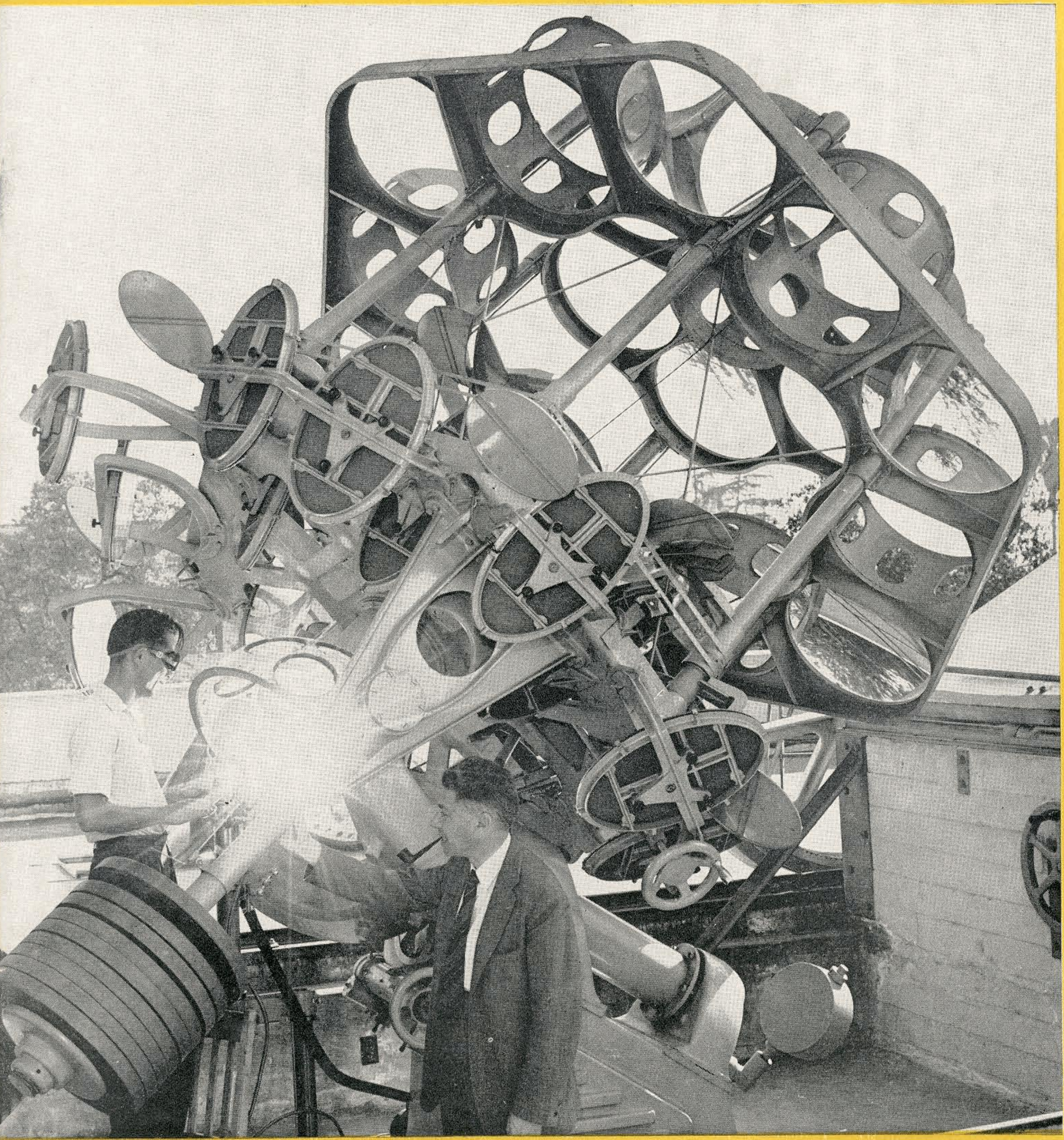
ENGINEERING | AND | SCIENCE

FEBRUARY/1956



Solar Furnace . . . page 13

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

ENGINEERING AND SCIENCE

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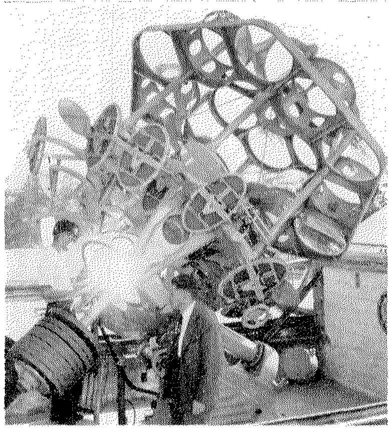
IN THIS ISSUE



On our cover this month is Pol Duwez (with the pipe), professor of mechanical engineering, and Eugene Loh, metallurgist for the Stanford Research Institute, working with Caltech's solar furnace. The brilliant flash in the photo is the concentration of sun rays on a piece of refractory oxide in the focal area. Dr. Duwez tells how solar furnaces achieve temperatures as high as 3200°C. on page 13 of this issue.

Bayard Brattstrom, a herpetologist, becomes a kind of weatherman in his type of research, though he looks back as far as 75 million years to see what the weather was then—and discovers, among other things, that the northern United States and part of Canada were tropical areas, complete with alligators. He uncovers this kind of information by studying snakes, as he explains on page. 22.

Dr. Brattstrom spent last year at Caltech as a research fellow in paleoecology. He got his BS from San Diego State College and his MA from UCLA. All during his undergraduate years he managed to hold down an impressive brace of jobs at the San Diego Natural History Museum—specifically: assistant curator of herpetology; director of education; and assistant in botany, entomology, invertebrates and paleontology. At present he's working in the zoology department at UCLA.

PICTURE CREDITS

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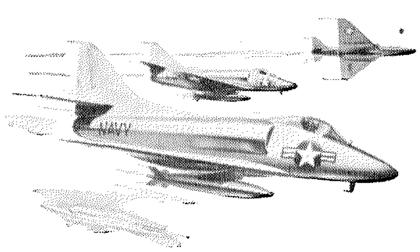
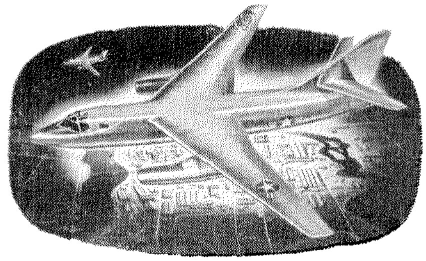
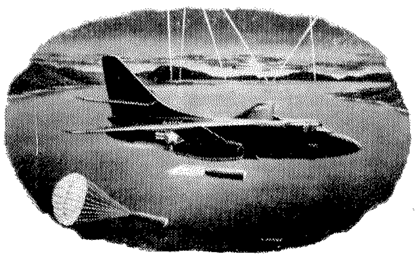
F4D, "SKYRAY"— only carrier plane to hold official world's speed record



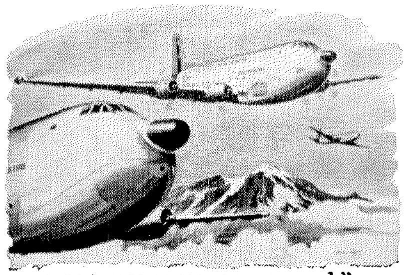
A4D, "SKYHAWK"— smallest, lightest atom-bomb carrier



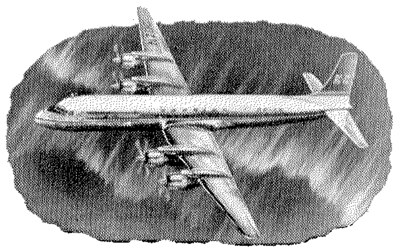
RB-66 — speedy, versatile jet bomber



A3D, "SKYWARRIOR"— largest carrier-based bomber



C-124, "GLOBEMASTER"— world's largest production transport



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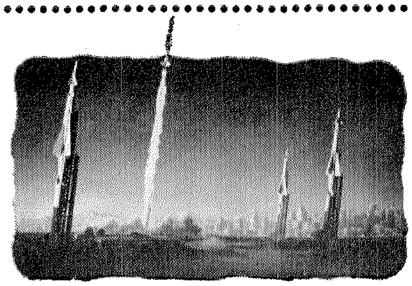
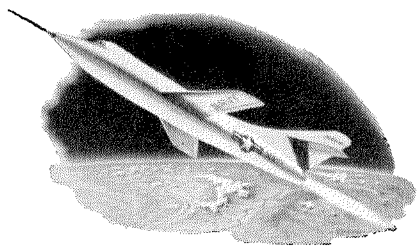


"NIKE"— supersonic missile selected to protect our cities



D558-2, "SKYROCKET"— first airplane to fly twice the speed of sound

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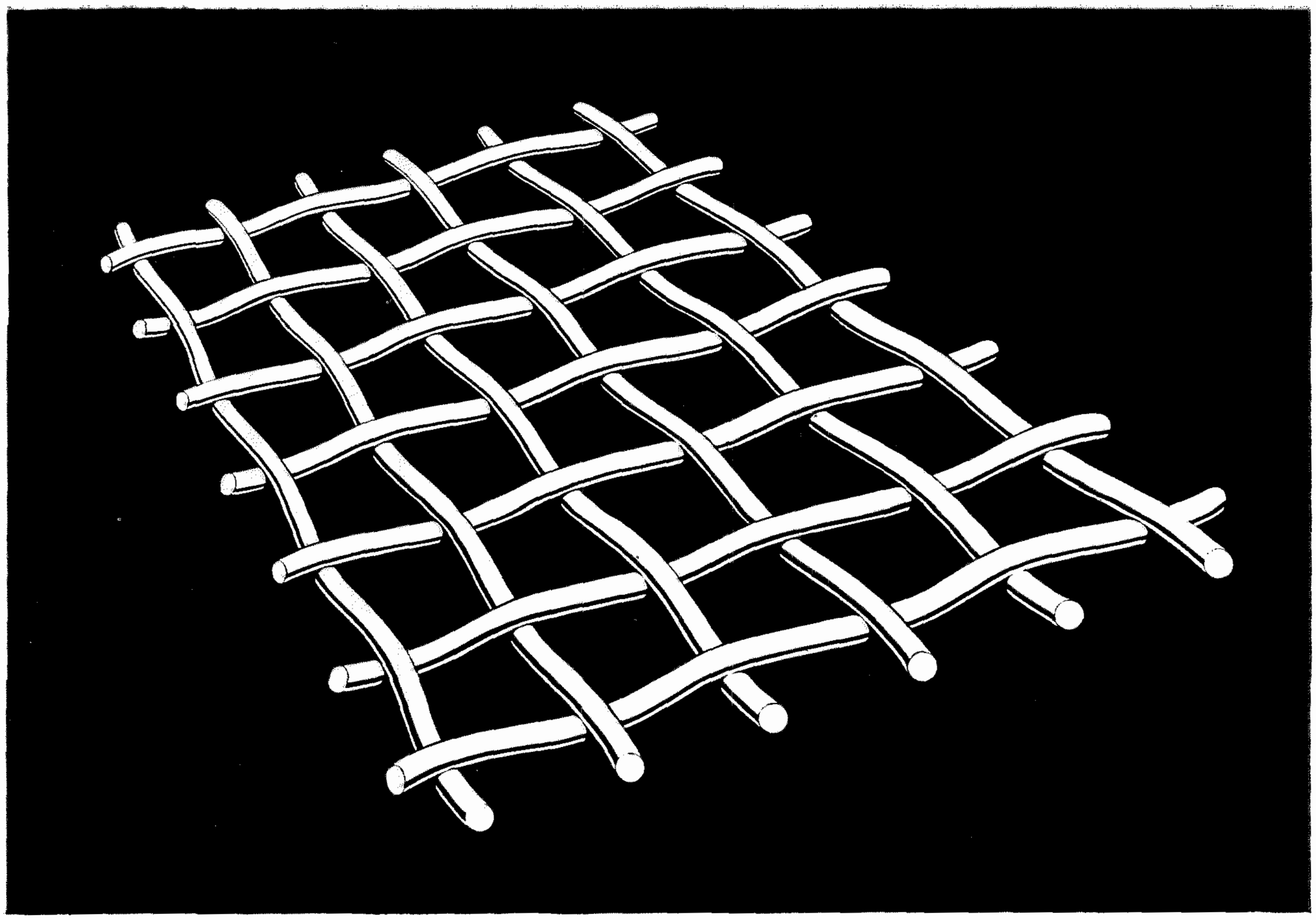


BOOKS

THE NEW ASTRONOMY
THE PHYSICS AND CHEMISTRY OF LIFE
FIRST BOOK OF ANIMALS
ATOMIC POWER
AUTOMATIC CONTROL

Scientific American Books,
Simon & Schuster, New York $1 each

THESE FIVE BOOKS are the first in a new series of *Scientific American* paperbacks. Each book is made up of a collection of articles from the magazine. The articles have been re-edited, in some cases, to bring them up to date (since they appeared in the magazine as far back as 1948) and to make them comprehensible to an even broader audience than that reached by the magazine. The original magazine illustrations, which were often in color and of some complexity, have been reduced to simple line drawings in the books.

Each book includes from 12 to 24 separate articles, covering various phases of the particular field of science under consideration. "The New Astronomy" consists of 20 articles concerning recent discoveries about the nature and structure of the universe.

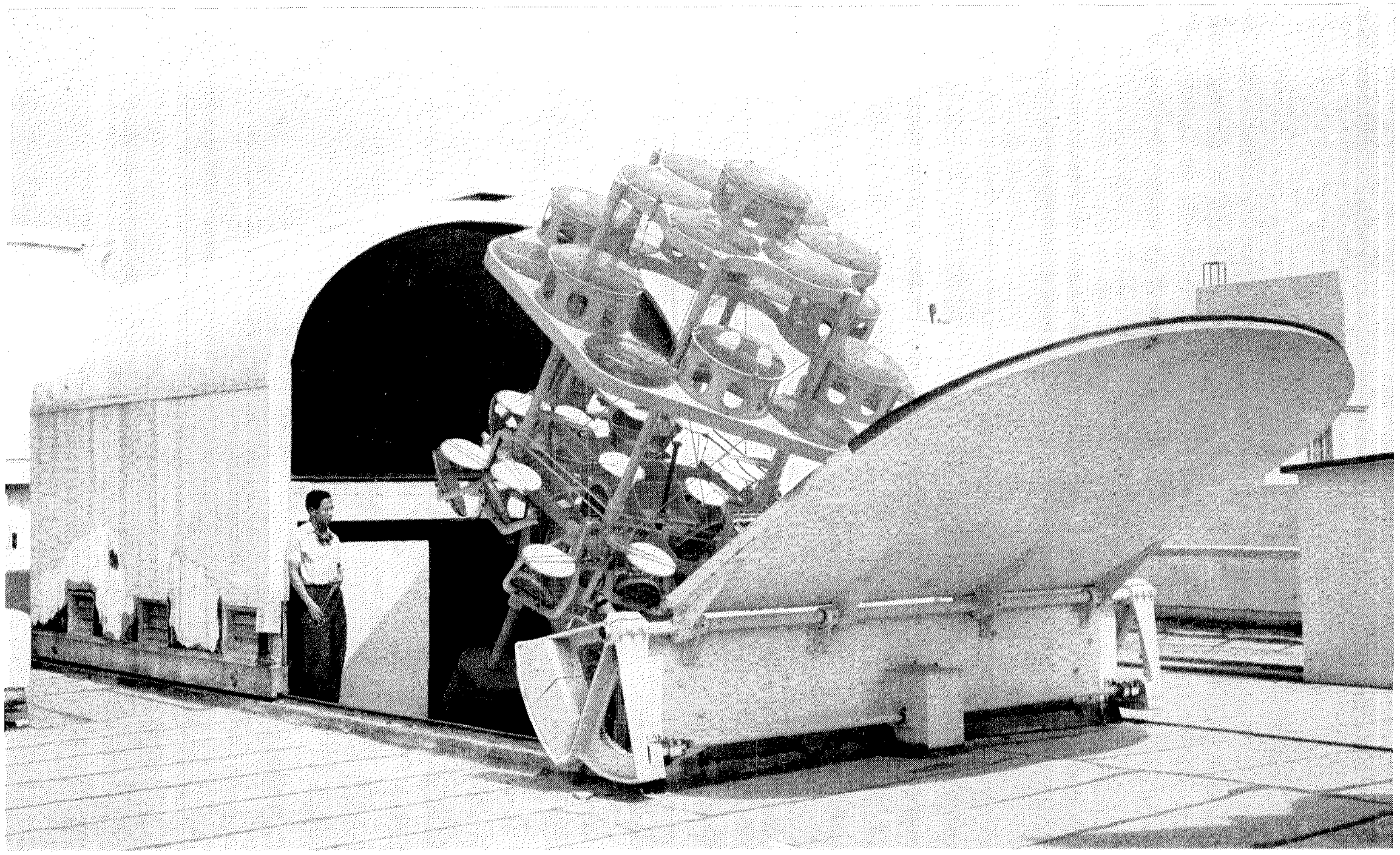
"The Physics and Chemistry of Life" includes articles on the origin of life, the structure of proteins (by Linus Pauling, Robert Corey and Roger Hayward), the chemistry of heredity, viruses, genes (by George Beadle), enzymes, cell division and the electrical activity of the brain.

The 24 articles in "The First Book of Animals" describe some scientific investigations of animals which provide interesting insights into the workings of life.

"Atomic Power" begins by explaining the basic principles of atomic fission, covers reactors, resources, fission products, radiobiology, thermonuclear reactions, the economics and politics of atomic power and the Geneva Conference of 1955. As the editors explain, it is a book that emphasizes the constructive, beneficial uses of energy liberated from the atomic nucleus, rather than the bombs.

The articles on automation in "Automatic Control" are a good antidote for the layman who has already been bewildered by both the Sunday-supplement writers and by the cybernetics experts. Starting with the basic principle of "feedback," the book describes the applications of self-regulating machines to business (the automatic office) and industry (specifically — automatic chemical plants and an automatic machine tool), considers the economic impact of this new industrial revolution and then tells about some of the awesome "giant brains" we'll be seeing soon.

Any regular reader of *Scientific American* is familiar with the clarity and comprehensiveness of its articles. In these paperbacks these qualities are, if anything, even more pronounced, so that the books may well attract a brand new audience of popular-science readers. They *should*, at any rate. And the price—as anyone can see—is right.



Caltech's solar furnace, built almost 25 years ago, is now being used for high temperature materials research.

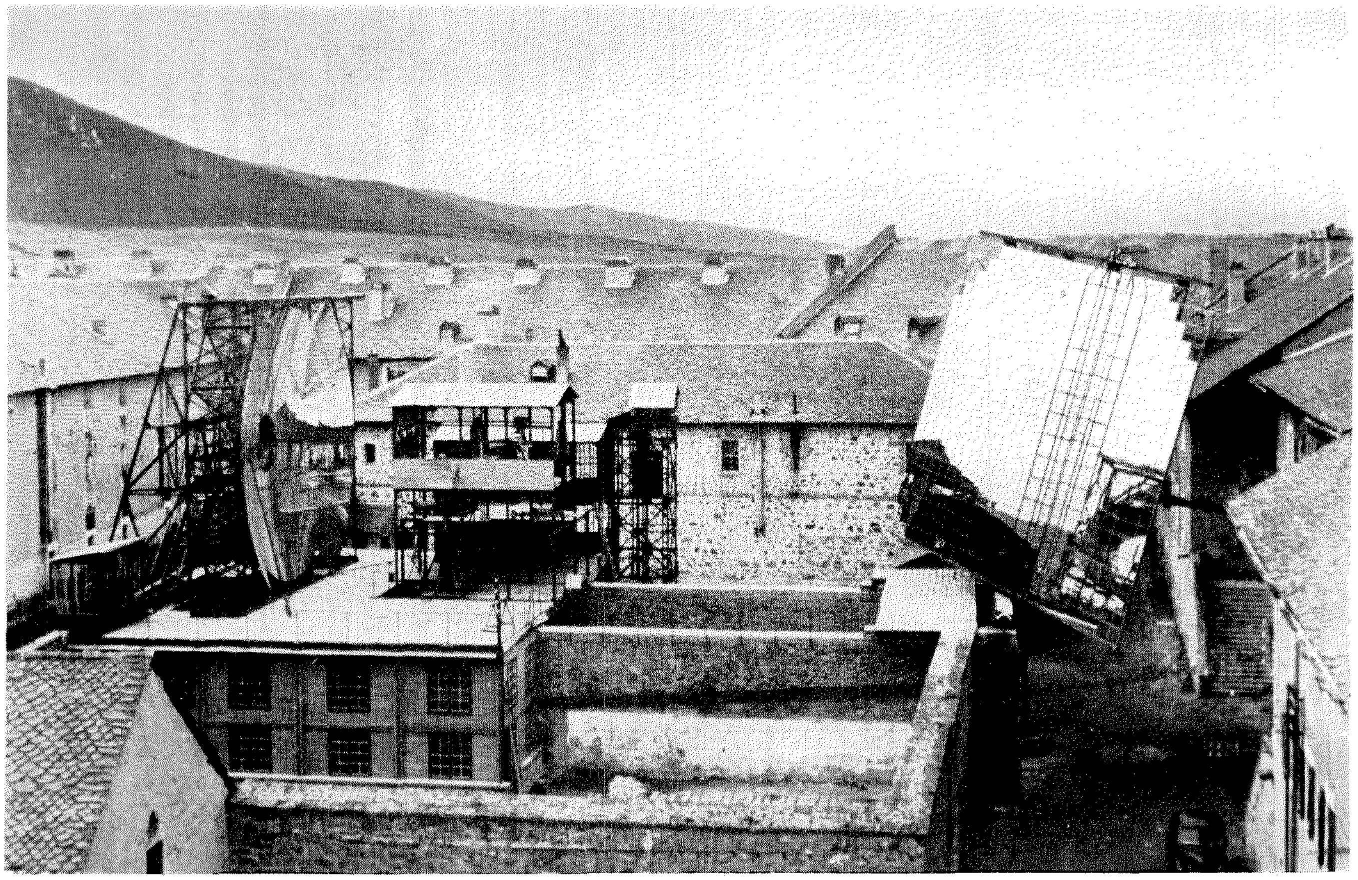
THE SOLAR FURNACE

It uses the sun's rays for high temperature research

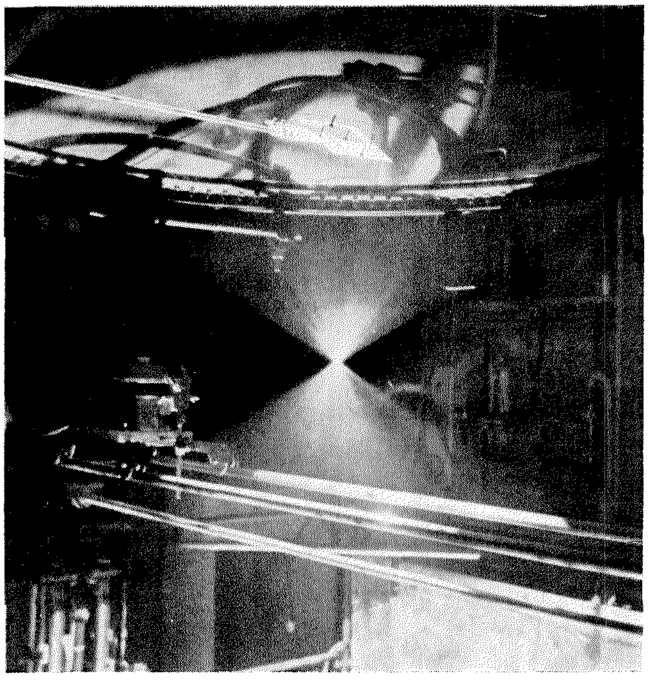
by POL DUWEZ

A SOLAR FURNACE is not exactly a furnace, but an optical system in which the solar radiation received by a collector is concentrated into a small area. If this highly concentrated radiant energy is received into a cavity, heat is generated and very high temperatures may be obtained. This cavity, which is really the furnace, is a minor part of the whole system, and solar furnaces should rather be called solar energy concentrators.

The idea of using solar energy to produce high temperatures is not new. In 212 B.C. Archimedes presumably set fire to the Roman fleet by concentrating the sun's rays on the ships by means of several hundred plane mirrors. In the 17th and 18th centuries both mirrors and lenses were used, and in 1772 Lavoisier built a furnace with a collecting lens having a diameter of about 5 feet, in which he almost reached the melting point of platinum (1773° C.) After La-



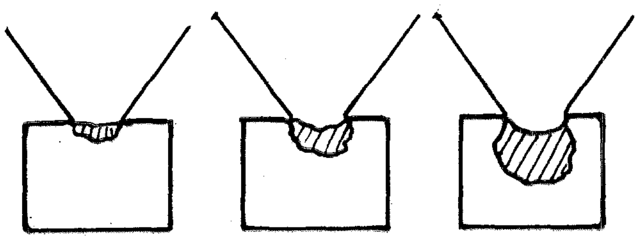
An overall view of the 35-foot solar furnace in Montlouis, France. The parabolic mirror at the left is fixed, while the plain mirror at the right reflects the sun's rays into the parabola and tracks the sun automatically. The sun's rays are concentrated in a cone on a furnace located in the structure shown between the two mirrors.



One of the six 7-foot parabolic reflectors at the laboratory for solar energy in Montlouis, France. This furnace, in which the concentrated cone of sun rays has a vertical axis, is most practical for metallurgical studies.

voisier, until the beginning of this century, solar furnaces were completely ignored. In 1921 Straubel and his collaborators at the Zeiss Co. in Germany constructed what may be considered as the first modern furnace of the reflecting type. With a glass parabolic mirror of about 6 feet in diameter and a focal length of 2 feet, they reached temperatures of the order of 3000° C. Since then parabolic mirrors of various sizes have been used. W. Conn, who collaborated with Straubel, built a 10-foot furnace and installed it at Rockhurst College in Kansas. This furnace, made of aluminum alloy sheet, is now in operation at Convair in San Diego and is used for studies in high temperature materials. Searchlight mirrors 5 feet in diameter are also relatively good concentrators and are in operation in various laboratories in the United States.

The largest installation of solar furnaces of various sizes is located in Montlouis in the French Pyrenees. Professor Felix Trombe, head of the laboratory for the study of solar energy, now has in operation 6 furnaces made with German parabolic searchlight mirrors 6.5 feet in diameter, and one large furnace 35 feet in diameter. This large-size reflector is made of 3500 small plane mirrors which are attached to a steel frame of parabolic shape. In order to achieve the best possible



The concentrated effect of the sun's rays melting a block of solid material from the inside out.

focusing, each mirror is mechanically bent to a curvature approaching that of the ideal parabola. A still larger furnace, more than 100 ft. in diameter, has been designed and components of the reflector have been tested. The power of this large installation will be about 1000 kw. W. Conn's design was adopted by Professor Guillemonat who built a furnace 27 ft. in diameter in Algiers. The parabola is made of 144 panels of electropolished aluminum formed to the desired curvature. In Soviet Russia, a large solar energy research laboratory has been established near Tachkent, but there is no report so far about the existence of solar furnaces designed specially to obtain very high temperatures.

Lavoisier's furnace was not the last one ever built with lenses as a means of concentrating the sun's energy. Between 1930 and 1932 a lens furnace was erected at Caltech by George Ellery Hale and his collaborators, with the objective of achieving a high-temperature source for spectroscopic studies. The furnace, located on the roof of the astrophysics building, is now being used for high temperature materials research.

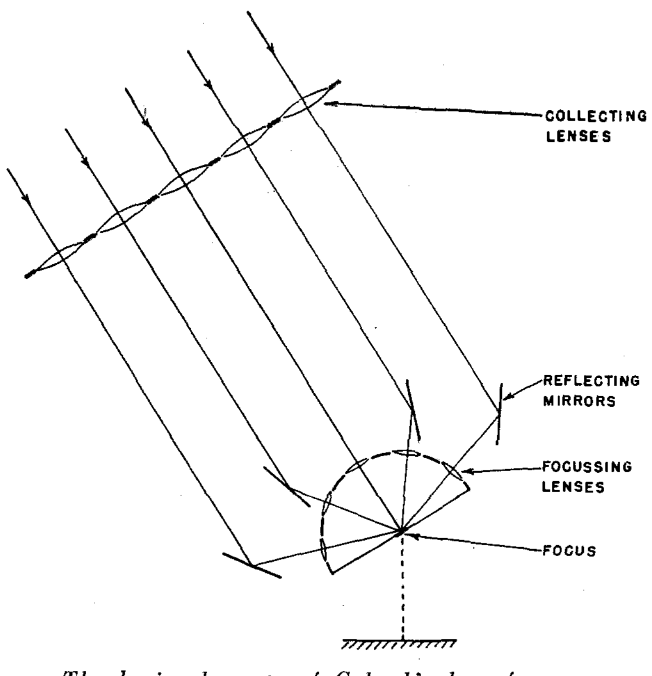
Advantages of the solar furnace

To anyone familiar with the field of very high temperatures, the performances of existing solar furnaces will not appear very spectacular. Temperatures of the order of 3000° C. may be obtained through many different techniques: flames, electrical resistance heating (using graphite or tungsten elements), induction heating, arc melting in neutral atmosphere or levitation melting. All these techniques, however, have limitations—mostly because they require a certain type of atmosphere around the specimen under study. The flame heat source is always highly chemically reactive; the use of tungsten or graphite as an electrical heater, or as a susceptor in induction heating, requires a neutral or reducing atmosphere; arc melting and levitation are limited to electrical conductors. In a solar furnace, the heat source, in the form of a cone of radiation energy, may be called 'pure heat,' and does not impose any restriction to the kind of atmosphere which surrounds the specimen. It is indeed possible to place the object to be heated in a transparent vessel (made of glass or fused silica) and fill this vessel with any suitable gas. Operating under high vacuum is also a rather easy experimental technique.

Another outstanding feature of solar furnaces is the very concentration of heat obtainable within the focal area (the sun's image). Because of this high heat flux, heat is provided over a relatively small portion of a solid sample and, as shown in the diagram at the left, melting of the inside of a solid sample may be achieved so that the material under study serves as its own crucible. This possibility of heating a body from the inside out, which is unique to the solar furnace, is extremely useful in melting refractory substances which react very rapidly with any known crucible material at high temperature.

The research project which is now being carried out with the Caltech furnace makes full use of these two outstanding features of solar heating, namely, pure heat and absence of crucible. The first project is an investigation of highly refractory thorium oxide and zirconium oxide (melting points 3200° C. and 2750° C., respectively). These compositions can be melted in air at the focus of the furnace, thus assuring an oxidizing atmosphere around the melt, which is impossible to achieve in any known laboratory furnace at these temperatures. The second project is concerned with the structure of ceramic bodies based on mixtures of titanium and zirconium dioxides, in which, however, the oxygen content is less than it should normally be These complex sub-oxides are extremely reactive and must be melted in an atmosphere of inert gas. The absence of crucible and the possibility of operating in a glass vessel filled with helium make the solar furnace an ideal tool for such investigation.

The principle of construction of the Caltech solar furnace is shown below. Nineteen lenses, each two feet in diameter and pointed toward the sun, are arranged in a hexagonal close-packed array. Since all the images are to be superimposed, secondary lenses 7.5 in.



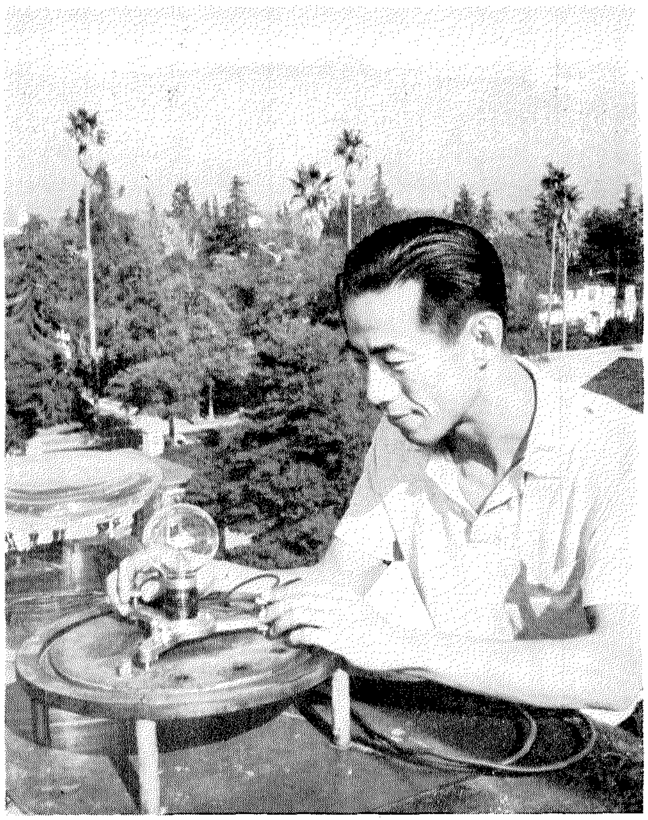
The basic elements of Caltech's lens furnace.

in diameter are arranged on a hemisphere centered at the focal point. For all lenses, with the exception of the center one, it is necessary to deflect the rays before they reach the secondary lenses, and that is done by a series of 18 plane mirrors. The sun's image, at the focus, is one half inch in diameter.

The entire optical system is mounted like a telescope on an equatorial axis and has a synchronous drive so that the furnace stays pointed on the sun. The lenses are permanently attached to the frame but the plane mirrors can be adjusted for best focusing conditions. This is done most conveniently by making use of the full moon. The negligible heat flux in this case permits observing the moon's image on a ground glass and adjusting each plane mirror by centering every one of the 19 images around the focus.

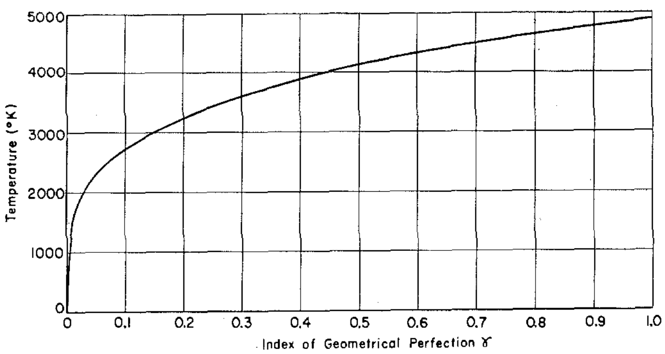
An analysis of the performances of the Caltech furnace was made and it has been established that, as far as maximum attainable temperature is concerned, this lens furnace is equivalent to a parabolic reflector furnace with a ratio of focal length to diameter equal to 0.7. A maximum theoretical temperature can be computed if a perfectly insulated black body cavity with a solar constant of 2 cal/min/cm^2 (2 calories per minute and per square centimeter) is used, thus eliminating atmospheric absorption. Assuming that there are no losses through the optical system, this maximum temperature is approximately 4200° C. A realistic figure may be arrived at by taking 1.6 cal/min/cm^2 for solar radiation (this figure was reached only three or four times in Pasadena during the last three months) and by estimating the absorption and reflectivity coefficients of the lenses and mirrors to be 0.85. Under these conditions, the maximum temperature would be around 3400° C. Although no accurate measurements have been made so far, temperatures of the order of 3100 to 3200 have been reached—as evidenced by the fact that thorium oxide, whose melting point is 3200° C. + 100, has been melted in the furnace. Realizing that the furnace was designed by astronomers, it is not surprising to find that its performances actually meet the design criteria.

The temperature obtained with the Caltech furnace is probably close to the maximum capability of a lens



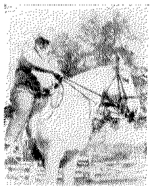
Dr. Eugene Loh checks the pyroheliometer on Caltech's solar furnace, which gives a continuous record of the intensity of solar radiation.

type solar furnace. The parabolic reflector furnace is capable of higher temperatures, at least in theory. With a parabolic reflector having a focal length to diameter ratio of 0.45, it should be possible to reach a temperature of 4500°C. This figure was obtained by taking a solar constant equal to 1.6 cal/cm^2/min (which is not unusual in many parts of the United States) and a reflectivity co-efficient of 0.85 for the mirror surface. In this analysis, however, the parabolic reflector was assumed to be optically perfect, and that is the most difficult condition to satisfy in practice. The degree of perfection of a parabolic reflector used in a solar furnace may be defined as the ratio of the actual heat flux received through the sun's image at the focus to the heat flux that should be received if the reflector were perfect. This index of quality has a very large effect on the maximum temperature attainable.

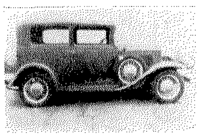


The effect of the optical equality of a parabolic reflector on the maximum attainable temperature.

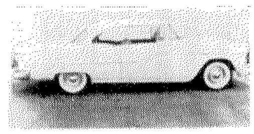
As shown in the diagram at the left, a relatively poorly built reflector with an index of quality of only 0.2 is capable of temperature of the order of 3000°C. Most of the existing parabolic furnaces are in the range of 3000°C., and therefore their index is about 0.2. To achieve temperatures from about 3500 up to 4500° C. it would be necessary to construct a parabolic reflector in which more than 80 percent of the radiation collected by the mirror would be concentrated within the sun's image area. It is believed that there is no physical limitation in building these high performance parabolic mirrors, but their cost might be very high.



FROM HORSES



TO HORSEPOWER



by PETER KYROPOULOS

IN NOVEMBER, 1895, with all of *four* cars registered in the United States, a magazine called *The Horseless Age* made its bow to the public. In its first number, E. P. Ingersoll, Editor and Proprietor, wrote in his editorial:

". . . The appearance of a journal devoted to a branch of industry yet in an embryonic state, may strike some as premature. . . . But those who have taken the pains to search below the surface for the great tendencies of the age know that a giant industry is struggling into being here. All signs point to the motor vehicle as the necessary sequence of methods of locomotion already established and approved. The growing needs of our civilization demand it; the public believe in it and await with lively interest its practical application to the daily business of the world."

That is pretty good guessing, considering that there were only a number of more-or-less successful inventors playing around with automobiles. All wisdom sprang from Europe, where the automobile was developing into a rich man's toy.

The number of cars increased rapidly:

1895	4
1896	16
1897	90
1898	800
1899	3,200
1900	8,000
1910	468,500

In 1903 R. E. Olds made 4,000 Oldsmobiles, which sold for $650 each.

In 1902 the Ford Motor Company began to build cars. In 1903 it sold 1,700 cars ranging in price from $850 to $950. The total sale was $1,163,000.

In 1921 Ford made 933,720 Model T's and sold them for $546,049,449. The price was from $325 to $600.

Ford employment had risen from 125 in 1903 to 33,000 in 1921. By 1903 a new industry had been born, and with it a new way of life for the American people.

Between 1900 and 1955 there were a total of 1686 makes of cars. Of these, 18 are still on the market today.

About 67 million people in the U. S. have drivers' licenses. Of these, around 30 percent are women. We have 35 million families who own cars. These people are buying at the rate of 6 million cars per year.

In this country, as a whole, we spend about 10 percent of our national income on automobile transportation—or, in terms of car-owning families, about 12.5 percent. The wisdom of devoting this much money to the car is not under discussion. This is what people are doing.

Of course, not everyone buys new cars. The ratio of used to new car purchases varies between 1.5 and 2. The used car is the people's car. The person with the limited income can choose among a wide variety of cars at prices ranging down to $15 or $20. Efforts to sell small European cars as cheap transportation are not particularly successful as long as people can get a full-size car for less money. The German Volkswagen or "People's Car" is supposed to put the masses on wheels. In the U. S. the used car is the "People's Car."

The automobile is a package containing about 125,000 miles of transportation. Of this package a person buys whatever he can afford. The cost of new and used cars for the last four years is as follows:

New Cars	Million Buyers		Average Cost	Net Cost (less trade-in)
1954	4.3		$2,720	$1,730
1953	4.9		2,650	1,660
1952	3.6		2,680	1,560
1951	4.4		2,390	1,440
Used Cars		**Ratio Used/new**		
1954	8.6	2.0	800	600
1953	7.8	1.6	920	640
1952	2.2	2.2	950	700
1951	7.3	1.7	790	570

This table does not illustrate the *depreciation* of a certain car, but only the yearly variation of prices.

Depreciation as a function of car age goes about like this:

Years Old	**% Depreciation**
1	40
2	50
3	60
4	70
5	80

Just how long the useful life of a car can be is shown by the fact that, of the 10.2 million Chevrolets running around in 1954, about 135,000 were of 1936 vintage or older. For Ford the corresponding figures are 8.1 million and 376,000.

The life expectancy of cars has steadily increased over the years:

Year of Scrapping	**1925**	**1935**	**1952**
Average life of vehicle (yrs.)	6.5	8.3	14.3
Accumulated mileage during lifetime	26,000	42,000	125,000

Much has been said about the length of time a car should be kept. There is little evidence that it makes a great deal of difference in the first three years. A study of new car buyers in 1954 showed that all new car buying families kept their cars for 3.2 years, nearly independently of make, except for Cadillac and Lincoln owners, (largely in the $10,000-plus income group), who kept their cars for 2.4 years. Only 7.7 percent kept them longer than 5 years.

Aside from the materialistic reasons for turning in cars, there are intangibles which make us decide. There are many good reasons, which we talk about, and the real reason, which we keep to ourselves.

This is illustrated by the story of the father and son discussing the son's girl friend. Father thinks she is okay, he guesses, but not very good looking. Sonny agrees, but "she is the best I can do with that car of ours."

Buying the car is not the whole story. AAA gives some average figures for *operating cost* in 1955.

Variable costs:		
Gasoline and oil		2.29 cents per mile
Maintenance		.74 cents per mile
Tires		.51 cents per mile
	Total	3.54 cents per mile
Fixed Cost:		
Insurance		$104.46 per year
License fee		16.83 per year
Depreciation		447.36 per year
	Total	$598.65 per year
	or	$ 1.64 per day

Scrutiny of these figures shows that, as far as the individual family car driver is concerned, fuel economy is a grossly overrated item. By changing from 15 miles per gallon to 20 mpg we only change the cost per mile from 8.3 to 7.8 cents per mile (based on 10,000 miles per year), a difference which is hardly worth all the bragging that it brings about.

Looking at fuel economy from the point of view of *natural resources*, rather than individual savings, we get a different picture indeed.

In 1954 the gasoline used by automobiles in the U. S. amounted to 13.5 billion dollars (including 3.5 billions in taxes). All central power stations and railroads paid a fuel bill of 1.5 billion dollars.

A fuel saving of 10 percent in the automobiles of the country saves more than the fuel cost of all central power stations and railroads.

The market for small cars

Exactly what it costs to build a car is shrouded in secrecy. However, a few interesting observations, bearing on the subject, can be made.

The sum total of raw material costs in a car is probably no more than $300 (body steel costs about 8 cents per pound). This cost depends on the size of the car. The labor cost in processing the material may be guessed to be of the order of 3 or 4 times that amount. It is not much affected by size, since it takes as long to build a small car as it does to build a large one. That is one of the answers to the question why we don't build a really small car: It would not be appreciably cheaper merely because it is small.

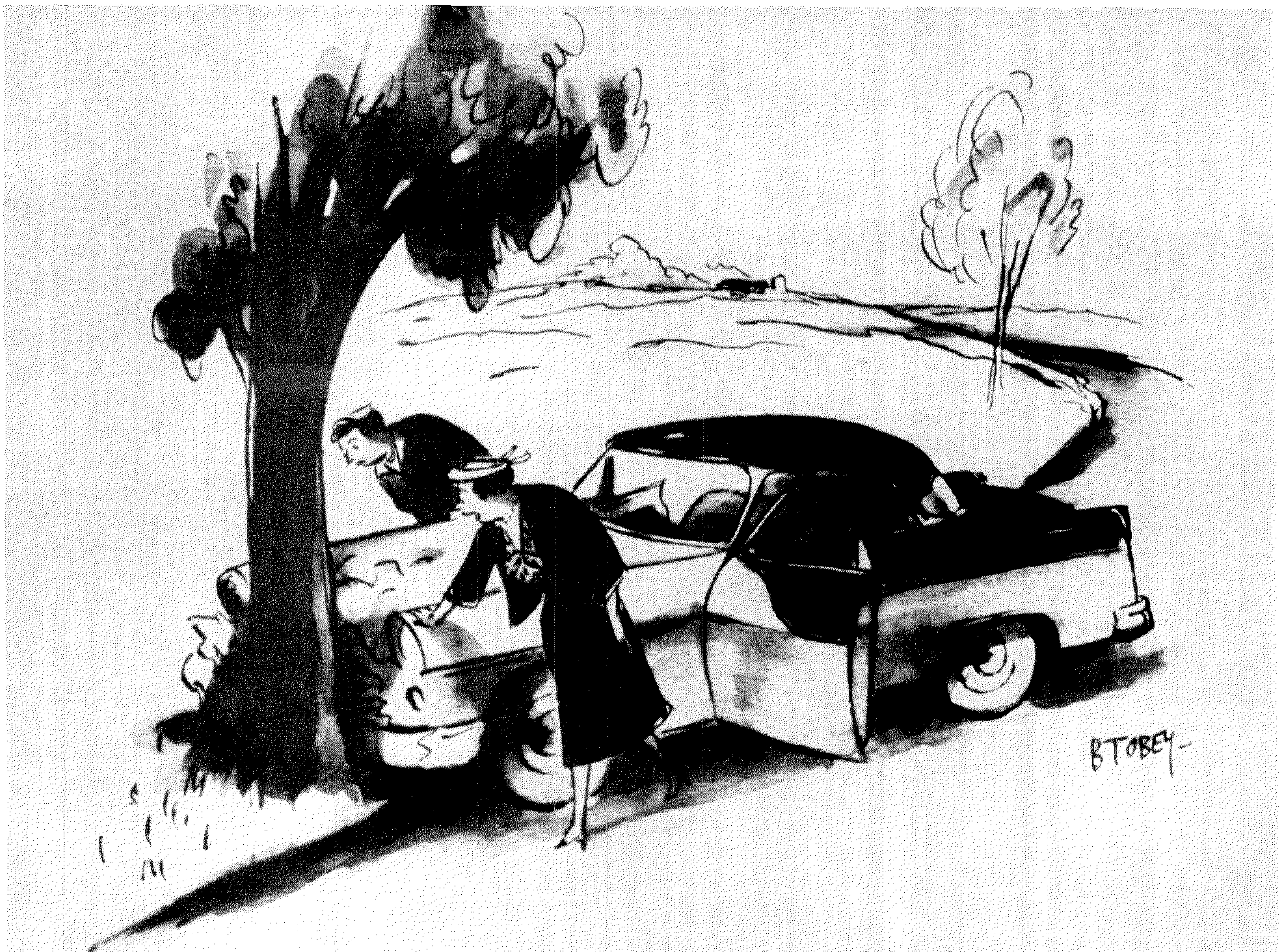
A true market for small cars simply does not exist in this country. If we think of the small car as a *second car*, the market is at once limited since only about 11 percent of the car-owning families own 2 cars. Most of these people do not buy two cars new, but keep the older one.

The sales figures bear this out. In 1954 the sales of Volkswagen and MG were, respectively, 6344 and 3454, or a total of about 10,000 cars. This compares with a total sale of 6.6 million cars. Only .15 percent of the car buyers wanted a small car. Even if we double that figure to allow for people who bought the other smaller cars, it is not enough for any manufacturer to be attracted.

Incidentally, the total *import* in 1954 was 34.5 thousand or roughly .55 percent of the total cars sold in the United States.

Chrysler built an experimental austerity model by eliminating such things as chrome trim and bumpers, insulation, dual tailights and other items not absolutely necessary. The running gear was left untouched. By their own report they wound up with the "worst, noisiest, most uncomfortable, ugliest automobile you ever saw." The saving was $150. For years buyers have favored the "de luxe" models. They would rather buy the lower priced car with extras than the higher priced one without them.

This discussion would not be complete without some data on taxes. While inflation has doubled the car price,



"I just hope it didn't do anything to the horsepower. Fred's so proud of that."

the total taxes, direct or hidden, on a car have quadrupled. In 1939 a resident of Michigan paid $143 in taxes on a car which sold for $1000 delivered, or 14.3 cents on the dollar. In 1952 the respective figures were: $583 on a car delivered for $2000, or 29.1 cents on the dollar.

Since we are on unhappy subjects, let us take a look at the accident rates. Needless to say, we should prefer to do without the 35,500 traffic deaths which occurred in 1954. If we look at the pertinent statistics, however, we find that we are doing better than we used to.

Year	Registration (Millions)	Miles Travelled (Millions)	Traffic Deaths	Deaths per 100 million vehicle miles
1927	20	159,000	25,800	16.3
1953	46	550,000	38,300	7.1

Cars have *increased* by a factor of 2.3, miles travelled by a factor of 3.5, traffic deaths by a factor of 1.5, deaths per 100 million miles have *decreased* by 53 percent.

Summing up a lot of data we can say:

Almost 40% of the deaths occur on weekends.

Saturday is the most dangerous day of the week.

Drivers under 25 years of age are involved in more than their proportionate share of accidents.

Three out of five deaths occur during the hours of darkness.

Ninety-five percent of the vehicles involved are in good mechanical condition.

"No matter the price, no matter how new, the best safety device in the car is you."

The same conclusion is reached in a study concerning the effect of horsepower on highway speed.

The highest-powered vehicles, while driven more frequently in the high speed ranges, are not driven at any greater maximum speeds than the lower-powered cars, except perhaps for those under 100 horsepower.

The vehicles with from 100 to 130 horsepower are driven as fast as any vehicle of any horsepower. It would appear that the critical factor in determining highway speed is still driver skill and not the vehicle.

It seems quite certain that many people get into trouble by going 45 mph when they should be going 15. All attempts to develop safety devices are good, but they cannot substitute for a sensible driver.

Engineering, styling and psychology

The development of the automobile shows three distinct phases:

(1) Gadgeteering and invention: During this period, we were happy if a car would run and take us places with reasonable certainty.

(2) Production development: We took advantage of the economy of mass production to keep the cost of the end-item down to a point where everyone could afford to own it. Cars evolved from luxury items to necessities.

(3) Now, development is concerned with refinements rather than with dramatic changes. Utility is taken for granted. The factors which control the purchase of a car are considerations such as comfort, appearance, riding qualities, quietness, and a host of intangibles, mostly of a psychological nature.

An anomaly

Among the many products of modern technology, the automobile has a unique position. It is the most complex and expensive piece of equipment which is built to be operated by people with a minimum of skill. A failure may well endanger the life of driver or innocent bystander. The car, once sold, has to live with its owner or driver, and has to be self-sufficient and foolproof. For this reason, the automobile is committed to a multitude of compromises which, at times, do not seem reasonable or sensible. We train pilots to fly airplanes. If they fail to become proficient they are fired. Here the equipment dictates the requirements of the operator.

Many of us are emotionally entangled with this piece of machinery. The first car, the first *new* car, the first scratch on the new car, are all highly important to a man. More so to men than to women, I think. There are a multitude of jokes and cartoons about automobiles. In 1915 there was published a collection of jokes about the Model T, complete with the Ford-owner's prayer: "The Ford is my automobile, I shall not want another one. . . ."

The car in the driveway is a measure of social stature to many people.

What did you pick that one for?

What makes a man decide on a car? Engineering features? Styling? His wife's opinion?

Fred may be fond of the horsepower (in the cartoon on page 19), but it is likely to be only his second reason.

People give the following reasons for their preferences:

1. Economy (low price, good trade-in, low maintenance, etc.)
2. Performance
3. Appearance
4. Construction
5. Comfort
6. Reputation
7. Dependability
8. Special features (automatic transmission, power steering, etc.)
9. Safety

This lineup shows that people are cost conscious. They value performance more highly than appearance. The car's reputation does not seem to matter much. Cadillac and Chevrolet rank about equally in this item. This shows that the term "prestige car" implies owner-prestige rather than car prestige.

Dependability is one of the things which people expect and take for granted—whence the low rank. Only those who have survived an accident, the imaginative and the extremely timid have in the past worried about safety, which ranks lowest on the list.

One thing is clear: in the buyer's mind engineering and styling are not separated clearly into compartments, nor are they in the manufacturer's mind, as far as I can see.

Why doesn't Detroit do it?

A detailed discussion of engineering details does not belong here, since we are concerned with the broader aspects. One question, however, needs to be answered: How does the U. S. car compare with European cars? The typical argument goes like this: Why doesn't Detroit put out fur-lined brake drums, since they have been so successful on European sports cars? (You may substitute any of your pet details for the fur-lined brake drums without changing the story).

During the last few years it has become fashionable to denounce the American automobile with a fervor usually reserved only for political and religious controversy.

A comparison of the differences and discussion of details can be found in recent literature. *Differences* there are, but a division into good and bad is not possible because so much boils down to a matter of taste. The differences arise chiefly from background and motivation.

In Europe the automobile has not developed into a necessity and a household appliance. It has largely remained a hobby item, used part-time for business. For this reason, sports cars are common in Europe. Economic limitations and traditional taxation of automobiles based on the "soak the rich" philosophy have produced what can be called the European utility car, such as it is.

Laurence Pomeroy, editor of the British magazine *Motor*, has summarized the situation most succinctly:

"Western Europe has a population slightly greater than that of the U.S.A., but is divided into 14 main national units, all of which restrict trade across their frontiers by quotas and fiscal devices. These are imposed primarily to preserve local employment and to conserve a pool of skilled labor upon which survival may depend in case of war.

" . . . the need of an automobile for personal transport is less in Europe than in the United States and the possibility of purchasing and operating an automobile is likely to be permanently lower.

"In practice more than 90 European cars out of 100 are purchased with company funds, but used for both business and pleasure.

"Companies . . . may endow their senior executives with expensive and exotic types of cars which will be regarded as the fruits of office . . . or they will seek to provide employees with transport at the bare minimum of cost.

"Outside America, there have . . . been few developments in motor roads. . . . In France under 100 miles of new road have been built since the war and in England expenditure has been almost entirely confined to the erection of 'Danger' and 'No Parking' signs."

These sentences have been quoted verbatim. They clearly illustrate the different background of European design and production.

European cars possess national characteristics. The majority are cheaper to build and to operate. They are smaller, lighter and narrower. Their road-holding ability is good on poor roads. Their performance is generally poor; they are noisy and uncomfortable.

In appearance, European cars are related to American styling. The Italians have rather enthusiastically accepted many American characteristics. The French and British have resisted American influence but are yielding. The Germans have developed along lines of their own, characterized by mechanical originality and lack of traditionalism.

European production figures are as follows:

Production of Passenger Cars in Europe (1953)

United Kingdom	520,000
France	360,000
Germany	355,000
Italy	133,000
Total	1,418,000
(United States	6,116,918)

Principal Manufacturers

United Kingdom	5
France	5
Germany	3
Italy	1

There are 36 small companies among the total of 50 European car manufacturers. In the U.S., there are only 6.

Production varies from 100 to 100,000 cars per year year for these manufacturers, and there are approximately 120 distinctly different designs.

A similar variety cannot be economically produced by the 6 U. S. manufacturers, nor has there been a sufficient demand. Driving in the U. S. is not a sport but transportation.

Last, but not least, there is also this perennial question to be answered: "Why doesn't Detroit do it?" Many things have been tried on experimental cars (for instance, rear engines, two-stroke engines, independent rear wheel suspensions, to name only a few). If such innovations have not been put into production, there is generally a reason which may not be apparent to outsiders and which is rarely publicized.

In general, it has not been economically successful to be different merely for the sake of being different.

A look into the crystal ball

C. F. Kettering suggests this method of predicting the future of automotive engineering: "Considering all *the factors, use the best extrapolation* you can, *push* it as high as you can, and, if you live to see it accomplished, you will be amazed that you missed it so far."

Here are some of my extrapolations:

Gas turbines are here to stay; will find their most suitable use in trucks, buses, military and earth-moving vehicles, perhaps in racing and sport cars. They will be supplemented by such devices as free piston gas generators and may appear in compound powerplants, together with gasoline or Diesel engines, to supply short bursts of high power.

Nuclear power could become an attraction if a small reactor can be built. With it the reciprocating steam engine may return from its somewhat undeserved oblivion.

The electric car may come in for some attention for short haul service. We have learned a few things about batteries and should be able to produce an acceptable vehicle.

With the increase in super-highway mileage we will need automatic steering. The car might be rolling along a beam produced by a buried cable. Once on the beam, the driver would push the control out of the way and relax. There will have to be proximity warning devices and emergency over-rules but, all in all, this is not very complex. It will take a lot of the monotony out of long distance driving; people can doze without wrapping themselves around trees.

These things are probably from 10 to 20 years off.

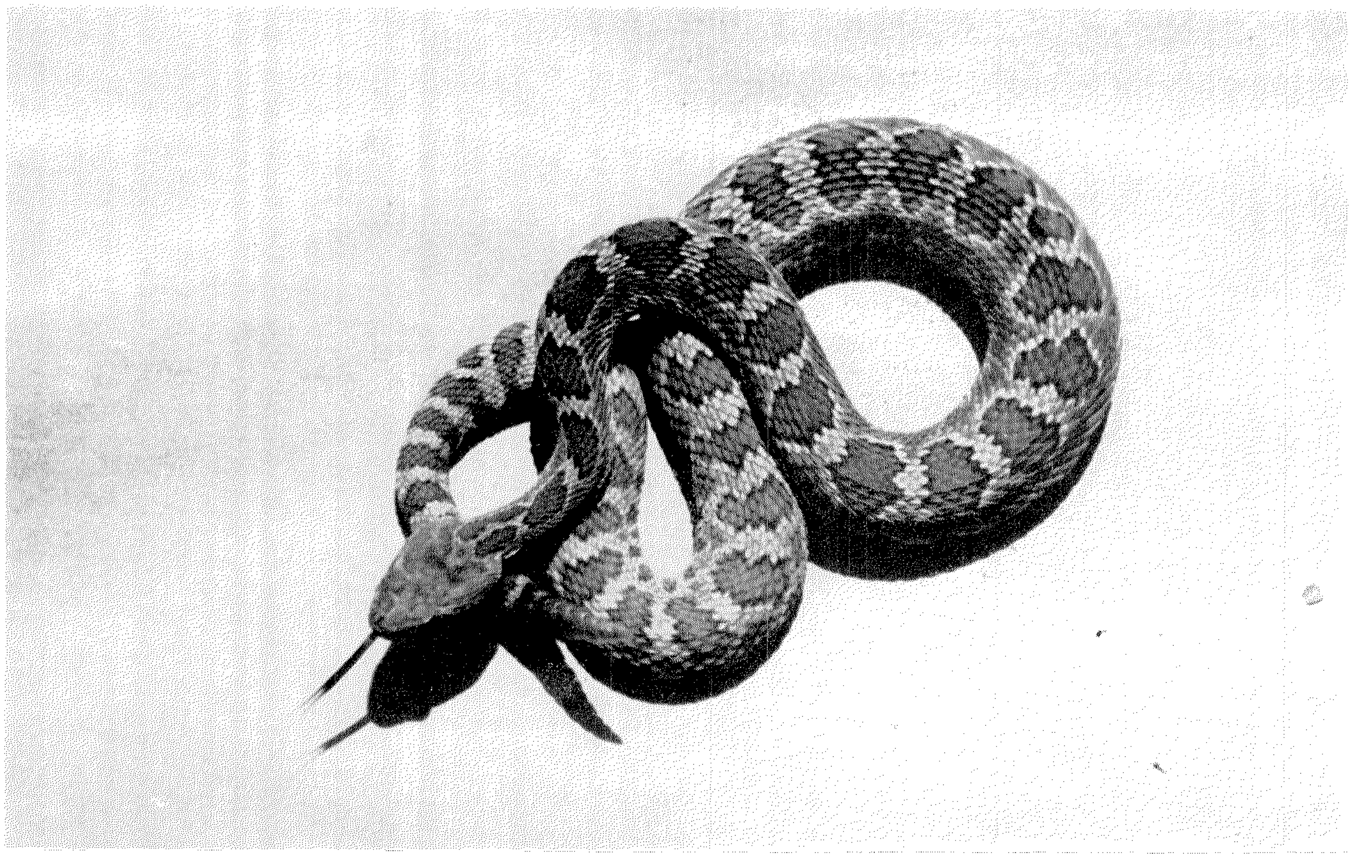
In the immediate future we will see more power, levelling off around 450 hp, the upper limit of what the two rear wheels can comfortably transmit.

Gasoline injection will appear in one form or another —may well turn out to be a fad, rather than a real step forward.

Compression ratios will go up and so will gasoline octane numbers. I am guessing at 15 to 20.1. Why not Diesel? Because at any compression ratio the spark-ignition cycle has a higher thermal efficiency than the compression ignition cycle of the same compression ratio. (Note to the readers who like to write to the editor: Before you break into loud snorts of indignation over this one, consult an elementary thermodynamics text.)

The possible gains in performance (acceleration, fuel consumption) from lightweight construction may well come in for some attention. This calls for more than a "material substitution program." It will require a lot of re-designing of components and development of aluminum die-casting of large parts.

In any event, there are not going to be any dull moments.



A modern Pacific rattlesnake, whose ancestors probably inhabited the tropical forests of Canada.

THE CLIMATE OF THE PAST

by BAYARD BRATTSTROM

CALTECH IS, OF COURSE, well known for its specialization in several fields of teaching and research. It is equally well known for the close relationships among the fields of research and the freedom from rigid boundaries between the academic divisions of the Institute (biology-biochemistry-chemistry, for example, or geology-geophysics-physics). It was surprising, therefore, to me to be repeatedly asked during my year at the Institute (as a research fellow in paleontology), "Just what is a biologist doing in a geology department?"

I am a herpetologist (one who studies reptiles and amphibians, such as snakes, lizards, turtles, frogs and salamanders). Two of my major interests are the ecology of modern reptiles and amphibians, especially their temperature requirements; and fossil reptiles and amphibians, especially those of more modern times (the Cenozoic, or the last 75 million years).

Some 60 million years ago, in Eocene times, tropical forests extended northward almost to the Arctic Circle, and plants like breadfruit, fig and magnolia were found as far north as southern Alaska.

From that time to this, the tropics have receded southward; and as they have fallen back they have become diversified into such types as deciduous forest, coniferous forest, grasslands, chaparral and so on. The deserts of the southwestern United States did not come into existence until about one million years ago.

All this we learn from the fossil plants we find and from what we know of the climatic needs of modern plants that resemble these ancient ones.

This science of the relation of ancient plants to their environment is now being joined by the study of ancient animals and their environmental relationship. The general field of research is called paleo-ecology.

Reptiles and amphibians are "ectotherms"—which means that they obtain all their body heat from external sources, absorbing heat from the ground, water, or sun. This is in contrast to the "endotherms," or birds

In the restricted lives of reptiles and amphibians, scientists now find clues to the climatic conditions of the past.

and animals which produce their own internal heat by metabolism. Reptiles and amphibians have relatively limited ranges of temperatures that they can tolerate. They also have definite "preferred temperatures" that they keep their body at by their behavior.

For example, a lizard crawls on a rock and absorbs heat from the rock and from the sun. When its body temperature reaches a certain level, it leaves its "basking rock" and begins eating, reproducing, and so on. In doing so, it may crawl in the shade for a while and, as a result, lose heat to the environment. The lizard will then return to the rock to bring its body temperature back to the "preferred" level.

The ranges and preferences differ for the various species or families of reptiles and amphibians. For this reason reptiles and amphibians should be useful for the determination of past climates.

A review of the temperature requirements of reptiles and amphibians, based on a number of different studies and research projects, has just been completed. We now have a fair idea as to the requirements of modern reptiles and amphibians, both in regard to the temperature requirements of individual species and families (as determined by field and laboratory studies) and in regard to the heat-gain and heat-loss problems in relation to body size. For example, the more northern reptiles and amphibians are all small. Only a small ectotherm can absorb enough solar radiation in the more northerly latitudes to get its body temperature up to the levels required for digestion, reproduction, or escape from enemies. Large reptiles, such as boas, pythons and monitor lizards, are found only in the more equable climates of the tropics.

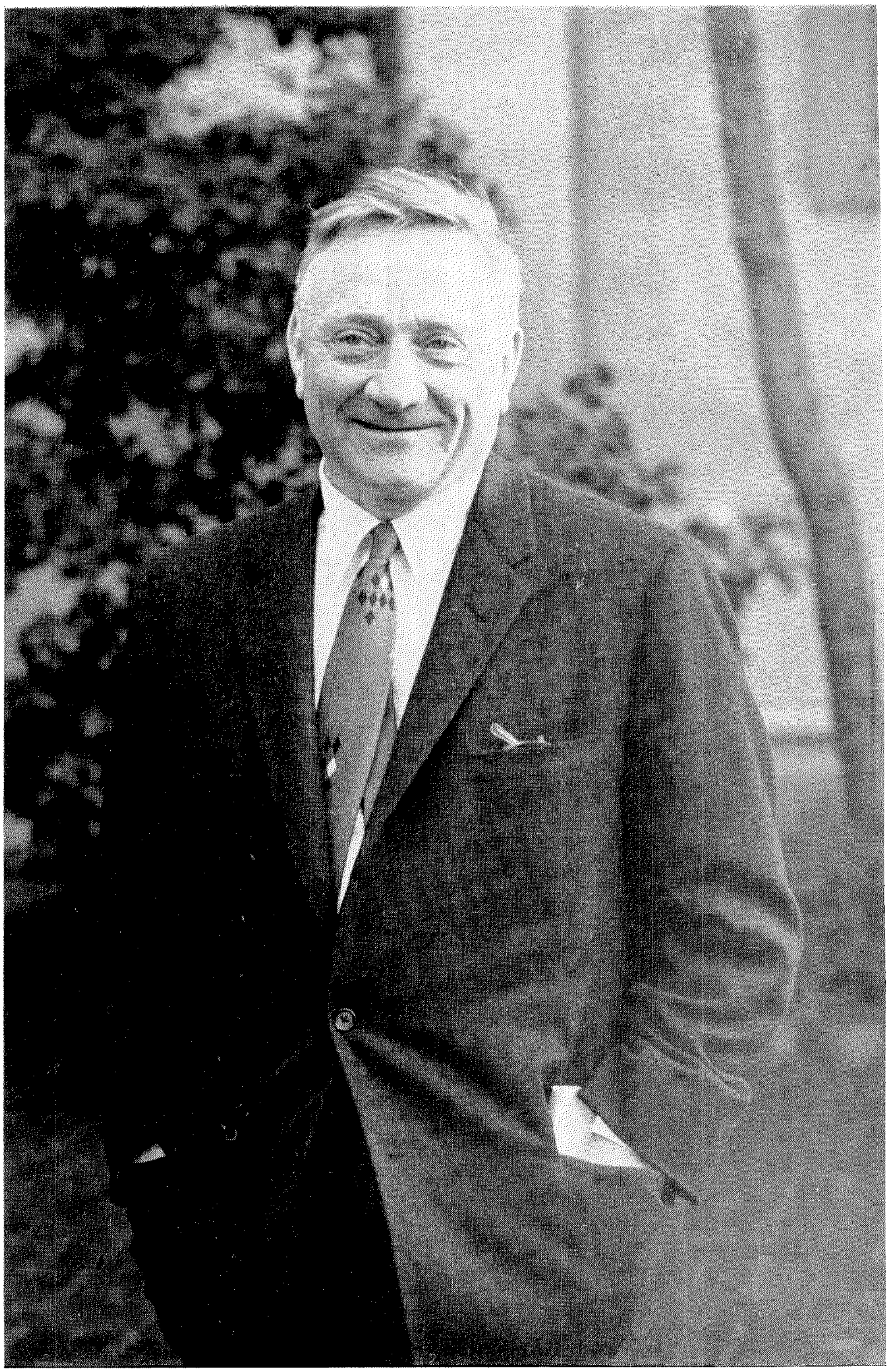
Reptiles and amphibians do not wander about like some of the large mammals, such as horses and bison, nor do they fly like birds, and only a few of them swim as do fish. Most reptiles and amphibians have "home ranges" or "territories" and hence live in a relatively small area; in fact, they probably never move out of an area of about 500 yards in diameter during their entire life. Reptiles and amphibians are, in addition, relatively restricted to certain habitats or plant associations. Such factors as these aid in making reptiles and amphibians useful for the determination of past climates.

The study of fossil reptiles and amphibians is becoming increasingly enriched through modern techniques of paleontology. In the past, usually only the large bones in a fossil deposit were found or saved. Modern techniques of washing, sifting, and sorting reveal that deposits previously considered barren have large faunas of small vertebrates. For example, a series of fossil reptiles and amphibians presently under study comes from many sites in Kansas that represent a time span from Middle Pliocene to the Recent (a span of about 5 million years). These collections include several thousand individuals of snakes, lizards, frogs, turtles, or salamanders.

A technique for the determination of past climates has recently been devised by the writer, based on the distribution and temperature requirements of modern reptiles and amphibians and the herpetological composition of a fossil deposit. With this technique such items as rainfall, temperature, or snowfall can be determined. Thus far the paleoclimatic data resulting from this technique conform with the paleobotanical picture. For example, the past distribution of alligators in North America conforms with the changing climates as determined by the paleobotanist. In the Eocene (60 million years ago) alligators occurred in southern Canada and Montana, as did the tropical and subtropical forests. About 15 or 20 million years ago, the range of alligators had slowly become restricted southward to Nebraska, along with the tropical and subtropical forests and swamps. The alligator of today occurs only in the warm subtropical region of the southeastern United States.

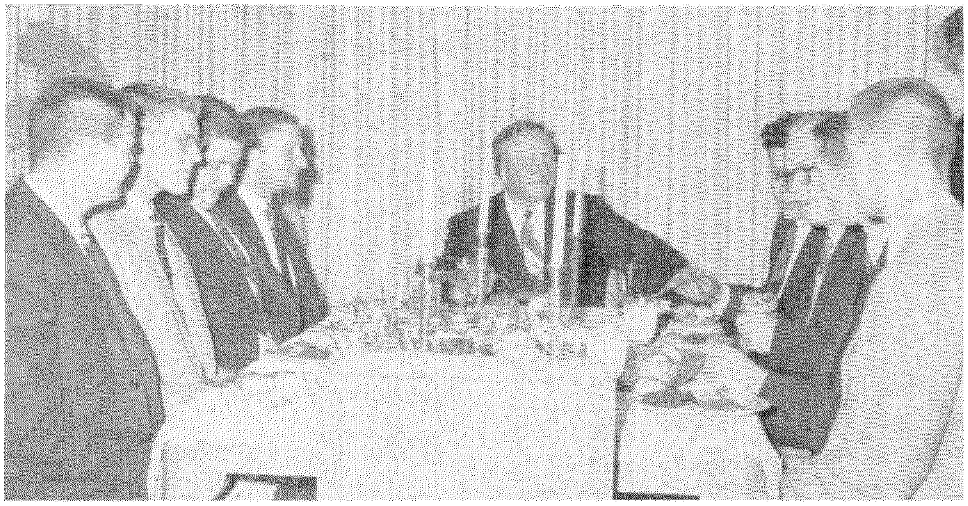
The climate for several fossil sites has been determined by this technique. For example, during the "heyday" of the La Brea tar pits (*i.e.*, after the mammoths and mastodons had become extinct, but when the dire wolves, sloths and saber-toothed tigers were still abundant) the Los Angeles basin had an average of 20 inches of rain a year (in contrast to its present annual average of 14.8 inches) and average winter and summer temperatures were some 5°F. warmer than today. It has also been determined by this technique that the San Pedro Valley of southeastern Arizona a million years ago was not a desert—as it is today—but an area with some 20-30 inches of rain a year (the rainfall there today averages 11.2 inches a year) and a temperature that was slightly warmer than that of the present.

The paleoclimatic technique based on the reptiles and amphibians is helping to supplement and refine the climatic picture presented by the fossil plants and it provides an independent check on the climates as deduced from the fossil plants. When the two differ for any one time and area, the basic assumptions and data of the two fields can be re-examined in order to arrive at a more accurate estimate of the climate of the past.



JUSTICE DOUGLAS AT CALTECH

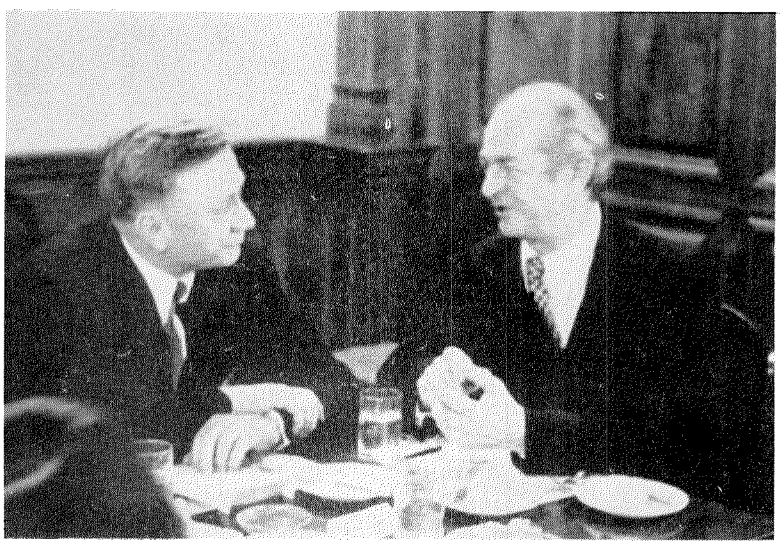
Associate Justice William O. Douglas of the U.S. Supreme Court comes to the campus as a Leader of America



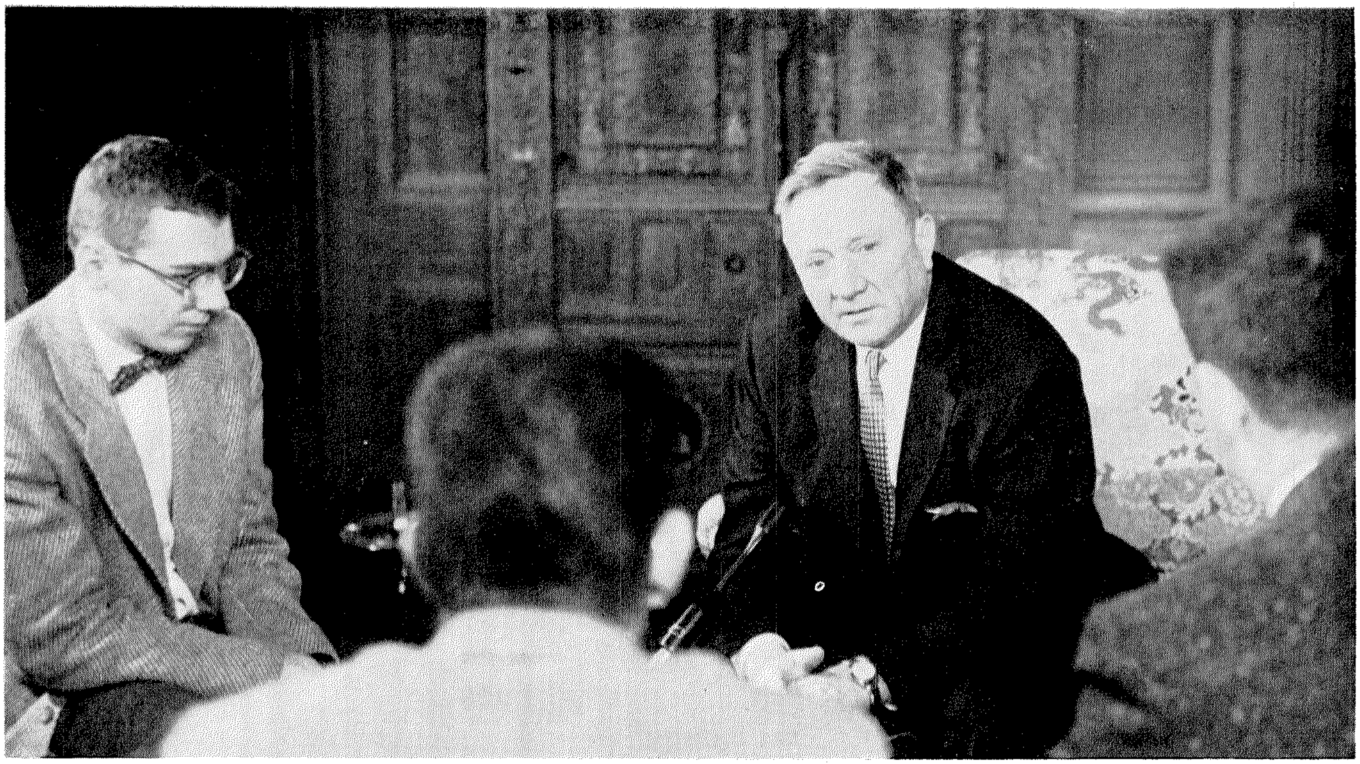
Associate Justice William O. Douglas of the U.S. Supreme Court spent four days on the campus early this month, as the second visitor in the YMCA's Leaders of America program.

They were four crowded days. The Justice spoke to undergraduates on "Russia—1956," giving impressions of his trip through the Soviet Union last summer. He repeated the talk for faculty members and their guests. He addressed the YMCA graduate-faculty forum on "The Bill of Rights." He answered questions put to him by a panel of students.

Though these were the most public of his appearances, they were by no means the whole story. Students also had ample opportunity to meet Justice Douglas in smaller, more informal groups, which provided an experience of considerable value to them, and—it is not impossible—to the Justice as well.

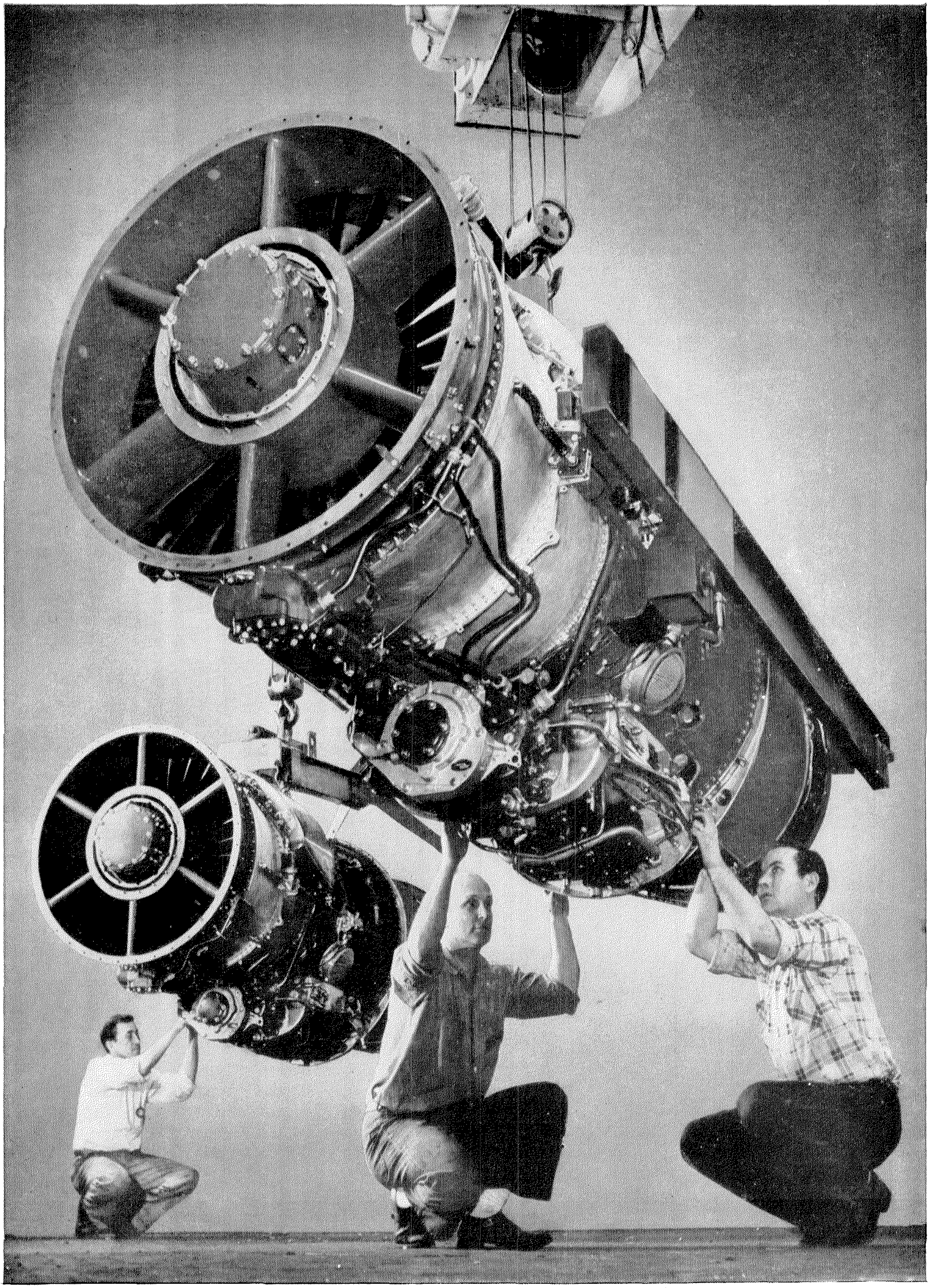


Top—Dinner with student leaders.
Center—Describing slides of his Russian trip. Mrs. Douglas, off right, manned the projector.
Right—Conversation with Linus Pauling.

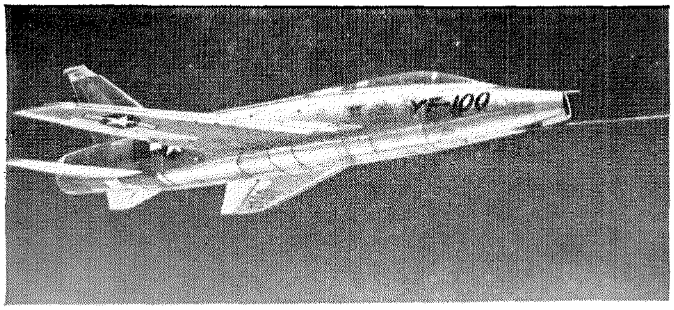


The Justice spent most of his time answering questions—of which the students had an inexhaustible supply.

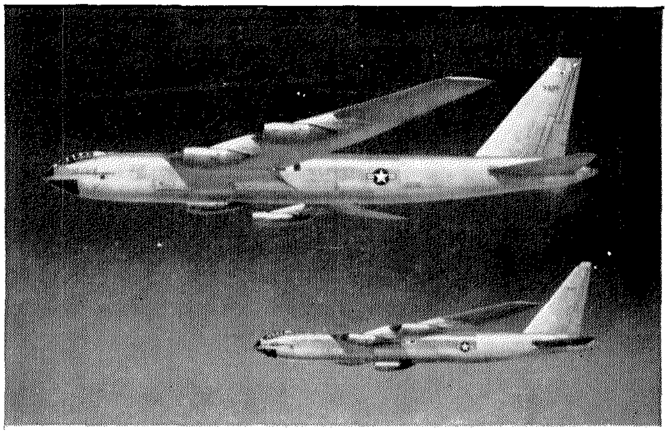
And some of the questions were not only surprising in themselves; they also came at surprising times.



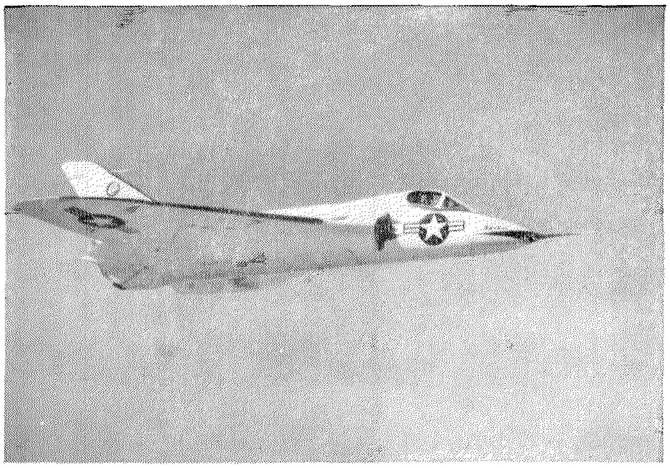
The J-57, in the 10,000-pound thrust class, is the most powerful turbojet engine now in production. A new generation of U. S. air power has been designed around this mighty new Pratt & Whitney Aircraft engine.



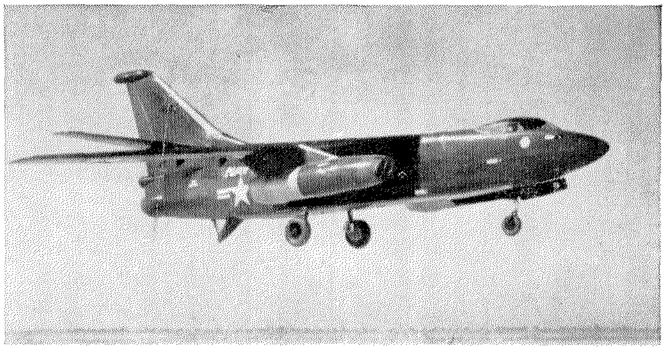
North American's F-100 Super Sabre, fastest Air Force jet fighter, is powered by Pratt & Whitney Aircraft's J-57 engine.



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



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



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

Blazing the Way for a New Generation of Air Power

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

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

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

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

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

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

PRATT & WHITNEY AIRCRAFT DEPENDABLE ENGINES

PRATT & WHITNEY AIRCRAFT

DIVISION OF UNITED AIRCRAFT CORPORATION

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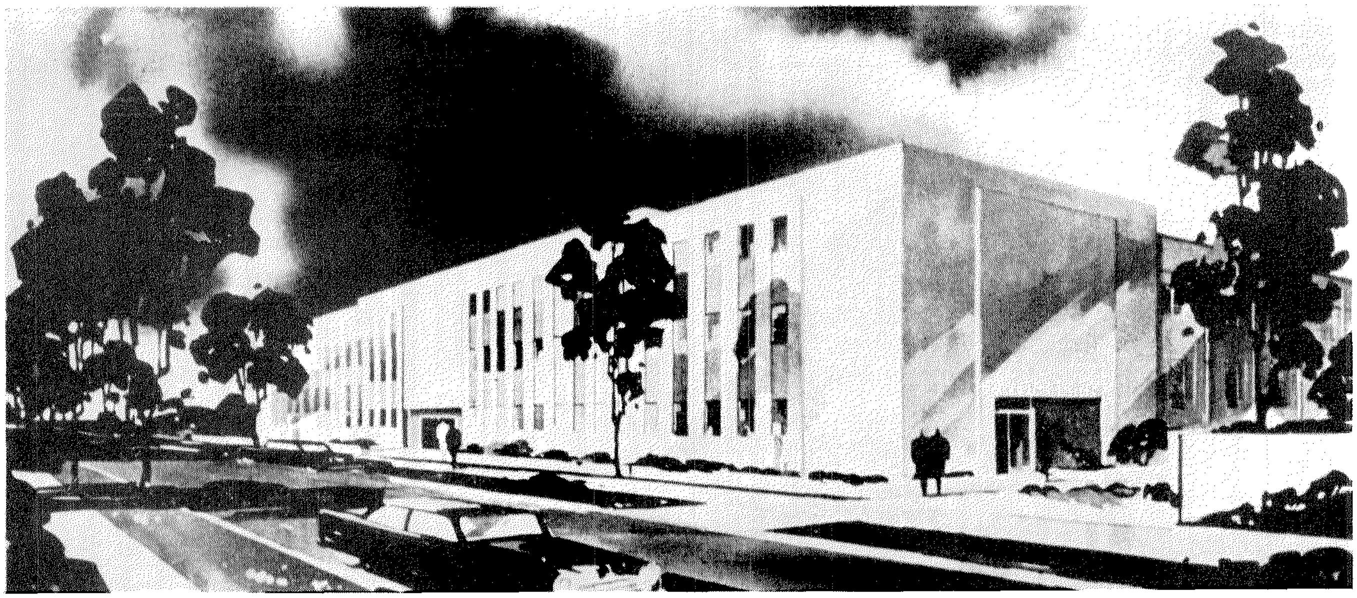


Architect's drawing of the new Eudora Hull Spalding Laboratory of Engineering

THE MONTH AT CALTECH

Engineering Building

CONSTRUCTION on the new Eudora Hull Spalding Laboratory of Engineering at Caltech will get under way this spring, and the building will probably be ready for use in the fall of 1957. The $1,500,000 laboratory is being financed by the Spalding Trust Fund. It will occupy the area north of the chemical engineering building, where the hydraulic model basin and the internal combustion laboratory now stand, on San Pasqual Street between Michigan and Chester Avenues.

The laboratory will be a five-story structure, with three stories above and two below ground. It will be 210 feet long and 58 feet wide, and it will have 60,000 square feet of floor space, and more window space than the existing engineering building.

The chemical and electrical engineering departments will share the new laboratory—chemical engineering taking the west half of the building and electrical engineering the east. Work in both departments will be expanded and the equipment they now have scattered around the campus will finally be housed under one roof. The chemical engineering work and equipment now in building T-3 will be moved to the new lab, as will the analog computer from West Bridge and the electrical engineering equipment in Kellogg. A new electronic computer will be installed in the building, and the internal combustion engine lab and the mechanical engineering shop will occupy the sub-basement.

Goddard Professor

DR. W. DUNCAN RANNIE, professor of mechanical engineering, has been appointed the new Robert H. Goddard Professor of jet propulsion at Caltech. The Goddard professorship is the principal post in the Institute's Jet Propulsion Center, established in 1948 by the Daniel and Florence Guggenheim Foundation. Dr. Rannie is the second Goddard Professor at Caltech. His predecessor, Dr. Hsue-Shen Tsien, resigned last June to return to his native China.

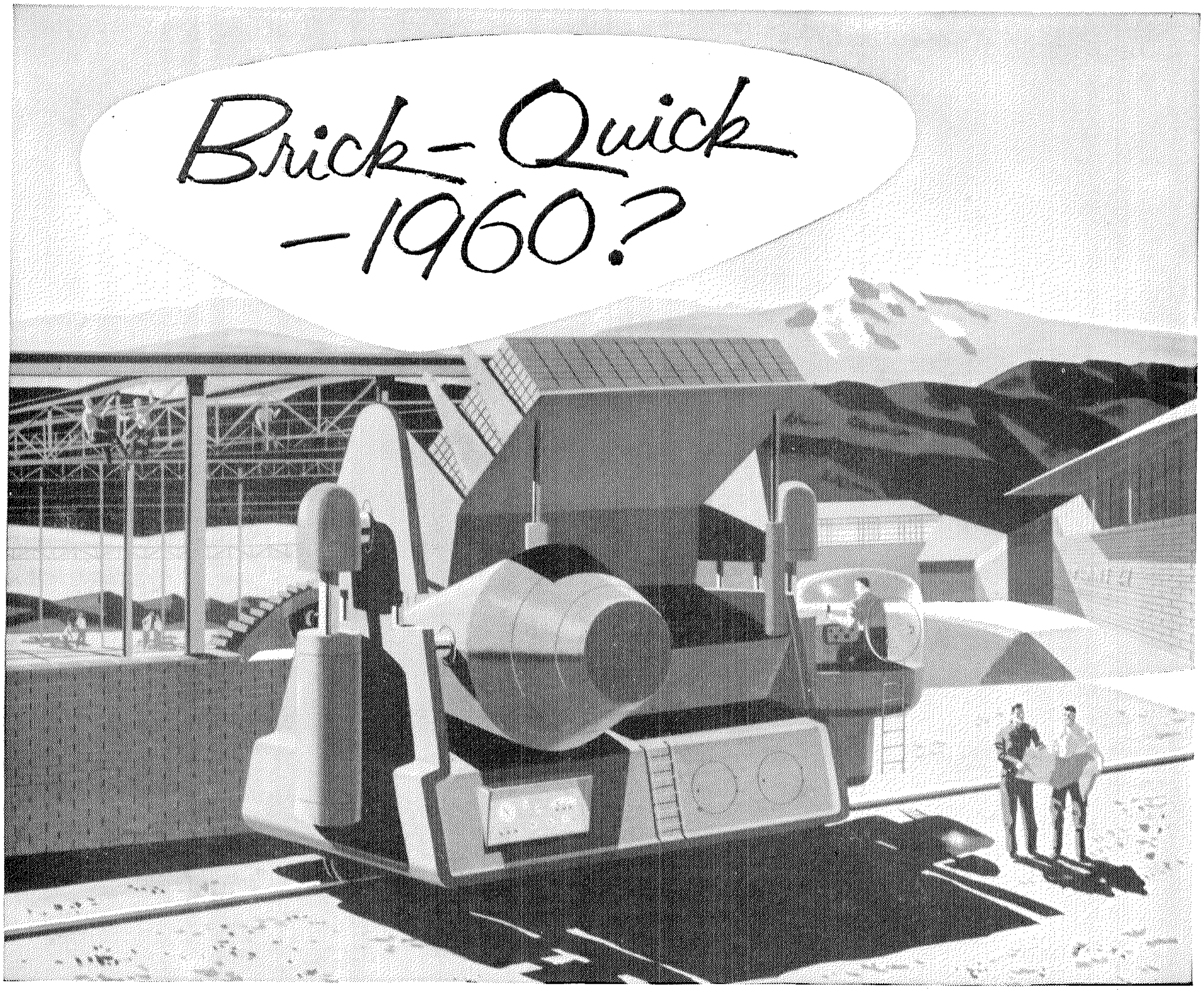
A graduate of the University of Toronto, Dr. Rannie came to Caltech as a graduate assistant in 1938. During the war years, he headed the aeronautics and thermodynamics group at the Northrop-Hendy Company. In 1946 he returned to Caltech and the Jet Propulsion Laboratory, where he was chief of the Ramjet section.

AFROTC—In Again

CALTECH'S AIR FORCE ROTC program, cancelled last month (E&S—January 1955) after being in operation for four years, has now been re-established. Caltech was

CONTINUED ON PAGE 34

NEW | DEPARTURES OF TOMORROW

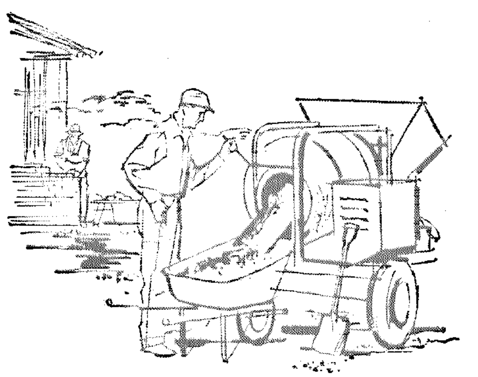


TOMORROW: This ingenious machine works from blueprints to brick walls in record time!

Skylines of the future may spring up overnight with equipment like this on the job. Brick-Quick **prepares and spreads the mortar, then lays and levels the bricks, points up and finishes walls** with ultra-speed and precision.

This fantasy may be a fact tomorrow! If it is, look for New Departure ball bearings to play a vital role in its successful operation. New Departures hold moving parts in positive alignment, take thrust and radial loads. And New Departure's constant research provides industry with bearings that operate under extreme conditions to make the newest advances workable.

NEW DEPARTURE •• DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT



TODAY: New Departure ball bearings assure dependable operation and long life for construction equipment of all kinds. These bearings support heavy loads, reduce wear and operate throughout the life of machines with little or no maintenance.

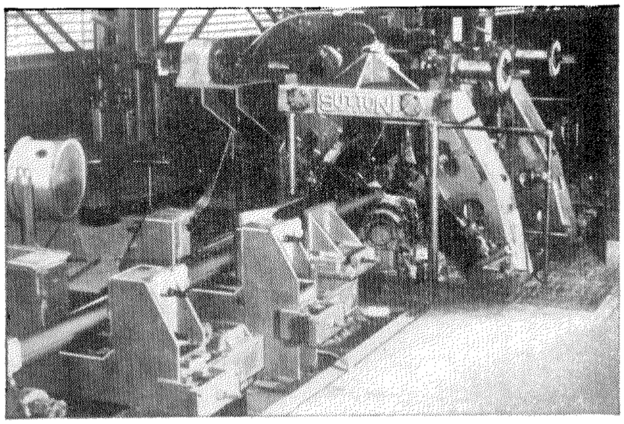
GM GENERAL MOTORS

NEW DEPARTURE BALL BEARINGS

NOTHING ROLLS LIKE A BALL

Another page for **YOUR BEARING NOTEBOOK**

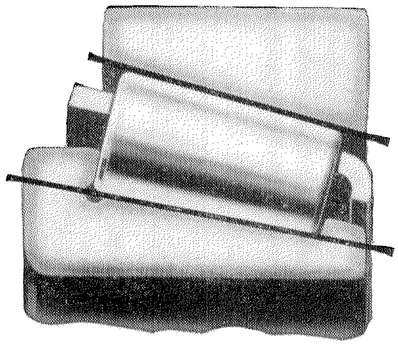
How to make a tube straightener true



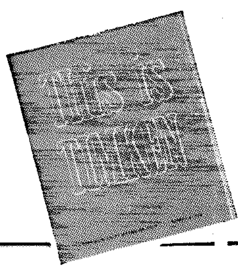
The engineers who designed this tube straightener were faced with the problem of building a machine that could withstand the constant stresses of handling 16½″ O.D. tubes of standard thickness and yet provide the necessary precision. Their answer was to mount the two driven rolls and the five idler rolls on Timken® tapered roller bearings. Timken bearings take both radial and thrust loads in any combination and have the extra load-carrying capacity to keep the rolls in rigid alignment.

Why TIMKEN® bearings have high load capacity

This cross-section of a Timken tapered roller bearing shows one reason why Timken bearings stand up under heavy load conditions. There is full line contact between the rollers and races. It's this full line contact that distributes the load over a wider area, giving Timken bearings their extra load-carrying capacity.



Want to learn more about bearings or job opportunities?



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

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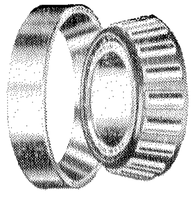
TAPERED ROLLER BEARINGS



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

one of 25 institutions (out of 188) at which the units were being discontinued; they will now be re-established at any of the institutions that want to remain in the program.

"In trying to economize through disestablishment," the Air Force stated, "it became apparent that patriotic interest and enthusiastic support for the AFROTC in the majority of the institutions affected outweighed the potential dollar and manpower savings involved."

Junket

ROYAL W. SORENSEN, professor of electrical engineering, emeritus, is leaving early in March to be the special representative of the American Institute of Electrical Engineering at the 150th celebration of the Verein Deutscher Ingenieure in Berlin in May. From there he will go to Paris to attend CIGRE, the International Congress of High Voltage and Power Transmission Systems which will be held from May 30 to June 9. From there on, the trip becomes a vacation, and the Sorensens will visit other parts of Europe—stopping to celebrate their golden wedding anniversary in Venice—and return home in August.

Seismological Annex?

CALTECH'S SEISMOLOGICAL LABORATORY has received a $75,000 grant from the Kresge Foundation of Detroit, Michigan, for the construction of a much-needed annex to the present seismological building—conditional on the Institute raising the additional funds needed ($175,000) from other sources.

Announcement of the grant was made last month at a conference of representatives of the 21 organizations supporting the Seismological Laboratory's program of earthquake reasearch.

Among the companies represented at the conference were Bethlehem Pacific Coast Steel, Southern Pacific, Union Pacific, the Santa Fe Railroad and the Pacific Telephone and Telegraph Company.

Honors and Awards

DR. ARNOLD O. BECKMAN, an alumnus of Caltech, a former faculty member, and now on the board of trustees, has been elected president of the Los Angeles

CONTINUED ON PAGE 38

Chamber of Commerce for 1956. A member of the board of directors of the Chamber of Commerce since 1954, Dr. Beckman also served as a vice-president and chairman of the Air Pollution Control Committee last year. He is president of Bechman Instruments, Incorporated, which he founded in 1940. He is also president of Arnold O. Beckman, Inc., scientific instrument manufacturing company; the Berkeley Scientific Division of Beckman Instruments, Inc., and the Helipot Corporation a subsidiary.

PRESIDENT L. A. DUBRIDGE was chosen as one of ten outstanding Americans to receive an Award of Merit from the Los Angeles branch of the National Vocational Guidance Association at its annual Awards banquet held last month. Dr. DuBridge was acclaimed a "senior statesman of science, distinguished educator, devoted to the encouragement of study and careers in the fields of pure science, research and engineering."

THEODORE VON KARMAN, Caltech profesor emeritus and chairman of the planning board of Gruen Precision Laboratories, Inc., was awarded the Daniel Guggenheim Medal in New York last month for "notable achievement in the field of aeronautics." Dr. von Karman is credited with having spurred the U. S. lead in the design of supersonic aircraft as well as originating the concepts that led to starting research on the first plane to break the sound barrier.

Arrivals and Departures

RALPH HULTGREN, professor of metallurgy at the University of California, Berkeley, returns to the Caltech campus this month as a research associate in chemistry. Dr. Hultgren received his PhD at Caltech in 1933.

JULIUS MIKLOWITZ, associate professor of applied mechanics since the first of the year, was formerly with the Naval Ordnance Testing Station as head of the applied mechanics branch of their research division. He received his PhD from the University of Michigan and, prior to that, did three years of research in plasticity work at the Westinghouse Laboratories.

JOHN L. STEWART, assistant professor at the University of Michigan, arrives this month to be associate professor of electrical engineering at Caltech. Dr. Stewart spent two years with the Jet Propulsion Laboratory at Caltech from 1949 to 1951 doing research in radar, analog computors and current theory.

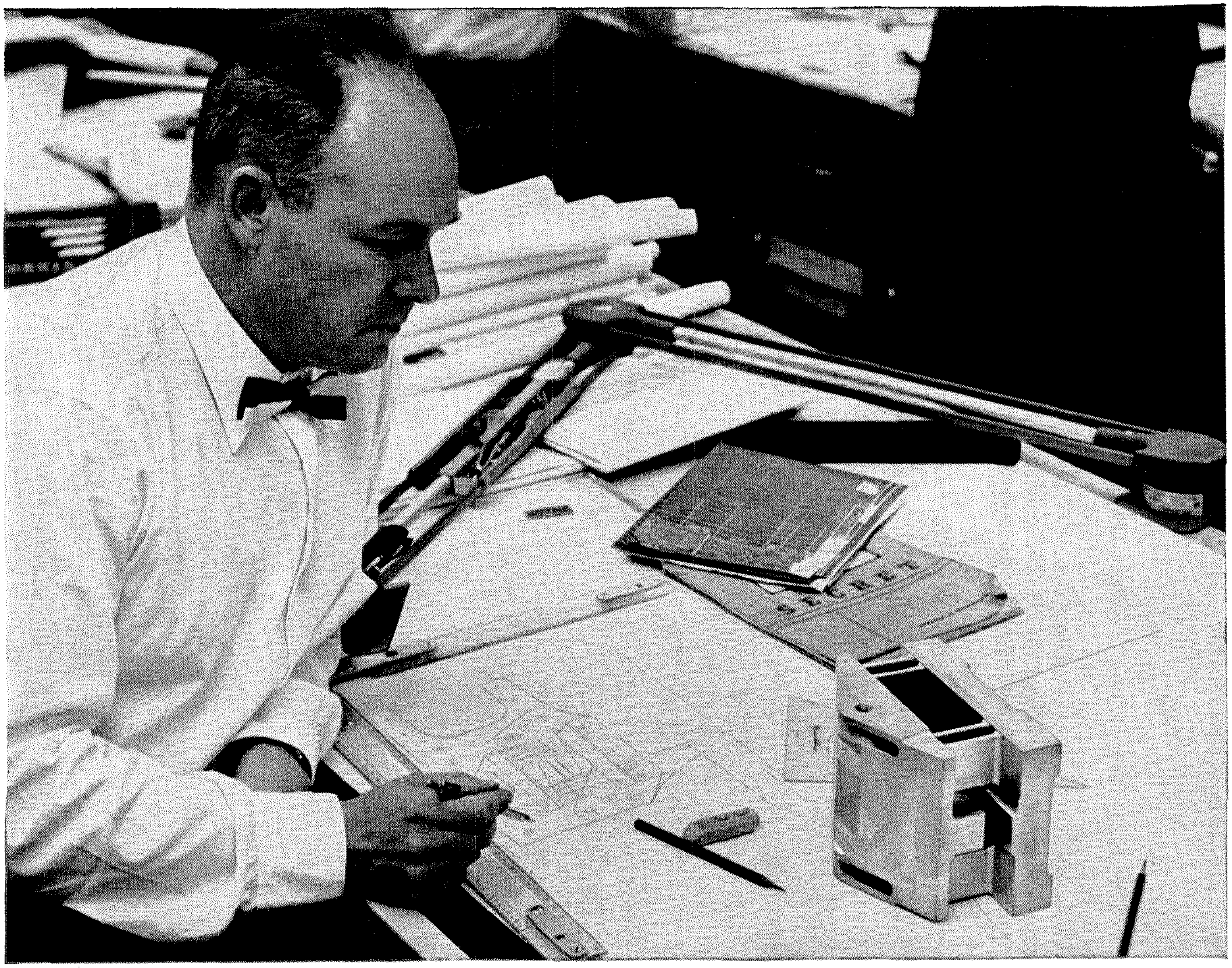
FRANK E. MARBLE, associate professor of jet propulsion at Caltech, left this month to spend the spring term at Cornell's Graduate School of Aeronautical Engineering as a visiting professor, offering courses on combustion in jet engines and rockets.

FRITS W. WENT, professor of plant physiology, leaves on February 13 for a tour as a National Lecturer for Sigma Xi. He will visit universities in 18 states and give approximately 37 lectures based on his research in environment and its role in plant growth.

Caltech Associates

STUART O'MELVENY, president of the Title Insurance and Trust Company, has been elected president of the California Institute Associates. Mr. O'Melveny has been a member of the Caltech Associates since the organization was founded in 1926 by 100 of the leading citizens of southern California. Dedicated to advancing the welfare of Caltech, the association now has 241 members.

Others newly elected to office were W. Herbert Allen, vic president, and Ernest A. Bryant, Jr., treasurer. Homer D. Crotty, John G. Baum, and John S. Fluor were elected as directors. Incumbent officers re-elected were Seeley G. Mudd and William Clayton, vice presidents; and Alxander King, secretary.



Thrust gage design is this Boeing engineer's "baby"

From layout to missile firing, this project is a Boeing engineer's responsibility. His assignment: to design an engine mount that will isolate from other loads and measure within ½ of 1% accuracy the tremendous in-flight thrust of a guided missile.

The mount, called a thrust gage, must fit engine and airframe without modification of them, and must "grow" equally in all directions during a temperature rise of several hundred degrees in less than a minute. The object is a stronger missile engine mount with less than half the weight of the present one.

This is typical of the challenging and creative assignments given Boeing engineers. There are more than 6,000 of them—mechanical, civil, electrical, aeronautical and nuclear engineers, and mathematicians and physicists. And more engineers of all kinds are needed.

This engineer is finishing his layout, with the preliminary mockup before him. Next, he will supervise draftsmen and engineering aides in final drawings. Then he will work closely with other engineers in production, structural testing, instrumentation and telemetering. Creating this thrust gage gives him responsibility, career growth, and a real sense of professional achievement.

Boeing engineers have career stability in a soundly growing company that now employs more than twice as many engineers than at the peak of World War II. Living is pleasant for them in the progressive, comfortable-size communities of Seattle and Wichita.

These men take satisfaction in knowing they're on a winning team that has created such aviation milestones as the new 707 jet tanker-transport, the giant B-52, and the Boeing B-47, "backbone" of Strategic Air Command. There's a rewarding job awaiting you now at Boeing in design, research or production.

For further Boeing career information consult your *Placement Office or write to either:*

JOHN C. SANDERS, Staff Engineer—Personnel
Boeing Airplane Company, Seattle 14, Wash.

RAYMOND J. B. HOFFMAN, Admin. Engineer
Boeing Airplane Company, Wichita, Kansas

BOEING

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SEATTLE, WASHINGTON WICHITA, KANSAS

How to construct a model instructor

A HANDFUL OF US got profound the other night, trying to understand the techniques of Institute teaching. We ended up by creating a model instructor —one we've only seen bit by bit. Constantly we hear that it doesn't matter who the instructor is if the students will go after the subject. Still, we'd like to register for our model man's course next term.

"First of all, this model instructor should be eager to teach the subject matter. This spark of eagerness is transmitted to the class . . ."

"A great instructor stalks into class with the main points to be covered firmly in mind before he starts speaking. He uses some legitimate ploy to command attention (like maintaining tight class discipline). Then, speaking clearly, he begins to make his points till the class loses the thread. Because this class is in an atmosphere where a student can say, 'Hey, wait, I don't understand,' or 'Stop, you made a mistake,' the instructor stops. He doesn't consider this interruption a personal affront to his competence (this calls for maturity—which it is not unfair to expect of a man who is instructing); he explains the point. Then he's off again, offering his main points and buttressing them with a hundred vignettes from the outside world to get the student to think of and with these new ideas . . ."

"If he puts his foot in his mouth—or worse, puts it not much of any place at all—he backs off gracefully and pins down his meaning. He doesn't bother to create the childish myth of instructor-infallibility. (We have begun to see even our fathers as fallible people; we don't need any new heroes to fill in the gap)."

"The soul of imagination is novelty. The masterful instructor has real command over *novelty* and *imagination*. One is a fickle maiden to be seduced by the other. *Imagination* in the student's mind is courted by a balanced combination of routine and *novelty*. Our instructor sets up a routine of homework, quizzes and class procedures. For novelty he depends on human applications of his subject matter or ingenious and intellectually 'pretty' steps, a little beyond the student at present. These *and* others will excite the young man, maybe, with a lust for untried fields of learning. . . ."

"One prime asset of the good instructor is secret because others are unconscious of it. This is the difference between learning alone and learning from living men. This is communication with the students beyond handing over the subject matter of the course. The instructor is master of the subject matter, so he can be probing the student reaction to it. In this way he *can* maintain a continuous evaluation of the student's progress. This means that the actual test will serve mainly as a goad to the student, rather than as a measuring tool. The man who finds this contact easiest hasn't any barrier between him and the student. The man who fails to come up to this measure has a huge barrier to vault. He might try being friendly with the guy while putting over his points. The student is ignorant or he wouldn't be taking the course. Let's not confuse his ignorance with his low intelligence. The student didn't pay tuition for a theatrical display of arrogance. . . ."

In our profundity, we assumed a student who is somewhat interested in the courses offered; let's say he's pulling a low C average. He is right in the area where a good instructor can do the most. He'll lay out his brain to be inoculated, and nothing more, until he blunders onto a man who seems to take an interest in him as well as his subject. This student will work for a guy like that, ignoring the credits offered, even giving the ultimate: thinking about the subject while he is lolling around on Saturday nights.

If the instructor can manage this, he's laid the groundwork for some fresh, new accomplishment in the field, and has gained one kind of immortality.

—*Russ Hunter '57*

ALUMNI NEWS

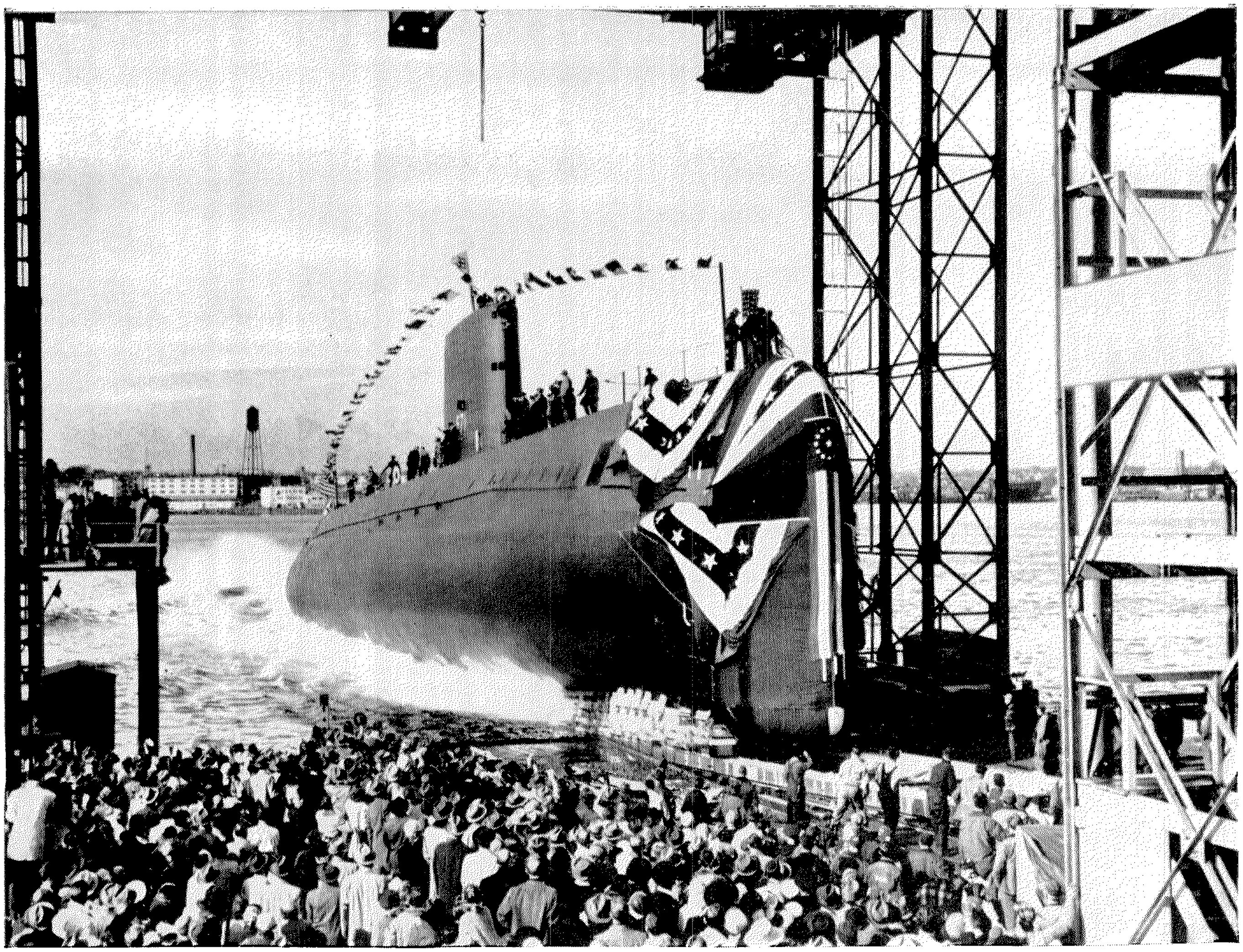
Alumni Seminar Day

THE 19TH ANNUAL Alumni Seminar Day will be held on Saturday, April 7. Committee members working out plans for the event are: Hugh Carter '49, director in charge; C. W. Lindsay '35, chairman, Alumni Seminar committee: Raymond E. Cox '27, chairman, catering; Richard A. Andrews '42, chairman, registration; Howard B. Lewis, Jr. '48, arrangements; and Wesley Hertenstein '25, Institute relations. Arthur Schneider '42 is chairman of the program committee, assisted by John T. Bowen '42, Horace W. Baker '35, L. Fort Etter '34, John L. Mason '47 and Paul D. Saltman '49.

Although program arrangements are not yet complete, early plans include a symposium of three speakers—Drs. William Fowler, Jesse Greenstein, and possibly Fred Hoyle, of Cambridge University in England—who will discuss the creative processes of the universe. Also scheduled is Dr. William Pickering, who will talk on earth satellites.

San Francisco Dinner Dance

THE SAN FRANCISCO CHAPTER of the Caltech Alumni Association will hold its Pre-Spring Dinner Dance March 2 on Treasure Island, as guests of Ensign Walter Eager '53. Beginning with a social hour at 6:30 and dinner at 7:30 (choice of prime ribs or lobster), the dance will be held in the Treasure Room of the Treasure Island Officer's Club. The cost per couple is $8.50. For reservations or more information about the dance, call Don Loeffler (50 Overlook Court, Walnut Creek), whose telephone number is YE 4-9240.



PERSONALS

1903

Richard W. Shoemaker writes from Grass Valley that he and his wife took a three-month cruise around South America early last year. Dick reports a good many changes in the cities of Rio, Sao Paulo and Campinas where he worked over twenty years ago.

1919

Fred A. Marshall, Ex '19, died of a heart attack on December 10, 1955. He had been resident manager of the Value Line Fund in Los Angeles for the past three years. Prior to that, he was Pacific Coast representative of Pioneer Fund, Inc. He leaves his wife; one son, Charles; and three grandsons.

1922

Emil D. Ries, MS, who has been with the Du Pont Company for 25 years, retired on January 1. As general manager of Du Pont's polychemicals department in Wilmington, Delaware, Emil directed its expansion as a large-scale supplier of plastic materials, nylon intermediates and more than 100 other chemical products for industry and agriculture. Before joining Du Pont, he was a professor of chemical engineering at Pennsylvania State College and also director of the college's division of industrial research.

Robert J. Crissman, who was formerly traffic manager for Pacific Telephone's west division, has now been appointed general traffic supervisor for southern California. Bob has been with Pacific Telephone since 1922 when he started as a traffic chief. In his new job, he will supervise activities of over 14,000 telephone operators and supervisors.

Donald F. Shugart, who has been a structural engineer in Pasadena for a number of years, recently went into partnership with another Caltech alumnus, *Stanley H. Mendes* '47, in Santa Barbara.

1924

Kenneth B. Anderson reports from San Francisco that "as of September, 1954, our previous company, Coast Counties Gas and Electric, merged with the Pacific Gas and Electric Company. I am now general superintendent of technical services for the latter. Last June our daughter, Barbara, made us proud grandparents of Susan Lee Johnson, in Seattle. I have degenerated into an old-car fancier, being the proud owner of a 1925 Rolls Royce, a 1910 White and a 1907 Buick."

Howard Winegarden, MS '27, PhD '31, has retired from active line responsibility as head of the research division of Cutter Laboratories in Berkeley and will continue on a consultant basis.

1927

R. Meyer Langer, PhD, is teaching physics at the University of Indiana in Bloomington.

1930

Donald P. Barnes, MS, writes from Burma that "there is no smog of consequence and earthquakes are just a memory. But there are other problems, mostly lack of experience of how to do things and lack of wherewithal to buy things. Which is why our neighbors to the north have so much appeal—they are willing to take Burma rice.

"But a friendlier and happier people would be hard to find. Our firm (Tippetts Abbett McCarthy Stratton, Engineers) has been helping with the general development program; we prepared a comprehensive reconnaissance report in 1953 and we are continuing as general advisors in the formulation of all sorts of projects—ironing out specifications and contracting procedures, trying to help see that people remember to dig holes before putting in posts, and such.

"Living is reminiscent of Kipling. Gentle days and gentle people: that is, there seems to be little malice either in the taking of an occasional illegal head by the remote Nagas or the blowing up of the down-train from Mandalay. (By the way, my wife is having a delegation of Nagas for dinner on Union Day, February 12, if all goes well. The headman wears a brass gong in front, a three-foot two-edged Excaliber in the middle of his back—and an ingratiating smile).

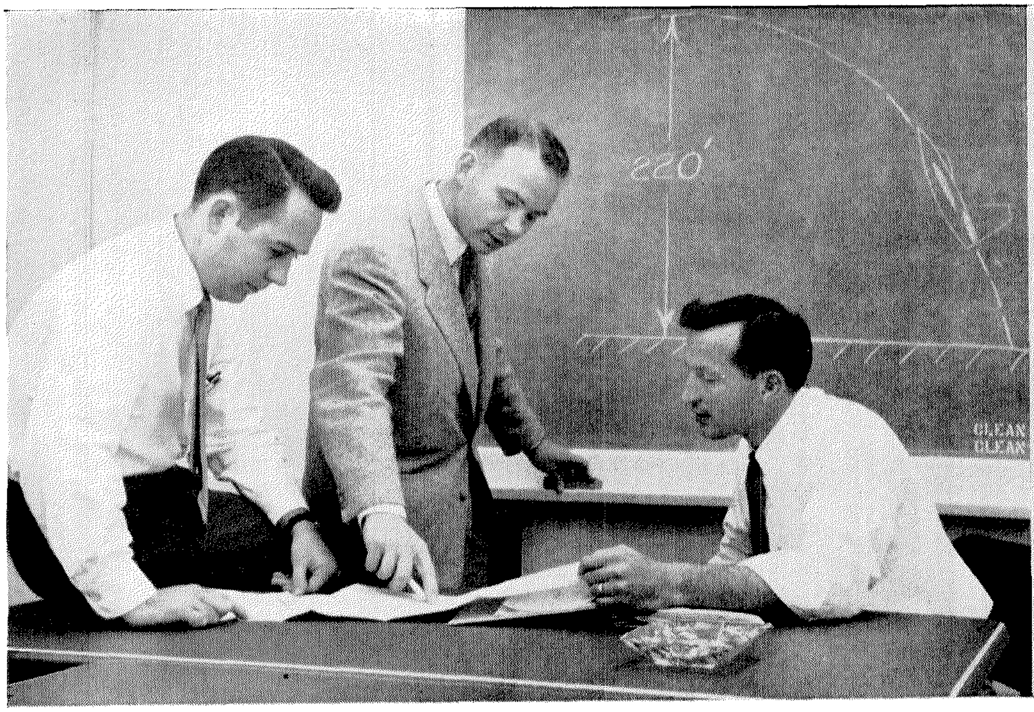
"While we have one friend who owns an alchemists' ring (it turns dull when he misbehaves—every Boy Scout should own one) and another whose grandmother was a certified were-tiger (reversible identity, presumably convenient for catching game), we have not yet seen the rope trick. We are looking for one for son Erik of the Colorado Mountain Club. Still, there are many kinds of magic, and if any of our old friends—or new ones—pass this way, we wish they'd stop in and share some of it with us."

1931

Ralph R. Wenner, PhD, assistant research director of the central research department of the Monsanto Chemical Company in Dayton, Ohio, died on October 27, 1955. Dr. Wenner attended Cooper Union, where he received his BS degree in 1926, and Northwestern University, where he received his MS in 1927.

1932

David Y. Wong, MS '33, reports on his activities in a letter from Hong Kong: "During the war years we shifted about



N. T. Avant, aerodynamicist (left), R. R. Heppe, Aerodynamic Department head (center), and C. F. Branson, aerodynamicist, discuss wind tunnel tests to determine transition height of a supersonic superiority fighter.

Hovering to High Speed Flight:

Lockheed Aerodynamics Projects Offer Advanced Problems

Aerodynamics Engineers at Lockheed are working on advanced problems that cover virtually every phase of aircraft. The full scope of their work can be seen in the wide range of aerodynamics problems encountered in Lockheed's diversified development program.

Among the advanced problems are:

1 Determine means of controlling a supersonic vertical rising aircraft through the transition flight stages from horizontal to vertical flight.

2 Determine the dynamic response of supersonic aircraft in high rate rolls by application of five degrees of freedom analysis procedures.

3 Study optimum operating descent procedures to minimize costs on a new turboprop commercial aircraft.

4 Conduct and analyze wind tunnel research on new and radically different external radomes to be carried at high speed by early warning aircraft.

5 Perform generalized aeroelastic analysis combining structural and aerodynamic knowledge to determine optimum lateral control devices for use on very high speed, low load factor aircraft.

These—and many other—significant problems have created new positions for experienced Aerodynamics Engineers and Aerodynamicists in Lockheed's expanding program of diversified development.

You are invited to contact your Placement Officer for a brochure describing life and work at Lockheed in the San Fernando Valley.

Additional information on these problems and data on Lockheed's Aerodynamics Division is available to interested engineers. Address inquiries to R. R. Heppe.

LOCKHEED AIRCRAFT CORPORATION

CALIFORNIA DIVISION BURBANK **CALIFORNIA** so much in Free China that we had a hard time keeping up our correspondence. Since coming to Hong Kong before the communists occupied Canton, things have been rather hard going for most of us from China. However, men possessing technical training and experience, such as medical doctors and engineers, seem to be a little better in our struggles. I shifted from being a building contractor to structural designing. After finishing the design of a 3-circle residence, the owner then gave me the job of designing the steel structure of a 12-story apartment building, the tallest of its kind in the Kowloon peninsula."

Jan G. Schaafsma, MS '34, was recently appointed manager of the laboratories department of the General Petroleum Corporation in Vernon. He's been with the company since 1934.

1933

Charles D. Perrine, Jr., writes from Claremont, where he is at Convair Pomona Division of General Dynamics Corporation, in charge of engineering operations (assistant division manager—engineering). "We produce the 'Terrier' anti-aircraft guided missile for the Navy," he says, and we're developing quite a litter of pups to meet possible Soviet advances. A home electronics lab keeps my hand in on the soldering iron, etc."

1935

Russel L. Maycock, Ex '35, is now with the Shell Chemical Corp. in Houston, Texas.

1937

Martin Poggi is northwest district manager for the Cook Electric Company in Seattle. Martin and his wife have three daughters, 3, 7 and 9 years old.

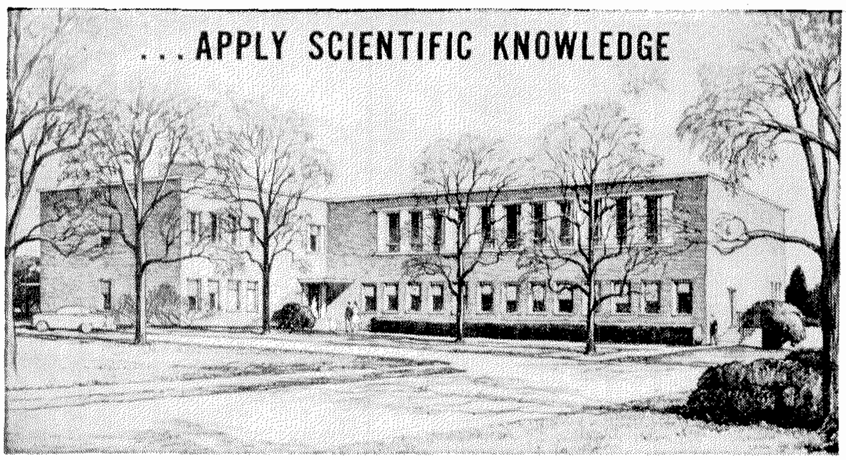
Comdr. Charles A. Van Dusen, USN Ex '37, was killed on December 15 when his parachute failed to open in an emergency drop near Altoona, Pennsylvania. It was reported by the Navy that his plane ran out of fuel during a proficiency flight. Commander Van Dusen was administrative aide to Vice-Admiral R. F. Good, Deputy Chief of Naval Operations (logistics) in Washington, D. C. He was a graduate of Baltimore Polytechnic Institute and had attended Johns Hopkins University, Caltech and the University of California. His career in the Navy began when he joined as an ensign in 1939, continuing in active duty since that time. Commander Van Dusen is survived by his wife; a son, Derek Lawrence, 3; and a daughter, Dagmar Dresden, 1.

1938

Carl F. Friend, who is with the Lockheed Aircraft Corporation in Dunwoody, Georgia, now has a fourth child, Sally Jane, two months old. The Friends' other

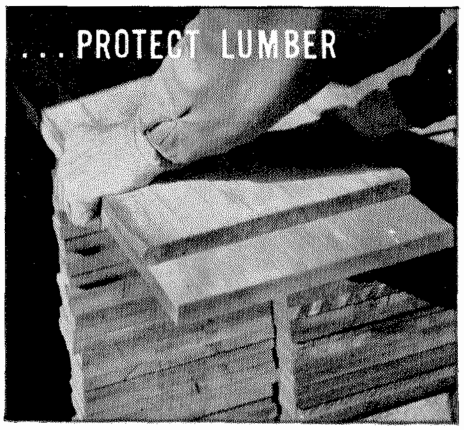
HOW *HERCULES* HELPS...

IN HEAVY TRAFFIC AREAS like this, floor tiles must be built to take a beating. Whether the tiles are of the rigid, mastic type or flexible flooring based on rubber or vinyl, Hercules Neolyn®, Mastolyn® or Staybelite® resin can contribute to lower processing costs and better wearing qualities. The wide variety of properties offered by these resins assures that there is one best suited for every floor tile formulation.



▲ **MORE THAN 17,000 VOLUMES** of scientific literature and tens of thousands of company research reports will be housed in this new $1,000,000 Technical Information Center at the Hercules Experiment Station near Wilmington. In addition, the structure will provide quarters for the many technical specialists who serve the scientific information needs of the Hercules research staff—making the Center one of the nation's most complete information services to an industrial research organization.

WHICH HAD THE TREATMENT? The clean, unsplintered piece has been treated with Hercules Paracol® wax emulsion, making it possible to use every inch of lumber that has been pre-cut at the mill. The untreated piece (top) is badly "checked" and a portion of the end must be discarded before it will be suitable for use. ▼



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G55-13

HERCULES
CHEMICAL MATERIALS FOR INDUSTRY

children are Marie, 12, Nancy, 9, and John, 4.

1940

Jerome Kohl writes that he is still chief engineer of the Western Division of Tracerlab, Inc., in Berkeley, and is active as a member of the board of directors of the Contra Costa County Park and Recreation Council.

1941

H. Guyford Stever, PhD, professor of aeronautical engineering at MIT, has been appointed associate dean of the school of engineering at MIT. He has been on leave from MIT since February 1955, when he went to Washington to serve as Chief Scientist of the Air Force. He will return to MIT next June.

1943

Warren Christianson writes that he "finally returned to California in 1951 after 8 years in Washington, D.C. in the Naval Research Laboratory. Since June, 1954, have been with the Motorola Research Laboratory in Riverside and now have a wife; two boys, 7 and 5 years old; a girl, 2; and a house on 5 acres. *Bob Johns*, '43, and *Harry Lass*, PhD '48, are also at Motorola."

1946

James A. Cullen, who was studying for his PhD at Caltech, was killed when his bicycle was hit by a truck in Pasadena on January 6. After receiving his BS in 1946, Jim served in the Armed Forces from 1948 to 1952 when he returned to the Institute as a graduate student. He had just completed the research necessary for his thesis in January.

Rev. James O'Reilly, MS, is chalking up his sixth year with the department of math and physics at Mount St. Mary's College in West Los Angeles, and his thirteenth year in California from Ireland. He spent most of last year in the hospital but is making a successful recovery from major surgery and will return to teaching duties this spring.

1948

Robert McClellan, MS '49, AE '55, died on January 4, of nephrosis. He was employed at JPL as a research engineer in aerodynamics and has worked there since 1951, when he transferred from the Caltech Wind Tunnel. Bob leaves his wife, Marion, and a seven-month-old son, Robert, Jr.

Patrick N. Glover writes that "at present I am district geologist for Shell Oil Company in Long Beach, on a six-month assignment in The Hague, Netherlands. My work will take me to Germany, Switzerland, England and either North or West Africa, but the majority of my stay will be in the Hague. One of the highlights of my trip will be a long geological trip through Switzerland in June or July. I will return to the States in August and will probably be at the head office in New York for six months, after which I hope to return to California. My wife and two boys—John, 5 and Michael, 4—are with me."

1950

Dean A. Rains, MS '51, PhD '54, has been appointed leader of the compressor group at the Propulsion Research Company in Santa Monica. Dean and his family—including Diane, 5, and Bruce, 3½—are living in West Los Angeles.

1951

Harry Sutcliffe, MS, reports that he is "married, with a daughter 10 months old—an angel with little horns. Been with Bechtel Corporation's hydro section for the past two years. Spent part of last winter isolated at Vermilion Dam, 7600 ft. up in the High Sierras. Grew a magnificent beard which I gladly traded for my wife's companionship when the snows melted. Living in Los Angeles. After graduation, worked for two years in London before returning home, and have been in soils work since graduation."

Robert J. Kurland has received a postdoctoral research associateship of the board of the National Academy of Sciences. Only five or six of these associateships are available in this country. Bob will be with the National Bureau of Standards in Washington, D. C.

1952

Jack McEwing is in the Army, stationed at Redstone Arsenal, the guided missile center at Huntsville, Alabama, where he does "inspection engineering" work on missiles with *Richard C. Brown*, '53.

Robert G. Blair recently transferred from the Grand Junction, Colorado, office of the U. S. Atomic Energy Commission, to the AEC's newly-opened Austin, Texas, office. Bob and his wife, Joan, have a seven-month-old son, John Robert.

Robert S. Davis, MS '53, writes from New Rochelle, N.Y.: "After leaving Caltech with my MS degree in chemical engineering, I decided to stalk the enemy in

You might be working on one of the following projects:

...an oil refinery in one of several U. S. locations or in Cuba, Columbia, Hawaii or England; a hydro-electric development in California; a steam-electric plant in California, Arizona, Utah, Florida or Korea; a nuclear powered electric generating plant in Illinois; a big-inch pipeline in Western Canada or Saudi Arabia; a butadiene plant in Texas—to name some of the most prominent on the current work schedule.

Either in the field or in a Bechtel office in San Francisco, Los Angeles or New York, you'd be in close contact with the latest developments in petroleum refining, chemical processing, power generation and pipeline transportation—key industries, every one.

A richly attractive career, stimulating work, opportunity for advancement...these are but a few of the benefits enjoyed by engineers who measure up to Bechtel standards.

As one of the world's largest and fastest growing engineer-constructors, Bechtel is helping to build the future. Find out how you can build your future by talking with your University Placement Officer about a career with Bechtel.

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his lair, so I enrolled in MIT to work toward my ScD degree.

"My wife and I spent the summer of '54 in Paris, on a fellowship from MIT and the French Petroleum Institute. We also managed to spend some time traveling in Italy, Germany, Belgium and France. On September 19, 1955 our first child, Steven Guy, was born in Boston, and on Sept. 22 I received my Doctor of Science degree.

"At the present time I am employed by the Scientific Design Co. in New York as head of their chemical engineering department, which has a complement of two.

"We'd be happy to hear from any other Techmen in the New York area."

1953

Richard M. Jaffe, who was formerly at JPL, has joined the technical staff of Hughes Aircraft in Culver City.

Thomas C. Stockebrand, says he's "now at Lincoln Lab of MIT, located in Lexington, Mass. My job is working with computers (digital type) dealing particularly with input-output equipment. I got my job here partly because it allows me to work part-time for my MS—they let you off to go to class! Toward the end of my hitch in the Army (I got out last September) I went down to Florida and soaked up sun for a week in Sarasota, but the highlight of the year as far as travel was concerned was my trip around the world during April. I saved up my leave time until I had about 40 days, then applied for a leave to Europe and left Washington, D. C. direct for Frankfurt, Germany, hitch-hiking on military aircraft. I stayed about two weeks in Europe and then spent about two and a half more returning home by air through Africa, Saudi Arabia, India, Thailand (a beautiful place), the Philippines, and Japan. The trip was a real experience but its main effect has been only to whet my appetite for more. It lasted in all 37 days, 25,000 miles, and about 100 hours in the air."

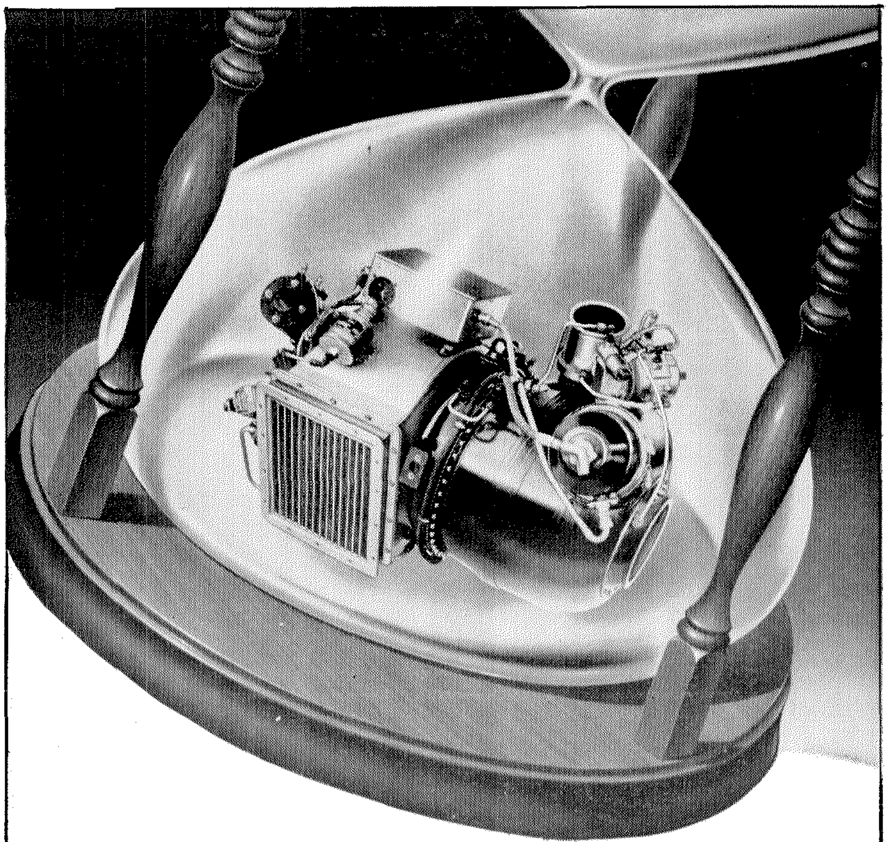
1955

Gerald E. Hooper was married on July 1 to Donna Ringer of Pasadena. After working with North American Aviation for several months, he received orders from the Air Force and is now stationed at Lindsey Air Base in Wiesbaden, Germany, as Communications Officer.

Thomas W. Noonan is a graduate student at Caltech on a National Science Foundation fellowship in physics.

Lewis F. Ellmore, Walter R. Menetrey, and *Thomas Trilling* are all working toward MS degrees under the Hughes Cooperative Fellowship Program sponsored by Hughes Aircraft. Lewis and Tom are at USC and Walt is at UCLA.

To the engineer with a bent for research . . .



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CALTECH CALENDAR

February, 1956

ALUMNI CALENDAR

April 7	Annual Alumni Seminar Day
June 6	Annual Meeting
June 23	Annual Picnic

ATHLETIC SCHEDULE

Varsity Basketball

Feb. 15—Caltech at Occidental
Feb. 18—Caltech at L.A. State
Feb. 21—UC (Riverside) at Caltech
Feb. 24—Pomona at Caltech

Varsity Tennis

Feb. 18—Pomona at Caltech
Feb. 25—Redlands at Caltech

Varsity Track

Feb. 25—Caltech at Occidental

Varsity Baseball

Feb. 25—Westmont (Santa Barbara) at Caltech
March 1—East L.A. Junior College at Caltech

FRIDAY EVENING DEMONSTRATION LECTURES

Lecture Hall, 201 Bridge, 7:30 p.m.

Feb. 17—A Demonstration of Critical Phenomena—
Dr. Bruce H. Sage

Feb. 24—Liquid Air—
Dr. Earnest Watson

March 2—The Strength of Metals—
Dr. David S. Wood

March 9—Transistors and Tubes—
Dr. Robert D. Middlebrook

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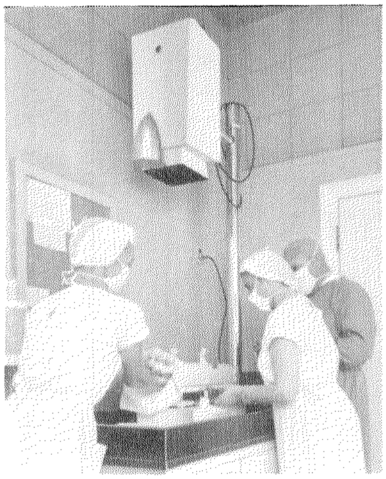
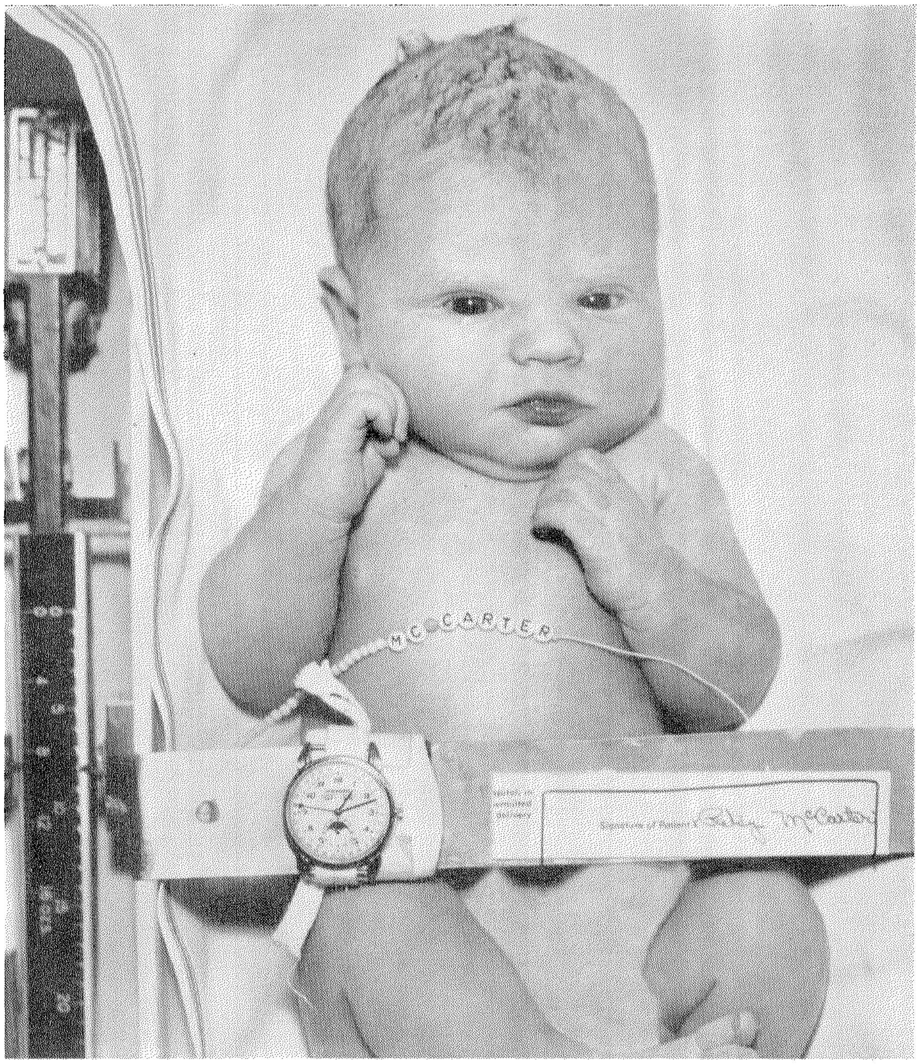
PHOTOGRAPHY AT WORK—
No. 19 in a Kodak series



Camera and film stand ready in the delivery room at San Antonio Hospital, Upland, California.



Teresa Jo McCarter, only minutes old—and still near mother—a photographic record makes identity certain.

New eyes open on a bright wonderful world

–and photography makes identification positive, records vital statistics in life's first few minutes

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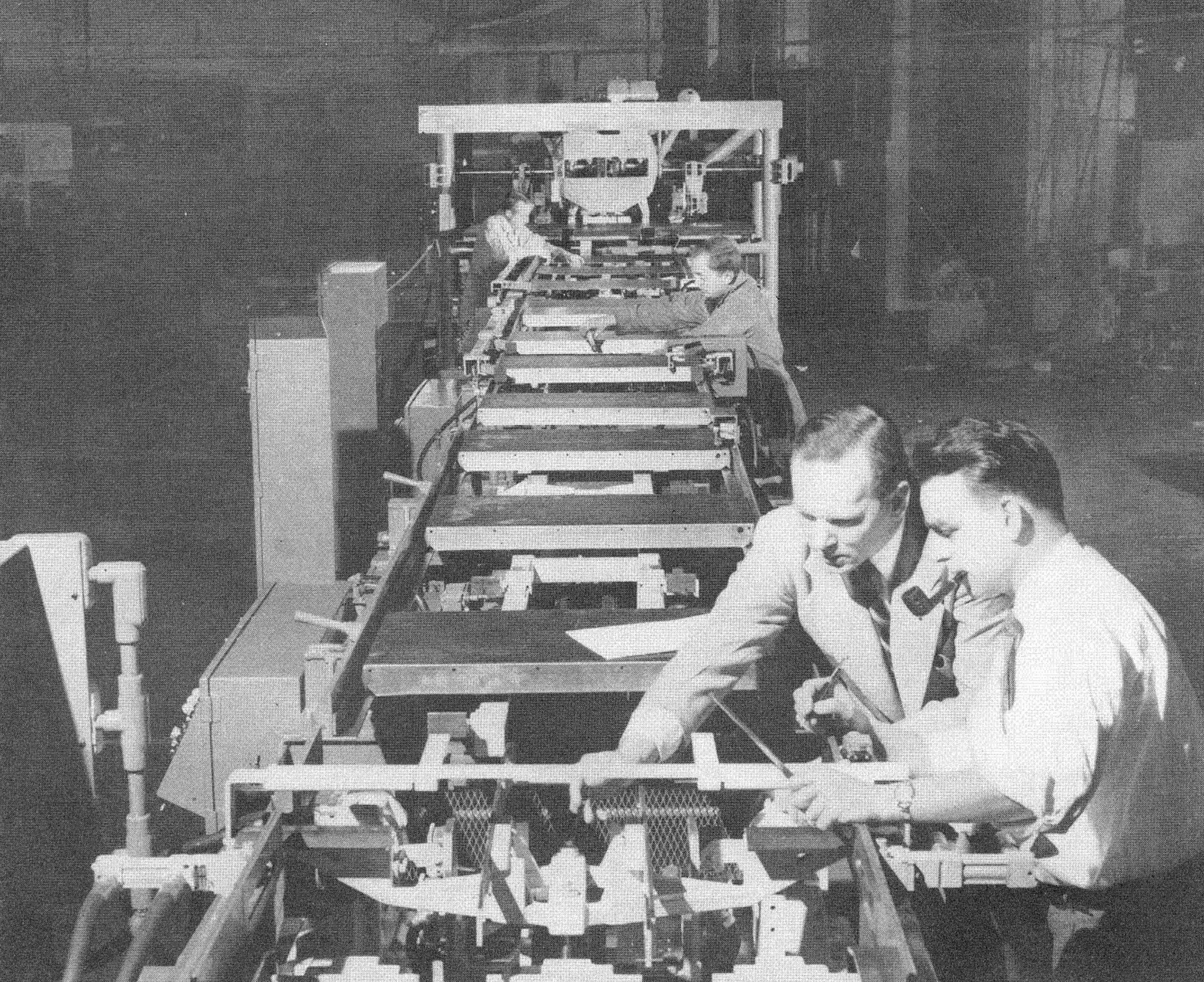

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Shown inspecting the door line, above left foreground, is Frank Foley, B.S. Industrial Engineering, Lehigh University.

956-5

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