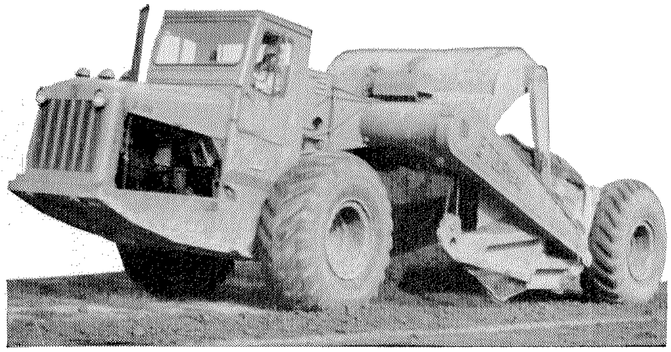
ENGINEERING | AND | SCIENCE

MAY / 1952

Smog Research . . . page 11

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

Another page for **YOUR BEARING NOTEBOOK**



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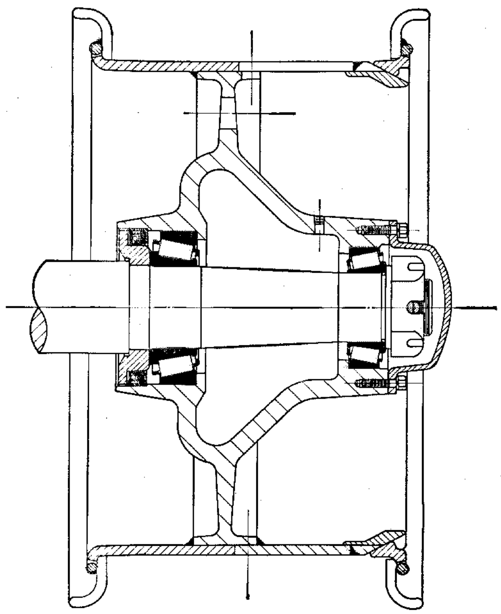

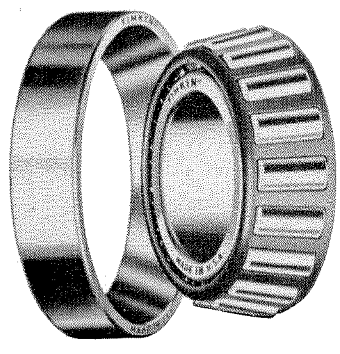

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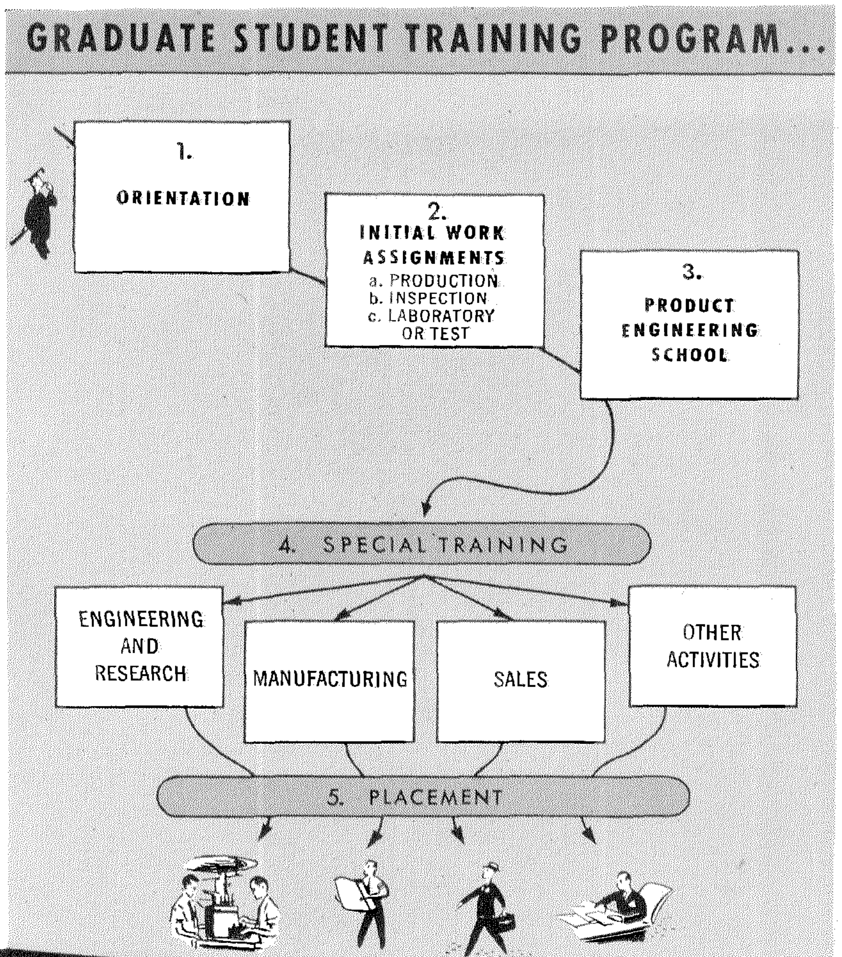

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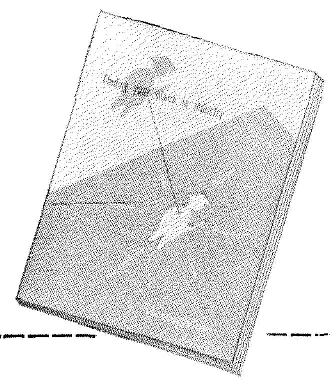

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You are giving away your standard of living

FANATICS in Germany, India, even some in America, say we should scatter our billions over the world in order to use up our surplus; otherwise (they say) it will dam up on us and cause a depression.

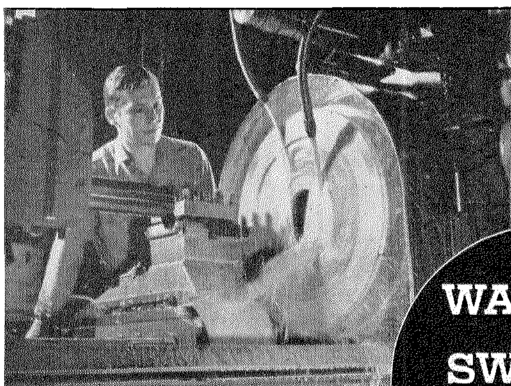
It is entirely possible that we should give away those billions for humanitarian reasons—that is another matter. But don't let's let greedy foreigners and stupid Americans say we're doing it for our own selfish interests. And don't let anyone of us think we are doing it by "soaking the rich". We are giving away (and, remember, perhaps we should, so long as we do it with eyes open) our standard of living.

You and I work, not for dollars but for what those dollars will buy. The more *things* there are in America, the more your day's work and mine will buy. The more steel there is in America, the more automobiles you can get at a low price. The more cloth, the more suits you can own. The more food there is, the better you and your family will eat.

There can only be so much of those things. When you ship them away; you do without. You seldom ship *money* abroad; money is only a token of exchange for the *things* that are going out of this country, out of your reach.

Perhaps that's good, perhaps that's wise. But we should realize what we're doing. Whatever we give away abroad comes out of what we have at home. Unless, of course, each of us produces that much more at his machine or plow or desk *every day*.

If every one of us *produces* more efficiently we can have the satisfaction of knowing we are doing something for the world without destroying America . . . the one strong hope of the world. If we "share the wealth" with the world, we will soon be sharing nothing but poverty. If we share our *increased production* and demand increased production in return, there will then be wealth *and* strength to share.



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BOOKS

THE PLANETS
by Harold C. Urey
Yale University Press $5.00

Reviewed by Robert S. Richardson
Mount Wilson and
Palomar Observatories

IT IS ALWAYS HARD to explain to people why the field in astronomy which has the greatest popular appeal—the study of the planets—is the one most consistently neglected by astronomers. When Mars is bright in the sky, people picture astronomers busily scanning its disk for signs of life, and it always comes as a shock when they are told that telescopes at large observatories are seldom turned on the planets except for the benefit of visiting firemen.

Astronomers have preferred to range far afield, to the neglect of bodies in their own backyard, probably more through expediency than indifference. The stars present us with problems relating to matter in an elementary state which we can attack theoretically with some hope of success. But when we come to the planets, we are confronted by matter in the form of solid compounds for which our best theories are often little more than conjectures.

Furthermore, study of the planets demands a borderline knowledge of several subjects which few astronomers possess to any degree. Undoubtedly the question most often asked an astronomer is, "Do you believe there is life on Mars?" But how many astronomers are equipped to give an intelligent opinion on this all-absorbing topic? The person to whom the question should really be directed is a biologist; or better still, a biologist *and* an astronomer working as a team. Recently an effort has been made in this direction, with the result that important advances in planetary research have already resulted.

The Planets is a discussion of the origin and development of the solar system, especially the terrestrial planets, from the standpoint of the physical chemist. The author starts with the assumption that the solar system consisted originally of a "dark globule" about 10^4 astronomical units in diameter, and evolved along the lines postulated by Weizsäcker, ter Haar, Kuiper, and others. The globule contracted with an increase in temperature until at length a star surrounded by a discoidal mass of gas and dust emerged. Turbulence within the mass led to the formation of protoplanets which increased their temperature by contraction. Planetesimals were also formed about this time and grew into larger bodies which moved in and out through regions of varying temperature. Toward the end of this stage most of the lighter elements had escaped, leaving the system nearly devoid of gas.

The terrestrial planets grew from accretion by impact with the planetesimals. In the absence of gas the bodies lost heat rapidly by radiation, until the temperatures of the planets were about the same as those that exist at present. This is one of the most important conclusions of the book: that the earth and other terrestrial planets were formed at

CONTINUED ON PAGE 6

I am Industry-1952

Ushered into a new world,
I had a bustling, brawling, bruising youth.
I was a potential giant awakening in a world of giants.
People were hurt when I first stirred in life;
Then I grew and learned;
Then I matured and knew that
Though I work with water and metal and chemicals and fire,
I am more than these things.
I am the people's work!
I am the people's dream!
I am the people!

With maturity, I have grown, too, in social responsibility
To the people,
To America!
And even to those beyond our shores.
My efforts are not in selfish interest;
Rather, all my brain and brawn strives for the good of the many.
I am the American way!

Now, I have sworn that these things shall be:
I shall deliver ever-better products to those who use my fruits!
I shall offer equal opportunity to those who work at my side
Whatever their race!
Whatever their creed!
Whatever their color!
Whatever their national origin!
I shall forever do my part to keep America great!

And why?
Because only in this way can I remain a healthy force in our free world.
For when I am healthy, America prospers
And tyrants tremble before my might.

I am America's life-blood!
I am America's strength!
I am the bulwark of
the World's freedom!

much lower temperatures than has been generally supposed. This is so contrary to our previous way of thinking that many will probably find it hard to accept at first. Undoubtedly the molten globe hypothesis is due for a lingering death.

The origin of the surface features of the moon is discussed at considerable length. Urey believes with Baldwin that both the craters and maria were formed by the impact of meteorites and planetesimals. From inspection of the surface features it is possible to draw a surprising amount of information about the collisions that produced them. The Mare Imbrium, for example, is due to the impact of a planetesimal 100 km in radius which approached the moon at a low angle from the northeast with a velocity of 2.4 km/sec. The pressure developed at contact was 170,000 atmospheres, enough to make the material flow like a liquid and splash to great distances.

The book is written in the form of a scientific paper with no attempt at popularization whatever. Anyone who picks it up with the idea that he can obtain a quick fill-in on the latest thought on the evolution of the solar system will be quickly disillusioned. Some sections are so detailed that they can hardly be "read" at all. They are almost like tables in sentence form.

That many will disagree with the arguments and conclusions drawn is inevitable. As the author remarks, every important argument has to be qualified with numerous "possibles" and "probables" and other adjectives and adverbs expressive of doubt and uncertainty. But there can be no disagreement as to the value of the stimulating and thought-provoking material which Dr. Urey has contributed to a field in which few qualified researchers have dared to venture in the past.

ELECTROLYTIC MANGANESE AND ITS ALLOYS

by Reginald S. Dean
Ronald Press, New York $12.00

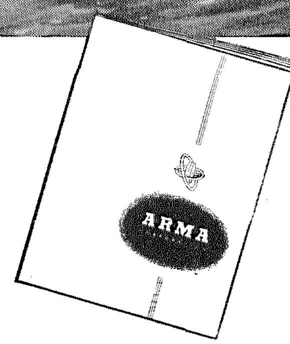
Reviewed by Donald S. Clark
Professor of Mechanical Engineering

Dr. R. S. Dean is recognized as an authority on the subject of manganese. He has been associated with developments in the production of manganese in the United States for a long period of time. Much of this experience was gained through his connection with the United States Bureau of Mines, where he was chief metallurgist and assistant director, and responsible for the direction of the Bureau's program for utilization of mineral resources — particularly manganese.

A book of this character is one of reference. It will not find widespread use because of its degree of specialization; hence the cost of the book is high. However, for those who wish to have a reliable book containing extensive data on manganese and its alloys for reference, together with an extensive bibliography on the subject, the book is worth the price.

A little more than one-third of the book is concerned with the production and properties of electrolytic manganese, while the remainder deals with nonferrous and ferrous alloys of electrolytic manganese. The book is well filled with tables and curves by which the quantitative information on maganese alloys is presented.

"On Target" Today demands electronic computations



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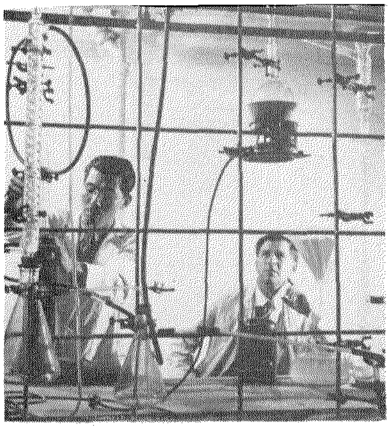
ENGINEERING AND SCIENCE

IN THIS ISSUE



This month's cover shows A. J. Haagen-Smit, Professor of Bio-Organic Chemistry at the Institute, and Frank Hirosawa, Research Assistant, fractionating material collected from smog. Dr. Haagen-Smit recently completed a full year as full-time Research Consultant to the Los Angeles Air Pollution Control District, working on the smog problem. In the December, 1950, issue of *E&S* Dr. Haagen-Smit made an informative report on the initial stages of smog research. On page 11 of this issue, in the article, "Smog Research Pays Off," he brings this research story up to date.

Peter Kyropoulos, Assistant Professor of Mechanical Engineering, hasn't written an article for *E&S* since May, 1951—but we've been getting requests for spare copies of that issue of the magazine ever since. Some people will even go so far as to say that the Kyropoulos article, "Take That Lead Out of Your Shoes," is the funniest they've ever read. Well, we'll admit it's the funniest we've ever *run*—and direct your attention to the fact that Dr. Kyropoulos has another automotive article in this issue—"High Compression Engines," on page 17. But let this be fair warning to all anxious readers: This one is not for laughs. There just isn't anything funny about a high compression engine.

John Weir's "Engineering Crisis," on page 23, is adapted from the talk he gave on this subject on Alumni Seminar Day last month. Dr. Weir is Associate in Psychology at the Institute.

PICTURE CREDITS

Cover	Ross Madden-Black Star
p. 34	Barry Bieler
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Takes a lot to lay a carpet in the jungle

The scene is "darkest Africa".

But Africa is lightening. Man's quest for minerals, for new areas for agriculture and trade, is slashing ultra-modern, glaring-white air strips in once impenetrable jungle.

Those pavers, portable air compressors, pumps and air tools—such as you might see working a city street—are Worthington Blue Brutes going to "lay a carpet" in that hole in the jungle.

Thus, Worthington, a major producer of equipment for public works, industry and farm, brings the fruits of American technical genius to the strange places of the world.

And illustrates, too, how the unique American talent of *diversification* helps public, employees and stockholders. For Worthington makes many things—not just construction equipment and pumps, but also engines, water works machinery, power transmission, petroleum equipment, air conditioning and refrigeration, many others.

Such diversification builds *stability* . . . makes Worthington, 112 years old, a strong link in the chain of American business.

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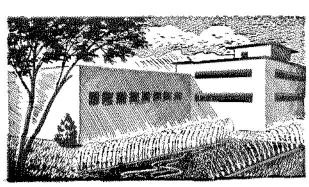
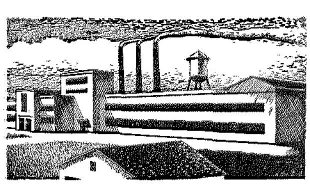
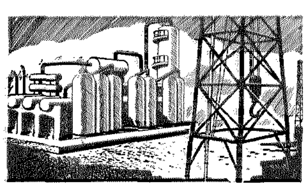


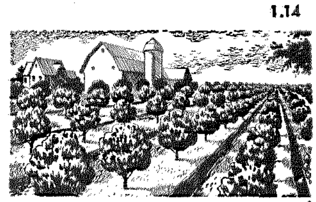
Good Water and Sanitation—engines pumps • water treatment • comminutors air compressors • air tools



Lower-Cost Manufacturing—pumps compressors • steam turbines • motors power transmission • air conditioning



Petroleum Products—compressors engines • pumps • chilling equipment refrigeration • decoking systems



More Abundant Food—compressors fertilizer mixers • air conditioning refrigeration • pumps

SMOG RESEARCH PAYS OFF

By A. J. HAAGEN-SMIT

OLD TIMERS in this area tell us how, on clear days, they used to be able to see Catalina Island from their houses in the foothills. Now, we talk about a nice clear day when we see only five to ten miles away.

A decrease in visibility is to be expected when so many people congregate in an area, but during the war years a few objectionable features were added. A peculiar smell developed—sometimes reminiscent of bleachpowder, sometimes of ozone, but usually with such an individual character that it is referred to as smog odor. Because of the great sensitivity of our sense of smell we can spot this odor long before a dense haze reduces the visibility to less than half a mile, and eye irritation begins to be felt.

To these effects were added throat and nose irritation. Farmers noticed a peculiar damage to their leafy vegetables. Gardeners became aware of the yellowing of newly seeded lawns. And rubber manufacturers became concerned about the pronounced rubber cracking observed in the area.

It was some time before the public became sufficiently aroused and demanded that something be done about this air pollution problem. In 1947 an organization was formed which could study the problem regardless of city limits, and which was given the legal tools to enforce the measures necessary for improving the situation. This organization now functions as the Los Angeles County Air Pollution Control District.

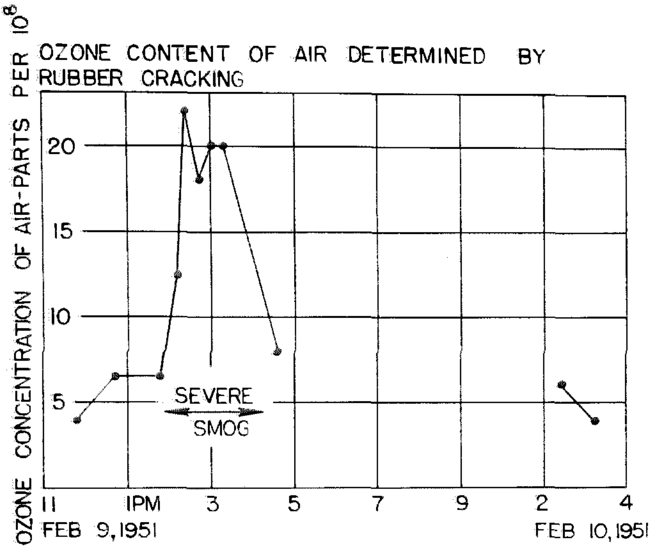
There were plenty of opinions on how to attack the problem. At one end of the scale were those who did not see the use of any research. Their philosophy was, "Where there's smoke, there's smog." At the other end of the scale were those who wanted to postpone taking any restraining measures at all until research had definitely established which particular sources contributed to the smog nuisance and whether they could be called health hazards.

Fortunately for those suffering from smog, the newly founded District, under the guidance of Dr. Louis C. McCabe, decided that obvious sources of smoke and fumes should be controlled, and that—parallel to this program—research should be carried out on the chemical analysis of the air to discover the presence of any unknown pollutants.

This program has been carried out with great vigor by Dr. McCabe's successor, Mr. Gordon P. Larson. Dust and fumes from numerous sources have been reduced to the level they were at before 1940. Although some improvement was noticeable after these known sources were for the most part controlled, dense smog continued to roll over Los Angeles and its environs. The answer to this puzzling problem has been given by research on smog.

This research was carried out at the District Laboratory and, in addition, contracts were made with the California Institute of Technology, the University of California, Chaney Laboratories, the Bureau of Mines, the Bureau of Standards, and Beckman Instruments, Inc. In this way, experts in the field of analysis, plant physiology, instrumentation, meteorology and aerosols were mobilized in an attack on the problem.

It was found that the most characteristic chemical property of the Los Angeles air during a smog period was the oxidizing capacity demonstrated in the release of iodine from neutral buffered potassium iodide solutions. The presence of peroxides of organic nature was postulated, and it was reasonable to assume that these could originate in oxidation processes of organic material in the air with other air constituents, such as ozone and nitrogen oxides. These reactions were demonstrated by a vaporphase oxidation of unsaturated hydrocarbons with ozone and with nitrogen oxides. When a cracked gasoline was used as a source of olefins, aerosols were produced which were eye-irritating and which also simulated the smell usually associated with Los Angeles smog.



Rubber cracks faster as smog becomes more severe

Evidence that these reactions play a role in the Los Angeles smog problem came from the study of rubber cracking and crop damage in this area. It has long been known that ozone has a characteristic cracking action on raw or vulcanized rubber when the rubber is under strain in a bent or stretched condition. Low concentrations of ozone are used commercially for comparative tests on rubber compounds, but when a standardized rubber is used, this method can serve as a sensitive measure for ozone concentration. The normal cracking time in the Los Angeles area on smog-free days is 40-60 minutes, corresponding to 0.02-0.03 parts per million of ozone. On a severe smog day values as high as 0.22 parts per million have been measured, corresponding to an initial cracking time of only six minutes. In this case, the cracking time of the rubber was determined every hour, and the corresponding ozone values plotted (above). The sharp rise shown on the chart corresponds closely to the subjective judgment of the severity of the smog. Enzymatic methods have shown that the peroxides—the reaction products of ozone and organic material—show a similar rise during the smog period.

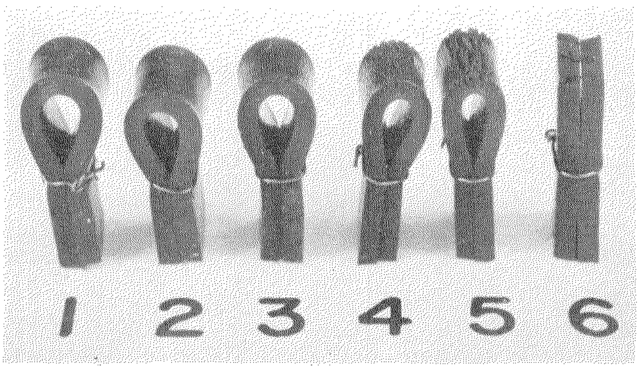
An important contribution to the understanding of the chemistry of the Los Angeles smog was made by the study of crop damage in a cooperative enterprise of the Los Angeles County Air Pollution Control District, the California Institute of Technology and the University of California. For the determination of the crop damaging materials present in the air, five different plants were used—spinach, beets, endive, oats and alfalfa. The smog symptoms on these indicator plants are the production of a metallic sheen on the lower surface of leaves on spinach, sugar beets and endive; yellowing of oats; and a bleaching of the leaves of alfalfa, producing an oak leaf pattern. These varied symptoms distinguish this damage from the effect of previously known toxic materials.

In view of the strong oxidizing action of the smog, and the suspected presence of considerable amounts of easily oxidizable material from petroleum products, fumigations were carried out with ozone and vapors of a cracked gasoline. The development of the damage symptoms, such as oiliness of the underside of the leaves of spinach and endive after a few hours of fumigation, as well as the further development of the symptoms on all five indicator plants, was indistinguishable from that noticed on plants exposed to smog.

To establish the nature of the agent responsible for the damaging effects, the gasoline was distilled in ten-degree fractions and these were released in a fumigation room together with ozone. Maximum damage was obtained with the fractions boiling between 39 and 69 degrees Centigrade. These results are shown in Chart A (p. 13), in which the estimated degree of damage is plotted against the average boiling point of the gasoline fractions used in the fumigations. A prerequisite for this effect is the presence of a double bond. However, the size of the molecule has a pronounced influence on the severity of the reaction. In fumigation with ozone and homologues of ethylene, optimum plant damage is observed with olefins of 5 and 6 carbon atoms, as can be seen in Chart B.

The concentration of ozone at which damage occurs with the olefins is well within the range of the ozone concentrations found in the atmosphere. In fumigation experiments with ozone a series of oxidation products is formed. The primary product, the ozonide—itself a peroxide—undergoes a series of changes leading to other peroxides and finally to aldehydes, ketones and organic acids. It has been shown that the active agent must be found in the peroxides formed as intermediates in the oxidation of the hydrocarbons.

In addition to ozone there is another powerful oxidation agent in the smog atmosphere: the nitrogen oxides. These oxides, under the influence of light, rapidly oxidize organic materials. To study these reactions, a fumigation room was built from Plexiglass, which permits the use of practically the entire spectrum of the sun available to the lower regions of the atmosphere. When a cracked gasoline was released in the presence of nitrogen oxides and sunlight, typical smog damage on plants was observed. In addition, characteristic smog odor and eye irritation were apparent.



Ozone in air is measured by effect on rubber under strain. Degree of cracking indicates concentration.

In order to determine the nature of the hydrocarbons which, upon oxidation, are responsible for the eye irritation, ten-degree fractions of gasoline were used, while the oxidant was adjusted to 0.4 ppm. of nitrogen dioxide and 0.2 ppm. of ozone. These conditions duplicate those present in the atmosphere during smog conditions.

Observers sensitive to eye irritation on smog days compared their reactions in these fumigations with those experienced under conditions of natural smog. In experiments with concentrations of 1.6 ppm. of gasoline fractions the eye irritation was definite in the range of 50 to 80° C, as shown in Chart C. A comparison of Charts A and C shows that maximum plant damage and eye irritation occur in about the same boiling-point region of the gasoline fractions. Eye irritation is, however, observed also in fractions with boiling points below 35° C.

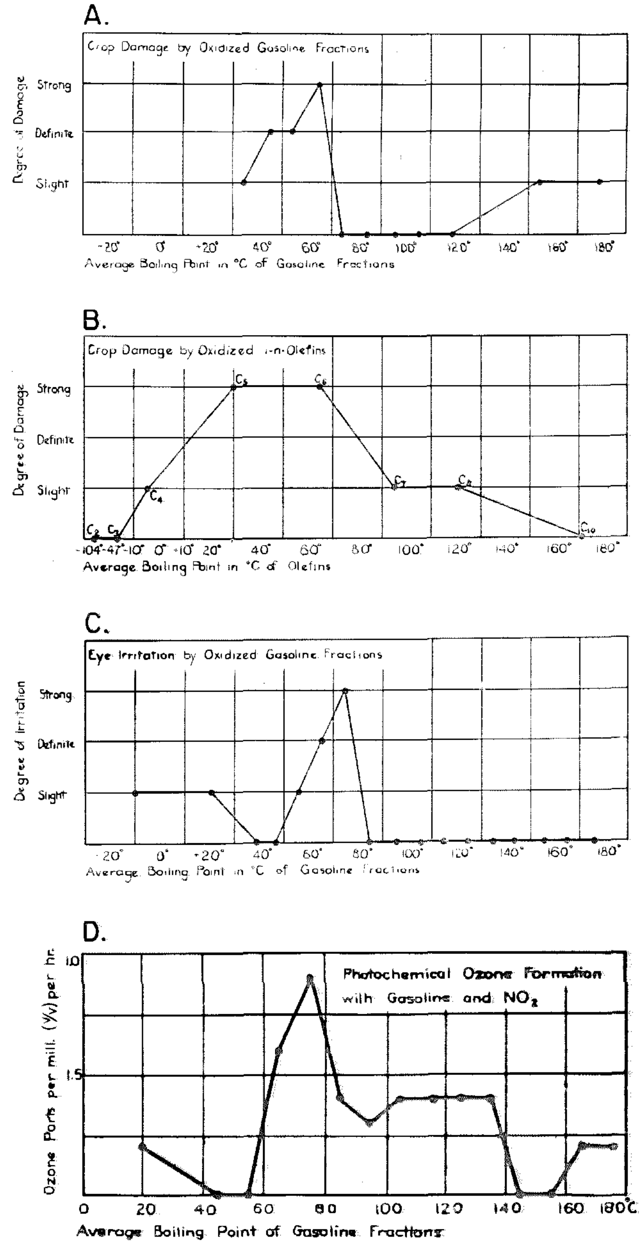
These findings were confirmed with pure olefins, and definite smog effects were obtained with concentrations as low as 0.2 ppm. of hydrocarbon. As in the crop damage experiments, the irritating agent consists of peroxides; the end products of the oxidation—aldehydes and acids—cannot be responsible for the irritating action since their concentrations, even upon complete conversion of the hydrocarbons, are considerably lower than those required for irritation.

Experiments in the fumigation house using NO_2 and O_3 and sunlight for the oxidation of the gasoline fractions have shown that within a few minutes a haze develops. These effects are especially noticeable with ring compounds with a double bond in the ring. Experiments on the oxidation of di-cyclopentadiene and indene in the presence of NO_2 (nitrogen dioxide), O_3 (ozone) and sunlight have shown that in a concentration of 50 parts per million of hydrocarbon a blue haze completely obscuring the vision over a distance of only eight feet fills the room. Even at 10 ppm. the blurring of objects is already noticeable over this short distance.

A large part of the aerosol droplets collected from the air have been shown to be of an oily nature, and the chemical analysis has shown that their composition resembles that of droplets found in the artifically produced aerosols of oxidized hydrocarbons.

Parallel with these investigations, the analytical work carried out on samples of pollutants collected on filters and in bubblers has shown the presence of the more stable end products of the reactions mentioned above. In the hands of Dr. Martin Shepherd of the National Bureau of Standards, the mass spectrograph gave valuable information on the multitude of hydrocarbons present in the Los Angeles air, and in addition he was able to show the similarity between the artificially oxidized mixtures of hydrocarbon and that occurring in smog.

The most puzzling property of the smog air, the high oxidizing capacity, remained to be solved. This oxidant, calculated as ozone, amounts to 0.5 - 0.6 ppm. on severe smog days. This oxidant is measured by iodine release



Experimental Crop Damage (Charts A and B), Eye Irritation (Chart C) and Ozone Formation (Chart D)

from neutral buffered KI (potassium iodide) solutions and a large part of the iodine release is due to the presence of nitrogen oxides, which, in the concentrations at which they occur in the Los Angeles atmosphere, oxidize the KI solution. The more interesting fraction of the so-called total oxidant of smog is that which closely simulates the behavior of ozone in giving typical rubber cracking. This fraction was shown to rise during severe smog, and, in the standardized rubber cracking test mentioned earlier, cracking times of six minutes were observed, corresponding to an ozone concentration of 0.22 ppm. The natural ozone concentration on the earth surface is reported to be of the order of 0.02-0.03 ppm.

These values were confirmed by using the rubber cracking test in unpolluted desert and beach areas. It is unlikely that additional ozone could be drawn from the higher atmosphere when the presence of inversion conditions characteristic of smog conditions prevents this free exchange. Further evidence against such a possibility is presented by the nearly complete absence of rubber cracking at night. This observation points to photochemical processes in the formation of the rubber cracking material.

Rapid rubber cracking comparable to that observed during smog periods was observed during the plant fumigation experiments with nitrogen oxides and sunlight only in the presence of organic material, such as hydrocarbons.

When gasoline fractions are used in concentrations of 0.1 to 1 ppm. the presence of 0.4 ppm. NO_2, rapid cracking occurs in the same boiling-point region in which the most intense crop damage has been found, as shown in Chart D on page 13. This effect on rubber was confirmed by the use of branched saturated hydrocarbons and olefins as well as their oxidation products: alcohols, aldehydes, ketones and acids. The rubber cracking material was isolated and identified as ozone.

It is interesting to note that the most marked ozone formation in oxidation of gasoline fractions occurs in the same boiling point region where the most extensive crop damage and eye irritation have been observed, and we conclude that ozone formation and peroxide formation are closely related phenomena. In many of these oxidations we have shown that the amount of ozone formed is many times greater than that of the organic material or the nitrogen oxides present, and we have to conclude that ozone is formed in a chain reaction.

The photochemical dissociation of NO_2 with sunlight provides a continuous source of atomic oxygen for this reaction, since NO_2 is regenerated through oxidation of NO by molecular oxygen. It is postulated that in the chain reaction leading to ozone formation, peroxide radicals are formed which react with molecular oxygen to form ozone. After the peroxide radical has released one of its oxygen atoms, it may be reoxidized and again react with molecular oxygen.

To test this hypothesis the photochemical oxidation of diacetyl was studied, since it is known that diacetyl under the influence of light easily forms free radicals. In this experiment the addition of NO_2 is not necessary for the transfer of light energy, since diacetyl absorbs light in the visible range of the spectrum. Diacetyl in concentrations of 2000 ppm. in a 2 liter flask gives rapid rubber cracking, and in half an hour the concentration of ozone has reached 30 ppm. The lowest concentration of diacetyl at which cracking of rubber could be observed was 40 ppm.

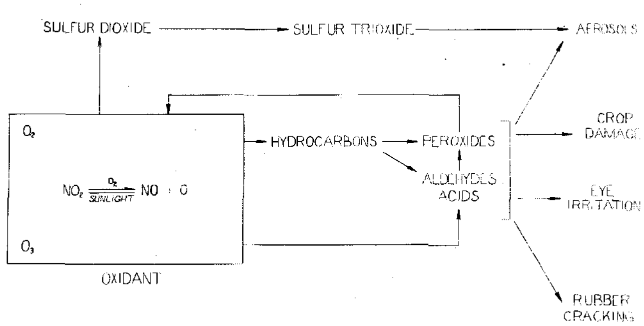
It has been proven by isolation and chemical identification that ozone was also formed in this case. These findings were confirmed by mass spectrographic measurements carried out by the Consolidated Engineering Corporation. Rubber cracking without the addition of nitrogen oxide is observed when butyl nitrite is exposed to light. It is known that, in the absence of oxygen, alkyl radicals and nitrogen oxides are formed by the decomposition of butyl nitrite. Our expectation that, in the presence of oxygen, ozone would be formed, was confirmed by the rapid rubber cracking observed.

In the photochemical oxidations with nitrogen oxides, ozone formation up to several parts per million has been demonstrated with concentrations of air pollutants of the same order of magnitude as those found in the smog atmosphere. The abnormally high ozone content of smog air, and consequent severe rubber cracking during such a period, is therefore readily accounted for by the ozone formed in these reactions.

The experimentally demonstrated ozone formation in air containing hydrocarbons or their oxidation products, and nitrogen oxides under the influence of sunlight, establishes a definite relation between the major nuisances observed during a smog period and is strong evidence of their common origin.

On the basis of experiments it is possible to condense the major features in the development of irritating and nuisance effects in the Los Angeles atmosphere, as shown in the diagram below. The oxidant is represented by a complex of factors consisting of atomic oxygen formed by the photochemical dissociation of nitrogen dioxide and ozone produced in the photochemical oxidation of organic material. The oxidant reacts with hydrocarbons and their oxidation products, producing peroxides and further degradation products. The arrow leading from the peroxides to the oxidant indicates the participation of these compounds or their radicals in the formation of ozone. Included in the general picture is the oxidation of sulfur dioxide to sulfur trioxide as a contributor to the decrease in visibility. This oxidation is known to be catalysed in the presence of nitrogen oxides, which are released at the same time in combustion processes.

As a result of the teamwork initiated by the Los Angeles Air Pollution Control District the major cause of the smog has been recognized. The problem of crop damage, eye irritation, haze, smell and ozone formation has been brought to a practical solution. All these phenomena are due to the same cause—the emission of large quantities of hydrocarbons and nitrogen oxides to the air. The District has not hesitated to follow up the conclusions which could be drawn from the research studies. An intense source study has been made of all major contributors of organic material and of nitrogen oxides to the air.



Atmospheric reactions in smog formation

The Second Technical and Administrative Report from the Los Angeles Air Pollution Control District reveals that approximately 2,000 tons of hydrocarbons and 250 tons of nitrogen oxides are lost to the air daily.

The nitrogen oxides are released in all combustion processes and have nearly doubled since 1940. This is also true for the type of hydrocarbons which have been shown to be mainly responsible for the nuisance effects of smog: olefins and branched saturated hydrocarbons.

The main reason why nuisance symptoms developed during the war years is to be found in the revolutionary change in the composition of gasoline. The diagram at the right shows the difference between old and new gasoline. The nonreactive paraffins in straight run gasoline have been replaced in the cracking process by paraffins with branched chains and by olefins. Both groups of compounds are readily oxidized and lead to the formation of peroxides and ozone, thereby producing all of the typical smog nuisance effects.

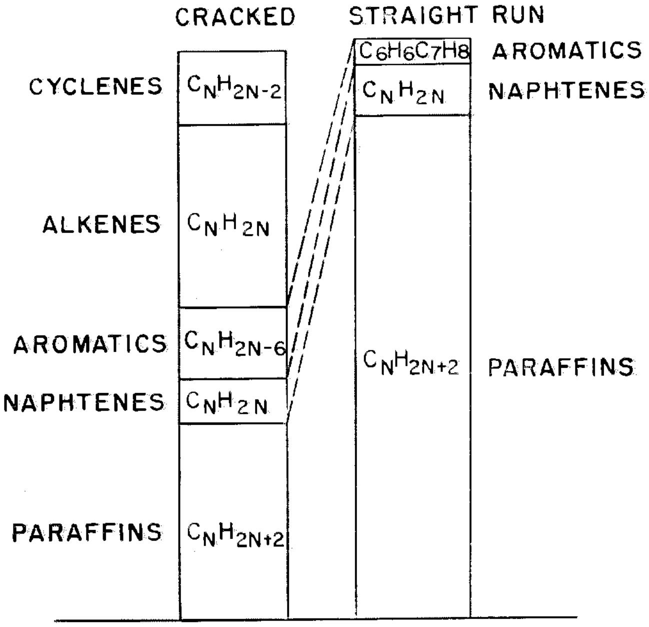
The cracking process gives a much higher yield of gasoline from crude oil than the old distillation process. With the enormous increase in the demand for gasoline it is not economically feasible to go back to the old process. Until changes in the composition of the present-day gasoline have been made it is necessary to handle modern gasoline as a potential irritant, and losses have to be prevented wherever possible.

Skimming ponds at the refinery, baking in the sun, lose considerable quantities of volatile material. Old-fashioned storage tanks, warming up in the sun, expel additional hydrocarbons. Such devices belong to the past, and will undoubtedly be replaced by separatory tanks and floating tanks.

Following the distribution of gasoline to the consumer, there are losses involved in filling tank cars, gasoline storage tanks at filling stations, and finally, the tanks of automobiles. These losses are considerable, as a rough calculation shows. When a gasoline tank of an automobile is filled, 15 gallons of vapor are replaced with liquid. Usually we don't give any thought to this loss. Per car filling, it amounts to the loss of about 1/10 of a gallon, or 2.5 cents. This seems a small amount, but since 2.5 million gallons of gasoline are used daily in the Los Angeles area, then 2.5 million gallons of vapor are lost in the filling of cars alone—a release of 50 tons daily.

Similar losses have occurred when the gas station filled its tanks, when the tank car was filled, etc. If we assume some four of these transfers, 200 tons of gasoline are lost to the air. The engineering difficulties do not seem too great to overcome such a loss, at least at the marketing installations.

More difficult to solve will be the problem of incomplete combustion in the automobile. More efficient combustion, especially during acceleration and deceleration, might be possible. Some proposals have been made, suggesting the combustion of the unburned fuel in a separate unit. Such ideas are, however, still in the experimental stage, and we can hardly expect results

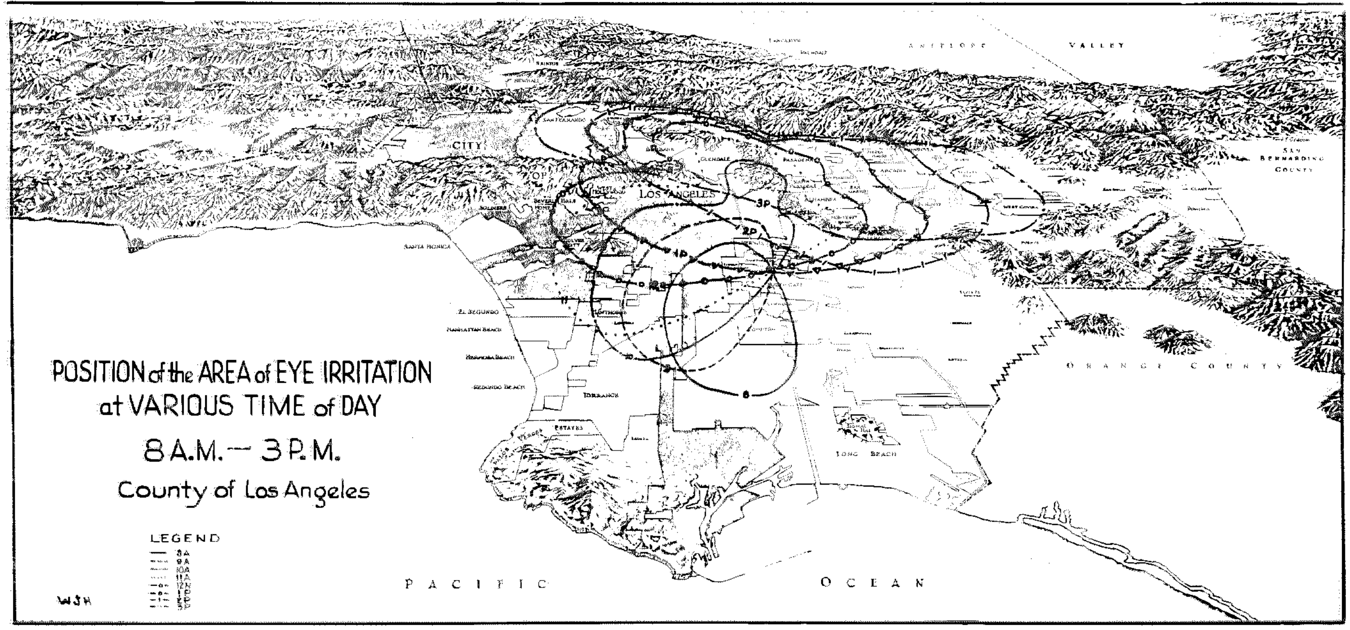


Comparison of old and new gasoline shows the factors responsible for making cracked gasoline a potential irritant

of such inventions in a few years. Since most of the hydrocarbons are released during deceleration, downtown traffic with its many stop signs contributes materially to the hydrocarbon losses. The construction of freeways, as is now going on in Los Angeles, will help in cutting down the losses. Efficient community transportation will eventually replace much of the nerve-wracking traffic of today, and a considerable reduction in the use of fuel, as well as in air pollution, can be expected.

Estimates made by the L. A. County Air Pollution Control District show that nearly equal quantities of hydrocarbons are lost by automobiles and by the petroleum industry—the combined total amounting to 2,000 tons daily. From such computations one could draw the conclusion that automobiles and the petroleum industry are about equal contributors to the smog condition. However, in these compilations of data the time and place of release of the hydrocarbons and their oxidation products do not appear. Smog is experienced only during part of the day. In Pasadena, the mountains disappear from view in the early afternoon, and reappear after a few hours. At the County Air Pollution laboratory at 52nd Street and Santa Fe Avenue, the smog wave arrives in the morning and leaves in the afternoon. The very existence of a smog wave shows that the whole Los Angeles area does not produce smog in equal density.

The movement of the smog cloud over this area is well illustrated by a map (p. 16), made by the District, plotting the density of telephone complaints on a smog day. The area of greatest pollution, first recorded at 8 o'clock in the morning, slowly moves northward and squeezes through the gaps in the low mountain range separating Pasadena from the Los Angeles area and at 3 o'clock has covered San Fernando and the San Gabriel Valley.



The most reasonable explanation of this phenomenon seems to me the sudden release of hydrocarbons from the relatively small refinery area shortly after sunrise, when tanks are warming up and skimming ponds are rapidly beginning to lose a major part of their daily contribution, which has collected and remained unvolatilized during the cool night.

On the other hand, the automobile operates during the whole day, and therefore spreads its contribution more evenly during that time. In addition, the loss is spread over a far larger area than that from the oil industry. Consequently, we can expect a relatively high concentration of hydrocarbons originating in the small refinery area, superimposed on a more evenly distributed lower concentration from automobile exhaust gases. With wind velocities of 4-5 miles per hour, the pollutants slowly move north, and we should expect to see the smog cloud approaching at about 9 o'clock at the County laboratory, and at noon in Pasadena.

During that time, ample opportunity exists for the oxidation of the hydrocarbons. Power plants, industries and automobiles furnish a continuous supply of nitrogen oxides for the photochemical oxidation and formation of ozone. The smog wave will be materially reduced through control measures now being taken by the petroleum industry. There is, however, a great deal more to be done.

We should realize that in each case of air pollution it is not very likely that 100 percent reduction can be achieved. A reasonable balance has to be found between what is desirable and what is economically feasible. About 600 tons of SO_2 were being released daily before the refineries decided to convert some part of it to sulfur. At present, about 300 tons are still going into the air, not from the refineries, but from fuel burners, automobiles, etc. Since this pollution is not confined to a major industry but is released in millions of small combustions, we have reached a situation whereby it is difficult to remove any additional SO_2 from the air. Fortunately, the SO_2 concentration has dropped to such a level that it rarely exceeds 0.1 ppm., which cannot be considered harmful.

The same situation is true for dusts and fumes of a miscellaneous group of industries. Control devices have been installed in many of them. None of these are 100 percent effective, and the allowable emissions are set after considerable study and discussions of the economic possibilities.

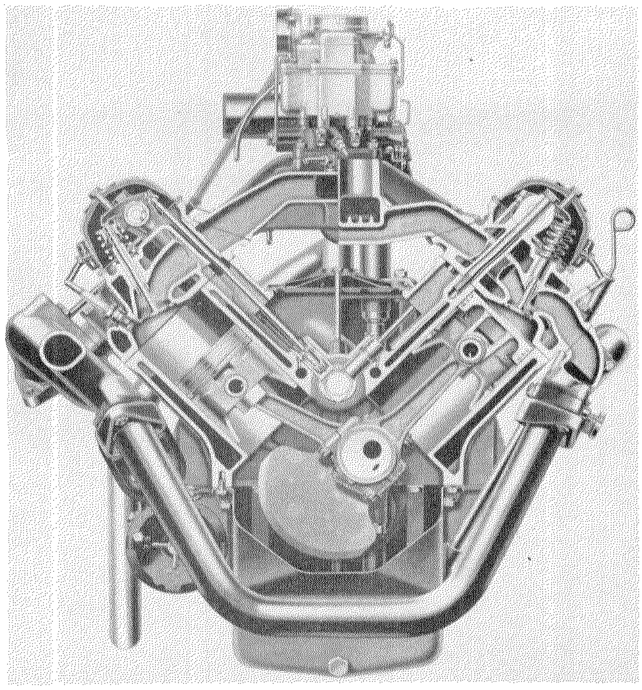
It is clear, therefore, that every new industry, and every person entering this area, is going to add to the existing air pollution. With the increase in population and the advent of new industries the problem of smog control becomes increasingly difficult. Already the District has studies underway on the possibility of zoning for air pollution purposes. Fortunately there are definite signs that we are on the road to cleaner air. The activities of Los Angeles Air Pollution District and of the industries have brought many of the emissions to prewar level and a good start has already been made on the recovery of the major cause of the smog: the hydrocarbons.

Gradually the frequency with which the dense smog is annoying us will become less and less. Eye irritation and crop damage will be the first symptoms to disappear. The visibility will undoubtedly improve, but there will remain the contribution from individual sources like the automobile and the incinerator, so that the District must call on all of us to cooperate in the fight for clean air.

In view of the outstanding achievements of the Los Angeles County Air Pollution Control District, we help ourselves when we give this law-enforcing agency our wholehearted support in eradicating the smog nuisance completely. Smog is on the way out; let us speed up its departure and let us keep it out.

HIGH COMPRESSION ENGINES

By PETER KYROPOULOS



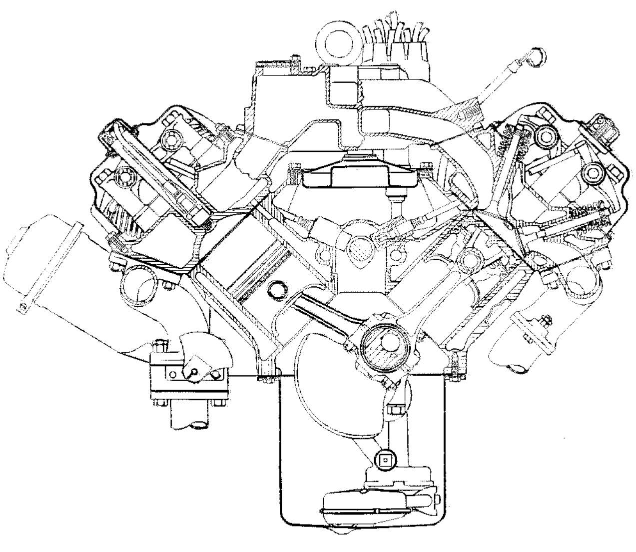
1. *General Motors Research Engine (Rocket Engine)*

They're providing real gains in power as well as in specific fuel consumption—but there's still a joker in this game

THE HORSEPOWER of automotive engines has been increasing steadily during the past years. Ronald Colman in the radio show, "The Halls of Ivy," expressed this, somewhat qualitatively, when he said, "Never has so much horsepower been given to so many jackasses." This is neatly put, but the subject is open to a more quantitative and detailed analysis.

Ample statistics on the change in engine data are available (Ref. 1). It is sufficient and less tedious to examine a summary of such data, which is presented in Table I, and shows the percent change in the most important design and performance parameters.

Table II shows some of the data for engines of recent design, at which we shall take a closer look.

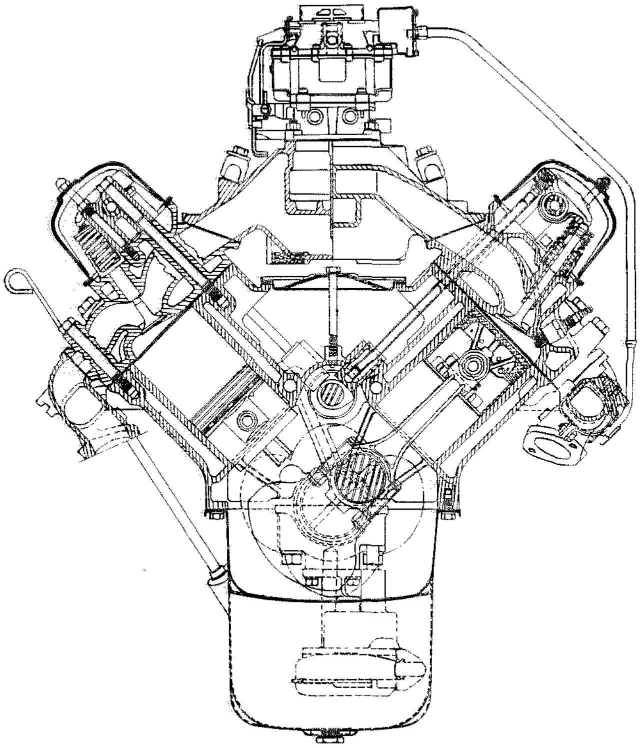


2. *DeSoto Engine*

TABLE I

Engine Design Trends 1940 - 1951
(Changes in percent)

HP/cu. in.	+37.5
Compression ratio	+36.0
Brake horsepower	+33.0
Brake Mean effective pressure	+ 3
Bore	+ 3
Stroke	— 9
Displacement	— 3.2
Displacement per cylinder	— 1
Piston speed	+ 5
Rpm	+13



3. *Studebaker Engine*

Structure of the high compression engine

Before considering performance, let us examine the engine structure. Figures 1, 2 and 3 show, respectively, typical representatives of current V-8 engines (Cadillac, DeSoto, Studebaker).

All three engines, as well as others (Oldsmobile, Chrysler, Lincoln) are 90° V-8 engines with overhead valves. All of these engines are nearly "square," meaning bore and stroke are nearly the same (see Table II). There are simple and valid reasons for this:

All these engines are designed for compression ratios of about 12:1, even though they are not now sold with ratios higher than at most 8:1. The high compression ratios require extreme rigidity of crankcase and crankshaft; otherwise the engine will display "roughness," a term used to denote combined bending and torsional vibration. This is not caused by knock but merely by high compression-end and peak pressures.* The V-8 is easily balanced and made stiff, both in crankcase and crankshaft and hence is the logical configuration, next to the in-line six. The V-6, although stiff structurally, is not easily balanced and offers little advantage over a V-8.

Overhead valves are dictated by the geometry of the cylinder and head for high compression ratios. The clearance volume becomes so small that an L-head does not have sufficient space for valve opening. Good valve opening, and hence good breathing, is just as important as high compression ratios, even though it is not nearly as much publicized and advertised.

Bore-stroke ratios of one and less, although common in reciprocating aircraft engines, are new to the automotive production engine. They have resulted in a material decrease in piston-friction and hence friction horsepower, which is a direct gain in brake-horsepower. At the same time, shortening the stroke permits increased engine speed without increasing the mean piston speed. The mean piston speed is a measure of the flow losses in the intake valves; if, therefore, this speed remains con-

* This is also the reason why, in "souped-up" stock engines, the higher the compression ratio, the more they behave like rock crushers.

TABLE II

1952 Automobile Engine Design Data

Make	Type	Bore	Stroke	Bore/stroke	Displacement cu. in.	Compression Ratio	Maximum BHP	RPM at max. BHP	BHP/cu. in.
Cadillac	V-8	3.813	3.625	1.05	331	7.5	190	4000	.574
Oldsmobile	V-8	3.75	3.438	1.09	303.7	7.5	160	3600	.526
Chrysler	V-8	3.813	3.625	1.05	331.1	7.5	180	4000	.544
DeSoto	V-8	3.625	3.344	1.08	276	7.1	160	4400	.579
Studebaker	V-8	3.375	3.125	1.07	232.6	7.0	120	4000	.516
Lincoln	V-8	3.8	3.5	1.09	317.5	7.5	160	3900	.504
Ford 6	OHV-6	3.56	3.6	.99	215.3	7.0	101	3500	.468
Willys	F-head 6	3.125	3.5	.89	161	7.6	90	4000	.559
Buick 70	in-line 8	3.438	4.313	.80	320.2	7.5	170	3800	.530
Chevrolet	OHV-6	3.50	3.75	.935	216.5	6.6	92	3400	.425
Plymouth	L-head 6	3.25	4.375	.74	217	7.0	97	3600	.448
Ford V-8	L-head	3.19	3.75	.85	239.4	7.2	110	3800	.470
Mercury	L-head V-8	3.19	4.0	.80	255.4	7.2	125	3700	.489

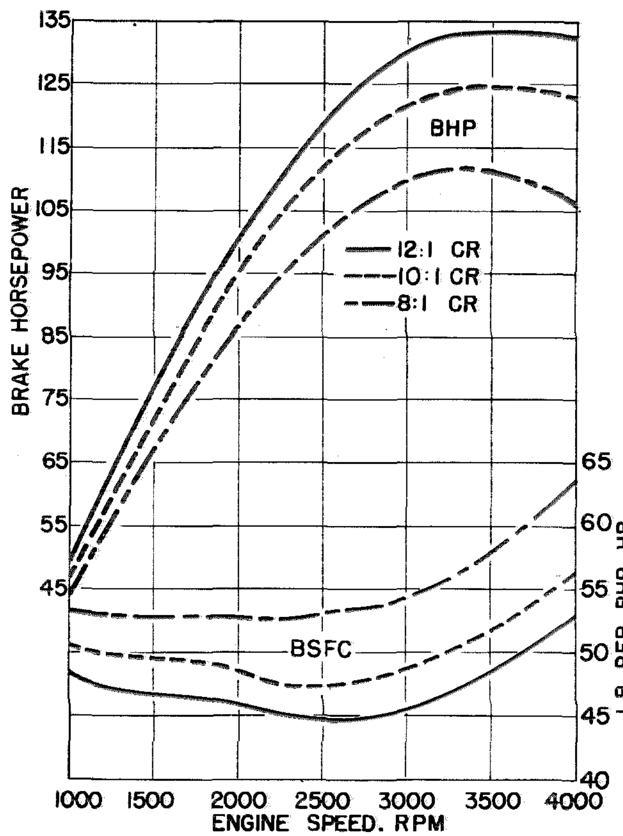
stant, the breathing capacity of the engine is unchanged.

The engines discussed so far appear rather similar, which they are, indeed, with the exception of the valve arrangement of the Chrysler "Fire-Dome" engines. The cylinder head is hemispherical and the valves form a V rather than being in a plane. This arrangement is well known and practically universally used in motorcycle and aircraft engines. The central location of the spark plug results in a shorter flame travel than in other head configurations. Other things being equal, the combustion chamber with the shortest flame travel has the least tendency to knock (Ref. 2). The spherical head and rocker arm assembly is more expensive to produce than any other head. This fact, rather than ignorance, has prevented manufacturers of production engines from adopting this cylinder head. (Let us keep in mind here that we are concerned with engines produced and producible by the million. European manufacturers with production of 25⅜ cars per year are in a position to do a lot of things which are not feasible in our production.)

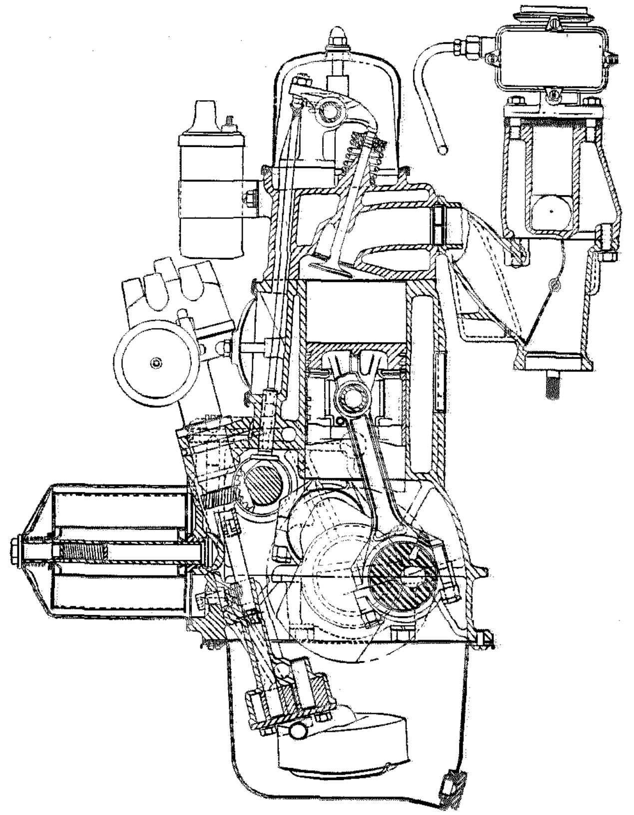
Last, but not least, we have the Ford 6 (Fig. 4) as a typical representative of a new family of six-cylinder engines designed along much the same lines as the new V-8's: high compression ratio, great rigidity, short stroke, good breathing.

In summary we can say that engine designers are improving performance:

(1) By raising the compression ratio. This increases power output and decreases fuel consumption.



5. *Brake Horsepower as a Function of Engine Speed and Compression Ratio (GM Research Engine)*



4. *Ford Engine*

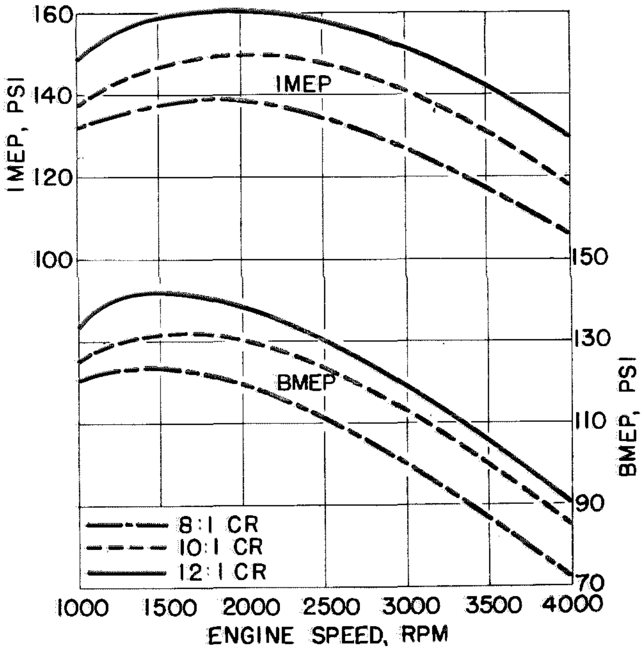
(2) By reducing engine friction. This increases the output per cubic inch displacement and improves the specific fuel consumption (lbs-fuel/bhp-hr).

(3) By improving the breathing capacity of the engine. This raises the output per cubic inch displacement and permits higher engine speeds, which, by itself, increases the output.

We shall now examine the effectiveness of these three measures separately.

Why high compression ratios?

We have, so far, compared structural details of engines. The implication has been that it is intuitively obvious why high compression ratios are desirable. The question is now: just what happens to the performance of a full-scale engine if the compression ratio is increased? This has been investigated (Ref. 3) using a General Motors engine, essentially an Oldsmobile Rocket in which *only* the compression ratio was changed. Fig. 5 shows brake horsepower plotted against engine speed for three compression ratios. Peak bhp increases by about 20 percent while the specific fuel consumption decreases by the same amount as the compression ratio is increased from 8 to 12. Similarly, the brake mean effective pressure (Fig. 6) increases numerically, but the shape of the curve remains the same. Since bmep and torque curve are identical, it is seen that torque-speed relations are not changed by increased compression ratios, a fact which is not appreciated by many hot-rod hopefuls.



6. *Brake and Indicated Mean Effective Pressure as a Function of Engine Speed (GM Research Engine)*

Friction horsepower *increases* with compression ratio (Fig. 7). This is due to increased bearing pressures as well as increased gas pressure on the piston rings.

Heat dissipation is essentially unchanged by increased compression ratio (Fig. 8). It is well to recall the energy balance in an engine, as shown in Fig. 9. Approximately 1/3 of the energy supplied by the fuel is transformed into brake work, delivered for our use. One third of the energy leaves through the exhaust, and the last third represents cooling losses to water and oil. If we look at it this way, the radiator which we are tempted to consider as an inferior piece of hardware, takes on more importance.

Engine performance—car performance

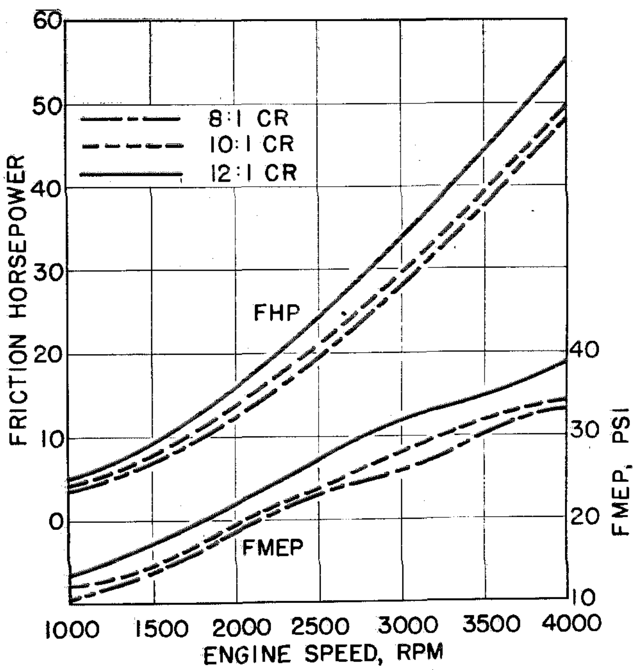
Finally we have Fig. 10 which translates the engine performance into car performance, assuming the power required of a typical passenger car. The effect of axle ratio is shown in this diagram, in order to emphasize the importance of this parameter. Comparing cars with identical axle ratios, the improvement in mileage is about 17 percent. If we specify that the car shall have the same acceleration with 8 and 12 compression ratio, we can afford to reduce the axle ratio from 3.6 to 3.1 with an additional gain of about 10 percent in mileage.

How about engine friction?

The increase in friction with compression ratio was shown in Fig. 7. Comparing, however, the newer (square) engines with their older, long stroke, counterparts, a definite gain is noted, due to reduced stroke and careful attention to design details. Comparing the Cadillac V-8 side-valve engine (1948) with the 1949 OHV (Over Head Valve), friction horsepower has been reduced from 45 to 37 horsepower at 3200 rpm. For the same engines, fan and waterpump horsepower have been reduced from 6.3 to 3.3 at 3200 rpm, i.e., by about 50 percent. Although the total amounts of power absorbed by friction are not very large, worthwhile gains are being made by constant efforts to improve detail design.

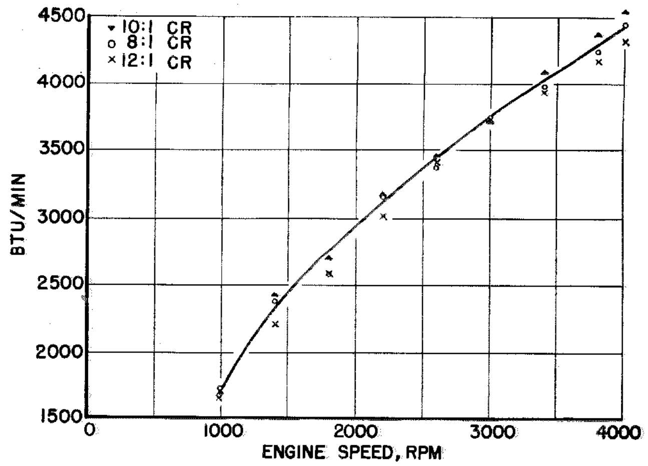
Breathing capacity

The output of any thermodynamic power producing machine is proportional to the mass flow of working medium passing through the engine. In the spark ignition (automobile) engine the fuel air ratio varies only within narrow limits throughout the operating range. The power output is, therefore, proportional to the air flow through the engine. Anything that restricts the flow of air through the engine reduces power. We use this effect when we close the throttle. Valve size, valve opening, intake and exhaust manifolding and carburetor design have decisive effects on air flow (breathing) in the engine, and engine designers are constantly at work on these items. It is difficult to find data which isolate this effect, but we have one which illustrates the point well. Fig. 11 shows brake horsepower vs. rpm for a stock Chevrolet (216.5 cu. in.) engine with stock head and with a special head which has larger intake valves and an auxiliary intake manifold. No other changes were made. The improved breathing resulted in an increase of about 20 percent in maximum power at full throttle. A warning to the all-too-eager beaver is in order. The gain in full throttle maximum power is no measure of the improvement in part throttle cruising mileage, which will be small for the existing special head, unless the manifold-carburetor combination is drastically improved.



7. *Friction HP and Friction Mean Effective Pressure as a Function of Engine Speed (GM Research Engine)*

Another example of gains from improved breathing without complete redesign is represented by the Willys F-head, shown in Fig. 12. The basic L-head engine remains unchanged. The L-head is replaced by a head with one intake valve, actuated by rocker arm and pushrod. This permits a very large intake valve diameter as well as lift, and results in materially reduced intake losses which, in turn, increase full throttle output. This measure remains a makeshift solution. The fact that Rolls Royce uses the F-head design does not persuade the writer of this discussion that it has heretofore undisclosed merits.

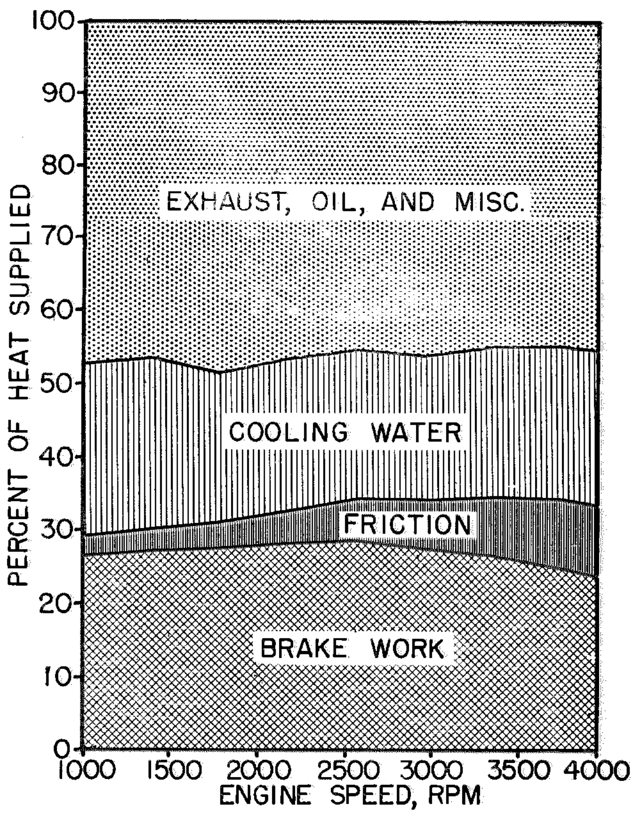


8. *Heat Rejection to Cooling Water as a Function of Engine Speed (GM Research Engine)*

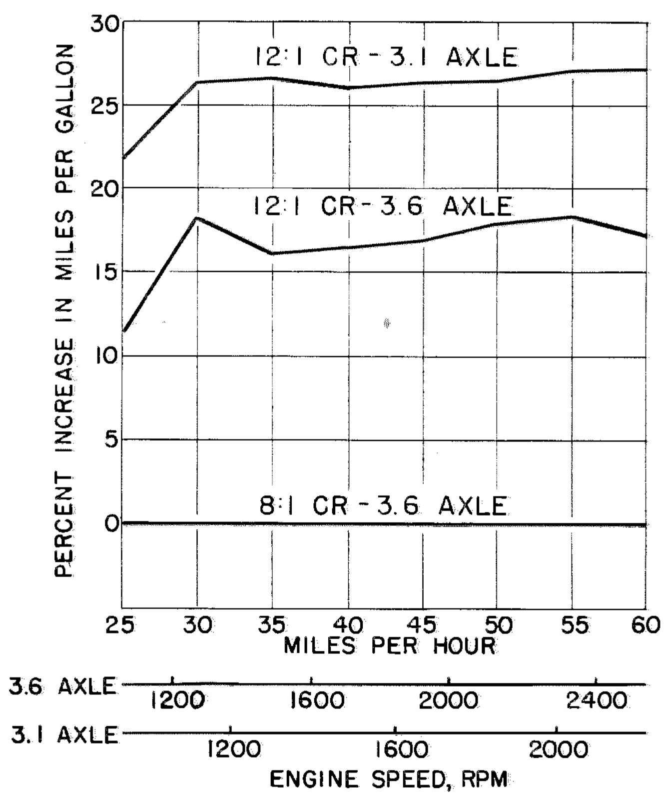
Fuel and maintenance requirements

It was pointed out that the new engines are designed for compression ratios around 12:1 but are now sold with about 7.5:1. This corresponds to an octane requirement of about 82 which is met by present premium fuels. At 12:1 compression ratio the octane requirement is of the order of 100.

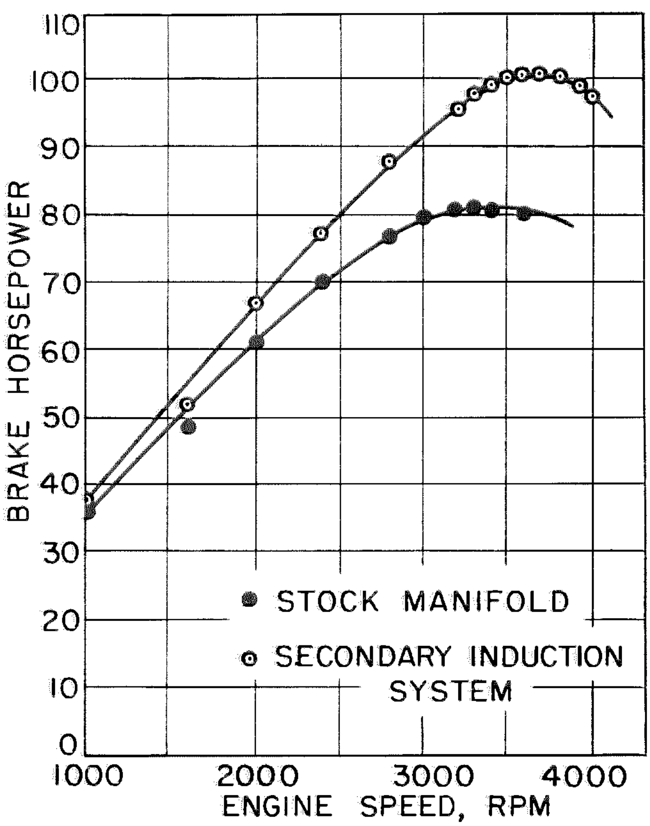
Although service experience is generally good, engines require more careful tuning and ignition and carburetor maintenance. This is to be expected. If compression ratios are to be increased in the future this will become even more important. Engine cleanliness becomes the more essential, the higher the compression ratio, since octane requirements increase rapidly as deposits build up in the combustion chamber. Perfect valve and piston ring seal is necessary if high compression ratios are to be effective. Where the compression-end pressure and peak firing pressure are, respectively, 200 and 750 psi at 7:1 compression ratio, they are 450 and 1100 psi at 12:1. The full advantage of the high compression ratio is lost if appreciable leakage occurs. Improved maintenance methods are being developed, such as the "head on carbon removal" method which employs a rice blast through the spark plug hole to remove carbon without necessitating removal of the cylinder head. Nevertheless, somewhat more frequent tuning and other maintenance operations must be expected.



9. *Breakdown of Energy Supplied by Fuel to Engine (10:1 Compression Ratio—GM Research Engine)*



10. *Effect of Compression Ratio and Rear Axle Ratio on Mileage for a Typical Car. (GM Research Engine)*



11. *Effect of Improvement in Breathing Capacity on Full Throttle Power (Chevrolet 216.5 Cu. In. Engine)*

Now that we have horsepower, —what can we do with it?

As we have seen, real gains in power as well as in specific fuel consumption have been made and further improvements are readily available. There is, however, a joker in this game: the word "specific" fuel consumption, meaning the pounds of fuel per brake horsepower-hour. No matter how low a figure this may be, multiplied by a large number of horsepower it comes out to be a goodly number of pounds and hence gallons (there are about 6 pounds of gasoline to a gallon).

The power required for level road cruising is moderate. Table III shows average values for 11 cars (Ref. 4).

The difference between power-required and power-available is immediately apparent. What happens to this difference? It is used for acceleration and to ruin a potentially good mileage. Modern automatic transmissions permit high accelerations with extreme smoothness which makes the driver forget how much power he is actually using. It is rather futile to advise restraint in acceleration. If the power is there, it is going to be used. It is equally useless to ponder whether this is good or bad or whether manufacturers or customers are to be blamed for this development. Approximately 20 percent of the cars sold in 1951 belong to the so-called "overpowered" class. The resulting driving habits are presumably what prompted Mr. Colman to make his remark.

TABLE III

Average Road Horsepower: 1949 Cars

Speed (mph)	20	40	60	80	100
Road Power Required (hp)	5	15	30	65	145

REFERENCES:

(1) *Automotive Industries*, March 15, 1950

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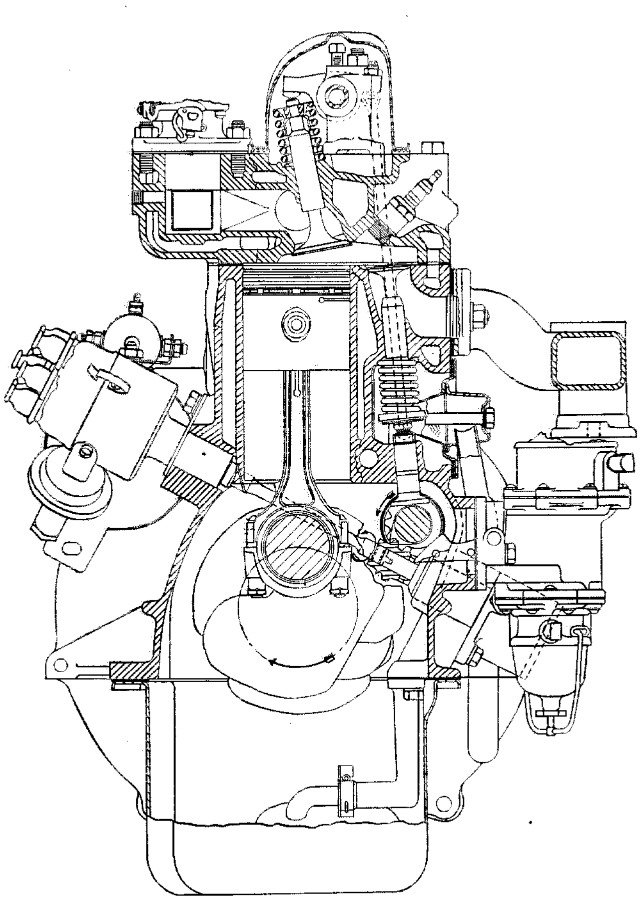
Figure 2 *Automotive Industries*, November 1, 1950
Figures 3,4 *Automotive Industries*, February 1, 1952
Figures 5-10 *SAE Journal*, June, 1949
Figure 11 *Motor Trend*, March, 1952
Figure 12 *Automotive Industries*, January 1, 1952



12. *Willys Engine (F-Head)*

THE ENGINEERING CRISIS

—and what you can do about it

By JOHN R. WEIR

AS MANY CALTECH graduates know, being a scientist or an engineer is an excellent way to make a living. By and large, engineering is one of the best paying major professions in the country, and in addition has a world-wide market. If you were to travel abroad you would probably never be in a country where sooner or later you would not encounter an American engineer. It seems to me there is probably no more stimulating, rewarding and exciting profession on earth.

Engineers and scientists represent less than one half of one percent of our total population, yet they are one of the primary sources for the progress and security of our nation at peace or at war. Look around you. The dwelling you live in, the water you drink, the clothes you wear, the car that carries you, the streets you drive on, the lights you light, the hospital that helps you—every piece of equipment indispensable in your life and mine is a product of America's small and talented family of engineers. Each is a fruition of an engineer's dream, and we have as yet only touched the borders of the needed engineering achievements.

It is the engineers who enable us to avoid the limitations of a standstill economy. They are truly the new aristocracy, and as far as personal opportunities go, let me point out the amazingly widespread climb of engineering-qualified students to the top as general executives in American enterprise.

The priceless ingredient of adequate management is judgment. This means knowledge, balance and the courage to make hard decisions. It means basing conclusions on facts, but with the training, ability and vision to weigh these facts as realities, and to exercise judgment on them on an overall basis. This ability does not come as a result of a hunch, or on a personality basis, but rather from a broad and inclusive training.

On the record there is no better training than engineering for general advancement in business and industry. This is indicated by the results of a recent Columbia University survey which states that "40 percent of industrial management is engineer-trained, replacing both the lawyer and the banker in top industrial posts."

More specifically, there are 13 presidents of the subsidiary companies of U. S. Steel who started as engineers. There are 20 presidents of associated companies in the great Bell Telephone System; of these 10 graduated as engineers. Fourteen members on the Board of Directors of the Standard Oil Company of New Jersey are engineers. At least 15 top executives of Anaconda Copper and its major subsidiaries are graduate engineers. Over half the vice presidents and 90 percent of the top executives in the five divisions of Union Carbide started up the ladder as engineers. Nearly half the top officials of the General Electric Company started as engineers. Within the General Motors Corporation the Chairman of the Board of Directors, the President, one of the four executive vice presidents, sixteen of the vice presidents, and sixteen of the members of the Board of Directors are engineers.

Of the graduates from M.I.T., 930 are listed in *Who's Who in Engineering*. Of Caltech graduates, about one in every four occupies an executive position of one sort or another.

If a student goes to engineering college: he is 44 times more likely to be an officer in American industry than if he goes to no college at all; he is 30 times more likely to be an officer than if he goes to some kind of college other than engineering; and he is 12 times more likely to be president of a company than a graduate of a liberal arts, business, law, or other non-engineering college.

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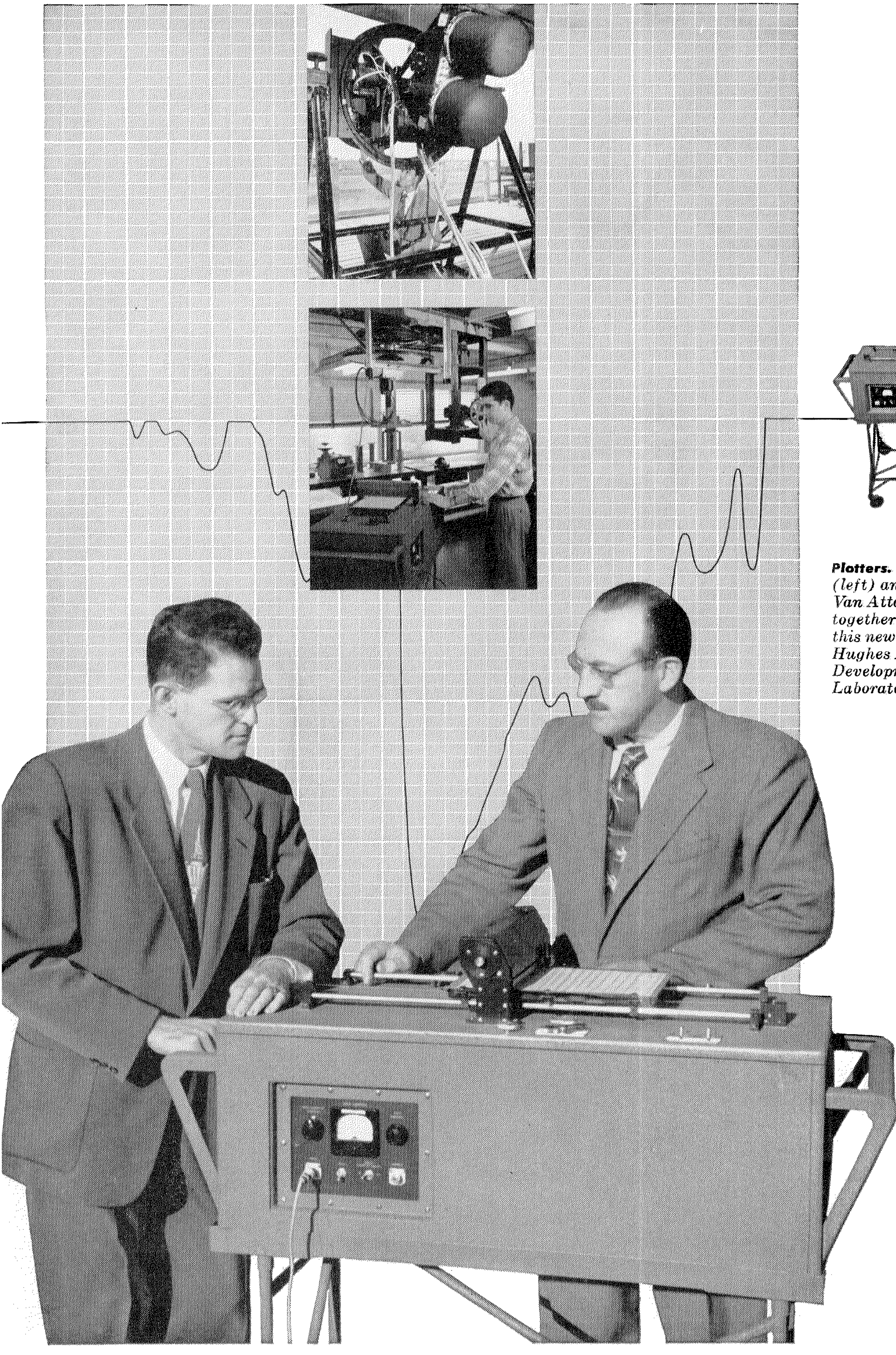

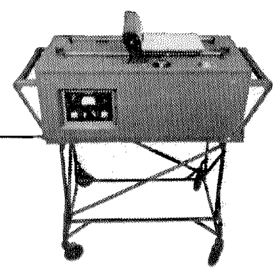

Plotters. *O. A. Tyson (left) and Dr. L. C. Van Atta worked together in developing this new machine at Hughes Research and Development Laboratories.*

ENGINEERS . . . CONTINUED

How about the dollar income of engineers and scientists? A survey by the Los Alamos Scientific Laboratory covering over 31,000 professional scientific personnel employed in 167 private organizations, gave the following results: A student graduating from an engineering school with a bachelor's degree can expect to make an average of $3500 to $4000 a year. At the end of ten years this will increase to roughly $6000 a year. If he has a doctor's degree he can expect to begin work for approximately $7500 or 8000.

There are, then, very considerable rewards in engineering and science in America. Yet there exists today a critical shortage of engineering personnel.

At the present time there are about 400,000 engineers in the U. S. There is an estimated present shortage of about 95,000; that is, there are 95,000 military and civilian jobs now vacant. The rock bottom estimate of the number of new graduate engineers which will be required each year for the next four years is 30,000. The present shortage of 95,000, plus the need per year for the next four years, indicates an accumulated demand in 1955 of nearly 215,000 new engineers.

Engineers—how's the supply?

Now let's look at the supply side. How many engineers will become available during these next four years? This is the number currently enrolled in our engineering schools who will graduate by 1955, for it takes four years to make an engineer. In June, 1951, about 38,000 engineers graduated from engineering schools. According to present enrollment figures there will be 26,000 in 1952; 17,000 in 1953; and 12,000 in 1954. An optimistic estimate of this number is 70,000, leaving a shortage over the next four years of 145,000.

There seems to be general agreement in industrial management that within five years there will be about 60 percent fewer engineers than our economy needs to preserve our standard of living and to make this nation secure in war.

It seems obvious that, except for occasional recessions, the demand for scientists and engineers will continue to rise at an increasing rate for an indefinite period of time. There are no clear signs of easing of world tension; there are no indications of a decline in the opportunity for America to continue its world leadership; and throughout the world, wherever one looks, one can see increasing opportunities for technological advances. The ability of man to consume is unlimited, and will not be denied; the age of science and technology has just begun.

It seems to me there are two major reasons for the present and prospective shortage. One set of factors tends to reduce the supply of engineers, the other serves to increase the demand for them.

Two quotes from two notable teachers epitomize one of the major influences in reducing the supply. "The major concern of thoughtful citizens today is the alarming over-emphasis on mechanics aside from technology," says one. And another: "What a laugh it is when we consider the root cause of our current world crises stems from the fact that our technical scientists in their perfection of techniques for destruction are so far ahead of our social scientists whose principal job it is to teach men how to live together peaceable and constructively."

Statements like these have obviously served to channel adolescent high school graduates into the social sciences and humanities rather than into the scientific and technical professions. The new hero is the manipulator of men rather than the manipulator of machines. This interest in people is a particularly desirable life goal for the adolescent, for he is most concerned with people and what they think of him.

Overstocked on engineers?

Another important influence which has reduced the supply of engineers was a report of the Department of Labor issued on March 8th, 1950. It predicted, in part, that "so many engineering students will be graduating in the next few years, 1950-54, that many graduates will be unable to get engineering jobs."

The effect of this report was immediate and profound. Young folks and their parents seemed to drop the idea of an engineering education like a hot potato; engineering schools immediately suffered a drastic drop in enrollments. Percentage-wise, the drop was nearly three times as large as the drop in other collegiate groups.

The final trend that might be mentioned in this regard is the drop in enrollment in high school physics classes. It is a practically universal rule that an applicant cannot obtain admission to an engineering school unless he has had physics in high school. Yet the enrollment in high school physics, in the Los Angeles area, has dropped from 19 percent in 1900 to 8.5 percent in 1939, to 5.6 percent in 1950. The reasons for this are two-fold. First of all, the subject is relatively difficult and most high school students prefer to elect easier ones. Secondly, high school study counselors—who are usually not professionally trained, and thus are not aware of many job opportunities and requirements—tend to encourage students to look around, to study in broad areas before they begin to specialize. As a result, the specialization necessary for engineers in about the tenth or eleventh grade fails to take place.

And the demand?

These are some of the factors affecting the supply of engineers. What are the factors affecting the demand? The most important are the military and defense demands. These services are taking from 25 to 50 percent of all engineering graduates. This can be easily understood when one recognizes the increase in complexity of military equipment: For example, it takes three times as many engineers to make a jet plane as it did to make

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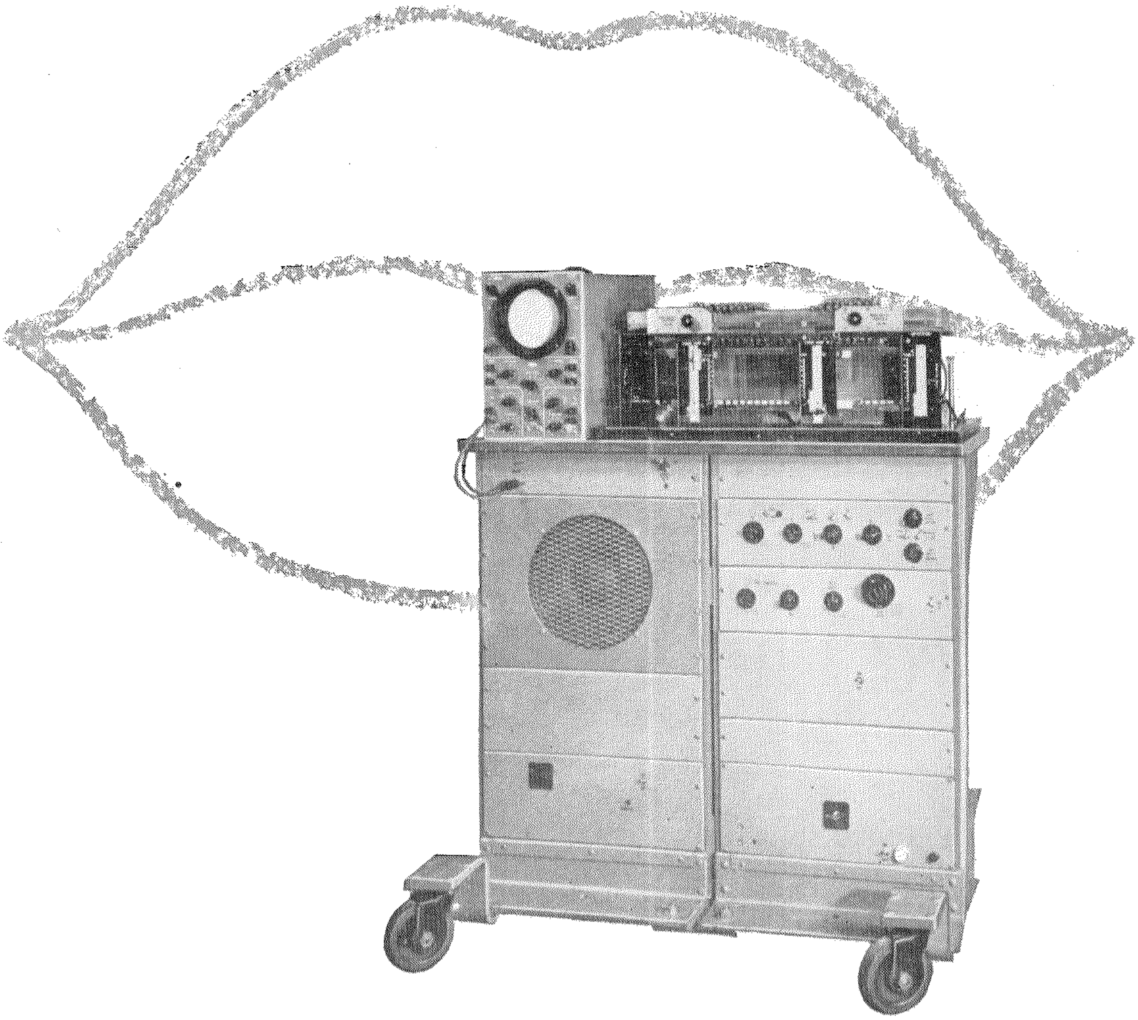

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a reciprocating engine plane. It took nearly 3,000,000 engineer man hours to put the thunder jet fighter into the air.

Another important factor is a population increase of roughly a quarter of a million a month, or approximately $2\frac{1}{2}$ million per year. This alone would demand an important increase in the total number of engineers if our technical complexity were merely to stand still.

Finally, and equally important, is the ever-increasing consumption of technical equipment, material, and knowledge which grows as man becomes more familiar with and accustomed to the conveniences and pleasures afforded by the development of modern science and engineering.

This crucial shortage of engineering and scientific personnel, then, has three significant aspects.

What the shortage means

First, it represents a tremendous threat to the security of the free world, for this security is based upon our technological development and the shortage places a very real limitation on our national defense effort and the production of defense equipment.

Secondly, as the shortage causes engineering personnel to be spread thinner and thinner, it seems to me that we may expect a considerable amount of second-rate engineering to be done on essential national products. This would mean the production of second-rate goods and equipment at a time when we need the best possible quality and quantity.

Thirdly, this shortage means a limitation in the quantity and quality of the engineering personnel working in private industry. I think I may safely predict that in the future it will become increasingly difficult to get graduate engineers and scientists to staff our industrial plants.

What can be done about it

What can be done about this? Several things can best be done on a *national* basis. (1) Suggestions have been made to the armed forces that they use their drafted or enlisted engineer personnel more efficiently. (2) Some kind of educational campaign is needed which will demonstrate the irrationality of the argument that technology is the cause of all the world's many ills. (3) Suggestions have been made that engineering personnel who have been given jobs which do not involve activities in the engineering field be relocated to function in technical capacities. (4) Highly-trained engineering personnel can well be relieved of much routine detail and also work, which might be done by less highly trained people, and finally, (5) there is hope that something can be done to reduce the shortage by the National Science Foundation, a nation-wide government-sponsored training program for engineers and scientists. (Note, however, that the budget for this foundation was recently reduced 77 percent, providing an additional illustration of the trend in this field which is under discussion here.)

And what YOU can do

Now I would like to suggest some specific procedures which engineers themselves might instigate. The first is that of spreading information. It is necessary that some one provide some kind of continuing information for the use of high school counselors. This information should concern job opportunities and job specifications in engineering and science. It should contain a description of what being an engineer involves, what he does, what kind of people he works with, how much money he may make—the employment possibilities. It should also list the job requirements—what he will have to learn to become an employable engineer.

I would like to suggest that engineers and scientists working in industry go out of their way to talk to groups—either parents or high schools groups—concerning engineering and science as an occupation, including what it has meant personally to the engineer who is doing the talking.

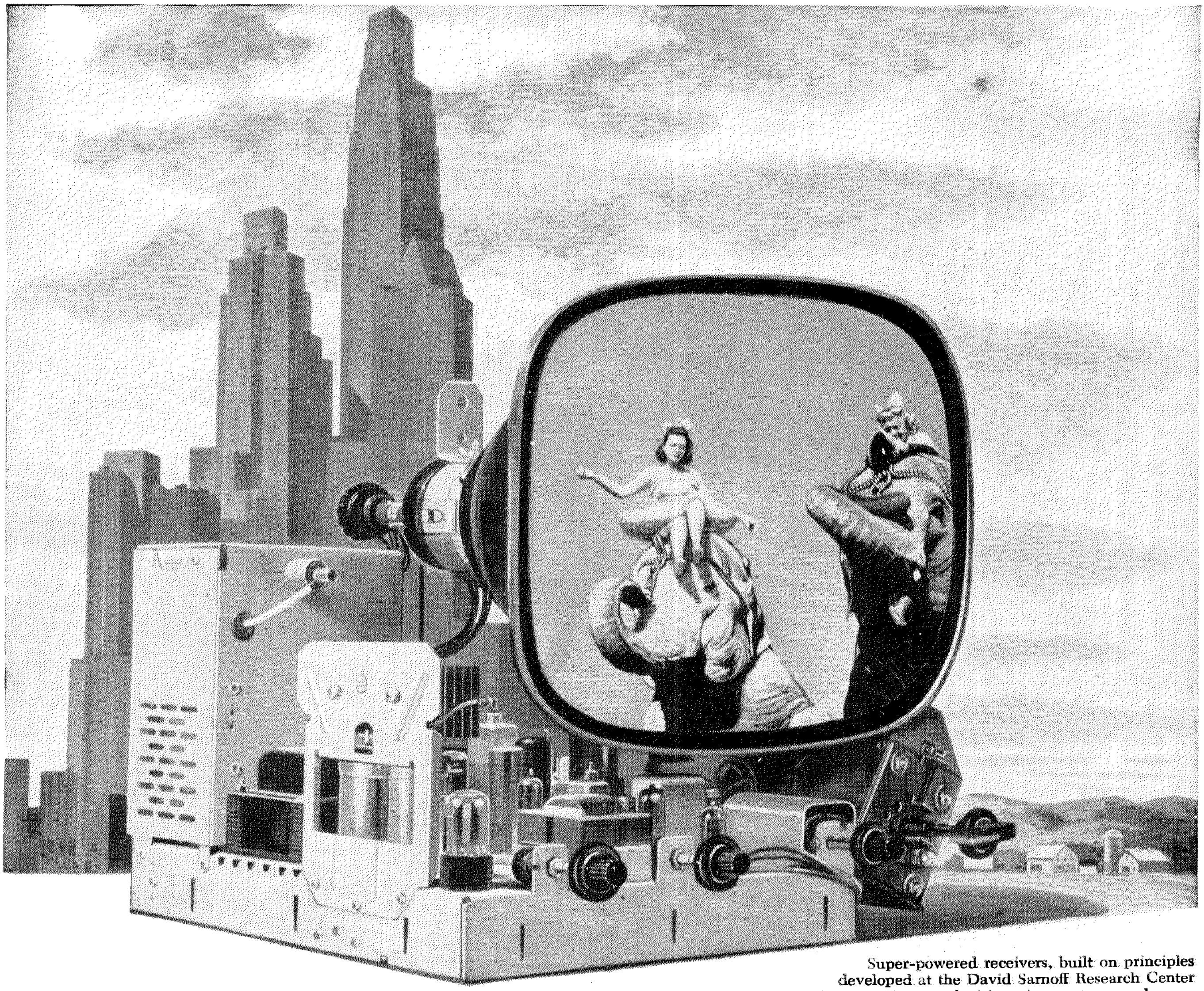
I would suggest a coordinated campaign to make available to high school students instructional tours of plants, with considerable emphasis on the specific functions and activities of the scientist and the engineer within the plant.

The second major activity is that of providing student scholarships to enable the needy students to go to technical school.

I would suggest that various industrial concerns provide scholarships for these students; that they establish contests for the promotion of engineering and science students with scholarships as the reward; that they provide the possibility for the most promising of their employees to go to engineering or technical school.

President DuBridge has suggested that the engineering societies get together and raise, by mutual industrial contribution, a scholarship fund to send to engineering schools each year, one hundred boys who cannot go without financial help. For $200,000 a year they could offer 100 four-year scholarships averaging $2000 each; that is, $500 a year to 100 of the most promising applicants—and his guess is that for each winner, about three to five others would have their interest sufficiently aroused by the contest, so that they would find other sources of funds, and go to college anyway.

Any or all of these procedures may be carried out by individual companies. However, it seems to me the ideal solution would entail the formation of a committee or foundation from among all industrial and engineering firms in an area. This group would have charge of the planning and execution of the procedures designed to relieve the shortage. The problem demands measures commensurate with the seriousness of the threat to the American way of life.



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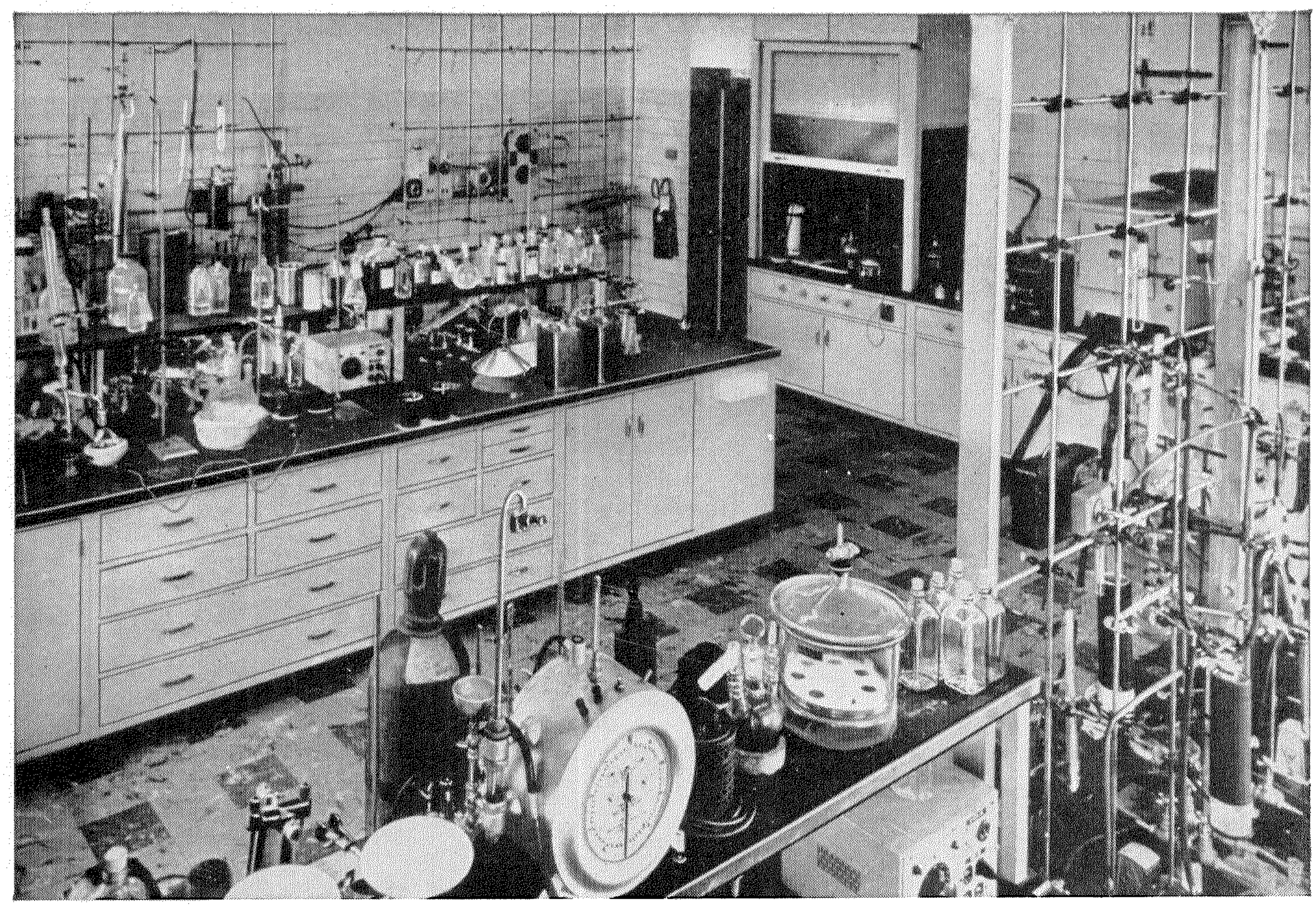

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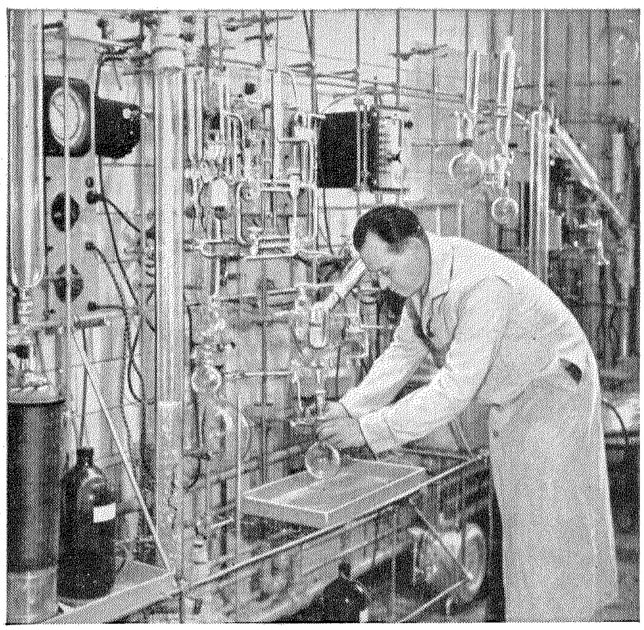
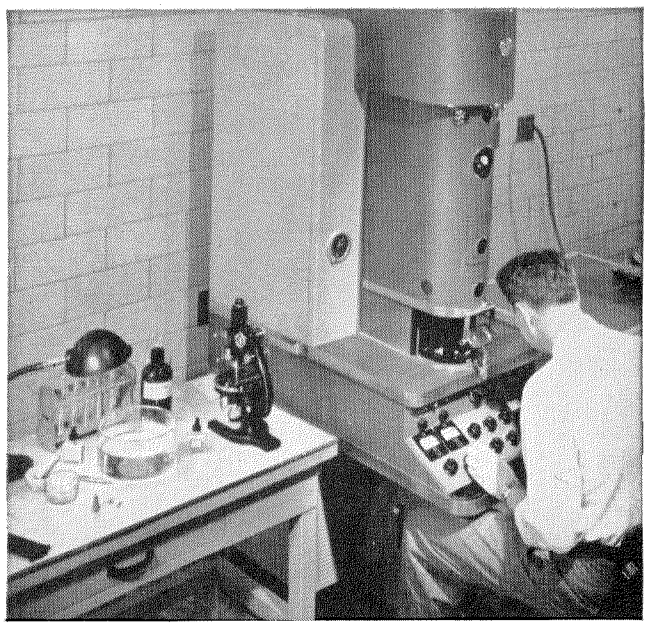


UNDER THE SINCLAIR PLAN, chemistry laboratories like these are open for the first time to independent inventors.



ELECTRON MICROSCOPE, capable of magnifying 100,000 times, is typical of the expensive equipment now available.

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Many inventive people have responded to the Sinclair Plan's offer of laboratory facilities—to others who wish to do so, a suggestion: There is promise and profit in oil-based synthetics.

EIGHT months ago, Sinclair turned over a part of its great laboratories at Harvey, Illinois, to independent inventors who had promising ideas in the field of petroleum products but who did not have the facilities needed to develop or prove out their ideas.

To date nearly 5,000 people have submitted ideas to the laboratories, and the Plan is recognized as a valuable service to independent inventors. As a result we have made the Sinclair Plan part and parcel of the long-range operation of our company.

There may be *inventive people interested in this Plan* but wondering what sort of ideas or what areas would be profitable to explore. To those people we suggest the field of petrochemicals. Such things as plastics, synthetics, substitutes and new materials as yet undeveloped—made from petroleum—offer great opportunities for invention and reward.

If you have an idea of this sort—or in the general area of petroleum products or applications—you are invited to submit it to the Sinclair Research Laboratories. In your own interest, each idea must first be protected by a patent application or a patent.

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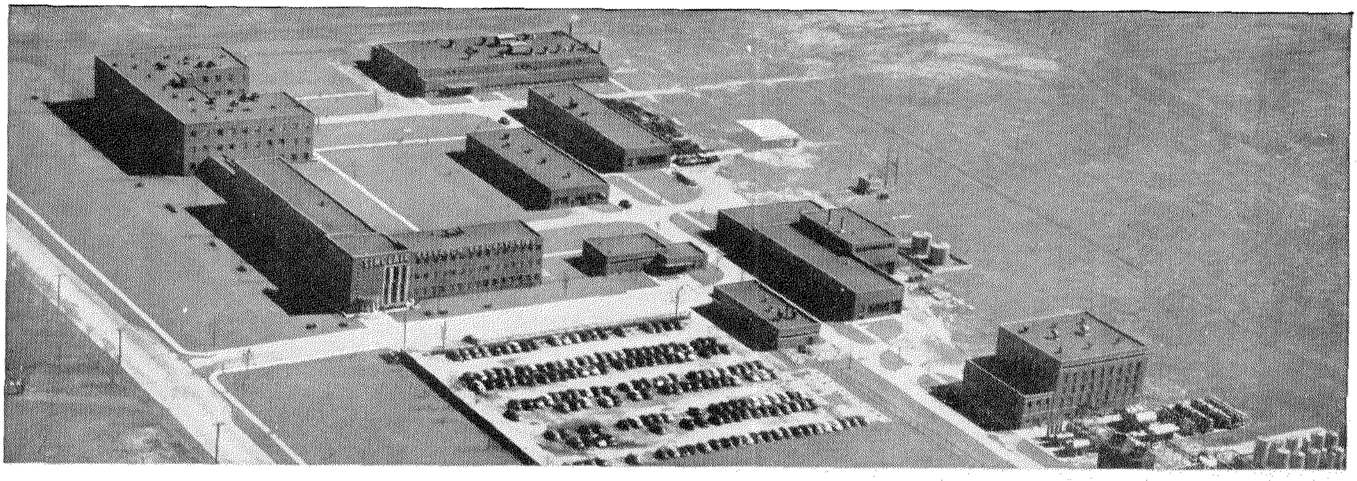
This agreement in no way hinders the inventor from selling his idea to any of the hundreds of other oil companies for whatever he can get. Sinclair has no control over the inventor's sale of his idea to others, and has no participation in any of the inventor's profits.

HOW TO PARTICIPATE: Instructions are contained in an Inventor's Booklet available on request. Write to: W. M. Flowers, Executive Vice-President, Sinclair Research Laboratories, Inc., 600 Fifth Avenue, New York 20, N. Y.

IMPORTANT: *Please do not send in any ideas until you have sent for and received the instructions.*



SINCLAIR RESEARCH LABORATORIES—nine buildings containing the most modern testing equipment known—have contributed many of today's most important developments in petroleum.

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SINCLAIR—for Progress

THE 1952 ECONOMY RUN

After their excellent performance in 1951, Caltech engineering students were again offered the privilege of being deputized official American Automobile Association Contest Board Observers for the 1952 Mobilgas Economy Run. The purpose of the Run is to provide an impartial, practical test of 1952 model automobiles under all kinds of driving conditions. It is sponsored by the General Petroleum Corporation, and sanctioned by the Contest Board of the AAA.

An AAA observer must accompany each contest car from the time it is arbitrarily selected from the manufacturer's assembly line, broken in (2000 miles maximum), and driven in the official run. During this time the observer is responsible for the automobile's stock status, for preventing additives or special petroleum products from being used, and for seeing that normal and legal driving techniques are used. Caltech engineering students are selected for this job because they are impartial, have a technical background, and seriously believe in the honor system.

Over a hundred students rushed to sign up for the 1952 Run, and Dr. Peter Kyropoulos, Assistant Professor of Mechanical Engineering, who supervises this activity, appointed Craig Marks, M.E. graduate student, to assist him in the organizational task. The thirty observers used on the final run were chosen from the original applicants on the basis of performance demonstrated during the break-in runs, experience (some were in last year's run), and ability to spare the necessary time.

The 1952 Run covered 1415.4 miles, from Los Angeles to Sun Valley. The first contest car made its official start from Los Angeles at 3 A.M. Monday morning, April 14. The other cars followed at two-minute intervals. The caravan headed toward Pomona on Highway 99, passed through Palm Springs about 6 A.M. and went on to Blythe, the first official refueling station. At Blythe the local high school band, with majorettes and cheer leaders, was on hand to give the contestants a first-class welcome. After refueling, the procession crossed the Colorado River into Arizona and proceeded through Prescott to Williams, the second refueling station, and on to the Grand Canyon, the first overnight stop. Total elapsed time allowed from Los Angeles to the Grand Canyon was 12 hours and 53 minutes, which most of the entrants used to full advantage.

The second day of the Run started at 1 A.M. Tuesday morning for the observers. Car assignments were made after breakfast and preparations were made for the 3 A.M. start. The second day's journey skirted the south rim of the Grand Canyon to Cameron, and headed north to the Marble Canyon refueling station. From Marble Canyon the motorcade proceeded up to the 8010-foot elevation of Jacob's Lake and down into Utah and Zion National Park, where there was a stopover for brunch.

From Zion the Run continued to Beaver, Utah, a refueling station, and on to Salt Lake City, where the cars were impounded on the grounds of the State Capitol for the second overnight stop. Elapsed time from the Grand Canyon on this leg of the trip was 14 hours. The observers refueled on steak dinners and hit the sack.

At 5:30 A.M. Wednesday morning activity began for the final leg of the Run. Observers were assigned and the first car started at 7:00 A.M. The route from Salt Lake City was through Ogden, across the Idaho border to Twin Falls for refueling, and then to Sun Valley. Elapsed time for this leg was 8 hours and 7 minutes, making a total elapsed time of 35 hours for the run, an average speed of 40.5 miles per hour for 1415.4 miles.

At Sun Valley the contest cars were leveled and their gas tanks filled to determine total fuel consumption for the Run. Results were computed on the basis of ton miles per gallon—or total weight of the automobile, plus payload in tons, times 1415.4 miles, divided by total fuel consumption in gallons. The sweepstakes winner was a Mercury Monterey driven by Bill Stroppe for a performance of 59.7 ton miles per gallon, or 25.4 miles per gallon. In addition, there were nine price-class winners and two special lightweight class winners.

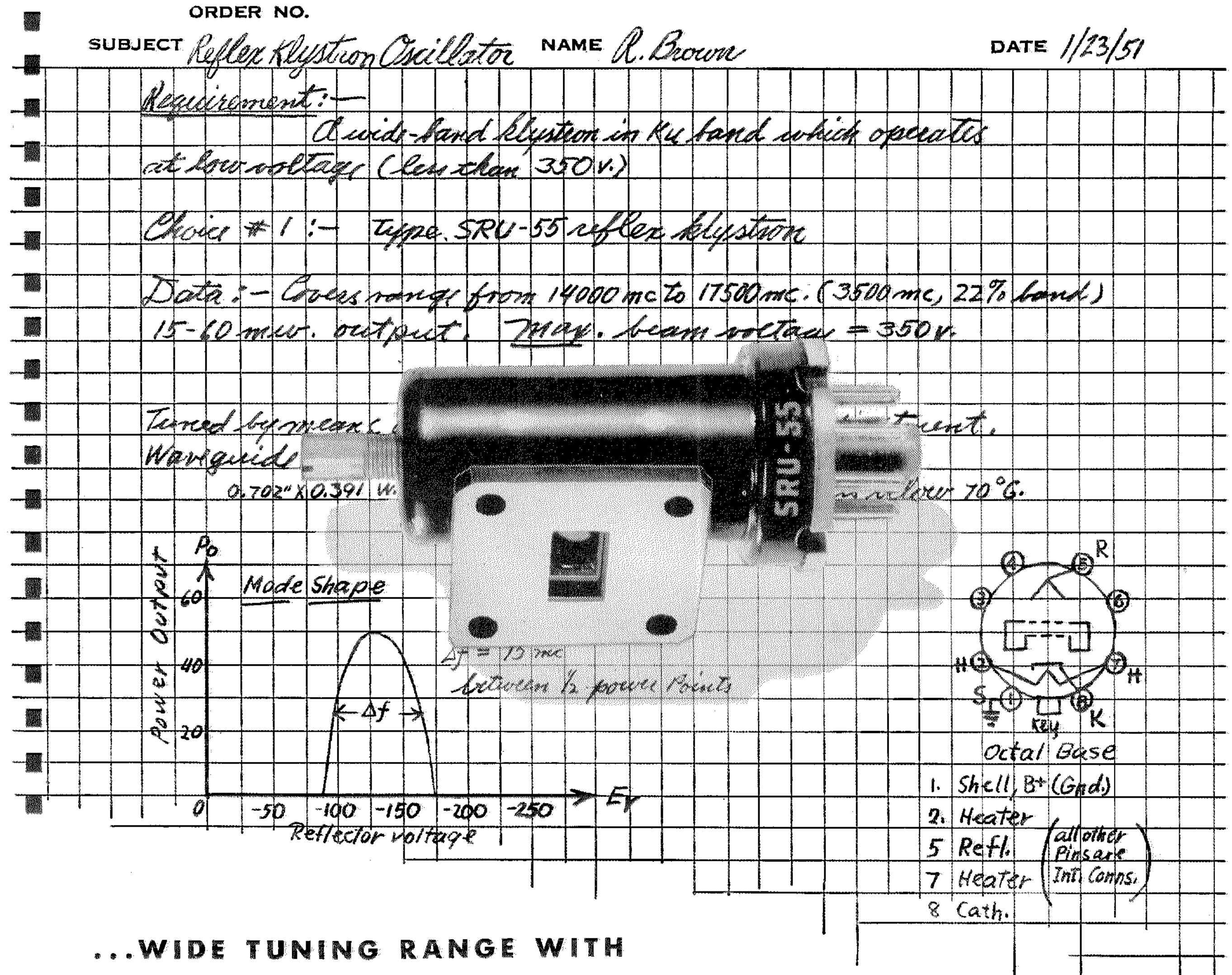
After final refueling the observers were finished with their official duties on the Run. Wednesday evening and all day Thursday were spent sightseeing, skiing, swimming and generally having a good time. The General Petroleum Corporation generously provided the meals, the ski lift, and a banquet. Each observer received fifty dollars plus expenses for the official Run and additional salary for break-in activity.

On Friday the Techmen boarded a Pullman car for a 30-hour return trip to Los Angeles on—it was generally agreed—the slowest train in existence.

Dr. Peter Kyropoulos deserves a great deal of credit for his excellent organization of observers' activities during the Run. As a token of appreciation Kyro's charges presented him with a plaid sport shirt for his square dance appearances. The observers' performance was highly complimented by the entrants, the AAA, and General Petroleum. And Clarence Beesemeyer, Executive Vice President of General Petroleum, was so moved by Kyro's candid phraseology in his observers' instructions that he quoted from them during the awards ceremony.

All in all the Economy Run shapes up as such a stimulating activity for Caltech students that there seems no reason why Kyro shouldn't have half the student body on his application list for 1953.

—Bill Wright '51



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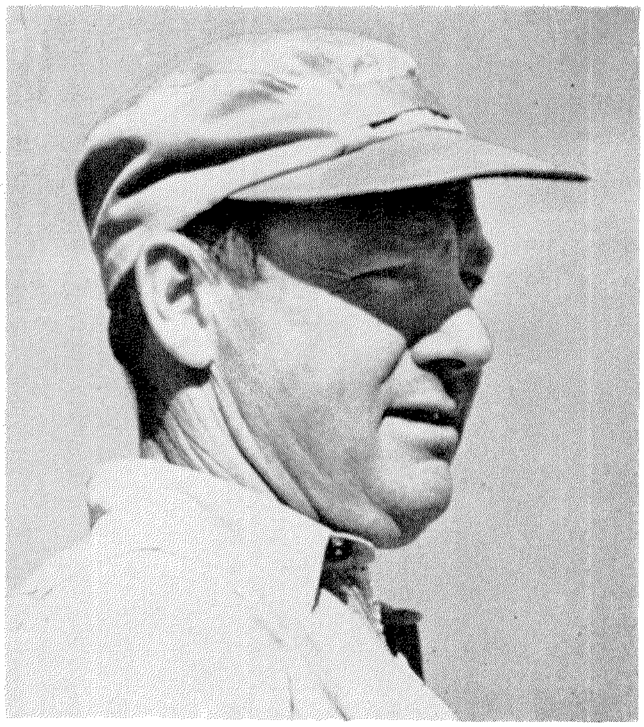


ROBERT P. SHARP

Professor of Geomorphology

LIKE MOST GEOLOGISTS, Robert P. Sharp spends as little time indoors as he can get away with. Since he is Professor of Geomorphology in the Institute's Division of the Geological Sciences, and in charge of the elementary geology course given to all Caltech sophomores besides, he is forced to spend a certain amount of time in classrooms and laboratories. Since he has also been serving, during the past year, as president of the Caltech Alumni Association, he is forced to spend a certain amount of additional time in conferences and meetings. Nevertheless, he would far rather—and, at the slightest excuse, does—take off to check on a glacier in Alaska, conduct a short trip into the field, or—all else failing—run around the track in Tournament Park.

Apparently all this outdoor activity has a highly salutary effect on his classroom teaching. His course, in fact, bears a certain resemblance to a Billy Graham revival, in the way it manages to convert unsuspecting students to the lifetime study of geology. And, as another tribute to his teaching, *Life* Magazine several years ago, through an intricately designed poll of students in 52 colleges, chose Sharp as one of Eight Great Teachers of 1950. Sharp is still highly suspicious of this poll, and—far from considering it an honor to have been named a Great Teacher by *Life*—maintains that it has taken most of the past two years to live down the reputation it gave him among his colleagues.

As an undergraduate at Caltech, Bob Sharp was a Good-Sized Man on Campus—a three-year letterman, quarterback on the football team, captain of the team in his senior year, as well as vice-president of the student body. He stayed on to get his M.S. here in 1935, then went to Harvard on a scholarship. He received his Ph.D. there in 1938, for a thesis involving a structural and physiographic study of the Ruby-East Humboldt Mountains in Nevada—an area which not only proved ideal for geologic study, but (Sharp took care to check this in advance) offered wonderful trout-fishing besides.

Sharp joined the faculty of the University of Illinois in 1938 and remained there until 1943, when he was commissioned into the Arctic, Desert and Tropic Information Center of the Army Air Forces.

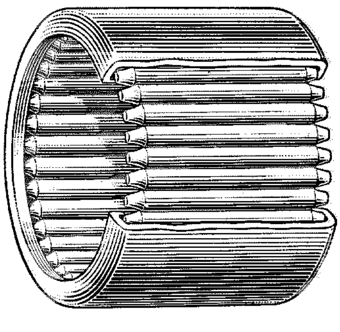
He served a good deal of the time in Alaska and the Aleutians. In a typical operation, Sharp, Bradford Washburn—a civilian photographer and explorer—and two volunteer Air Force flying officers were set down at the base of Mt. McKinley in Alaska, to camp on the glacier there and test Air Force cold weather equipment.

Sharp and Washburn were old hands at this kind of rugged camping, but the Air Force men had never seen the inside of a tent before. Theoretically, these four men had crash-landed. They were discovered by Search and Rescue, and supplies had been dropped to them. Their problem was, first of all, to survive—and, in the process, to find out how well this could be done with standard Air Force equipment.

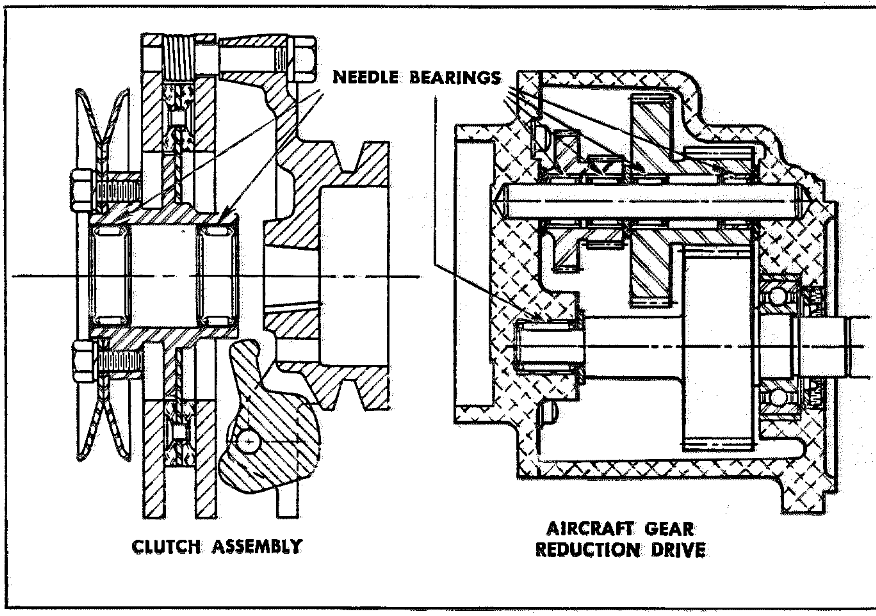
They had to work out the answers to such questions as: Can you sleep in a regular Air Force flying suit, without a sleeping bag? (Sharp's answer: No—not if you're interested in getting any sleep.) They also had to decide whether to sit it out on the glacier and take a chance on being picked up, or try to walk out to civilization.

CONTINUED ON PAGE 36

The Torrington Needle Bearing needs little space—saves time in assembly



The Torrington Needle Bearing is a completely self-contained unit consisting of a full complement of small diameter rollers and a single retaining shell. This unit design and construction greatly simplify handling and speed assembly, and help reduce the size and weight of related parts.



Typical installations of Torrington Needle Bearings are characterized by simplicity of design. Needle Bearings are made for shafts as small as 5/32" up to those as large as 7¼".

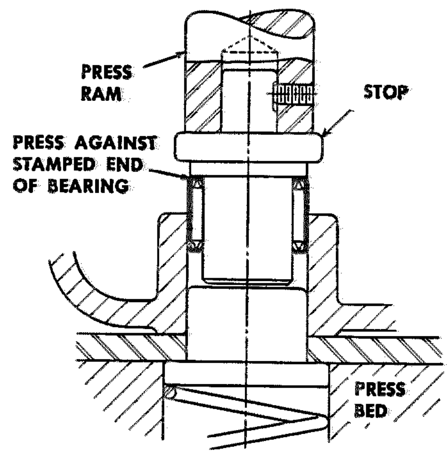
High Load Capacity in Small Space

Because the many rollers distribute loads over a large contact surface, a Needle Bearing has a very high load capacity in relation to its size. In fact, the Torrington Needle Bearing has a higher rated radial load capacity than any other type of anti-friction bearing of comparable outside diameter. This not only permits the use of a smaller, lighter bearing for a given load, but also allows reductions in the size and weight of housings and other related components. The Needle Bearing's large inside diameter permits larger shafts to be used in cramped quarters, an important factor in many designs.

Installation Simplified

The installation of Torrington Needle Bearings is fast and easy. The housing bore is simply machined to proper diameter. The bearing is then pressed into this housing. An arbor press is normally used for this operation. No spacers or retainers are needed to keep the bearing in place. An accurately made shaft is required, of course, as it serves as the inner race in most cases and must be hardened and ground to correct size. For applications where an unhardened shaft is desired or necessary, inner races can be furnished for all Needle Bearings.

These advantages make Torrington Needle Bearings ideal for applications where space or weight is at a premium, or where mass production methods necessitate the use of a bearing that is as easy as possible to handle and install.



The use of proper tools for installing Needle Bearings speeds up assembly. The arbor press tools above are ideal.

Other features of Torrington Needle Bearings will be covered in other advertisements in this series. For additional information regarding Needle Bearings, please contact our engineering department.

THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.
District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON NEEDLE BEARINGS

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • BALL • NEEDLE ROLLERS

They decided to walk, and came down the glacier, out to the Alaska Railroad. This trip took two weeks—the whole operation about two months. Sharp and Washburn stayed in good shape; they even gained a little weight on the junket. But the Air Force men had a rough time of it and lost between 10 and 15 pounds apiece. In fact, if they'd been alone, they probably would never have made their way out, and the strongest conclusion reached in this experiment was that inexperienced personnel, in the Arctic, shouldn't be expected to move away from the area in which they land.

After the war Sharp taught at the University of Minnesota, then came to Caltech as Professor of Geomorphology in 1947. Geomorphology is defined as the science of landforms, dealing particularly with their genesis and evolution. Unlike a good many other branches of geology, geomorphology deals with *present* geologic processes, and Sharp's special geomorphological interest is the activities of live glaciers. By studying these, he is better able to interpret features in the canyons of the Sierra Nevada, the Tetons or the Rockies, which were filled with similar streams of ice thousands of years ago.

Sharp began his studies of Alaskan glaciers in 1941, and he has returned, with field parties, for further observations during the summers of 1948, 1949 and 1951 (which have been reported in *E&S* for November, 1948, and January, 1951).

Traveling man

Though summer trips to cool climates are one of the pleasures of the geological life, it is nevertheless a fact that, of the past six summers, Bob Sharp has spent one (1) with his wife—not to mention assorted and periodic field trips which have kept him away from home during most of the other academic vacation periods.

As anyone can see, this is a matter that calls for a great deal of wifely understanding—of which, fortunately, Mrs. Sharp has a full share. This may be partly due to the fact that she was trained as a geologist herself. She received a B.A. in geology at Carleton College, an M.S. at Northwestern, and she would have gone on to get her Ph.D. if she hadn't decided to become Mrs. Sharp instead.

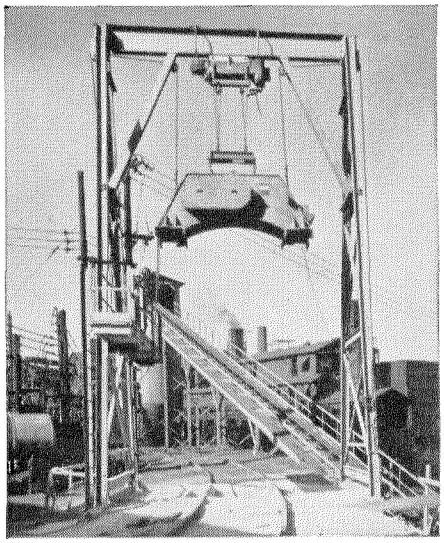
The Sharps now have a 17-month-old adopted daughter, and a pleasant house built about as close to the foothills as you can get in Altadena. Such ties of home and fireside, of course, exert a considerable influence on a wandering geologist. But a really seasoned geologist like Sharp can still bring some of the flavor of the field right into his home, when necessary, by scorning the effete bedrooms with which his house is equipped and sleeping, in solid comfort—outdoors.

"Find Yourself"

. . . without losing time!

by FLOYD O. SMELTZ, *Supervisor, Standardization Section*
WEST ALLIS WORKS (*Graduate Training Course 1950*) *Ohio State—EE—1949*

SELECTING a specific job in the engineering field after graduation from college is a tough proposition for most of us. It was for me, and that's why I came to Allis-Chalmers. I thought I wanted to be a development engineer but I wasn't sure. Allis-Chalmers Graduate Training Course gave me an opportunity of trying design and development—and other types of work also. By my own choosing I am now engaged in challenging work which I hadn't even



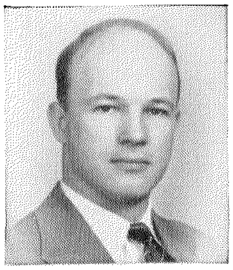
Allis-Chalmers car shaker empties coal and ore cars in minutes. Saves time . . . prevents injuries by keeping men out of car interiors.

considered while in school. The point is, all GTC's have the same chance of "finding themselves."

That's the outstanding feature of Allis-Chalmers Graduate Training Course. You have a very broad selection, and you yourself choose the type of training you receive. Of course you get help and guidance from experienced men throughout your training period. You need it, since there are jobs here that you have never dreamed of.

Finds Job Challenging

Take my job for instance. To the engineering student it probably sounds rather dull when compared with Advanced Thermodynamics or Electric Transients in Power Systems. But, in my opinion, the



FLOYD O. SMELTZ

most fascinating science is co-ordinating engineering and production efforts through standardization of procedures, parts and materials. As Supervisor of the Standardization Section and Chairman of the Standards Committee, I encounter new problems every day—no monotony here.

But that is only part of the story! I am also Secretary of the Chief Engineers' Committee and Secretary of the Development and New Products Committee. What could be more stimulating for a young engineer than to be at the crossroads, where he can watch the engineering planning of an expanding company?

No Limit to Opportunities

I never thought I'd be doing this when I graduated from Ohio State in 1949 and enrolled in Allis-Chalmers Graduate Training Course. As I mentioned, I was particularly interested in design work at that time. In fact, right now there is a patent applied for on an electro-magnetic relay device I designed. Yes, they even let me do development work while still a GTC student.

A student helps plan his own courses and is free to change his plans as new interests, new opportunities present themselves. He can divide his time between shops and offices—switch to design, manufacturing, research, application engineering, sales, or advertising—and can earn advanced degrees in engineering at the same time.

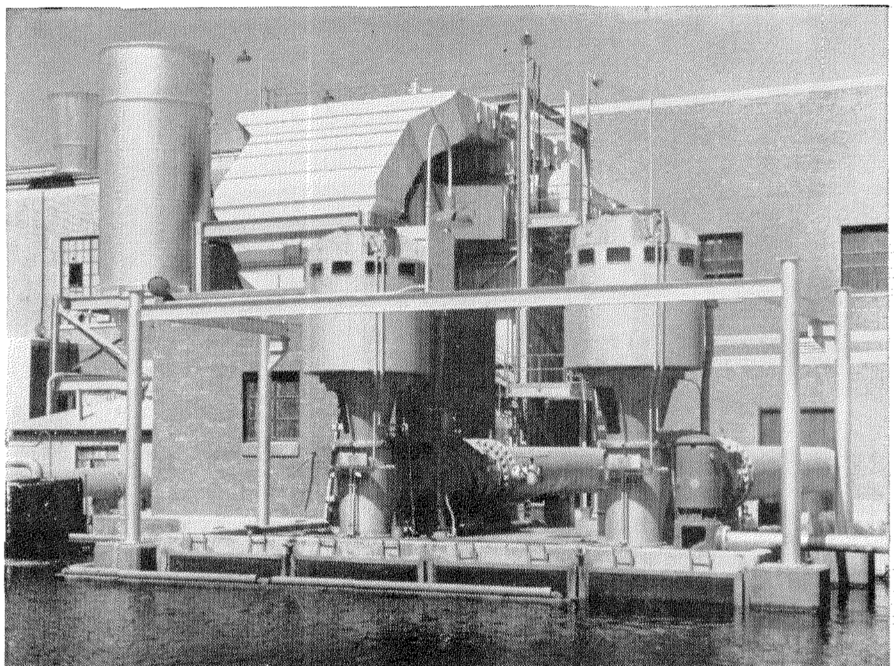
When he graduates from the course he is encouraged to go into the type of work he liked best while on the Graduate Training Course.

One of the reasons Allis-Chalmers offers so many opportunities is that A-C designs and builds machines for every basic industry, such as: steam and hydraulic turbine generators, transformers, pumps, motors, rotary kilns, crushers, grinders, coolers, screens, and other machinery for mining, ore processing, cement, and rock processing. Then there are flour milling, electronic equipment and many others.

There is no other organization that seems to me to offer the graduate engineer such a wide range of activities, or that gives him such a chance to find the type of work for which he is best fitted.

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin



Weatherproof motors for condenser cooling water circulating pumps were mounted outdoors to conserve valuable building space for a Texas utility.

THE MONTH AT CALTECH

National Academy

DR. RICHARD M. BADGER, Professor of Chemistry, and Dr. Carl G. Niemann, Professor of Organic Chemistry, have been elected to the National Academy of Sciences. Their election brings the present Caltech staff membership in the Academy to twenty-five.

Professor Badger has principally been engaged in spectroscopic studies of complex molecules in the infrared, visible and ultraviolet regions. He is currently investigating the structures of compounds related to proteins. His early studies helped to establish the existence of the hydrogen bond, in which a hydrogen atom links two molecules or parts of the same molecule. He also formulated Badger's rule, expressing the relationship between the forces acting between two atoms and the distance separating them. The rule has been useful in chemical thermodynamics as well as in determining the structure of molecules.

During the second World War he worked on fundamental physical problems for the Manhattan District and investigated the properties of smokeless powder for the Navy Bureau of Ordnance. He also was engaged on projects for the Office of Scientific Research and Development and the Army Air Corps.

Professor Badger received his B.S. from Caltech in 1921, and has been a member of the faculty here since he received his Ph.D. in physical chemistry in 1924. After four years as a Research Fellow he spent a year at Goettingen and Bonn, Germany, as an International Research Fellow. On his return in 1929 he became an Assistant Professor of Chemistry, was promoted to Associate Professor in 1938 and to Professor in 1945. He is a member of the American Physical Society and of Sigma Xi.

Professor Niemann's research has primarily concerned the chemistry of natural products such as carbohydrates, amino acids and proteins, and fatty substances occurring in nerve tissue. He is now investigating the properties of proteolytic enzymes, some of which help break up proteins into their constituent amino acids, while others help form proteins from amino acids. He has synthesized and studied the structure of a compound whose activity resembles that of thyroxine, a product of the thyroid gland which controls metabolic rates in the body.

His work in the second World War dealt mainly with methods of identifying and anaylzing chemical warfare agents. He was in charge of a section of the National Defense Research Committee working on this problem at the Institute, was an investigator for the Committee on Medical Research and scientific advisor and consultant to the Office of Field Services, U.S.A., in the Southwest Pacific area. For his war work he received a presidential certificate of merit in 1948.

Professor Niemann received the Ph.D. degree at the University of Wisconsin in 1934, did further research there, at the Rockefeller Institute for Medical Research in New York and, as a Rockefeller Foundation Fellow, at the University College Hospital Medical School in London. He joined the Caltech faculty in 1937 as an Assistant Professor, became an Associate Professor in 1934 and Professor two years later.

He is a member of the American Chemical Society, American Society of Biological Chemists, Chemical Society of London, American Association for the Advancement of Science and Sigma Xi.

Institute Officials

GEORGE W. GREEN, Business Manager, has now been elected Comptroller of the California Institute of Technology, reporting to the Board of Trustees as the fiscal officer of the Institute. Herbert H. G. Nash, Assistant Secretary, has been elected Secretary of the Institute. In these positions the two men succeed the late Edward C. Barrett, who served the Institute as both Comptroller and Secretary for many years before his death last February.

George Green came to Caltech in 1947 as manager of the accounting office. He had been with the Price Waterhouse Company for ten years before joining the Institute staff, and during the last war he served as a Lieutenant in the U. S. Navy. He was appointed Business Manager of the Institute in 1948. He is a certified public accountant and a 1937 graduate of the University of California at Los Angeles, where he studied business administration.

Bert Nash came to Caltech in 1922 as chief accountant, from a similar position with the North Star Oil Company

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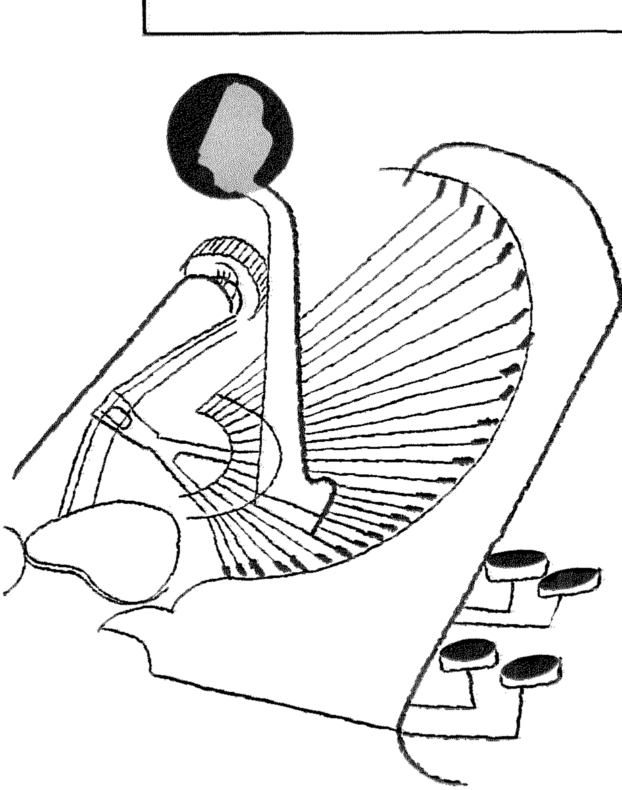
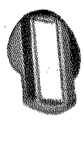
What's Happening at CRUCIBLE

about special shape type steel



5. The flash trimmed off after the swadging operation.



6. The finished type ready for hardening, plating and soldering to the type bar.

The production of Crucible steel for this job is the result of engineering and practical know-how combined with a special method of manufacture to assure a homogeneous microstructure for maximum forming properties, excellent surface characteristics for good die life, and close accuracy control for all dimensions of the shape.

The production of type steel requires the use of small precision rolling mills equipped with shaped rolls and operated by skilled workmen. During preliminary and *final inspection, shadowgraph equipment is constantly* used to check for size accuracy.

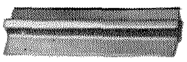
As a result of its outstanding quality, Crucible's special shape type steel is constantly in demand and used by leading typewriter manufacturers.

Crucible special purpose steel for type character application

The development of cold rolled special shape type steel is one of Crucible's important contributions to the business machine industry. A major part of the type characters used for the manufacture of typewriters are made from this special shape.

Here's the step-by-step process:

1. Cold rolled special shape produced by Crucible.



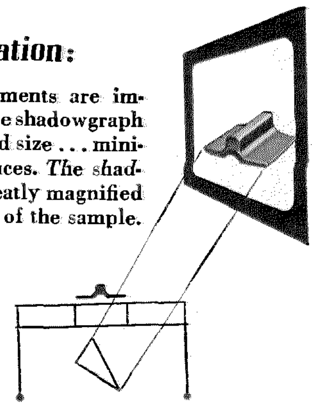
2. The type slug cut from the special shape material.

3. The wings of the type slug are *bent down and* taper formed toward the edges.

4. The type characters are cold *swadged on the* solid edge of the bent type slug.

Shadowgraph Operation:

Since micrometer measurements are impractical due to the shape, the shadowgraph is used to measure shape and size ... minimum and maximum tolerances. The shadowgraph is a projection, greatly magnified ... on a calibrated screen ... of the sample.



Schematic of shadowgraph

If you have a requirement for special steels—check with Crucible. Feel free to draw on the experience of our metallurgists and engineers. Crucible Steel Company of America, General Sales and Operating Offices, Oliver Building, Pittsburgh, Pa.

CRUCIBLE first name in special purpose steels

52 *years of* Fine *steelmaking*

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

in Winnipeg, Canada. A native of England, he moved to Canada at an early age and served in the Canadian Army during the first World War. He became an American citizen in 1933. He had been Assistant Secretary of the Institute since 1935.

Guggenheim Fellows

Four Caltech scientists have been awarded research Fellowships by the John Simon Guggenheim Memorial Foundation.

Dr. Harrison Brown received a three-year Fellowship and Drs. Jerry Donohue, Kenneth W. Hedberg and Marguerite M. P. Vogt, one-year Fellowships.

The Caltech recipients were among the 191 persons announced by the Foundation last month as winners of its annual grants to further the development of scholars, writers, artists and composers who have demonstrated an unusual capacity for research or unusual creative ability in the arts.

Dr. Brown, who came to Caltech from the University of Chicago last year as Professor of Geochemistry, received his Fellowship for research combining techniques of radiation chemistry and geology in search of new information about the history and construction of the earth.

His program includes setting up a geological time scale based on studying isotopes of lead found in ancient rocks and on Carbon 14 dating techniques for events within the past ten thousand years. He will also study the influences of geologic processes on the changes of isotope ratios occuring in nature, and the distribution of common as well as trace elements in rocks and minerals.

Dr. Donohue, a Senior Research Fellow in Chemistry, received his Fellowship for a program concerning X-ray analysis of the structure of crystalline proteins. He plans to leave in September for a year's study of methods used to determine protein structures at the University of Cambridge and Oxford in England.

He has been at Caltech since 1943. He received his Ph.D here in 1947, and has been associated with Professors Linus Pauling and Robert B. Corey in research which has produced information on the configuration of several amino acid and protein molecules (E&S—October, 1951).

Dr. Hedberg, Research Fellow in Chemistry, was awarded a Fellowship for research on the structure of gas molecules, particularly some of the oxides of nitrogen. He intends to leave next September for a year's

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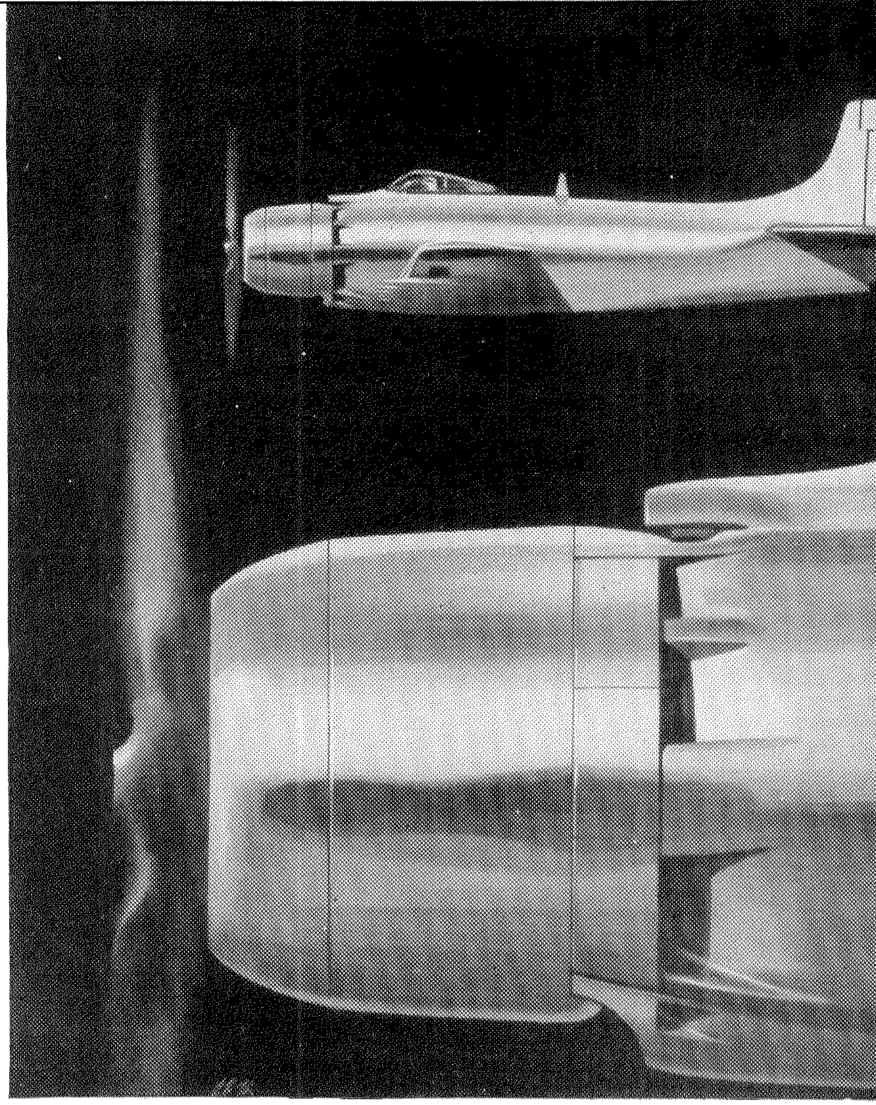
No Faster Finish



PROBLEM . . .

. . . finishes for aircraft and other military needs which can be applied fast, dry fast without baking, and stand up under severe service conditions.

SOLUTION . . .

. . . hot-spray lacquers now made by many companies from Hercules® nitrocellulose. These new lacquers, thinned by heat rather than solvents, permit more actual lacquer to pass through the spray gun. Now, one hot coat frequently does the job where two coats had been used.

COLLEGE MEN . . .

This is but one example of the far-reaching chemical developments in which you could participate at Hercules—in research, production, sales, or staff operations. It suggests the ways Hercules' products serve an ever-broadening range of industries and end-uses.

Hercules' business is solving problems by chemistry for industry . . .

. . . insecticides, adhesives, soaps, detergents, plastics, paint, varnish, lacquer, textiles, paper, rubber, to name a few, use Hercules® synthetic resins, cellulose products, chemical cotton, terpene chemicals, rosin and rosin derivatives, chlorinated products, and other chemical processing materials. Hercules® explosives serve mining, quarrying, construction, seismograph projects everywhere.

HERCULES

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study of electron diffraction techniques used by Professors O. Hassel and Otto Bastiansen at the University of Oslo, Norway. In addition to the Guggenheim Fellowship, he has received a Fulbright Award for this purpose. Dr. Hedberg has been on the Caltech staff since he received his Ph.D. here in 1948.

Dr. Vogt, Gosney Research Fellow in Biology, was awarded her Fellowship for studies of the mechanism of genetic recombination in bacteria. Dr. Vogt received the M.D. degree in Berlin in 1937. She then spent a year in research on Drosophila at the Institute of Biological Physiochemistry in Paris and did research in physiological genetics at her father's Hirnforschungs Institute, in Neustadt, Germany, until 1950. Dr. Vogt came to Caltech in September, 1950, and has since been doing work in bacterial genetics.

National Science Foundation

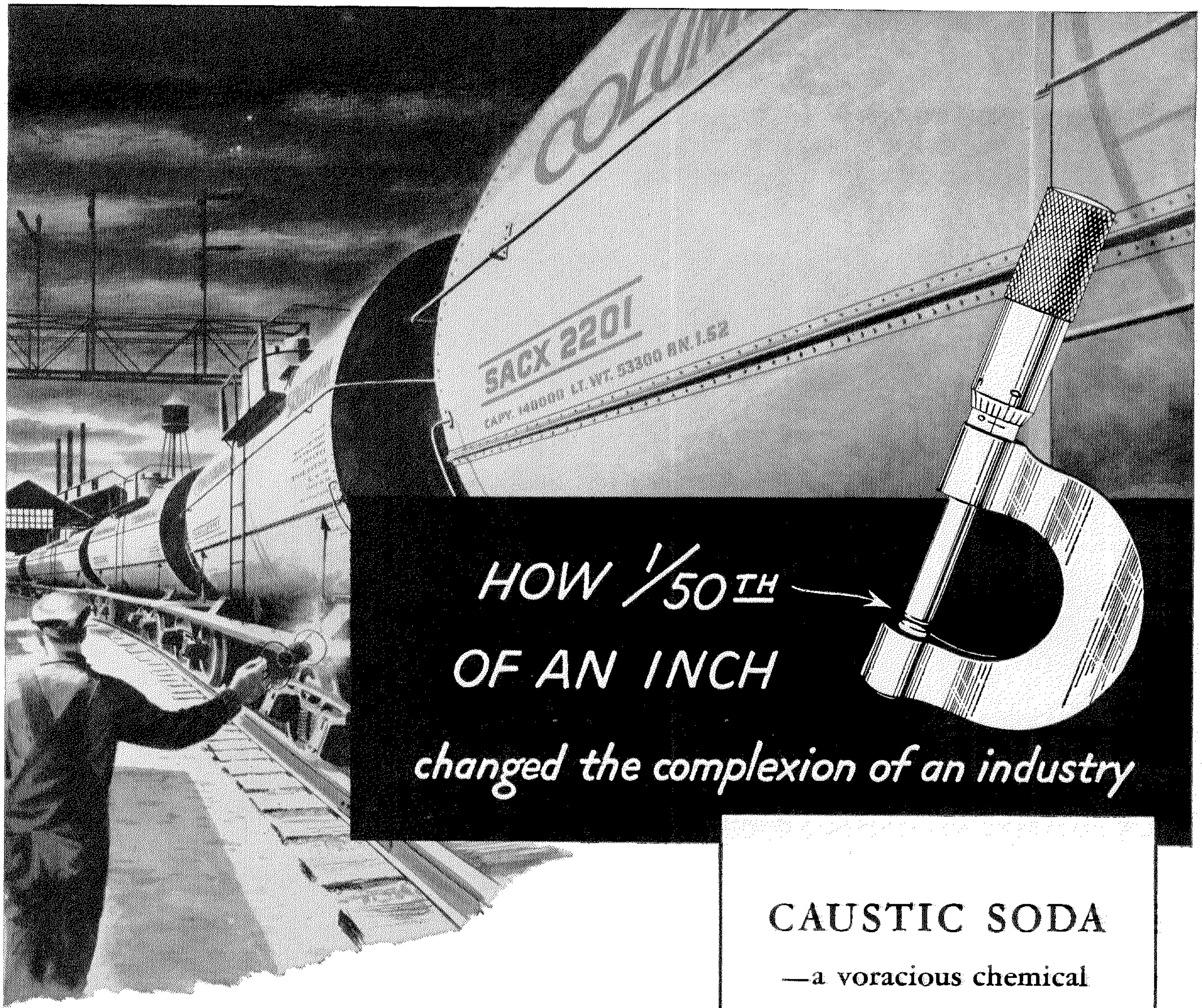
EIGHTEEN GRADUATE students at the California Institute of Technology and a research fellow at the Mount Wilson and Palomar Observatories are to receive National Science Foundation Fellowships for 1952-53.

They were among 624 persons throughout the country who were approved for the awards by the National Science Board, of which Caltech President Lee A. DuBridge is a member. Of these, Dr. DuBridge noted, 34 selected Caltech as their intended place of study, establishing the Institute among the first four in popularity. It was outranked only by the University of Chicago, M.I.T. and Harvard.

Postdoctoral fellowships will go to Dan L. Lindsley, Atomic Energy Commission Fellow in Biology, who expects to receive his Ph.D. this year; and Dr. Malcolm P. Savedoff, National Research Council Fellow at the Mount Wilson and Palomar Observatories. Lindsley plans to study at Princeton University and Savedoff at the University of Leiden, the Netherlands.

Predoctoral fellowships go to 17 men, all of whom plan to remain at Caltech: Robert L. Metzenberg, Jr.—biology; James A. Ibers, Paul J. Shlichta, Gary Felsenfeld, Walter C. Hamilton, and Joseph Kraut—chemistry; Norman H. Brooks, and William V. Wright, Jr.—engineering; Clarence R. Allen—geology; Lee M. Sonneborn, George H. Trilling, Stanley A. Zwick, Michael Cohen, Roy W. Gould, Robert J. Mackin, Jr., Victor A. J. van Lint, and William D. Warters—physics.

The National Science Foundation's predoctoral fellowships pay tuition and basic stipends ranging from $1400 to $1700, plus dependency allowances. Its postdoctoral fellowships have basic stipends of $3000, plus dependency allowances.



HOW 1/50TH OF AN INCH changed the complexion of an industry

A lining for tank cars which is only 1/50th of an inch thick—scarcely more than a film—first made practicable the shipment of liquid caustic soda in high concentrations without metallic contamination. As numerous processes necessitate the use of caustic in its purest form, this Columbia-Southern development has enabled many companies to effect economies in their use of this essential raw material.

In spite of its thinness, this patented lining effectively seals the caustic from the steel of the tank car, and its purity—even at highest concentrations—is safeguarded throughout transit.

This is one of a number of notable contributions to industry which have made Columbia-Southern one of the nation's great producers of alkalies and related chemicals.

CAUSTIC SODA

—a voracious chemical

The usefulness of caustic soda to industry is based upon this very power to attack and break down the chemical structure of many materials. In the manufacture of rayon, for example, caustic soda digests and purifies the cellulose . . . in the making of soap, it decomposes fats. This chemical activity of caustic soda makes it a vital raw material in a wide variety of industrial applications, and especially in the manufacture of other chemicals.

COLUMBIA-SOUTHERN CHEMICAL CORPORATION

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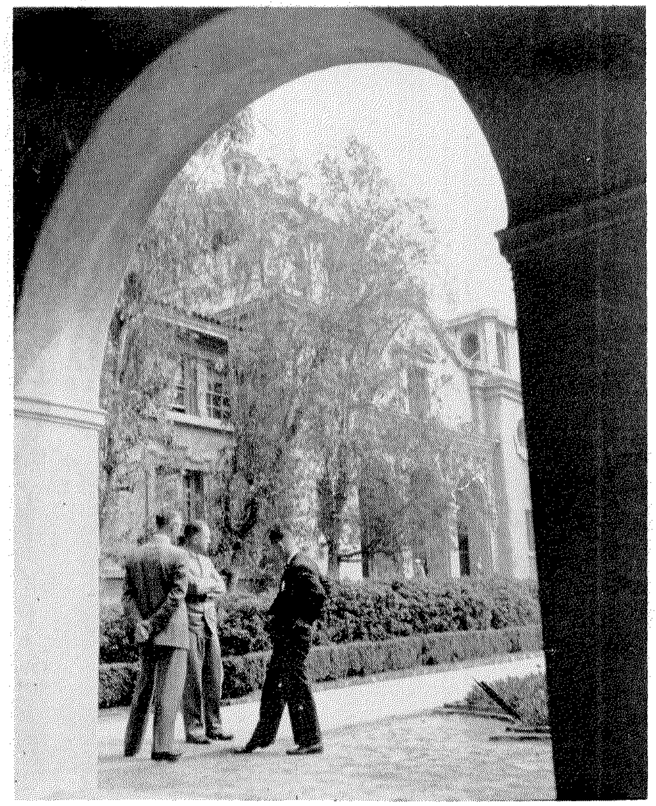
ALUMNI NEWS



Seminar Day, 1952

Seminar

More than 300 alumni, with their wives and guests, attended the Fifteenth Annual Seminar at the Institute on Saturday, April 12th. Next to last year's spectacular Seminar Day, when 500 people showed up, it was the best-attended Seminar in recent years. The credit goes to Gerald P. Foster '40, Director in Charge; Kenneth F. Russell '29, Chairman; the Program Committee consisting of C. Vernon Newton '34, Hugh C. Carter '49, Ray E. Kidd '34, and John C. Stick, Jr. '35; E. Harold Gandy '24, in charge of Public Relations and Printing; Frank E. Alderman '30 and Herbert C. Worcester '40, who handled the Catering; George C. Barber '40, Registration; and Ernest R. Hugg '29, Institute Relations.

In this, and the following months, *E&S* will print a number of the Seminar Day talks. Dr. J. E. McKee's "Fluorides" appeared in our April issue; Dr. John Weir's "Engineering Crisis" is on page 23 of this May issue, and Dr. A. J. Haagen-Smit's "Smog Research" is on page 11. Coming up: Harrison Brown's talk on "Natural Resources and Human Population."

Chapter Notes

The New York Chapter of the Caltech Alumni Association met on Thursday, April 24, for a dinner meeting at Whyte's Restaurant. L. Winchester Jones, Registrar and Dean of Admissions at the Institute, was the speaker of the evening, and talked on "Current Activities at Tech."

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SECRETARY-TREASURER — Arnold L. Grossberg '42
California Research Corp., 576 Standard Ave., Richmond

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

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U. S. Coast & Geodetic Survey

SECRETARY-TREASURER — Charles R. Cutler '45
830 World Center Building

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2203 13th St.

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Armour Research Foundation, 35 W. 33rd St.

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

SECRETARY-TREASURER — Harrison Lingle '43
Cherry Burrell Corp., 427 W. Randolph St.

PERSONALS

1922

Donald F. Shugart is president this year of the Structural Engineers Association of California. Last year he was president of the Structural Engineers Association of *Southern* California. Don moved his office to Pasadena over three years ago, and handled the structural work for the recently completed Parish building for the Pasadena Presbyterian Church at Colorado and Madison Streets. He also handled the design and construction of the new city refuse loading dock on South Raymond Avenue in Pasadena. He is now designing structures for two new buildings at the University of California at Santa Barbara. The Shugarts have two younger children still in school. Their older daughter, Margaret, now married, is teaching school in Duarte; and their son Alan, also married, and with a daughter nearly a year old, is working for International Business Machines in Santa Monica.

1925

J. H. Walker, Jr. reports that the Walker Potteries factory in Monrovia was totally destroyed by fire on February 17th. A new and larger plant is approaching completion on the same site, and production will be resumed this month.

Newton Templin was recently appointed Division Engineer in the Construction Division of the L. A. County Road Department.

Clarence Weinland, Ex., is now head of the applied research branch of the rocket department at the U. S. Naval Ordnance Test Station in Inyokern. Clarence became a grandfather recently — by courtesy of his daughter, Mrs. Shirley Hentzell. His son, Robert, is a sophomore in Burroughs High School in China Lake.

Michael C. Brunner is with the Petroleum Administration for Defense in Washington, working in the Production Division as Assistant Director. After his graduation from Tech in civil engineering, Mike worked for the Bethlehem Steel Corporation in Pittsburgh and in Los Angeles. In 1926 he went to work for the exploration department of Shell Oil Company and held various engineering positions before being named assistant to the president in San Francisco. In 1940 he was transferred to the Houston, Texas, area and made assistant to the exploration manager there. Upon joining the Army in 1941 he served as captain of engineers on Air Force construction, and later as director of research and training publications at the Engineer School at Fort Belvoir. He left the army in 1945 with the rank of colonel, and rejoined Shell Oil at Houston as assistant to the vice president of exploration and production. In 1947 he became production superintendent of Shell in New Mexico and a year later was made production manager of the Midland, Texas, area. Mike expects his present assignment with the Petroleum Administration for Defense to terminate next December, at which time he'll return to the Shell Oil Company again.

1926

P. E. Parker has been made District Superintendent of the Vernon City District of the Southern California Edison Company. He's living in Alhambra.

Bruno Schabarum was recently elected to the presidency of the Carl B. King Drilling Company of Midland, Texas. Bruno joined the company in 1944 as an engineering executive, and was promoted to general manager in 1949.

Eugene Kirkeby has recently recovered from an obscure nervous disease which had afflicted him since 1937. At that time, while working for the Union Oil Company, he found it necessary to give up his job and retire from business. A year and a half ago, he began taking a drug, artane, which was brought to his attention by an article in the *Saturday Evening Post*, and which helped him enormously. He is now able to take an active part in running a clothing store with his brother in his home town, San Luis Obispo.

1927

V. Wayne Rodgers was recently elected president of the Patent Law Association of Los Angeles for the next year. He is now a partner with *Alfred Knight* '22 in patent solicitation work.

1928

Harvey E. Billig, Ex., is medical director of the Billig Clinic for Rehabilitation in Los Angeles, and Professor of Physical Rehabilitation at Pepperdine College. He is leaving May 9th for Europe to give a series of talks for the International College of Surgeons. These will include the presentation of a paper at the 8th International Assembly of the International College of Surgeons, May 19-24, in Madrid, Spain, discussing an original new surgical method for correcting angulated bones.

1931

Carl F. J. Overhage, M.S. '34, Ph.D. '37, has been working at M.I.T., assisting in the establishment of a large Air Force project, for over a year. He is on leave from the

Color Control Laboratory at Eastman Kodak Company in Rochester, and expects to be back there by summer.

1932

Mills S. Hodge, M.S. '33, is Industrial Relations Supervisor at the Proctor and Gamble factory in Long Beach, and director of the Long Beach Chamber of Commerce. Since it's no longer his profession, he says, he's doing radio and TV servicing as a hobby.

Robert B. Freeman, M.S. '33, Ph.D. '36, has been made Assistant to the Vice President in Charge of Operations of the Columbia-Geneva Steel Division of United States Steel. He started his industrial career as a metallurgist at the Torrance, Calif., Works of Columbia, and was transferred to the San Francisco headquarters office in 1938. In 1941 he was named Metallurgist at the Pittsburg, Calif., Works, and three years later became Works Metallurgist. He was appointed Chief Metallurgical Engineer in November, 1948.

Bob is a member of the American Iron and Steel Institute, the American Society for Metals, the Association of Iron and Steel Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Testing Materials, and the British Iron and Steel Institute. He and his wife and two children live in Millbrae, Calif.

1933

C. G. Schulze has joined the staff of Century Engineers, Inc. in Burbank, as a design specialist in the Preliminary Design Division. He is spending full time on proprietary article development.

1934

Everett H. Pier died on April 8th, of a heart attack, at Las Cruces, New Mexico. Everett was engineer in charge of electric and electronic installation in guided missiles for the Santa Monica division of Douglas Aircraft. After graduating from Caltech he was employed by the Shell Oil Company in electronic research, and joined the Douglas engineering staff as a design specialist in 1941.

Jack Higley reports that they now have *four* children: Joanna, Paul, Larry, and John, with ages ranging from six to one, in the above order. Everyone is doing very well, with minor exceptions such as the present, when all four have the measles. They have outgrown their house, too, and have moved to a new one only a few miles away, in Newton Center, Massachusetts. Jack is still with the Transducer Corporation, but has a new job as Assistant Chief of Research and Development.

1937

Harry H. Carrick, M.S. '39, has been transferred as Assistant to Superintendent from the San Joaquin Division of the General Petroleum Corporation to the Southern Division. He will work under Division Superintendent *E. V. Watts* '36.

1939

C. Howard Craft has recently been made manager of the Research and Development Department of the Engineering Division of Menasco Manufacturing Company in Burbank. Menasco makes hydraulic aircraft landing gear. The Crafts, with their three children—ages 6, 8, and 10—live in North Hollywood.

J. J. Browne has been promoted to Assistant to the Superintendent in the San Joaquin Division of the General Petroleum Corporation. He will work under the Division Superintendent, *D. G. Kingman*, M.S. '29.

1940

Donald H. Kupfer is to be married on June 7th in Washington, D. C., to Miss Romaine Littlefield, a fellow geologist and member of the U. S. Geological Survey. The Kupfers then hope to come to California and establish a home in the Southland.

1942

Criss Schwarzenbach and his wife have just completed a trip through Central America to Peru and back in a private plane. Criss is still president of U. S. Propellers in Pasadena.

1945

Thayne H. Young married Louise Lear of Sierra Madre on April 18. Thayne is on the engineering staff of the Guy F. Atkinson Company, now building the new Colorado Street bridge in Pasadena. Louise is a teacher of corrective speech in the school for cerebral palsied children in Altadena, and a graduate of Santa Barbara State University. The couple are living in Sierra Madre.

1946

Larry Haupt, M.S. '47 and *Harvey Lawrence* '47 got their pictures in the local paper in connection with setting up an amateur radio automatic relay station on Signal Hill for the amateur group participating in Long Beach civil defense.

Richard P. Schuster, Jr., M.S. '49, is Plant Manager of U. B. Bray Company in East Los Angeles. He and his wife are planning to move to Pasadena or San Marino soon.

Bill Bongardt is still working for the L. A. County Road Department, along with *Marvin Blair*, '48, M.S. '49, *Joe Williams* '48, M.S. '49, and several other recent Tech grads. His new boss is *Newton Templin* '25. The Bongardts moved into their new home in North Hollywood last year.

1947

Donald B. Seager, M.S., Engr. '48, has been an aerodynamics engineer at Lockheed Aircraft in Burbank for the past three years. He has two boys, aged six months and four years.

Paul Yankauskas took a business trip East last month, during which he spent two days with *Herman Heidt* '47 at the Harvard Graduate Business School.

John Pettley, M.S., married Barbara Cook on March 14. Barbara was secretary to Dr. Irving P. Krick when Krick directed the Caltech Meteorological Department. The Pettleys are living on the Webb School Campus in Claremont where John is teaching.

Darwin L. Freebairn, Jr., was married in St. Louis on March 13 to Margaret Cain. They honeymooned in Mexico City and are now living at Sunset Beach, Calif.

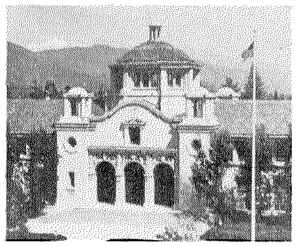
1948

Lt. Cdr. Richard I. Maddox, M.S., after receiving his degree at Caltech, went to work for the California Research Corporation at La Habra as Assistant Research Physicist on self-potentials in well bores. He was recalled to active duty in the Navy in July, 1951, and assigned as Executive Officer on the U.S.S. Prickett, a 2100-ton destroyer now in Boston, Mass. Dick has been ordered to duty with the Office of Naval Research next month in the Control Devices Section, so the Maddoxes expect to be established in Washington, D. C. by July. They have three children—Danielle, 5; Marya, 3; and Brian, 7 months.

Frank Tunglen, M.S., has given up his job as supervisor of testing at Caltech's Cooperative Wind Tunnel to accept a job recruiting goats for Korea. (That's right—goats). The new job is field representative for an organization known as "Heifers and Goats for Relief," directed by Rev. David E. Norcross of Pasadena. Milk goats and breeding stock are to be distributed directly to needy Korean families to meet the mounting hunger problem there. Frank is now concentrating on securing the sponsorship of interfaith church groups, service clubs, 4-H Clubs, etc. "I think by such grass-root gestures of goodwill toward other peoples of the world, we can alleviate the basic causes of war," Frank says.

1949

C. Harris Adams was married in January, 1951, and now has a five-month-old son. Harris is chief engineer of the El Ray Motor Company in Los Angeles, where they design and manufacture fractional HP mo-



ALUMNI CALENDAR

June 4	Annual Meeting
June 29	Family Picnic at Mt. Wilson

COMMENCEMENT ACTIVITIES

June 5	4:00 p.m.	Reception for Class of '52	President's Home
June 6	4:30 p.m.	Commencement Exercises	

CALTECH ATHLETIC SCHEDULE

BASEBALL

May 17	2:15 p.m.	Varsity vs. Occidental	at Occidental

GOLF

May 23	9:00 a.m.	All-Conference Tournament	at Whittier

FRIDAY EVENING DEMONSTRATION LECTURES
7:30 P.M. — 201 BRIDGE

May 16	"Nuclear Physics"	by Prof. R. F. Bacher
May 23	"Animal Reproduction"	by Prof. D. W. Bishop

PERSONALS . . . CONTINUED

tors both for civilian and for military uses.

Hardy C. Martel recently received one of eight fellowships awarded by the Radio Corporation of America to graduate students at designated universities who "display outstanding ability in fields of study related to radio, television, and electronics." At Caltech the RCA grant is made annually to support a graduate fellowship in the Department of Electrical Engineering. Hardy received his M.S. from M.I.T. in 1950, and is continuing work toward his doctorate in E.E. here at the Institute.

Fred T. Selleck is completing his second year of graduate work as a research staff member in the Caltech Chemical Engineering Department, having spent his first year with the Standard Perlite Corporation in Pasadena. He expects to marry Phyllis McDowell, Scripps '46, this summer.

Henry Fasola, Jr., has been working for the Caltech Jet Propulsion Lab for two years, as a development engineer in the design and development section. He reports that he's still single.

1950

Robert L. Stert is now a design engineer for the Radioplane Company in Van Nuys. Prior to this he worked at the Hydraulic Research and Manufacturing Company in Burbank. His oldest son, Bobby, was born in October, 1950, and Ricky was born last November.

Jerry Matthews has announced his engagement to Margaret Johnson, who will graduate from Redlands University this June. Jerry is in his first year of medical school at S. C. They plan to be married in June, 1953.

1951

James T. Luscombe has recently been appointed District Representative of the Gulf Coast States for the Beckman Scientific Instrument Company. He's working out of Houston, Texas.

Major James C. Norris, Jr. is Executive Officer of the First Provisional Marine Guided Missile Battalion at the Naval Ordnance Test Station in China Lake. On April 24, the Norrises had a new daughter, Elizabeth Anne. Their son, Jimmy, is now seven years old.

Royal S. Foote, M.S., now holds the position of Staff Geophysicist, Raw Materials Branch, Atomic Energy Commission. He is responsible for the instigation and supervision of geophysical research projects connected with the AEC's uranium prospecting program. His present headquarters are in New York City, but about 40 percent of his time is spent in travel. He is also continuing work toward his Ph.D. at Columbia University. The Foote family now numbers three, with the recent addition of a baby girl, Alison.

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