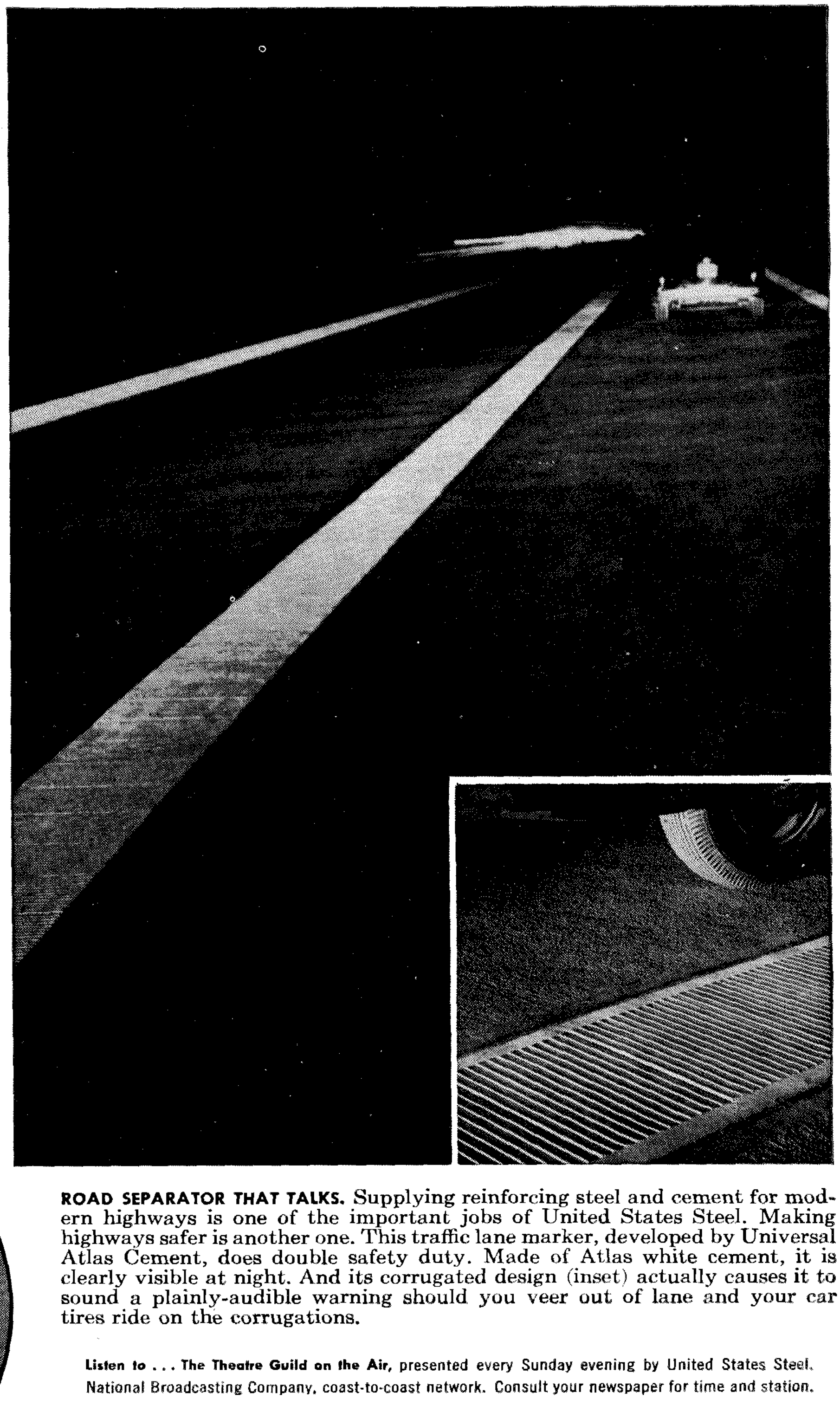

ROAD SEPARATOR THAT TALKS. Supplying reinforcing steel and cement for modern highways is one of the important jobs of United States Steel. Making highways safer is another one. This traffic lane marker, developed by Universal Atlas Cement, does double safety duty. Made of Atlas white cement, it is clearly visible at night. And its corrugated design (inset) actually causes it to sound a plainly-audible warning should you veer out of lane and your car tires ride on the corrugations.

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THE MONTH AT CALTECH

National Science Foundation

President DuBridge was appointed by President Truman last month to the Board of the National Science Foundation, set up by Congress to develop and encourage "the formation of a national policy for the promotion of basic research and education in the sciences."

The 24 appointees to the board—17 of them educators, 7 prominent in various scientific fields—represent all sections of the country. Besides Dr. DuBridge they include: Sophie D. Aberle, Special Research Director, University of New Mexico; Robert Percy Barnes, Head of the Chemistry Department, Howard University; Chester I. Barnard, President of the Rockefeller Foundation; Detlev W. Bronk, President of Johns Hopkins University; Gerti Theresa Cori, Professor of Biological Chemistry, Washington University Medical School; James Bryant Conant, President of Harvard University; John W. Davis, President, West Virginia State College; Charles Dollard, President of the Carnegie Corporation; Edwin B. Fred, President, University of Wisconsin; Dr. Paul M. Gross, Dean of the Graduate School, Duke University; George D. Humphrey, President of the University of Wyoming; Dr. O. W. Hyman, Dean of the Medical School and Vice President of the University of Tennessee; Robert F. Loeb, Bard Professor of Medical Services, College of Physicians and Surgeons; Dr. Donald H. McLaughlin, President of the Homestake Mining Co.; Frederick A. Middlebush, President of the University of Missouri; Edward L. Moreland, Partner, Jackson & Moreland, Engineers; Joseph C. Morris, Head of the Physics Department and Vice-President of Tulane University; Harold Marston Morse, Professor of Mathematics, Princeton University; Andrey A. Potter, Dean of Engineering, Purdue University; James A. Reyniers, Director of the Bacteriology Laboratories at Notre Dame University; Elvin C. Stakman, Chief of the Division of Plant Pathology & Botany, University of Minnesota; Charles Edward Wilson, President of the General Electric Co.; Patrick Henry Yancey, Professor of Biology, Spring Hill College.

Trustees

Chairman of the Board James R. Page announced the election of three new Institute trustees last month—Leonard S. Lyon, Harry J. Volk, and Robert W. Miller.

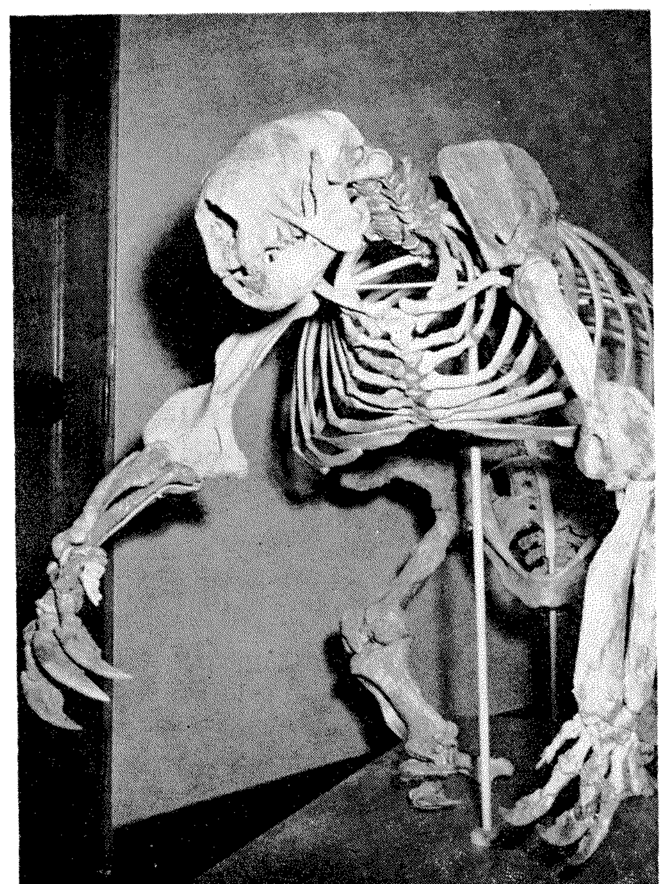
Mr. Lyon, a patent attorney, is a member of the firm of Lyon & Lyon in Los Angeles. He is president of the California Institute Research Foundation, a member of the U. S. Patent Office advisory committee and a lecturer on patent law at Stanford University.

Mr. Volk is vice-president of the Prudential Insurance Company in charge of western operations, with offices in Los Angeles. He is also a trustee of Rutgers University.

Mr. Miller is a director of the Standard Oil Company of California and president of the Pacific Lighting Company of San Francisco. He has the added distinction of being the first non-southern Californian to be elected to the Institute's 24-man board.

JPL Expansion

Bids for the start of a $608,000 construction, expansion and relocation project at the Jet Propulsion Laboratory should be announced this month. The work, which has been authorized by Congress, includes the demolition of ten small buildings which are now obsolete, construction of two new wings on the engineering laboratory, construction of a new warehouse, sound-suppression of the rocket-test valves, and landscaping. Funds have been allocated as part of the Military Construction Bill for the strengthening of the nation's defenses.



In its October issue E & S ran a picture of William V. Otto, Preparator in the Geology Division, surrounded by a mass of bones which he claimed would eventually make a reconstructed skeleton of a ground sloth. The awesome result, shown above, is on display in Mudd Hall.

Helping the world get its bearings

ALL THE WORLD MOVES ON BEARINGS—bearings of steel, of wood, of plastic, of rubber, of carbon, yes, even bearings of ruby and sapphire. All of them reduce the friction of moving parts. Every time you start your car or plug in your vacuum cleaner it is bearings that make possible smooth, efficient action at a variety of speeds and under almost any operating load.

Great roller and ball bearings of special alloy steels, running on their own smooth tracks, support our giant locomotives. Small bearings that fit in the palm of your hand are vital to your lawn mower, your washing machine motor, your mixer. And bearings, known as jewels, of ruby and sapphire, smaller than the head of a pin, increase the precision of your watch.

Other materials bring you other kinds of bearings, too. Carbon provides bearings in special cases where chemicals would attack metals. And in many ships the propeller shaft turns in plastic bearings that are not affected by salt water.

The people of Union Carbide have a hand in providing better materials that go into bearings of all sorts. Perhaps they can help solve your problems with materials of these or other kinds.

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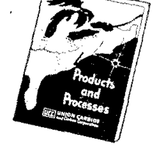

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THE BEAVER

Some Notes on Student Life

THE BEAVER GAVE a loud groan, took up a book concerned with the course he was most behind in, and ambled into the sun-flooded court. The mid-term blues —small wonder they called them "blue slips." The Beaver had got his share too.

As he selected a nice sunny nook and betook himself to a chair therein, he asked himself why it was that he was consistently behind—and concluded that it was due to the innumerable events which had taken place since the start of the school year. This masterpiece of rationalization was the one he always used.

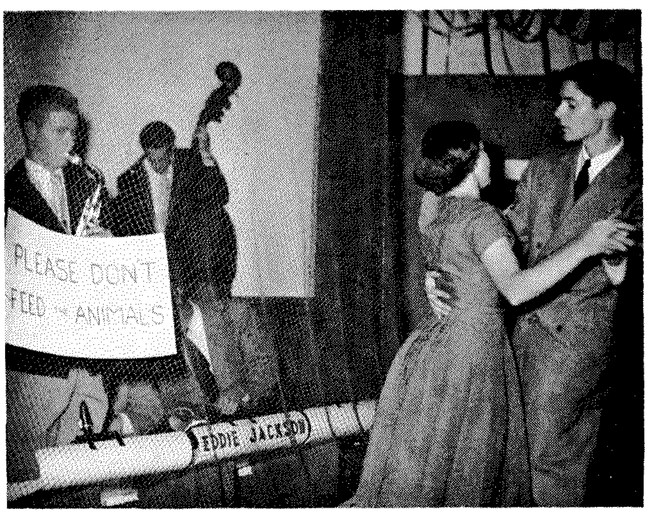
He grunted audibly as he thumbed through the index to find the approximate location of the material he was to have studied during the past seven weeks. The book creaked. The Beaver moaned.

Many faint X-ray lines, called "satellite lines", originate in atomic transitions between states of double ionizations.

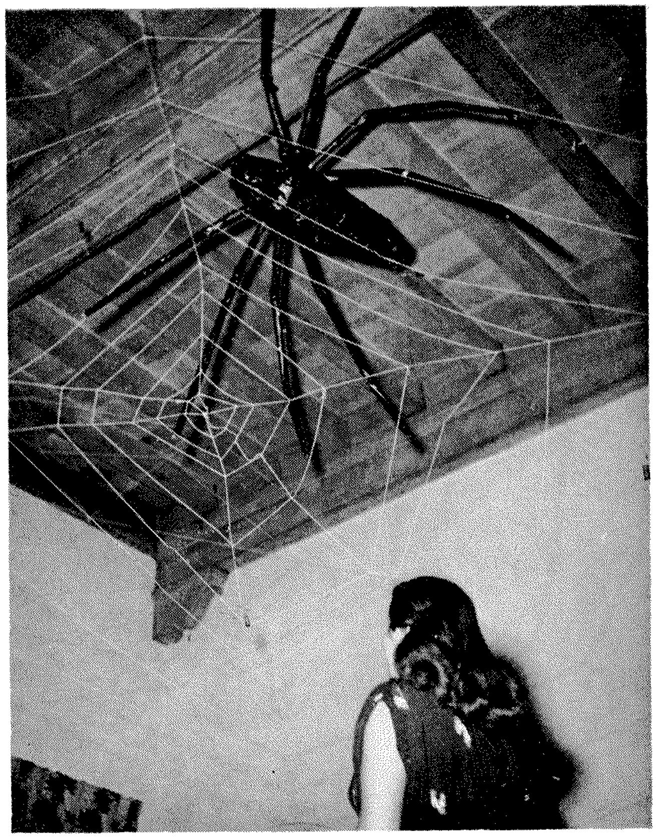
No sooner had the frosh rotation and initiation taken place than a series of exchange dances broke out. Then came the multiplicity of fall-term events.

Pajamarino

The Pajamarino was a great event. Tech men had donned gaudy night attire and danced with various degrees of madness around a bonfire of monstrous proportions. Then, escorted by several motorcycle policemen, they proceeded to the American Legion Hall, bellowing all the while. Prizes were given to those in the most fantastic costumes—and there were many such. At the American Legion Hall, where the Occidental crew held forth with short skits and song routines, the female-starved Tech men sat beady-eyed and swayed imperceptibly to the strains of the romantic songs that issued from the red-lipped coeds.



Dabney took on a circus atmosphere for the inter-house dance, put its orchestra behind bars for safety's sake.


Blacker went back to nature for inter-house dance decorations, which included this larger-than-life spider.

But this could not last. The Tech cheer-leaders gyrated and whipped up such amazing response that even those from Oxy were heard to shout "To hell with Oxy". When the affair broke up, sleepy-eyed Pasadenans were astounded to see pajama-clad Tech men cavorting in the streets, and were left to wonder at the curricula given at the Great White Edifice which could cause so much somnambulism.

A difference in the arrangements of the electron spins requires that the atomic wave functions shall be a different function of the coordinates.

Inter-House Dance

The Beaver sighed. Hard upon the Pajamarino had followed the inter-house dance. One of the disadvantages of the inter-house was the vast amount of preparation. A tremendous rocket began to shape up in the Ricketts courtyard, and the sound of carpentry issued forth at all times of day. The Dabney men found a certain fascination in building an electronic menagerie, and great boards of impressive dials, lights and relays were erected in order to control the lithe proboscis of a papier-maché elephant. The Blackerites fashioned a toad-stool of astronomical dimensions to serve as the entrance to their underground dissipatory. Fleming, in usual abandon, created a steamboat which included as a

CONTINUED ON PAGE 26

THE BEAVER . . . CONTINUED

major feature, a bar. Throop utilized its more functional architecture to set up such carnival concessions as a tunnel of love, a penny toss and a dart-throwing booth.

The Beaver Dances

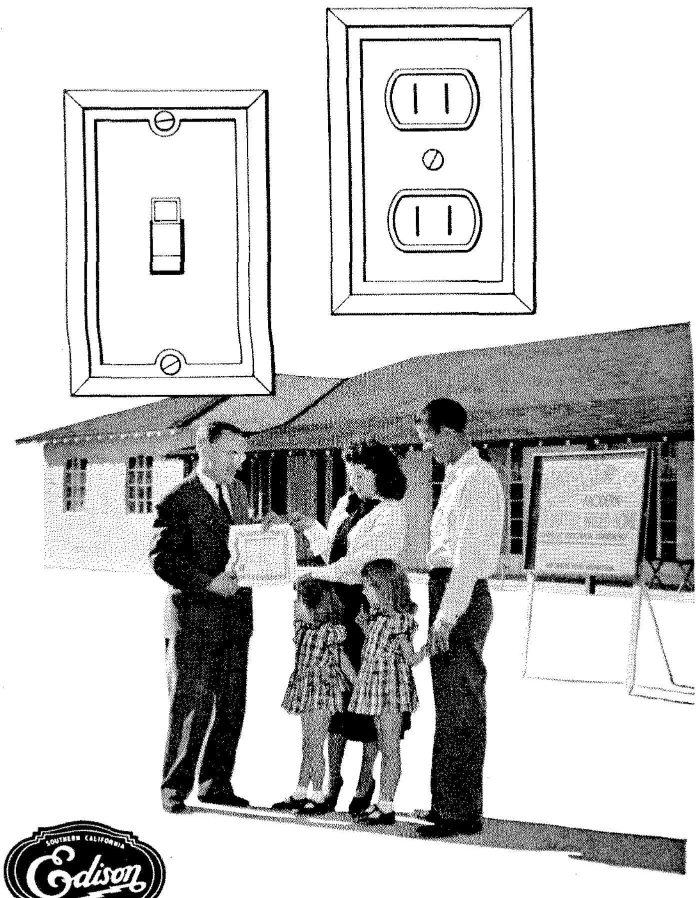
The Beaver delicately considered the words before him: *Noting what subshells of electrons are already filled in calcium, one can predict with reasonable certainty that the first excited states of—*

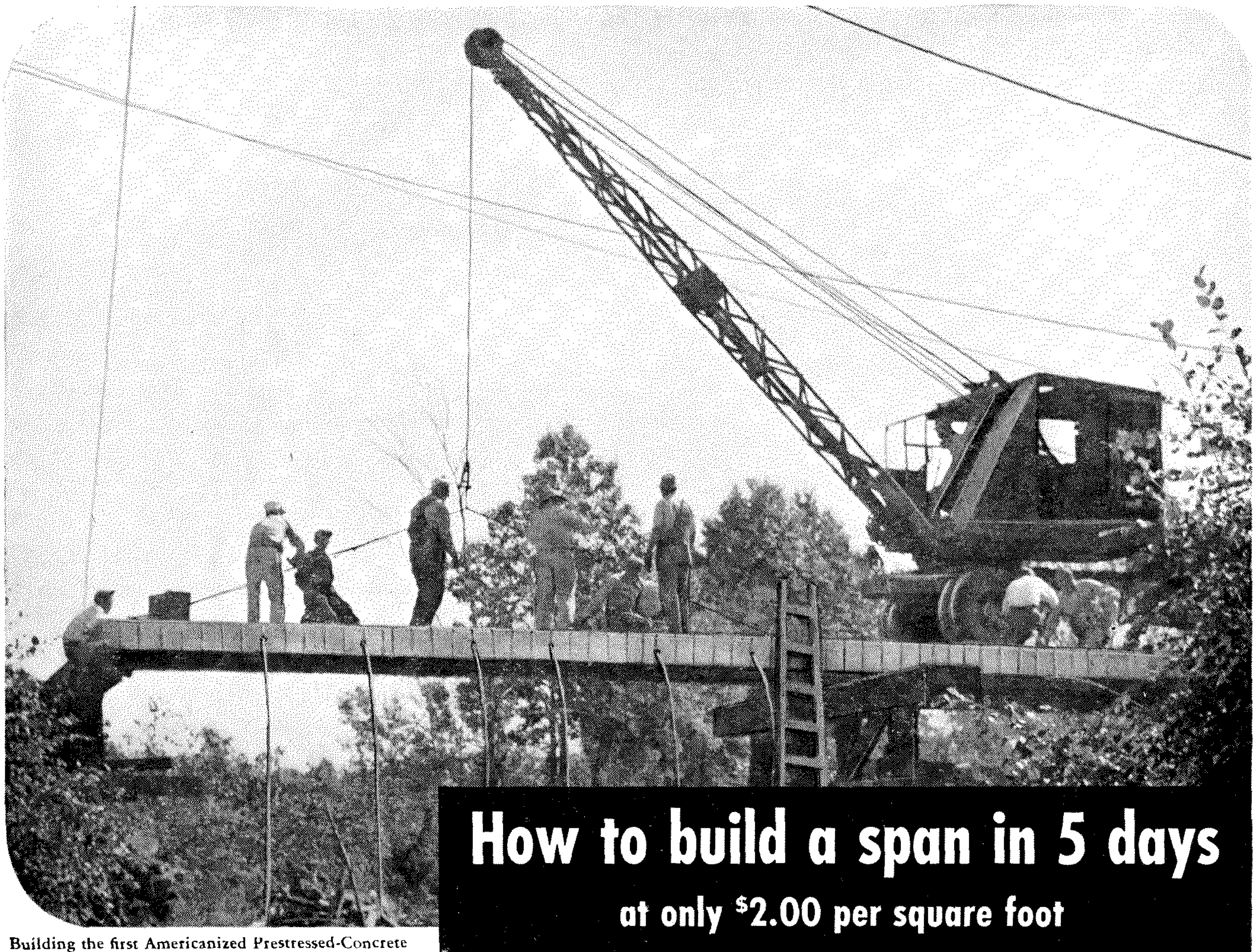
The dance itself had been a success. With studied fastidiousness the Beaver had donned resplendent clothing and escorted his date with meticulous care while she oh'ed and ah'ed with surprise as they proceeded from house to house. Many of the faculty had crept from their dusty tomes and were seen with their spouses. It was a source of satisfaction to the students to realize that the faculty considered their efforts worth viewing.

If, on the other hand, an atom with an incomplete valence-electron subshell is considered, —

Bah! It was small wonder the Beaver was unable to get anything done. The Mudeo had come and gone, and the impossible had happened for the third time in the history of Tech: the Frosh had won. The Frosh pulled together and hauled the indignant Sophs into the muddy pit, though when it was later pointed out that the Frosh had had five more men than the Sophs, the tug-o-war victory was transferred to the Sophs. The sack race proved futile to the second-year men; the newcomers hopped away to an easy win. The Sophs sole win was the wheelbarrow race. They navigated the muddy pit with remarkable speed while the Frosh tried the less effective method of a submarine crossing. But the upper-classmen never again gained the initiative. The horse and rider event proved earth-shattering; one remaining Frosh team wiped out three sets of Sophs. Even in the mud fight for eleven tires the judges had to bestow the laurels on the Frosh. And so it went till the score against the Sophs was 5-2. It was the Sophs who were bent on throwing the Junior judges into the pit, as custom required, but the joy-laden Frosh managed to help a few escape. It was all most erratic.

The sun had managed to escape the Beaver's nook. The printed words flowered up at him through the blue haze: *Due to the large spin-spin interaction of the electrons in LS-coupling,* S_1 *and* S_2 *precess rapidly around their mechanical resultant S.*





How to build a span in 5 days

at only $2.00 per square foot

Building the first Americanized Prestressed-Concrete Bridge. Crane which exceeds designed load capacity of the bridge operates safely on the unfinished span before its concrete slab has been laid or lateral prestressing applied.

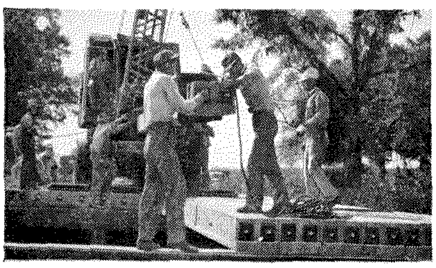
The bridge, located in Madison County, Tennessee, was designed by Bryan and Dozier, of Nashville . . . built by Madison County Highway Dept. under supervision of Edwin C. Rogers, County Engineer. Concrete blocks by Nashville Breeko Block & Tile Co.

IN OCTOBER the first Prestressed-Concrete Bridge in the United States was put in service. Its roadway, designed for a 15-ton load, was of an entirely new design which permitted amazing speed of construction and cost only $2.00 per square foot. With the experience gained, it is estimated that similar spans to be built will be erected in five days—ready for traffic in 14 days—and at an even lower cost.

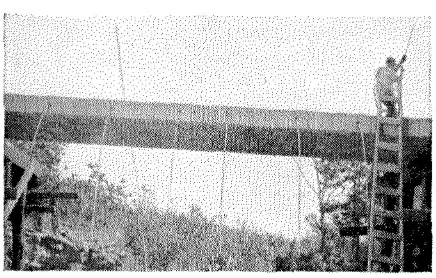
The span is made up of beams formed of machine-made concrete blocks laid horizontally with mortar joints. Two Roebling Prestressed-Concrete Galvanized Strands running through longitudinal holes in the blocks were placed under tension, converting each beam into a self-contained monolithic concrete unit. After the beams were erected in place, the span was covered with a continuous, mesh-reinforced concrete slab and laterally prestressed when the concrete had cured to strength.

Americanized Prestressed-Concrete, employing special cold drawn steel wire and specially designed fittings, is an exclusive Roebling development. It makes available a new construction material with an exceptional strength-weight ratio . . . a material economical in itself and a real time-saver! Its potentials quickly recognized, it has already been adopted in several structures, including use for floors and roof of a large commercial building now under construction.

The Roebling engineering staff is ready to help your engineers work out problems connected with new applications for Prestressed-Concrete.



Swinging the assembled concrete beams into place to form the deck cover for the bridge. Beams are only 11⅝" deep.



Americanized Prestressed Concrete employs special galvanized cold drawn steel wire and specially designed fittings. It is these recent Roebling developments which make possible this type of construction.

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CIVIL DEFENSE

Some warnings and recommendations

by GRANT V. JENKINS '24

Los Angeles Civil Defense Co-ordinator

Because of the disturbed world situation, many people in the United States have felt that no time should be lost in adequate preparations for the passive defense of the country; however, at the national level it is only within recent months that consideration has been given, beyond mere planning, to this problem. States and local governmental jurisdictions have been ahead of the national administration in this regard.

Modern war is total in that it requires the whole effort of the nationals involved to continue its progress. The airplane has made it possible for one nation to successfully attack the civilian morale, homes and cities which lie behind the military defense of an enemy, and as a consequence the civilian has become an intimate part of the war machine of his country. Civil defense, in these modern times, must therefore take its place alongside the military defenses of the nation.

Civil Defense Objectives

The objectives of a civil defense program for a large, heavily populated industrial area can be stated as follows:

1. To save the greatest number of lives
2. To be prepared to render the greatest possible aid to the injured
3. To give the greatest possible protection to property
4. By every means at hand, to maintain the morale of the community at its highest level
5. To be prepared to go to the assistance of neighboring stricken communities

Civil defense must be integrated into and be an intimate part of the government structure. All volunteers will work under heads of existing units of government. A well-developed organization, capable of functioning in an emergency, will include: Administration, supply, recruitment and training of volunteers, public information, medical and welfare services, law and order, fire services, communications, transportation, and emergency types of engineering services, such as utilities, public works and sanitation.

Certain of these divisions, such as fire and police, will carry out their normal responsibilities, but with augmented volunteer forces; other divisions, like public health will add new duties to their normal peacetime responsibilities; still other divisions will be peculiar to a civil defense organization and will have no comparable government group already establshed. However, city or county employees will head these emergency divisions, and will organize them within the Civil Defense structure.

It is also basic in civil defense planning to use the services of each citizen in the place where his ability, training and willingness to serve contribute most to the total effort; thus it is logical that citizens with scientific or engineering training will be given responsibilities which naturally grow out of their peacetime work.

Civil defense in the last war meant primarily protection of one's own block from blast and fire. Too many see civil defense in an atomic war as the same parochial task, with a Geiger counter added to the bucket of sand and the gas mask. To a certain extent this will still be the case; self-help in the early stages of a disaster is still stressed; but to a much greater degree than heretofore conceived, civil defense must be an organized effort of the civilian population as a whole to keep the country as a whole a going concern.

The Scientist's Responsibility

One can readily see that the engineer and scientist has a definite and particular responsibility in civil defense. To be specific, the following requirements can be suggested for consideration at this stage of planning:

1. Trained radiation monitors become the most important individuals after a low ground or underwater atomic explosion. At first they may assess the intensity and location of the radioactive contamination by penetrating as far as possible into the affected area, and thus determine the danger areas. They will accompany the rescue missions and direct the evacuation operations. Later the radiation monitors will recommend the decontamination and rehabilitation operations of an area.

2. While there is a tendency to emphasize the atomic bomb, civil defense preparation does not neglect the more conventional types of attack with incendiaries, chemicals and bacteria. Newer techniques in defense

CONTINUED ON PAGE 30

CIVIL DEFENSE . . . CONTINUED

against them will call for most intelligent planning. Only people of scientific background can be expected to assume leadership in these fields of detection, protection and decontamination.

Let the people know

3. Because of their education, scientists and engineers can interpret the facts of the atomic age to those less trained in these matters. They can help educate our people to the real hazards of modern war; and, on the other hand, to the great benefits to mankind which can develop from the atomic developments of the last decade. If the American people know the facts, rather than many of the lurid tales which pass for scientific knowledge, they should be more inclined to take in stride what lies ahead.

4. Because of their training, engineers should analyze each proposed civil defense measure, assess its effectiveness and assist in the development of plans for implementing it. Each proposal should be judged both for its correctness and effectiveness, and for its common sense as a contribution to the total defense program.

5. Because of their leadership in their respective communities, scientifically trained persons can help by taking a realistic view of this business of war and its implications. They should not be lulled into a false sense of security because of any temporary military success. We are dealing with an enemy that is too strong to be defeated easily.

Some general advice

As to general advice — do not spend money on gadgets, special drugs or expensive books, and discourage others from doing so. Get your information from official sources.

Discuss civil defense with your family, friends and associates, and be prepared to guide the thinking of less-informed people.

Think through a few simple rules you would follow in case of an attack. This business of preparation is largely common sense applied to a specific problem.

Be continuously conscious of the problem of sabotage. We recognize that there are people in our communities and industrial life whose loyalty is to be questioned. Without being part of a witch hunt, be intelligently alert to the many clues which will point out those who would destroy our way of life.

Prepare yourselves, and encourage your family to become better prepared for a war situation by taking all available training in first aid, home nursing and such allied subjects.

When called upon, identify yourself with a defense unit in the capacity where your training will best serve.

ALUMNI NEWS

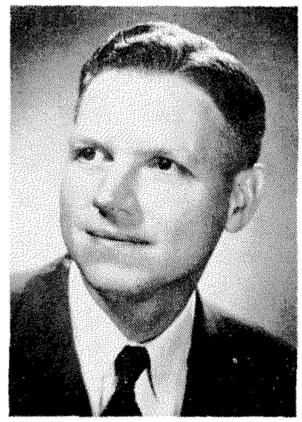
E & S Publisher

Harry K. Farrar '27, publisher of *Engineering and Science Monthly* since 1946, turned over the position last month to Richard Armstrong, M.D., '28. Mr. Farrar, staff engineer with the Pacific Telephone & Telegraph Co. in Los Angeles since 1941, was transferred this fall to the company's San Francisco office. He is now working under the General Studies Engineer, in the General Administration Department, which coordinates and checks on the work of the four Telephone Company areas—Washington-Idaho, Oregon, Northern California-Nevada and Southern California.

Mr. Farrar served as Treasurer of the Alumni Association in 1942-3. A member of the Board of Directors of the Association since 1943, he was Chairman in 1944-5.

Dr. Richard Armstrong, new publisher of *E & S*, has been a practicing Ophthalmologist, with offices in Pasadena, since 1946. He is a member of Tau Beta Pi and the medical society Alpha Omega Alpha. He is on the staffs of the Huntington Memorial Hospital and St. Luke Hospital, and is Assistant Professor of Ophthalmology at the College of Medical Evangelists in Los Angeles. On the board of the Alumni Association since last year, he has been Director in charge of Membership.

Prizewinner



James H. Jennison, '35, M.S. '36, head of the Development Engineering Division of the U.S. Naval Ordnance Test Station in Pasadena, last month won a $5,000 first award in the 1950 Welded Bridges of the Future competition.

Jennison's design of an all-welded 250-ft. highway bridge won out over those submitted by bridge designers from 16 countries in the annual contest sponsored by the James F. Lincoln Arc Welding Foundation of Cleveland, Ohio. The contest called for a design of a bridge to withstand specified loads and to be built of a specified type of steel. The program is intended to promote the building of better bridges for less money and with less steel. In describing his winning design, Jennison explained that "an equivalent riveted bridge would require 30 to 60 per cent more steel than the welded bridge."

Jennison, who has been in his present Navy position

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

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5112 Connecticut Ave., N.W.
Washington 8, D. C.

since 1945, was employed for seven years previously by the Bridge Department of California's Division of Highways. His 1950 prize is not the first he has won. In a 1947 contest run by James F. Lincoln he received a $2,000 second award in Structures, for a paper on a 300-foot span all-welded movable bridge for launching test torpedoes at the Naval Ordnance Test Station. He also received an Honorable Mention award in the 1949 Welded Bridges Program.

Homeward Bound

THREE CHINESE GRADUATES of Caltech, who were removed from their China-bound ship in Yokohama on September 12, were finally cleared by government officials in Japan on November 22, and proceeded on their way home.

The three men—Dr. Chuong Yao Chao, Ph.D. '30, and research fellow in physics at the Institute since 1948; Dr. Chum Lo, who received his Ph.D. in aeronautics in 1950; and Dr. San Chuin Shen, who received his doctorate in biology last June, were on their way home to China when they were removed from the S. S. President Wilson in Yokohama without explanation. Their subsequent release was also without explanation.

Neither the Justice Department in Washington nor Gen. Douglas MacArthur's headquarters in Tokyo would comment on the action. The only word to reach the Institute was a brief telegram from Chao to President DuBridge which read: "Matter cleared. Sail shortly for Hong Kong with Shen and Lo. Best regards."

Chapter Note

AT ITS FIRST FALL meeting on November 30 the New York Chapter had Dr. George T. Felbeck, Ph.D. '43, as a guest. Dr. Felbeck, who has been connected with Oak Ridge since 1942 as project manager in charge of operation of the gaseous diffusion plant, is currently vice-president of the Carbide and Carbon Chemicals Corporation, heading up the Physical Processes Department. He spoke to the New York Club on "Non-Military Aspects of Atomic Energy".

Alumni Calendar

SOMETHING HAS BEEN ADDED to the Alumni Calendar for 1950-51 (which you'll find on this page by the way) —a picnic for alumni and their families, to be held sometime in May. This event will take the place, this year, of the usual spring field trip and the summer stag field day—and it is hoped that it will combine the best features of both those activities. Right now, the committee is trying to make arrangements to hold the family picnic at the Munz Resort, in the hills west of Palmdale. The Resort has a swimming pool, fishing pond, baseball diamond, a lake for boating, and barbecue facilities—and, what's more, it's run by a Tech alumnus, Arthur N. Etz, Ex-'35. We'll let you know when the date and place are confirmed.

The next important event on the Alumni Calendar is the dinner dance on February 3. This is to be held at the Oakmont Country Club, with LaVerne Boyer and his orchestra furnishing the music.

ALUMNI CALENDAR

1950-51

February 3	Dinner Dance
April 14	Alumni Seminar
May (date to be set)	Family Picnic
June 6	Annual Meeting

Directory

ALL BASIC INFORMATION has now been turned in for the Alumni Directory (are you sure *you* returned that card?) and is currently being classified. Copies should be going out by early February.

PERSONALS

1912

J. D. Merrifield writes from Rocky Ford, Colorado, that his business as a manufacturer of food packaging machinery is rolling along nicely. In Minneapolis recently he met and had a fine long talk with Robert E. Ford, "the professor that we old-timers held in high esteem."

1923

Don Loughridge, Ph.D. '27, Senior Scientific Advisor to the Secretary of the Army in Washington, D. C., writes that his oldest daughter is now married to a member of the civil engineering staff at the University of California; his oldest son is also married, has two children, and was with Boeing Aircraft in Seattle until he was called back into service with the Navy last month. He was a submariner in World War II. Don, Sr.'s third child is studying at American University in Washington, D. C., in the medical field.

1924

Reinhardt Schuhmann Sr., Ph.D., writes from Gunnison, Colorado, that he is just ending his 21st year as head of the chemistry department at Western State College of Colorado. He's president of the local chapter of the A. A. U. P. for 1950.

1925

H. P. Robertson, Ph.D., who is on leave from his Professorship of Mathematical Physics at the Institute and in Washington, D. C. as Director of Research of the Weapons System Evaluation Group in the Offices of the Secretary of Defense, writes that he hasn't had much chance to miss his colleagues from Caltech. There is a continual stream of them through Washington, and he runs into former students and acquaintances aplenty—as, for example, at the Alumni Dinner on October 20, where there were a number of former grad students of his vintage.

M. B. Karelitz brings us up to date with the information that, from 1946 through 1949 he was head of the Mechanisms Development Section of the General Precision Laboratory in Pleasantville, N. Y. Also he served as consulting mechanical engineer on the design and construction of the 164-in., 400-MEV synchro-cyclotron at Columbia University. And, in 1949, he was consulting M. E. at the Brookhaven National Laboratory on the 3-BEV cosmotron.

Since January 1, 1950, Mike has been Chief Mechanical Engineer with the Perkin-Elmer Corp. of Glenbrook, Conn., developing and manufacturing precision optical and electronic instruments. The Karelitzs now live in Fairfield, Conn.

1926

F. A. Brossy, Cdr., USNR, is now Assistant Naval Reserve Coordinator (Air) of the 4th Naval District in Philadelphia.

Victor F. Hanson writes from Wilmington, Delaware, where he's supervisor in Applied Physics at the DuPont Experimental Station. Vic is married, has two sons, 12 and 17 respectively, and lives in a 2,000-year-old farm house in Yorklyn, Delaware. During the past year Vic was invited to deliver a paper at the Stockholm conference on Instruments and Measurements (which was also attended by Maurice F. Hasler '29). He's Chairman of the Gordon Research Conference on Instrumentation for 1950 (a job which will be held by *Harold Washburn* '29 in 1951, and by *Howard Cary* '29 in 1952).

B. N. Sammer writes from Whittier, Calif. that he is now Chief Engineer for the E. P. Halliburton Company, in charge of the Portland Cement Plant Project for Brazil, after having previously been an electrical engineer on design and layout of the 25,000-kva, 13.8-kv Turbo Generator Plant, and 13.8-kv power transmission line with the Fluor Corp. Ltd. for the Arabian American Oil Co. He was general manager of E. P. Halliburton's Manufacturing Division for fifteen years, and District Engineer for the Halliburton Oil Well Cementing Co. for seven years.

Donald P. Macfarlane has been with Pacific Tel & Tel since shortly after graduation in 1926. At present he's Area Personnel Supervisor with offices in L. A. No news of weddings or babies from Don—probably because he's still a bachelor.

1927

Florent H. Bailly, President of Petroleum Engineering Associates, dug the first shovel of dirt last month at ground-breaking ceremonies for his firm's new building at 700 S. Fair Oaks Ave. in Pasadena. The building will provide laboratories and offices not only for Petroleum Engineering Associates but for its allied firms, Oil Properties Consultants and International Petroleum Consultants.

George K. S. Diamos, M.S., after being in the movie exhibition business for more than 20 years, last month joined the Roy Drachman Realty Company in Tucson, Arizona, as a real estate salesman. His family now includes Clay (10), Kathy (7), and Bill (13 months).

Arthur H. Warner, Ph.D., is now Director of Technical Operations at the Long Range Proving Ground Division of the USAF in Cocoa, Florida. "This is where they will test long-range guided missles," says Art. "The instrumentation is largely electronic, and opportunities for young graduates exist." Art's daughters, Hattie and Libby, are Frosh and Junior, respectively, at Pomona.

Kenneth Belnap writes that he's still a member of the partnership of Belnap & Belknap, Insurance Agents and Brokers, in L. A. His sons, Bruce and Raymond, are now 12 and 9 respectively.

1928

Russell J. Love reports that daughter Patricia (better known as Patti Love) enrolled as a Freshman at the University of Arizona this fall. Son James continues his Business Administration course at UCLA—and Papa continues to hope for another engineer in the family, next generation.

1929

James W. Dunham, Chief of the Los Angeles District Beach Erosion Unit, had a paper on "*The Refraction and Diffraction of Surface Waves*" presented at the October 11-13 meeting of the Institute of Coastal Engineering in Long Beach.

Bill Mohr, M.S. '30, has been ordered to 21 months active duty in the Army. Bill is a Colonel and commands the 370th Engineer Boat and Shore Regiment, at Fort MacArthur, California.

T. H. Evans, M.S. '30, writes from Fort Collins, Colorado, that he is Dean of Engineering at the Colorado Agricultural and Mechanical College there—also chairman of the college's Irrigation Institute, War Plans Committee and Artificial Precipitation Advisory Commission. Sounds like a full schedule.

1930

John G. Pleasants, M.S., Ph.D. '33, vice president in charge of manufacturing for the Proctor & Gamble Company, is one of three new company directors voted into office by shareholders at their annual meeting recently.

1931

A. J. Grafman has moved with his wife and son to Telaviv, Israel, where he is doing aeronautical work for the Israelean government.

1932

C. L. Killgore, Assistant to the Chief Designing Engineer in the Bureau of Reclamation at Denver, Colorado, was in Europe during June and July of this year—as an official delegate of the State Department to the International Conference on Large Electric Systems in Paris; as a representative of the Bureau at the Swedish State Power Conference during the Study Tour of Sweden; as advisor to the Assistant Secretary of the Interior at the Fourth World Power Conference in London, and during a tour of the hydroelectric power installations in Scotland. Mrs. Killgore accompanied him on this Grand Tour.

1933

Wendal A. Morgan writes that he is chairman of the Denver section of the American Institute of Electrical Engineers, has been head of the Power System Technical Section of the Bureau of Reclamation in Denver for about six years, and supervisor of the Bureau's A.C. Network Analyzer.

Robert R. Mead, who has been with the Ethyl Corporation since 1936 (with 3½ years out as an officer in the Army) has now been promoted to the position of Resident Manager for Ethyl in Kansas City, Mo. He will have charge of Ethyl activities in several widwestern states.

Bom MacDonald is a Lt. Colonel in the Army Engineers on 21 months active duty. Bob is Executive Officer of the 370th Engineer Boat & Shore Regiment.

Robert D. Fletcher, M.S. '34, Ph.D. '35, reports that he recently left his position as Chief of the Hydrometeorological Section of the U. S. Weather Bureau, to become Meteorological Consultant to the Air Force Air Weather Service in Washington, D. C. Bob is also busy in a civic capacity—as President of the Bannockburn (Maryland) Citizens' Assocation.

1934

R. A. Naylor writes from Stamford, Connecticut, that his most important acquisitions in the past several years have been a wife, Nancy, married May 6, 1946; and son, Ralph Jr., born December 19, 1949.

T. P. Thayer, Ph.D., recently returned from 6 months mineral exploration for the Liberia Mining Company. En route home, he was joined in Paris by Mrs. Thayer, and they spent a month in Europe, during which time Thayer—ever the geologist—spotted some real "wildflysch" and picked a couple of samples from an overthrust fault at the Jungfrau Joch. He is now back on the Washington merry-go-round, with the U. S. Geological Survey.

C. V. Newton reports that, since January 1, 1948, he has been Production Manager for the California Walnut Growers Association, in charge of plant operations and engineering. He's living in Pasadena.

1937

Hugh M. Gilmore Jr. writes from Lumberton, North Carolina, that he gave up photography for teaching after the war, and returned to UCLA for his teaching credential and Masters' degree. He taught math for one year at Newhall, California, and this year is teaching science and mathematics at Lumberton High School.

1938

Henry K. Evans is a Highway Transportation Specialist for the U. S. Chamber of Commerce in Washington, D. C. He is also editor of the new Traffic Engineering Handbook—just off the press—published by the Institute of Traffic Engineers.

1939

Charles Mackintosh, M.S., is teaching a course in Design of Timber Structures at UCLA this term.

1940

Don Kupfer spent last winter in the Mojave working on his thesis, went to the Black Hills with the United States Geological Survey for the summer and is now at

Yale "with modest hopes of eventually obtaining that elusive Ph.D."

Dumont Staatz, M.D. is in his last year of residency in Orthopedic Surgery at the University Hospital, Ann Arbor, Michigan. He has four children, Fred, 7; Bill, 6; Gretchen, 4; and John, 11 months. He'll finish his training program in July 1951.

Robert Osborne Cox, last heard from in June '49, writes from Florida that he is now a major stockholder and secretary-treasurer of the Lauderdale Marina. "The Marina," he says, "is still alive and kicking and there has been a gradual shift in its intention from an idealized yacht basin to a strictly sales and service organization. We do electrical work with technical overtones, plus a good deal of fairly tricky service work. You don't have to be a graduate engineer to be a good mechanic, but I assure you it helps.

"So far, I have found this type of business to be the most pleasant way of starving to death while working twelve hours a day and seven days a week.

Bob also says that he has recently remarried, and acquired three children.

1941

Fred W. Billmeyer Jr., got his Ph.D. from Cornell University in 1945, worked for the Rubber Reserve Corp. at Cornell during the war, and since then has been with the Polychemicals (formerly Plastics) department of the DuPont Company. He's at the Wilmington, Delaware, plant now, specializing in molecular weights of high polymers. Fred has been married and divorced, has one son.

John G. Partlow and his wife announced the arrival of their first child, Marilyn Ruth, on July 16. John is still designing turbine generators for Westinghouse in Pittsburgh, Pa.

1942

Roger Brandt writes from Weatogue, Connecticut, that after two years of teaching at the Hotchkiss School in Lakeville, Conn., he has gone back into engineering again. He is now Development Engineer for the Hartford Empire Company, and his work, so far, has been the development of packaging machinery. Roger says teaching is a wonderful life for those who like it, but after two years of it he came to the conclusion that he was a better engineer.

E. R. Bartlett, M.S. '47, has been working as Development Engineer at the DuPont Nylon Plant in Seaford, Delaware, since leaving Tech. He and his wife, Helen, drove as far west as Yellowstone on their vacation this summer, but could not quite make Pasadena.

Wayne MacRostie has been promoted to Senior Hydraulic Engineer with the California State Division of Water Resources in Sacramento. He is now directing a state-wide reconnaissance of flood-control problems.

1943

Robert A. Moore reports that he's been a father since last June 19, when Barbara Ann arrived.

1945

Charles M. Davis, M.S. '46, s now living in Ames, Iowa, where he has a fellowship in the Electrical Engineering Department at Iowa State College, and is working for his Ph.D.

Don Leinweber, Job Engineer for the Fluor Corp. in Los Angeles, was married on June 24 to Louise Bruington.

Wallis T. Fleming comes up with recent news about himself:

"1949—Served as President of the Tolleson, Arizona, Farm Bureau Local.

May 4, 1950—Our first baby arrived—a girl named Wilma Ann.

Oct. 2, 1950—Won sixth place award in James F. Lincoln Arc Welding Foundation National Agriculture Award and Scholarship program, for a paper written on arc-welding use in farming and agriculture."

1946

G. R. Pool was married in Pensacola, Florida, in June, 1948 to Dorothy Belden, a Los Angeles girl; was promoted to Lt. (jg) in the regular Navy in February, 1949; became father of a son, John Robert, in March, 1949; was designated a naval aviator and received his wings in November, 1949; and is currently assigned to an anti-submarine squadron (VS-21), permanently assigned at San Diego. He says, "We have been flying TBM Avengers, but expect to receive new planes before too long. My family is now living in Coronado, California, and I have been overseas since May of this year."

James F. Chalmers Jr. graduated from Harvard Business School in June '49, and is now Assistant to the Director of Manufacturing at Hughes Aircraft Co.

Frank H. Lamson-Scribner Jr., Lt. (jg) USNR, was recalled to the Navy in August of this year, has been in the Western Pacific. He is on military leave from Du-Pont, where he's a junior engineer.

C. W. Griffing, M. S., Prof. A. E. '47, is the father of a third child, Juliette Elizabeth, born September 21.

1947

Eugene M. Shoemaker writes that he is taking an educational furlough from the U. S. Geological Survey to work for his Doctorate at Princeton University.

John M. Mays received his Ph.D. in Chemistry from Columbia in June. He spent the summer in Europe, is now working in microwave spectroscopy as a National Research Fellow at Harvard.

Richard A. Boettcher, M.S., has been with the Arabian American Oil Company in Dhahran, Saudi Arabia, for the past two years. He's expected back in the U. S. next summer.

Carl Philip Spaulding was married to Suzanne Chute of Altadena in October.

Richard Davidson Young, M.S., was married to Ragna Bjornholt in Pasadena on October 8. He's working for his Ph.D. in physics at Tech this year.

1948

Abner Kaplan, M.S. '49, and Marie Henschel were married in Los Angeles on September 10.

Paul Fullerton writes from Flushing, Long Island, that he was married to Dorothy Ann Slagle in Denver, Colorado, last summer. Paul is working in the applied science division of the International Business Machines Corp., in New York.

J. E. Whitney, M.S., writes that he is married, has one child, a boy 1 year old, and is studying for his Ph.D. in Chemistry at the Universisy of Maryland.

1949

Doug Brown writes from North Hollywood: "About the only ones of the class of '49 that I have kept in contact with are geologists. *Neal Hurley* and *Charles Shaller* (former room-mates in Fleming) stayed together in Switzerland while going to different schools. The last I heard, Shaller was working for the U.S. in Frankfort, Germany. Neal entered Stanford this fall. As far as I know *Don Peterson* is still at Washington State. He is now the proud father of a baby girl. *Bob Fisher* is at Northwestern, *Joe Curray* at Penn. State. Joe married a Tech secretary and had a lucky break in becoming a member of the Penn. State faculty. And *Ray Heggland* is working for Continental Oil Co. in Texas.

"After leaving Tech I went to UCLA for one semester of graduate work. In spite of less work and better grades, I quit and went to work for the Bridge Dept. of the Calif. Division of Highways."

At the time of this writing (October 10) Doug was vacationing, but expected to be drafted soon—he'd just passed his physical.

Gaelen L. Felt, M.S., Ph.D., has joined the staff of the Los Alamos Scientific Laboratory. During World War II and until September, 1946, he was employed at Los Alamos, first as a scientist with the Manhattan District and then by the Laboratory.

1950

Donald William Moore was married to Patricia Ann Price of Rosemead in September.

Howell Tyson Jr., and Dorothy Greathead were married in Westwood on September 25. They're living in Sierra Madre.

Don Royce and Judith Wingert were married in Whittier in July. Both Royces are now enrolled in the graduate division at Stanford. They're living in Menlo Park.

LOST ALUMNI

The Institute has no record of the present addresses of the men whose names appear in the list below. If you find your own name here—or that of someone you know—please drop a card, giving the current address, to the Alumni Office, C.I.T., 1201 E. Calif. St., Pasadena 4.

1900
Davidson, Leonard E.

1905
Sinclair, Arthur W.

1906
Norton, Frank E.

1911
Lewis, Stanley M.

1912
Humphrey, Norman E.

1913
Hovey, Chester R.

1914
Newton, Walter L.

1917
Mosher, Ezra D.

1918
Hainsworth, William R.
Harrison, Kenneth J.
Pease, Francis M.

1920
Hoenshell, Howard D.
Mosher, Frank R.

1921
Arnold, Jesse
Boggs, Chester A.
Hood, John H.

1922
Bruce, Robert M.
Cox, Edwin P.
Ries, Emil D.
Spencer, Gerald G.
Wesseler, Martin J.

1923
Little, Fred G.
McKee, George T.
Skinner, Richmond H.
South, Laurance G.
White, Paul M.

1924
Carr, John
Lovering, Frank R.
Miller, Palmer
Wolochow, David
Young, David R.

1925
Beed, Carl F.
Dent, William U.
McProud, C. Gilbert
Merrill, Robert A.
Miller, Leo M.
Smith, Dwight O.

1926
Anissimoff, Constantin I.
Barnes, Orrin H.
Chang, Hung-Yuan
Dixon, W. LeRoy
Foster, Alfred
Hardwick, Fray (Hamburger)
Hastings, James W.
Huang, Jen Chieh
Jaffray, George R.
Keech, Douglas W.
Paulus, George L.
Remington, Harry L.
Schabarum, Bruno R.
Schueler, Alfred E.
Ward, Edward C.
Yang, Kai Jin

1927
Gazin, Charles L.
Gilliland, Ted R.
Jackson, William D'A.
Marsland, John E.
Mesenkop, Louis H.
Mitchell, Allan C. G.
Moore, Robert M.
Nickell, Frank A.
Peterson, Frank F.

1928
Bell, Frank W.
Chilberg, Guy L.
Chou, P'ei-Yuan
Clark, Alexander
Eastman, Luther J.
Martin, Francis Crawford
McMillan, Edwin M.
Morgan, Stanley C.
Noel, Francis
Reinen, Otto F. Jr.
Shaffer, Carmun C.
Shepley, Bertie Halsey Jr.
Swedlund, Lloyd Edward

1929
Briggs, Thomas H. Jr.
Elder, John D.
Kuert, William F.
Lynn, Laurence E.
Murdoch, Philip G.
Nagashi, Masahiro H.
Nelson, Julius (Espinosa)
Noland, Thomas J. Jr.
Olman, Samuel
Rapp, John C.
Robinson, True W.
Sandberg, Edward C.
Thompson, Frank W.
Uyterhoeven, Willy
Wiley, Charles A.

1930
Allison, Donald K.
Brandon, Hugo
Butler, Albert
Ellis, Eugene
Grant, Edmund
Groch, Fred
Horton, Warren B.
Imus, Henry
Janssen, Philip
Leppert, Melvin L.
Moyers, Frank N.
Murphy, Franklin Mac.
Nye, Lawrence
Posner, Ezra C.
Russell, Lloyd W.
Sarno, Dante H.
Schubauer, Galen B.
Suzuki, Katsunoshin
West, Stewart
White, Dudley
White, Fletcher H., Jr.
Wilkinson, Walter D., Jr.
Zahn, O. Franklin

1931
Anderson, Maynard M.
Crossman, Edward B.
Folsom, Theodore R.
Green, Lowell F.
Hall, Marvin W.
Ho, Tseng-Loh
Hutchinson, Francis W.
Lindegren, Carl C.
Matison, Harry
Newby, Oscar M.
Stein, Myer S.
Thompson, Isadore
Voak, Alfred S.
Webb, Glenn M.
Weise, Carl A.
West, William T.
White, Thomas Robert
Woo, Sho-Chow
Yoshioka, Carl K.

1932
Bleakney, William M.
Focke, A. B.
Gregory, Jackson, Jr.
Martin, R. S.
Patterson, J. W.
Schroder, L. D.
Shuler, William R.
Thiele, Carl L.
Thomas, Richard N.

1933
Andes, Ammon S.
Applegate, Lindsay M.
Ayers, John K.
Laubenfels, Clarence R.
De Milita, Joseph
Fitch, Kenneth S.
Hsu, Chuen Chang
Kremmer, Colonel Paul H.
Kendall, Robert C.
Kitusda, Kaname
Larsen, William A.
Lockhart, E. Ray
Magden, John L.
Michal, Edwin B.
Murdock, Keith
Newmeyer, William L., Jr.
North, Dwight O.
Pierce, John R.
Rice, Winston H.
Rose, Robert S.
Schlechter, Arthur H.
Scholtz, Walter
Shappell, Maple D.
Skinner, Selby M.
Smith, Warren H.
Spicer, Charles B.
Warfel, John S.

1934
Carrick, Thomas H.
Chawner, William D.
Felt, Robert C.
Harshberger, John D.
Judson, Jack
Lutes, David W.
Marston C. Sargent
Newcombe, Dennis A.
Schneider, Charles L.
Paxson, Edwin W.
Radford, James C.
Rassieur, W. T.
Sunderland, Robert C.
Vosseller, A. B.
White, Charles
Willard, Kenneth A.

1935
Antz, Hans M.
Beakley, Wallace M.
Brown, Vinton A.
Ehrenberg, Gustave, Jr.
Estes, Harry

Frazee, John L.
Gelzer, John R.
Gross, Siegfried T.
Jackson, Oscar B.
Karp, Nathan
King, Fred C., Jr.
Koons, Harry M.
Lehmicke, David J.
Mathews, Elmo S.
McCoy, Howard M.
McNeal, Don
Miller, Eugene C.
Mills, Roscoe H.
Obatake, Tanemi
Osman, Kurt F.
Parr, Warren S.
Poole, Albert R.
Rivas, Dagoberto
Romer, Alfred
Schwartz, Jack W.
Simmons, Norwood L., Jr.
Wilson, Harry D.

1936

Beach, John Y.
Bolster, Calvin M.
Borys, Edmund
Breen, John M.
Brink, Frank, Jr.
Fahrner, Ted
Fleming, Morton K., Jr.
Hartlein, Robert L.
Kasnicka, Edward J.
Keleh, Maxwell
Kraght, Peter E.
Kurihara, Hisayuki
Lawrence, Franklin R.
Lovett, Benjamin B. C.
McKillip, John C. S.
Mendenhall, William R.
Ohashi, George Y.
Onaka, Takeji
Stern, Benjamin
Strange, Hubert E.
Streib, John F.
Uhrig, Leonard F.
Van Riper, Dale H.
Watt, Chauncey W.
Weber, Bruce T.
Zimmerman, Don Z.

1937

Bell, Willard Newton
Belzer, Thomas Russell
Bennett, Foster Clyde
Cheng, Ju-Yung
Clark, William Gilbert
Church, Harry Victor, Jr.
Delsasso, Lewis Alexander
Dusel, Alvin K.
Dykes, John Christopher
Easton, Anthony
Fan, Hsu Tsi
George, John Wesley
Gevecker, Vernon A. C.
Harrison, Arthur Elliott
Hatcher, John Burton
Lotzkar, Harry
Maginnis, Jack Lt.
Miller, Shirley Snow
Moore, Charles Kenneth
Munier, Alfred E.
Murphy, Joseph Nathaniel
Odell, Raymond H.
Offman, Richard E.
Park, Noel Robertson
Parry, H. Dean
Penn, William Lee, Jr.
Price Edward Thomas, Jr.
Quinn, Eugene Howard
Rechif, Frank A.
Rinehart, John Sargent
Schaffner, Paul Corwin
Schairer, Robert Sorg
Schombel,
Leonard Frederick
Servet, Abdurahim
Shuler, Ellis William
Tsubota, George Yoshio
Wylie, W. Gordon

1938

Balsley, James Robinson, Jr.
Carr, Robert B.
Davidson, Donald Douglas
Davidson, Robert Craig
Elliott, Bruce C.
Gardner, Edward M.
Gershzohn, Morris
Goodman, Hyman D.
Greenwood, Marvin H.
Henshaw, Paul C.
Hughey, Albert Hall
Jack, Samuel S.
Jetter, Ulrich
Kanemitsu, Sunao
Kazan, Benjamin
Kybal, Dalimil
Lassettre, Edwin
Lowe, Frank Clare
McLeish, Charles W.
Moorman, Thomas S.
Nysewander, Cecil W.
Ofsthun, Sidney A.
Okun, Daniel A.
Olds, Robert Horner
Osborne, Darrel W.
Parrish, John B.
Rynearson, Garn Arthur
Scoles, Albert B.
Stephens, William Edwards
Stone, William S.
Thomas, Robert C.
Tilker, Paul Owen
Tsao, Chi-Cheng
Wang, Hsih-Heng
Wang, Tsun-Kuei
Watson, James Wendell

1939

Asakawa, George
Burns, Martin Charles
Carstarphen, Charles F.
Coates, Leonidas Dixon
Crawford, Virgil Kenmore
Gullekson,
Ellsworth Eugene
Hendry, Noel Williamson
Hopper,
Richard Hutchinson
Hsueh, Chao-Wang
Jones, Winthrop Gilman
Liang, Carr Chi-Chang
McKinlay, James Robb
Mouat, Thomas William, Jr.
Neal, Wilson Hawkes
Poon, Yuk Pui
Robertson, Francis Allen
Shields, Alex M. II
Smith, Max F.
Streckewald, Paul Beals
Tatom, John Fletcher
Widmer, Robert Henry
Wilson, Harry David Bruce
Yates, Donald Norton
Yood, Bertram
Zukerman, Lester Goffin
Zumwalt, Lloyd Robert

1940

Abraham, Lewis Harry
Adams, Robert Powell
Akman, Mustafa Seyfettin
Anderson, O'Dean
Batu, Buhtar
Brettall, George Auvin, Jr.
Brown, William Emil
Crawford, James Vaile
Green, William Jeffrey
Gentner, William E.
Hartman, Edwin Phelps
Hohwiesner,
Henry George, Jr.
Holloway, John Marshall
Howell, William Jasper
Kemp, Leroy James
Lewis, William Dabney
Lovoff, Adolph
Lu Valle, James Ellis
Manildi, Joseph Frank
Nagle, Darragh Edmund
Neiswander, Robert South
Olney, Frank
Pai, Shih-I
Paul, Ralph Graham
Spooner, William Austin
Streightoff, Frank
Tao, Shih Chen
Tobin, Bernard M.
Van Driest,
Edward Reginald
Wang, Tsung-Su
Wasem, Richard
Wild, John M.
Williamson, John Bridgers
Wyman, Max
Yuan, Luke Chia-Liu

1941

Bailey, Howland Haskell
Baumgarten, Werner
Bruce, Sydney Clyde
Caldwell, Norman Hubert
Carlmark, Carl Wilbert
Crowson, Delmar L.
Damberg, Carl F.
Dieter, Darrell W.
Easley, Samuel James
Ellsworth, Richard Elmer
Feeley, John MacGregor
Fellers, Walter E.
Fisher, Robert E.
Gould, Martin
Guerin, Jack T.
Hamway, Daniel Sam
Helmick, Eugene W.
Jones, John W.
Lakos, Eugene A.
La Salle, Joseph Pierre
Lewis, Lloyd Alan
Miller, Joseph Alfred
Moore, Charles L.
Peters, Ralph
Porush, Isadore Irving
Richardson, John M.
Rupnik, John J.
Ryan, Frank R.
Shelton, Edward E.
Spitzer, Ralph W.
Standridge, Clyde Tilden
Swart, Leland G.
Taylor, D. Francis
Terhune,
Charles Houston, Jr.
Thomas, Delbert D.
Tiemann, Cordes Frederich
Truesdell, Clifford A.
Tyra, Thomas D.
Vartikian, Onick
Weiss, Joseph
White, John R.
Whitfield, Hervey Hayden
Yui, Eu-Ying

1942

Bebe, Mehmet Fikret
Bedke, Hazen H.
Callaway,
William Franklin
Chastain, John Alexander
Drake, John Archibald
Gayer, Martin R.
Gibbons, Robert Martin
Go, Chong-Hu
Grossberg, Allan L.
Horne, Othniel
Levin, Daniel
Lind, George W., Jr.
MacKenzie, Robert E.
Martinez, Victor H.
Mayer, Adrian S.
McCornack, Richard W.
McDaniel, Gene Warner
Muratzade, Enver Mehmet
Nichols, Peter Luke
Pollycove, Myron

Proctor, Warren G.
Rubel, John H. W.
Sokolsky, Oliver M.
Tovell, Walter M.
Yuan, Shao-Wen

1943

Allrud, Ralph Gordon
Bridgland, Edgar Parsons
Brown, Glenn Harold, Jr.
Harrison, Gerald
Ise, John, Jr.
Johns, Robert Ralph
Kane, Richard Francis
Levine, Robert Paul
Ling, Shih-Sang
Lund, Iver A.
McCoubrey,
Arthur Orlando
Miller, Herman
Rau, Ralph Ronald
Sweeney, William Edward
Vicente, Ernesto
Yung-Chiang Hwang

1944

Alpan, Rasit H.
Barfield, Howard P.
Baronowski, John J.
Bell, William E.
Birlik, Ertugrul
Boehnlein, Charles T.
Burch, Joseph E.
Dameson, Louis G.
Debevoise, John M.
Doll, Raymond E.
Estrada, Neuk S.
Feblowiez,
Ernst Alexander
Field, Almeron J.
Fu, Ch'eng Yi
Goldsmith, Edward Adolph
Gray, James B.
Harrison, Charles P.
Heinz, John A.
Hu, Ning
Johnson, William M.
Kern, Jack C., Jr.
Knopoff, Leon
Labanauskas, Paul Julius
Maier, Mark P.
Mapel, Robert W.
McCasland, Gifford E.
Millsaps, Knox
Mitchell, Robert Kidd
Oliver, Clifford W., Jr.
Ours, Statton R.
Phipps, Robert P.
Shults, Mayo G.
Silgado, Enrique F.
Stanford, Harry W.
Stein, Roberto L.
Sunalp, Halit
Tanyildiz, Sureyya Rafet
Timm, Wayne C.
Titzler, Henry N.
Trimble, William M.
Wilson, John Hart
Writt, John J.
Yik, George
Yoho, Lewis W.
Yungul, Sulhi

1945

Ari, Victor A.
Bozarth, Charles W.
Bunze, Harry Frank
Dunne, Brian B.
Freeman, Burton Edgar
Garvin, Walter W.
Jenkins, Robert P.
Keilin, Bertram
Krause, Jack Dewey
Lien, Wallace A.
Magneson, Norman James
Maloney, John Ward
Morelli, Dino Antonio
Pooler, Louis Gordon
Ridley, Jackie Lynwood
Smith, Dudley B.
Taylor, Edward C.
Trout, Robert Glenwood
Werme, John V.

1946

Anderson, John Berwick
Aydelott, Max Merton
Barton,
George Wendell, Jr.
Benton, Philip H.
Bernatis, Richard A.
Bowie, James Monfort
Bromley, Edmund, Jr.
Burger, Glenn W.
Conradt, Robert H.
Dyson, Jerome Packard
Esner, David R.
Fossier, Mike Walter
Hagenmaier,
Carl Frederick
Huang, Tsung Hsiung
Ingram, Wilbur Atwood
KeYuan, Chen
Lagerstrom, Richard P.
Lanni, Frank
Lewis, Frederick W.
Lowery, Robert H.
MacDonald,
Norman Joseph
McCarthy, James Lee
Miller, Jack N.
Monteath, E. B.
Nixon, Stanley Reed
Njus, Olav
Parker, James F.
Pentney, Robert Wilfred
Rapport, Maurice M.
Russell, Charles Roberts
Schmidt, Louis Vincent
Simmons, George F.
Smith, Harvey Franklin
Stone, Dean P.
Stookey, William C.
Tung, Yu-Sin
Uberoi, Mahinder S.
Warner, Richard C.
Weitzenfeld, Daniel K.
Webber,
Carroll Aubrey, Jr.
Whitlow, David
Williams, Ralph Curtis

1947

Atencio, Adolfo Jose
Atkinson,
Paul Gregory, Jr.
Cooley, William Crockett
Critchlow, Arthur J.
Das, Subodh Chandra
Fusfeld, Robert David
Garrison, Edward William
Hagelbarger, David
Huang, Ea-Qua
Hutcheson, Paul T.
Kalinski, Felix Andrew
Kelley, George Guldin
Kowan, Joel M.
Leo, Fiorello R.
McClellan, Thomas Rufus
Monoukian, John
Moorehead,
Basil Elmo Atkins
Purdon, David
Robinson, Leland P.
Rosell, Fred Edgar, Jr.
Shackford, Robert W.
Small, Richard Brigham
Smith, Alexander
Stephenson, Thor E.
Trabant, E. Arthur
Tredt, Joseph A.
Werner, Jerard

1948

Anderson, Jack Steele
Benefiel, Robert Ernest
Boutelle, George William
Buhler, James Logan
Burrows, Julian Sage, Jr.
Chapman,
Curtis Wheaton, Jr.
Cook, Edward Gaylord
Crawford,
William Donham
Drew, William Atwood
Eubank, Perry Huston
Hamilton, Carl Robert
Harned, Malcolm Stuart
Ludwig, Lloyd Gerald
McClellan, Robert
McCollam, Albert Edgar
Mills, Robert Leroy
Mitchell, Edward Eugene
Mooney, Harold Morton
Nay, Harvey Orin
Oberneck,
Thomas Edmond
Ogilvie, Douglas Clark
Parker, Frederick Dent
Parkinson,
Geoffrey Vernon
Slusher, John Thomas
Sollohub, Julian Vincent
Stewart, Robert Stanley
Stokely, Robert Gregg
Svimonoff, Constantine
Swant, Robert Kessler
Taylor, Edward Alexander
Taylor, James Kirkbride
Thorpe, James R., Jr.
Tomlin, Raymond Nicholas
Walters,
James Willard, Jr.
Wilkinson, Donald Pahl
Whittaker,
Arthur Greenville
Worcester, Bruce Alan

1949

Atkins, Douglas C.
Albert, Joseph L.
Barish, David Theodore
Bauman, John L., Jr.
Beardsley, Frank Howard
Bottenberg, William R.
Brown, George J.
Cantwell, Joseph R.
Cooper, Harold D.
Craighead, Emery Manes
Crate, James H.
Darling, Ralph E.
Dodge, John A.
Ford, Warren W.
Garrett, Joseph
Gilkeson, Fillmore B.
Gould, Roy W., Jr.
Greene, Ronald C.
Hrebec, George
Krasin, Fred Elvin
Love, John R.
MacKinnon, Neil A.
McElligot,
Richard Hardy
Mirza, Rafat
Moore, Robert T., Jr.
Nielsen, Jack N.
Petty, Charles C.
Rinehart, Marion C.
Ringness, William M.
Shore, Bernard
Wachter, John W.
Wallace, Richard A.
Waters, Robert R.
Wilson, M. Kent
Zieman, Clayton M.

1950

Adams, Robert Train
Alexander,
Joseph Brightwell
Barrie, Donald S.
Burket, Stanley Campbell
Bucholz, Werner
Brooks, Marvin Charles
Blaker, Robert Hockman
Brow, Raymond E.
Carhart, Richard Raymond
Crossley, Harry Eastwood
Curtis, Robert N.
Epprrecht, George
Francis, John P.
Frinstead, Robert Russell
Garrison, James Baxter, Jr.
Glaser, Donald Arthur
Goodwyn, James Cecil
Craig, Roy Phillip
Gross, Frederick A.
Higgins, William B.
Holmes, Geoffrey Bishop
Itano, Harvey Akio
Jenkins, Rodman
Katz, Louis
Koenig, Nathan Hart
Leinbach,
Frederick Harold, Jr.
Lemaire, Henry
Lerman, Leonard Solomon
Li, Chung Hsien
Ludwig, Rubin William
MacAllister, Robert V.
Masser, Harry Lacelles, Jr.
McDaniel, Edward Foy
McLaughlin, Jack Enloe
McMillan, Robert
Mesara, R. Reha
Montemezzi,
Marco Antonio
Mudgett, Walter L.
Petzold, Robert Frederick
Rosser, Willis A., Jr.
Schuch, Adam Frank
Pine, Frank W.
Pinckard, James Howard
Quigley, Milner Darwin
Rao, Valluri Sitarama
Roberts, Morton S.
Shoenhair, Jack Lawrence
Sletten, Harold Lewis
Soldate, Albert Mills
Stewart, Dale F.
Stolovy, Alexander
Strange, David Alloway
Strauss, Bernard Samuel
Sullivan, John Henry
Tang, You-Chi
Tollestrup, Alvin Virgil
Whitehill, Norris D.
Ycas, Martynas Freelandas

This is a picture of "PING"

It's a picture that gives automotive engineers clear-cut facts on performance—a picture that suggests how photography with its ability to record, its accuracy and its speed, can play important roles in all modern business and industry.

No, this is not the "doodling" of a man on the telephone. Far from it. It's the photographic record of an oscilloscope trace that shows, and times, detonation in a "knocking" engine. It all happens in a few hundred-thousandths of a second—yet photography gets it clearly and accurately as nothing else can.

Oscillograph recording is but one of countless functional uses of photography in bettering products and improving manufacturing methods. High speed "stills" can freeze fast action at just the crucial moment—and the design or operation of a part can be adjusted to best advantage.

And high speed movies can expand a second of action into several minutes so that fast motion can be slowed down for observation—and products be made more dependable, more durable.

Such uses of photography—and many more—can help you improve your product, your tools, your production methods. For every day, functional photography is proving a valuable and important adjunct in more and more modern enterprises.

Eastman Kodak Company, Rochester 4, N. Y.

Functional Photography

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Kodak
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Dean Foster Strong
California Institute of Technology
Pasadena, Calif.

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