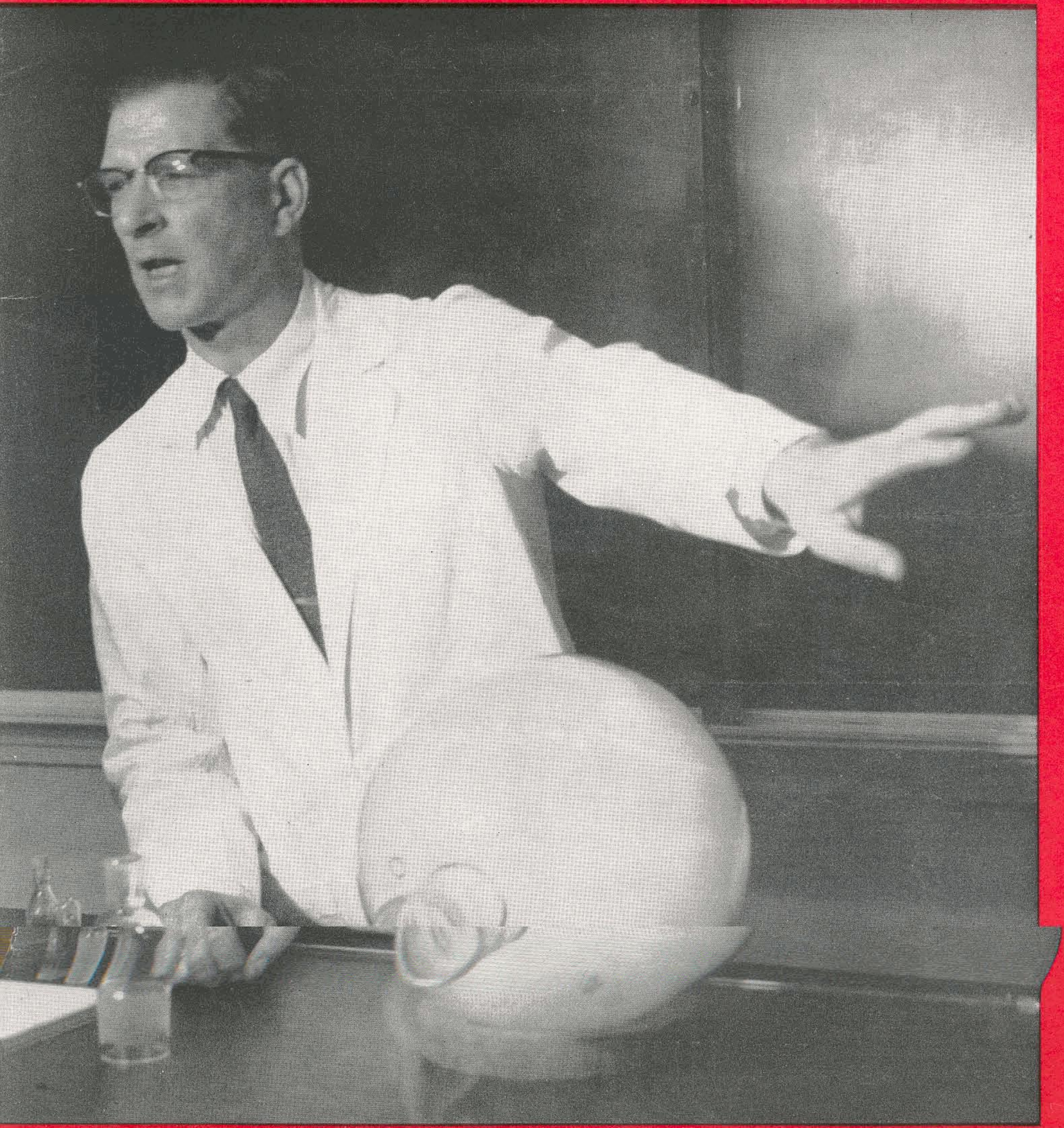
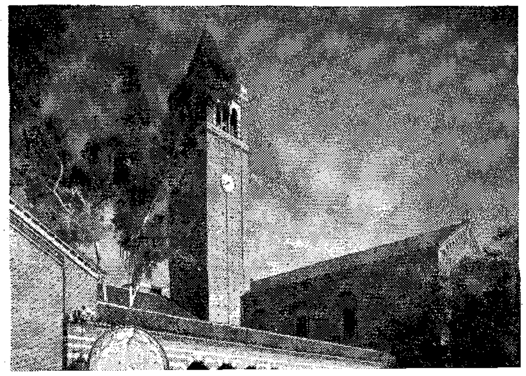
ENGINEERING AND SCIENCE

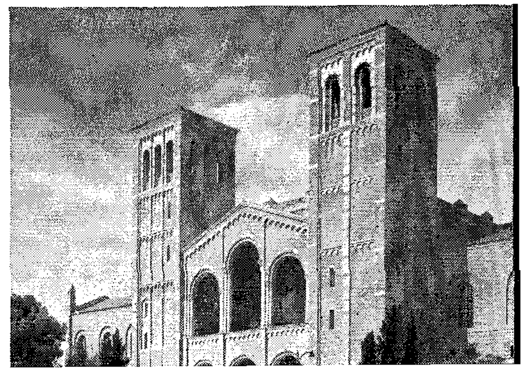
DECEMBER/1954



Smog . . . page 11

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY





BOOKS

AMERICAN SCIENCE AND INVENTION:
A Pictorial History
by Mitchell Wilson
Simon and Schuster, 1954 $10

THE JACKET BLURB on this book claims that it contains "more than 1,000 documentary pictures, combined with 130,000 words of dramatic narrative." One glance should convince anyone that the book contains *at least* this much material, since it measures $12\frac{1}{4} \times 9\frac{1}{2} \times 1\frac{3}{4}$ inches—making it a big book even by Simon & Schuster standards.

Happily, it's a good book too—as impressive in content as in appearance. Subtitled "the fabulous story of how American dreamers, wizards and inspired tinkerers converted a wilderness into the wonder of the world," it is a history of American inventiveness. It describes and shows the great American inventions and discoveries, the experiments and scientific thinking that led to them, the men responsible for them, and the effect that these things have had on our lives and times.

It runs all the way from Benjamin Franklin's inventions to the Atomic Age. Along the way it covers the development of such things as the reaper, the sewing machine, the Pullman car, the telegraph, telephone, aeroplane and automobile tire—as well as the scientific discoveries of such men as Gibbs, Michelson, Millikan, Einstein, Hale, and Pauling.

The author, Mitchell Wilson, is as well-equipped to grapple with this mass of material as anyone could be. An established novelist (best known, probably, for *Live with Lightning*), he is also a physicist (best known, probably, for his work as assistant to the late Enrico Fermi). As a trained scientist he has some idea of what material should be covered in a book like this; as a writer he knows how to make this material both interesting and understood.

The result is a book that ought to have enormous appeal for readers not ordinarily attracted to this kind of reading—and a book that will surprise professional scientists and engineers by having just as much appeal for them.

ART IN SCIENCE
A Portfolio of 32 Paintings, Drawings and Photographs from Scientific American
Simon & Schuster, 1954 $6

ANYONE WHO HAS even flipped over the pages of *Scientific American* must have been impressed by the high quality of the illustrative material in that magazine. Now that 32 examples of this material have been collected, boxed, and labeled as Art they seem handsomer than ever. Each plate is beautifully reproduced on an individual sheet of 11x13 heavy coated paper—not only suitable for framing, but practically crying out for it.

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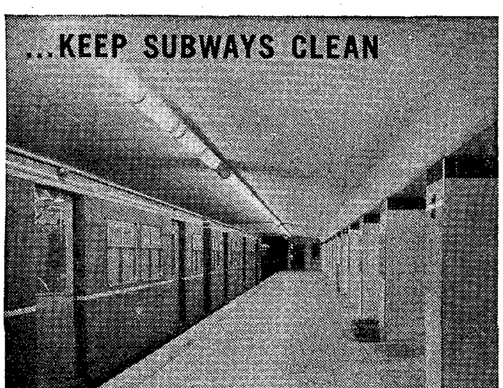

ONE PAINT IN A HUNDRED—Toronto's new $50,000,000 subway is modern in every way, including its glistening tile walls and brightly painted ceilings. For the ceiling, a paint was needed that could resist high humidity. More than 100 were tested and a paint based on Hercules Parlon® (chlorinated rubber) selected. On all types of surfaces, interior and exterior, Parlon paints are providing outstanding service at lower long-term cost.

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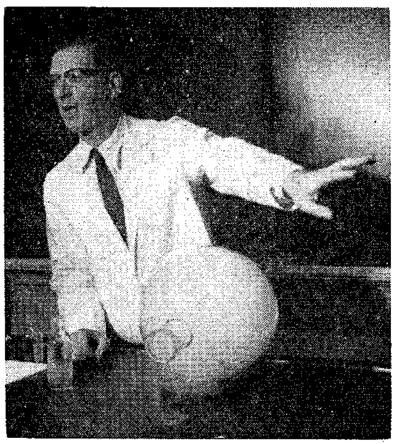

On our cover this month Dr. A. J. Haagen-Smit, Caltech Professor of Bio-Organic Chemistry, is making a particularly telling point during a demonstration lecture on smog. He has just mixed gasoline and ozone in the bottle in front of him and smog is pouring out of the bottle, just as it pours out over L.A. these days, more often than not.

Dr. Haagen-Smit has been devoting the major part of his time to smog research for just about five years now, and in 1950-51 he took a leave from Caltech to serve as full-time Research Consultant to the Los Angeles Air Pollution Control District. Twice before Dr. Haagen-Smit has reported in E&S on research in progress on smog (December 1950 and May, 1952). He brings the story up to date on page 11 of this issue with his article, "The Control of Air Pollution in Los Angeles."

Field Marshal Viscount Montgomery of Alamein, the British hero of World War II, visited Caltetch for several days last month as the guest of President DuBridge. While here, he was honored at a dinner given by the Trustees and the Associates of the California Institute of Technology at the California Club in Los Angeles. On that occasion Field Marshal Montgomery delivered a speech on "The Role of Science in Warfare of the Future." You will find this frank talk, which has already stirred up a good deal of controversy, on page 20 of this issue.

PICTURE CREDITS

Cover, 7, 11	Charles Kassler III
p. 21	Los Angeles Times
p. 30	Pasadena Star News
p. 32	Pasadena Independent

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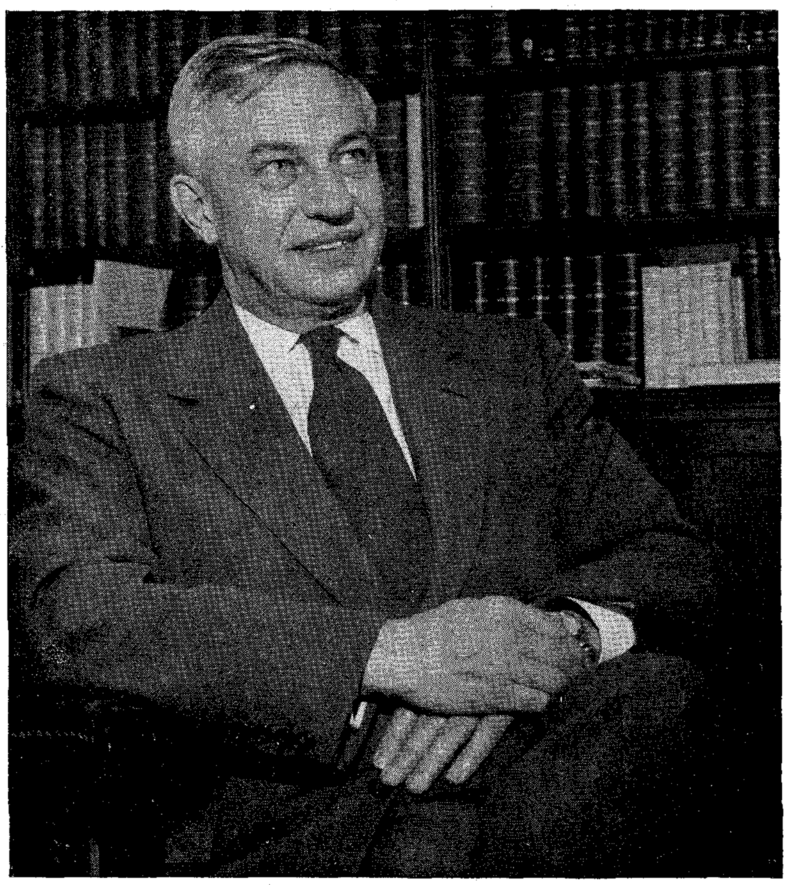


THE PRESIDENT'S REPORT

Some highlights from Dr. DuBridge's 1953-54 report on activities and research of the Institute

IN SHARP CONTRAST to many recent years in which major national and international events have shaken college campuses, the past year appears relatively uneventful. One is tempted to call it a "normal" year—though to define the term "normal" would not be easy. It is certainly not true that the year has been an uneventful one in the world at large. But either the events had a lesser reaction on our universities, or else our universities have become adapted to living in a world of turmoil and have stabilized their operations accordingly.

This latter would certainly appear to be the case at Caltech. American universities have acquired a continuing obligation to aid in strengthening the technology of national defense. Consequently we have for several years past placed our chief contribution in this area—the Jet Propulsion Laboratory—on a long-term basis. We expect to be operating this $12,000,000-a-year defense effort for a considerable time in the future—and are proud of its success.

Similarly, we are enlarging the Southern California Cooperative Wind Tunnel—at a cost to the participating companies of $8,000,000—in order that it may better serve the needs of an advancing aircraft industry.

These two enterprises are managed but not owned by Caltech. Through them we render a service to the community and the government. However, our major interest and service will always be the program of education and research conducted on the campus. Since it is not practical to teach students in one room and do "secret" work in the next, we do not carry forward military projects on the campus. Our campus contributions to the country are more basic than inventing new weapons; we are educating the men and uncovering the new knowledge which are necessary to future weapons—and to future peacetime technology.

Government service

At the same time various members of our faculty continue to devote many man-months of effort each year in direct government service. Professor H. P. Robertson has again been called away for an extended period, this time to serve in Paris as scientific adviser to General Gruenther, Supreme Allied Commander for Europe. Others, including your president, have been absent for many shorter periods. In these days when technology has made it possible for a nation to achieve overnight the destruction of an enemy's industrial and military capacity, and when technology can also offer the hope of preventing such disaster, it is clear that the government can never cease calling on scientists for help. And no loyal scientist will refuse such help.

These are the ways, at Caltech and elsewhere, that science serves the government. How does the government assist science?

The many difficult problems relating to the government support of (nonmilitary) science have not been fully solved but have become more or less stabilized. Although the National Science Foundation was looked upon as a mechanism for improving this situation, Congress has provided such meager funds that the Foundation can not yet be a commanding force. Worse still, Congress reduced the support of other research agencies this year by an amount at least as great as the increase in NSF funds, so that the support of basic science in universities is less than before.

While the national picture is thus somewhat clouded, our own research program at Caltech is of such high quality that we have had no difficulty in obtaining government financial assistance for the more important projects when we need it. Both private (including corporate) and government support for our program have increased and a reasonably stable and satisfactory balance between them now exists.

Selective service

The calls of the military services upon the students remain in a less than comfortable status. Selective service policies are neither uniform nor consistent nor stable. Two students from different districts may receive quite different treatment and this leads to a general uneasiness. The changing policies of the Air Force Reserve Officers Training Corps have also led to uncertainty—and to a drastically lowered enrollment in the Caltech unit. A student can find no way whereby he can plan ahead for his education and his military service so as to make best use of his talents. Indeed, he can adopt no plan which may not be changed suddenly and for no apparent reason. Some students can adapt themselves to such uncertainty; others find it most frustrating.

Such have been a few of the problems of steering a stable course in an uncertain world.

THE CAMPUS

As far as campus facilities are concerned this has been the most eventful year since the year 1938, in which the Mudd and Arms Laboratories were built. Construction was begun this year on both the new athletic center and the Norman Church Laboratory of Chemical Biology. Each structure will be a decisively important addition to our facilities.

These two buildings do not, however, solve all our most difficult space problems. An engineering building, a central library, a permanent health center, a graduate dormitory, a student union building, and an auditorium are still required to complete our campus plan.

FINANCES

The report of the Comptroller shows that again this year we just failed to break even on our current funds, having spent about $139,000 more than the income we received. Our unrestricted surplus fund was thus reduced by this amount. This, however, is well under one percent of our gross income.

Nevertheless, because of additions to capital funds, the net worth of the Institute showed an increase, rising to $55,785,435. Our endowment capital increased by $1,164,000 to the total of $30,007,692. The market value of our portfolio is nearly 8 million dollars higher than the above book value.

One of the most valuable single gifts ever made to the Institute was the bequest, in the form of a trust, of Eudora Hull (Mrs. Keith) Spalding, who died in 1942. This trust, consisting of securities, mineral rights, and the 5000-acre Rancho Sespe (near Fillmore, California) has regularly yielded an income of around $200,000 a year, occasionally reaching as high as $400,000. The Institute owes a great debt to Keith Spalding, trustee of this estate, for his wise management and his generosity in seeking to maximize the Institute's receipts from it.

During this past year the potential value of the Spalding trust was substantially increased by the discovery of oil on Rancho Sespe. Only two wells have been completed and, though they are excellent producers, it is too early to predict how extensive a field has been tapped. Several years of further drilling will be required to test the pool, since it is a very deep one (over 14,000 feet). Oil and gas royalties, which may in the next year or so amount to $150,000 per year, will be credited partly to income and partly to capital, and obviously will be a most welcome addition to our resources. At the same time the magic word "oil" must not lead to unwarranted illusions. A ten percent increase in our endowment income is most welcome, but it does not solve all our financial problems.

The costs of operating the Institute's program of education and research have continued the rise of recent years. The rise is caused partly by additions to and improvements in the program, partly by the general inflationary spiral, and partly by our attempt to increase our wage and salary scales. Our nonacademic pay scales are now comparable to the area rates. Our faculty salaries have been below the levels of those universities whose graduate and research programs are most nearly comparable to ours. We have, however, made good progress in the past two years in closing this gap. We can now say that—figured on the basis of 11 months of service—our annual rates for the younger ranks are about equal to those of the best universities but our top professorial salaries are a little lower. However, one must quickly add that *all* university faculty salaries are tragically low, compared to those of industry.

RESEARCH HIGHLIGHTS

THIS PAST YEAR several divisions of the Institute initiated the preparation of separate research reports. Four divisions each published a volume of from 100 to 200 pages containing a summary of the status of every research project in the division, including the names of participants and the sources of financing.

These are impressive volumes, indeed (available on request to those interested). They show how impossible it is to "summarize" in this present report the work of a division which is carrying forward more than 100 separate research projects (Biology, 144; Geology, 121; Engineering, 133; Chemistry, 119). It is like "summarizing" the Encyclopaedia!

Yet certain projects here and there stand out because of some element of particular interest. A few of these are indicated herewith.

Smog

The Institute has avoided for many reasons undertaking on its campus any extensive project on air pollution. However, when it became plain that smog affects plants in a research greenhouse and affects delicate chemical analyses (and also hides our mountains), it was inevitable that some one would take an interest in it. Several years ago Professor Haagen-Smit—a distinguished biochemist—suggested that most of the objectionable features of Los Angeles smog (which is very different from the old Pittsburgh or St. Louis "soft-coal smog") were caused by oxidized components of gasoline vapors. Laboratory tests enabled him to produce from gasoline and ozone artificial smog which smelled, tasted, and looked like smog—and affected green plants in the same way. This idea broke the back of the scientific mystery about the nature of smog and allowed a concentrated attack on the problem of working out the detailed chemistry of the atmospheric processes, and initiated a search for the most important sources of the offending substances. Elimination of the emissions from refineries and oil storage tanks in Southern California is now well on the way to completion. Gasoline service stations and automobiles are less easy to control. But the attack is in full swing, and with a new and active private organization—the Southern California Air Pollution Foundation —now fully engaged in the effort, there is hope that progress may be accelerated. (See page 11.)

Microsecond chemistry

During the postwar years many startling advances have been made in techniques in both physics and chemistry for dealing, on the one hand, with very tiny amounts of material—a thousandth of a millionth of a gram—and, on the other hand, with very small intervals of time, down to hundredths of a millionth of a second. Physicists are now quite skilled in electronic measurements of exceedingly fast processes involving very short times. Microseconds are important in chemical reactions, too. An explosion, for example, is just a chemical reaction which goes very rapidly, and may be all over in a few millionths of a second. The speed of the reaction is clearly dependent upon how fast the individual atoms and molecules are moving. Hence, a technique for getting a fast "snapshot" of the reaction is useful to determine what is taking place. Recently Professor Norman Davidson and his co-workers have used optical methods to observe reactions caused by the passage of a shock wave through a gas. In this process molecules are dissociated and a quick "picture" of the process can be obtained.

Geochemistry

The measurement of millimicrograms is important in the relatively new field of geochemistry. Here much has been and continues to be learned about the origin and development of the earth by the measurement of tiny quantities of uranium and lead in rocks, in meteorites, or in the ocean. The very slow radioactive decay of uranium into certain isotopes of lead has provided a sort of "clock" which has been running ever since the earth was formed some four and a half billion years ago. As geochemists learn how to read this clock they learn the age not only of the earth itself but also of younger formations of sedimentary or volcanic rock.

Isotopic chemistry—the measurement of the relative abundance of different isotopes of an element—is opening a most powerful tool for many purposes. Thus it appears that in fossil fuels—coal and petroleum— the ratio of the carbon isotope C^{12} to the carbon isotope C^{13} is larger than in present day living plants. However, a study of the C^{12}/C^{13} ratios within successive tree rings of individual living trees has shown that this ratio is larger in the outer rings. Apparently the burning of fossil fuels in homes and industry has increased the carbon dioxide content of the air and also the C^{12}/C^{13} ratio during the past 100 years, and trees and other plants which absorb carbon dioxide indicate this changing carbon content.

This is but one interesting example of how a new technique yields new information about the earth's history.

Turbulent flow

When a gas or liquid is pumped through a pipe, forced into a reservoir or into a combustion chamber, or caused to stream past an object in a wind tunnel, the flow is generally not smooth like a quiet deep river, but is turbulent like a mountain torrent. When the turbulent fluid stream strikes a surface, hot or cold, it transfers to it momentum (and this results in a force) and the fluid also gives up, or takes away, heat. A good share of the chemical, oil and aircraft industries can be said to be based on phenomena of turbulent flow. Yet the detailed characteristics of momentum and heat transfer in such flow are not fully understood. The chemical engineering group at Caltech has had this as a major field of interest for many years. The aim is to develop a basic theory and to make measurements of specific materials which will allow accurate predictions of the behavior of the fluids in a new chemical processing plant, for example. One particular problem recently examined was the rate of evaporation of a liquid droplet falling through a gas.

The synchrotron

When very high energy X-rays (above 250 million volts) fall on a hydrogen nucleus—a proton—the charge on the nucleus is "peeled off" in the form of a meson, leaving a neutron behind. There is nothing startling about this to a physicist. It was discovered several years ago that mesons could be "created" in the vicinity of nuclei by X-rays or gamma-rays. But it was startling to find from a detailed study of this process, carried up to over 500 million volts with the Caltech synchrotron, that the meson had a sort of virtual existence in (or near) the proton *before* its "creation". Thus, one more fact of meson physics is added to our store of knowledge. This particular fact, however, is very puzzling to the physicists and seems to deepen rather than reduce the mysteries of nuclear physics.

The synchrotron has been shut down temporarily while alterations are being made which will allow it to accelerate electrons to over a billion electron-volts energy—double the present level. This modification was planned from the start of the synchrotron project but it was deemed desirable to begin operation and gain some experience for a couple of years at the lower energy.

The synchrotron, incidentally, has proved a spectacularly successful machine and it has been most productive. In these days of "nuclear secrecy" it should be emphasized that neither the synchrotron nor any of its results are secret. It is located in the building where the 200-inch Palomar mirror was ground, and the same observation balcony overlooking the equipment is still open to the public.

Astronomy

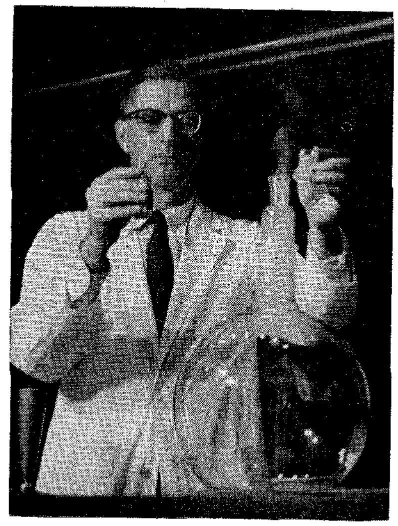
The past two years have been exciting ones in the field of astronomy—an excitement which can be largely credited to the new observations made possible by the 200-inch Hale telescope. The performance of this instrument and the new results on the nature and structure of the universe have certainly exceeded the highest hopes of George Ellery Hale and the others who dreamed of and built this magnificent instrument.

The first surprising discovery was that of Dr. Walter Baade several years ago when he found, contrary to supposition, that the stars in the vicinity of the sun are not typical of all the stars in our Milky Way Galaxy. Our sun is far out near the edge of the Galaxy in one of the spiral arms. It now appears that such stars are probably younger than the stars near the center and have quite different characteristics and composition. This has required a revision in the scale of distances as determined by the apparent brightness of certain types of stars. In addition, Dr. Allan Sandage has developed more accurate instruments for measuring brightness, thus correcting certain previous errors. The net result was the discovery that the great spiral nebula in Andromeda—our nearest neighbor universe, similar to our Milky Way—is 2.5 times as far away as had been thought. It is, therefore, 6.25 times as big and as bright as had been assumed—making it a colossal universe of stars, indeed. A second and more distant nebula has been measured and found to be 4 times as far away as previously determined—and hence 16 times as big and bright.

Thus a whole new conception of the distances and sizes of the nebulae has been introduced which gives us a new concept of the size and the age of the universe. It will take much more data, however, before adequate determinations can be made of other nebular distances and hence before new size and age numbers can be deduced. But it seems clear that the faintest and most distant nebulae are not a mere 1 billion light years distant but may be 2 to 4 billion light years away.

The discovery a few years ago that the heavens contain sources which emit radio-frequency energy has opened up a new field of astronomy. We now know that the sun itself emits radio waves and these show irregularities which are synchronized with sunspot disturbances and with large flares at the sun's surface. Also there are sources of radio energy in space, called "radio stars", some of which can be identified with known sources of visible light, and some cannot. These may be dark masses of matter which emit only radio waves. In any case the radio spectrum now has become as important to astronomers as the visible spectrum and it is clear that work in this field must be initiated here. Funds for this purpose are now being sought.

THE CONTROL OF AIR POLLUTION IN LOS ANGELES



by A. J. HAAGEN-SMIT

THE SAME METEOROLOGICAL and geographical conditions which made the Los Angeles basin famous set the stage for a serious air pollution problem when five million people and their industries began to crowd this area. The inversion condition, a warm layer of air above the colder, ground layer, prevents dispersal of the pollutants. This layer of polluted air is blown inland by a slow sea breeze during the day, to return frequently at night, carried by an even slower land wind.

Detailed meteorological studies at ground level show that on days of severe smog stagnant air conditions usually prevail during the night and early morning hours, which permit the build-up of pollution. When the inversion height is lower than 1,000 feet, air pollution becomes noticeable; people begin to complain of eye irritation and odor, farmers notice damage to their crops, and a dense haze blankets the area.

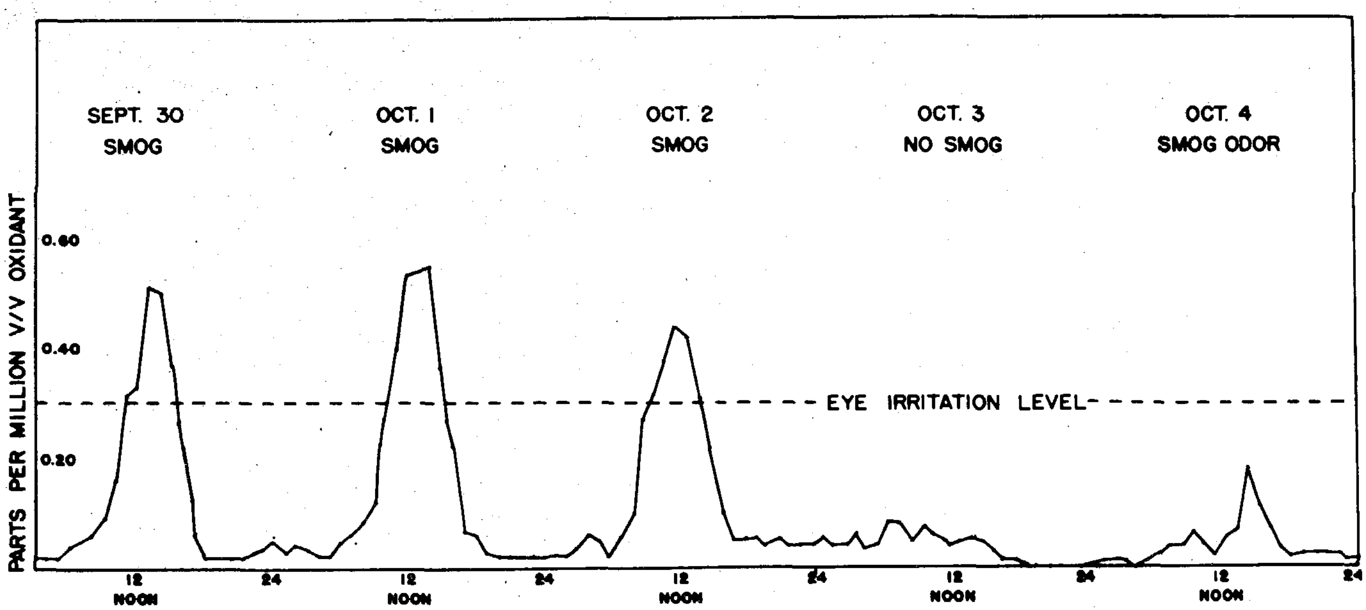
The chemical analysis of smog air shows the presence of a great number of materials, among which are sulfur dioxide and dusts, well known as trouble-makers in other industrial areas. Control measures by the Los Angeles County Air Pollution Control District have brought these emissions below the 1940 level, when the word "smog" was still unknown in California. Hundreds of tons of sulfur are now recovered at the refineries, and emissions of metal dusts from foundries and steel mills are largely controlled.

Public burning dumps have been abolished, but private rubbish burning still goes on, and there is considerable opposition to replacing it with more advanced disposal systems. Another needless source of pollution is created by the "smokers"—automobiles which, because of poor maintenance, continually emit smoke from their exhausts. But even cars in good condition produce smokes which, by depositing on the outside as well as on the inside of our houses, raise our maintenance costs. These same deposits are at present causing concern to the medical authorities.

While these visible sources are not responsible for typical smog damage to crops, and the eye irritation caused by them is mostly of a local nature, their contribution to at least one aspect of the smog—the haze—already justifies the insistence of the Air Pollution Control District that the numerous small sources of smokes and fumes should be controlled. Anyone desiring clean air should support the authorities in this part of their difficult and often unpopular task, which is essential to obtaining better visibility.

This part of the control program is not expected to reduce considerably the eye irritation felt over hundreds of square miles, nor will it give relief to the farmer, reduce the peculiar chemical odor associated with smog, or prevent excessive rubber cracking in this area.

Chemically, the most characteristic aspect of smog is its strong oxidizing action. The intensity of this oxidizing action correlates closely with eye irritation and other smog symptoms such as plant damage, rubber cracking, and smog odor. The amount of oxidant can readily be determined through a quantitative measurement of iodine liberated from potassium iodide solution, or of the red color formed in the oxidation of phenolphthalin to the well-known acid-base indicator, phenolphthalein. To demonstrate these effects, it is only necessary to bubble a few liters of smog air through the



Chemically, the most characteristic aspect of smog is its oxiding action. Daily determinations show that the oxidant rises shortly after sunrise, reaches a maximum in Pasadena between 1-2 p.m., is practically absent at night.

colorless solutions. A marked color change occurs, indicating the presence of oxidizing materials.

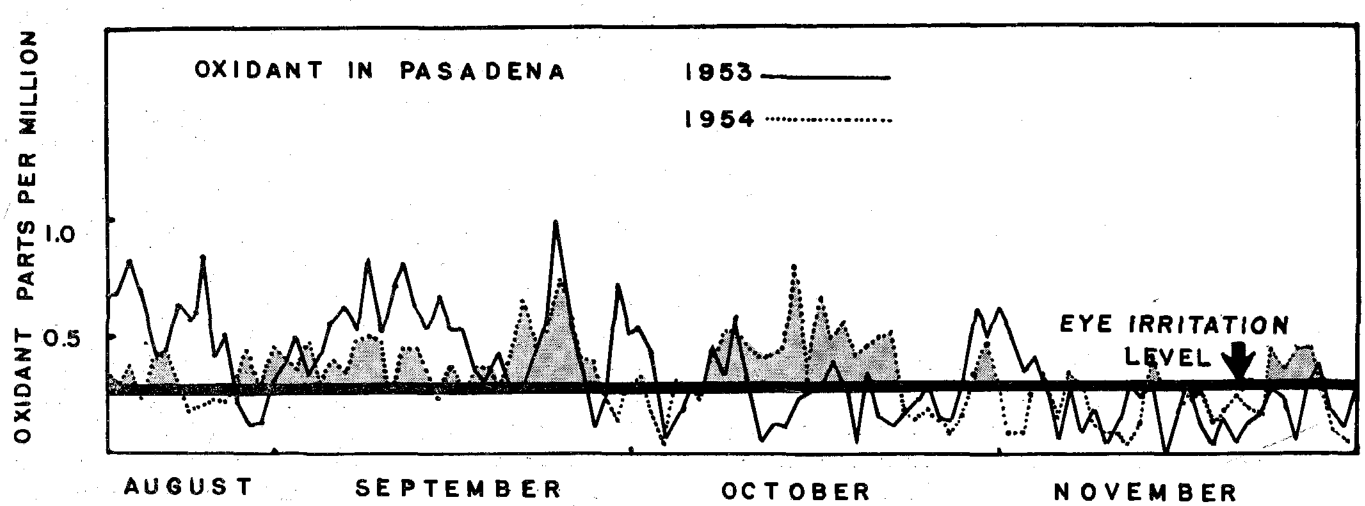
Daily determinations (as in the chart above) have shown that shortly after sunrise the oxidant rises, and reaches a maximum at some time during the day—in Pasadena most often from one to two o'clock. At about sundown the oxidant decreases considerably, and it is practically absent during the night. We have been measuring these effects for more than a year, and have found that when the oxidant value passes a certain level, eye irritation occurs.

The chart below shows the fluctuation in the daily maximum recorded at the California Institute of Technology in Pasadena. The fluctuations are largely caused by meteorological conditions. However, there is a distinct weekly pattern which shows that Sundays are definitely less smoggy than other days of the week, especially Thursdays and Fridays. This phenomenon is not clearly understood. It could be due to reduced activity of industry as well as to a change in the traffic pattern during week-ends.

The value of these records lies in the objective estimation of smog intensity, and when continued, the data will be an aid in judging progress made in smog control.

From these records we can see that the worst smog period this year, from August through October, was not as bad as last year, either in intensity or in duration (hours per day). Nevertheless, the eye irritation level was exceeded in Pasadena during that time on 65 out of 90 days.

The oxidizing action of smog air is due to the release of large quantities of organic material, mostly hydrocarbons, and oxides of nitrogen. When these gases are exposed to sunlight, eye-irritating substances are formed, and in the fumigation of plants typical smog damage *symptoms are produced. At the same time aerosols*



Fluctuations in daily maximum of oxidant in Pasadena show that this year's worst smog period was not as bad as last year's—and reveal a distinct weekly pattern, with Sundays definitely less smoggy than other days of the week.

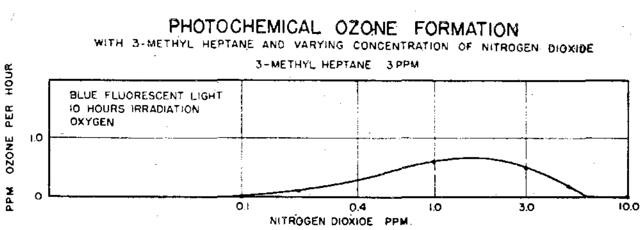
(pollutants in the air which are so small they do not settle out, but are in stable suspension) are formed and a smog odor is apparent. Plant damage observed in this area is quite different from that caused by sulfur dioxide or fluorine compounds, and its reproduction in fumigations with the photochemical oxidation products of gasoline and nitrogen dioxide (NO_2) was the basis of one of the most convincing arguments for the control of hydrocarbons by the oil industry.

It was interesting that the same damage could be obtained when ozone was mixed with gasoline vapors in the absence of sunlight. In the vapor phase reaction of ozone with olefins present in gasoline we may expect the formation of ozonides and other substances of peroxidic nature, as well as acids and aldehydes. The possibility of producing typical plant damage and other smog symptoms by the oxidation of hydrocarbons either with nitrogen dioxide, air and sunlight, or with ozone, indicated that similar products are involved, and further research has established that *ozone actually is produced in the air by the action of sunlight on organic material in the presence of nitrogen dioxide.*

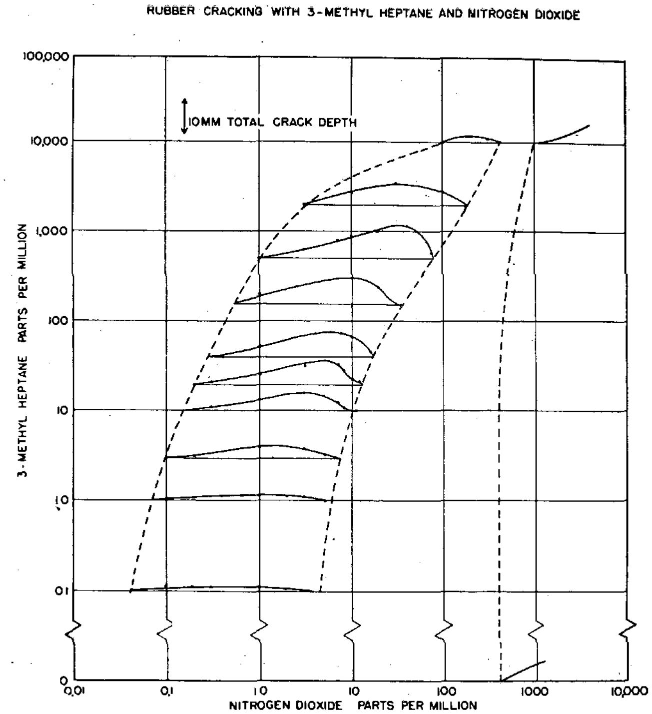
The concentrations of organic materials—hydrocarbons, aldehydes and acids—and those of the oxides of nitrogen determined in our polluted air fully account for the high concentrations of ozone found in this area. During severe smog attacks, ozone concentrations of 0.5 ppm., twenty times higher than in country air, have been measured. From such analyses the quantity of ozone present in the basin at that time is calculated to be about 500 tons.

Since ozone is subject to a continuous destruction in competition with its formation, we can estimate that several thousand tons of ozone are formed during a smog day. It is obvious that industrial sources or occasional electrical discharges do not release such tremendous quantities of ozone. A transport of ozone from the upper air is also out of the question during inversion conditions.

The mystery of the abnormally high ozone content of smog air was solved several years ago, and our discovery that photochemical oxidation of organic material is accompanied by ozone formation gave further scientific evidence for the necessity of controlling hydrocarbon emissions. It also made clear why the oxidant values rise during the day and decrease as soon as the day is over. Ozone, a major part of the oxidant, is generated



Photochemical formation of ozone is responsible for severe rubber cracking in this area. Cracking of standardized rubber is now a test method for estimation of ozone in air.



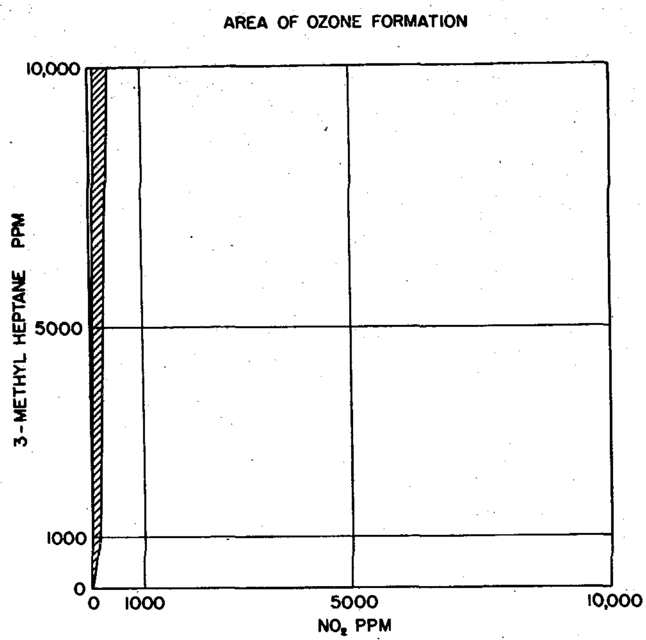
Phenomenon of ozone formation is limited to a definite range of concentration of hydrocarbon and nitrogen dioxide.

in the presence of sunlight, but as soon as this production decreases in the evening, the reactions which destroy ozone gain the upper hand and rapidly remove it from the atmosphere. The eye-irritating reaction products, however, can often be noticed in the air for a much longer time.

The photochemical formation of ozone is also responsible for the severe rubber cracking observed in this area. Rubber is an unsaturated hydrocarbon, and its reaction with ozone is similar in principle to that of ozone and the unsaturated components present in gasoline. We have used the cracking of standardized rubber as a convenient and highly specific test method for the estimation of ozone in the air. During severe smog initial cracking appears in about four minutes, as compared to an hour or more required on smog-free days, or at night.

In duplicating the photochemical ozone formation in the laboratory, known concentrations of hydrocarbons and nitrogen dioxide were exposed to artificial light and the ozone formed was measured by the rubber cracking method or by chemical means. It is found that for a given hydrocarbon concentration—for example, three parts per million—a small but definite amount of nitrogen dioxide is necessary before ozone can be detected. After passing through a maximum at about 2 ppm, of NO_2, the ozone formation decreases, and is nearly absent at about 5 ppm., as shown in the chart at left for 3-methylheptane.

The results of many measurements at different concentrations of hydrocarbon are presented in the chart at the above on a logarithmic scale. We see that the phenomenon of ozone formation is limited to a definite range of con-



Limited area of concentration in which ozone formation occurs is clearly shown in linear presentation.

centration of hydrocarbon and nitrogen dioxide, and this is even more striking when a linear presentation is used (above). The composition of the air in Los Angeles during smog days is in the order of 0.4 to 0.8 ppm. of NO_2 and 1-2 ppm. of hydrocarbon, and falls directly within the range at which ozone formation occurs. The amounts of ozone formed in laboratory experiments correspond closely to those measured outside.

The phenomenon that ozone formation is limited to definite relative proportions of hydrocarbon and nitrogen dioxide, observed with 3-methylheptane, is apparently quite true for other saturated hydrocarbons, as well as for olefins, and their oxidation products, acids and aldehydes. It has been observed that as the length of the carbon chain increases from four to nine carbon atoms, the ozone-forming capacity becomes greater. Methane, ethane and propane were found to be inactive. The highly branched hydrocarbon, 2, 2, 3-trimethylbutane (triptane), well known for its anti-knock value and high critical compression ratio, does not form ozone in any appreciable quantities, even upon prolonged irradiation. On the other hand, the unsaturated n-heptene-3 is very active in this respect. The chart at the right compares the relative ozone-forming capacity of these compounds with our standard hydrocarbon, 3-methylheptane. This marked effect of branching and the location of double bonds on ozone formation is being further investigated to explore the possibility of a change in fuel composition.

From a practical point of view, it is important that the irradiation of gasoline vapors (straight run, as well as cracked) in the presence of nitrogen dioxide also leads to the formation of ozone, and the Los Angeles County Air Pollution Control District has demonstrated the ozone-forming property of air near sources of hydrocarbon release.

The oxides of nitrogen necessary for this reaction are formed in all high temperature combustions through a reaction between nitrogen and oxygen from the air. The main sources are the burning of fuel gas, fuel oil and gasoline, whereby nearly 500 tons of nitrogen oxides are produced per day. No satisfactory way for the control of nitrogen oxides is known yet, and therefore most of the attention is given to the other partner in the smog reaction, the hydrocarbons.

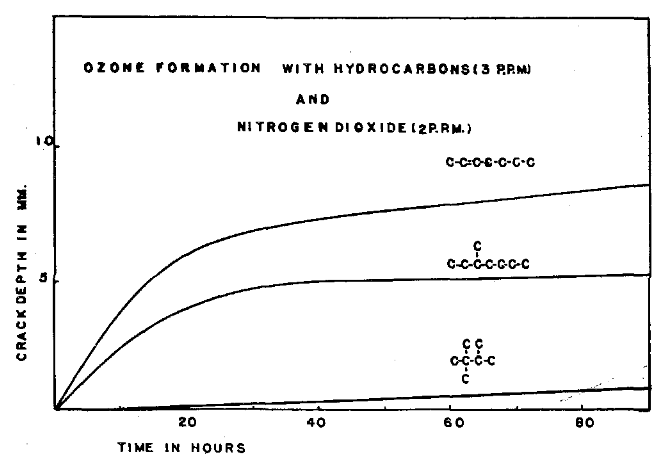
The hydrocarbons are emitted to the air by evaporation from storage tanks and through many activities of the oil industry. The control of these sources is well under way, and about 400 tons of hydrocarbons per day are now being collected which formerly went to waste. The remaining emissions are estimated to be approximately 250 tons per day.

Automobile exhaust

The other large source of hydrocarbons is automobile exhaust. The exhaust contains both ingredients for the production of smog—hydrocarbons and oxides of nitrogen—and this ready-made mixture gives all of the typical smog symptoms upon irradiation with sunlight.

The exact knowledge of the range of concentration of hydrocarbon and NO_2 where ozone formation takes place was very helpful in showing that automobile exhaust after irradiation gives ozone. The only data required are the hydrocarbon and nitrogen dioxide concentrations in the exhaust sample. Then from the graph on page 15 we can read how far the sample must be diluted to reach the ozone-forming area.

The exhaust of a cruising car contains about 600 ppm. of NO_2 and 600 ppm. of hydrocarbon. A dilution of 600 to 1 brings it into the area of ozone formation. For acceleration exhaust, with its high NO_2 content, a dilution of 1,000 to 1 is necessary. Deceleration exhaust falls within the area, and idling exhaust contains too little NO_2 to be able to form ozone upon dilution. However, if we mix deceleration, idling and acceleration exhausts, the "stop-and-go" phase of driving, we have a mixture that is equal to that of cruising exhaust, and ozone can be formed.



Comparison of relative ozone-forming capacity of other saturated hydrocarbons with standard, 3-methylheptane.

The important conclusion is that somewhere behind the car the exhaust gases will be sufficiently diluted to form ozone.

More than 4,000,000 gallons or 12,000 tons, of gasoline are consumed each day in the Los Angeles area. To this should be added 30,000 gallons of lubricating oil which are also burned or lost. The loss in unburned or partially burned gasoline from the exhaust is about seven to ten percent of the gasoline used, and it is estimated that the emission of hydrocarbons to the air is on the order of 300,000 to 400,000 gallons, or about 1,000 tons per day.

Driving conditions in Los Angeles

The Los Angeles County Air Pollution Control District has determined the gasoline losses during idling, acceleration, cruising and deceleration. The losses are not equally divided over the different phases of automobile operation. As a result of a survey on driving conditions in Los Angeles, we can estimate the time spent on each phase. Tabulation of these results shows the relative importance of the different phases of automobile operation with respect to hydrocarbon emission.

DRIVING CONDITION	IDLING	ACCEL.	CRUISING	DECEL.
Time Driven—%	18	18	46	18
Gasoline—gal. hr.	0.45	2.25	1.52	1.22
Hydrocarbon Concen. mg./liter	5.8	0.8	0.9	15.0
Exhaust Flow cu. ft./min.	14.2	56.0	28.4	30.2
Hydrocarbons into Atmosphere—units	17	8	13	62

It is interesting to note that although only 18 percent of the driving time is spent in deceleration, 62 percent of the total hydrocarbon loss occurs during that time. Stop-and-go traffic, which includes deceleration, idling and acceleration, contributes 87 percent to the total loss. Substantial improvements in exhaust emission can therefore be expected from a reduction in the number of required stops. The use of freeways allows a constant flow of a large number of vehicles with a minimum of stop-and-go driving. The construction of freeways is therefore an excellent means towards the reduction of exhaust fumes.

The automobile industry in Detroit is seeking a solution through improvements in engine design, carburetion, etc., and it was recently announced that a 30-50 percent reduction of the hydrocarbon emission would be feasible.

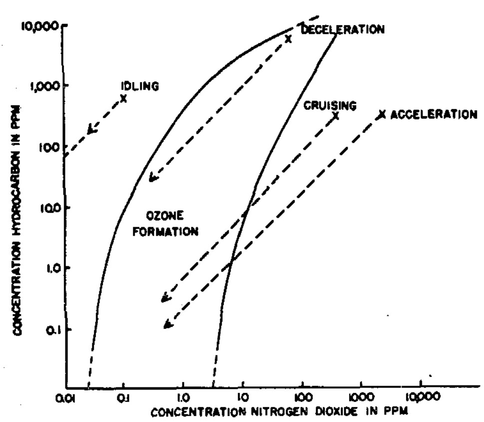
The increase in the number of freeways and the improvements in fuel economy are, of course, most welcome to the driver. This cannot be said for the attempts to reduce the exhaust emission through the use of rather expensive corrective devices on the exhaust. There is a great deal of misconception about the purpose of these gadgets and the conditions under which they have to operate. The removal of carbon monoxide, for example, does not help in the reduction of smog. It is often overlooked for each gallon of fuel consumed, one quart of water and more than half a pound of chemicals are leaving the exhaust. Removal by scrubbers or chemical agents is therefore impractical.

The main ingredients that we want to remove from the exhaust by such devices are of hydrocarbon nature, and the only practical way to remove them is by combustion. At the present time, two so-called "afterburners" show definite promise. However, considerable time for testing is needed before these muffler-type burners can be recommended for adoption by the two-and-a-half million automobile owners in this area. It is held possible that these mufflers can be installed in the not too distant future on trucks and buses.

Also under way are investigations on the effect of fuel composition on the irritating properties of the exhaust gases. The feasibility of converting at least buses and trucks to the use of LPG (Liquid Petroleum Gas) is being considered, since hydrocarbons such as propane and butane are free from some of the objectionable qualities of gasoline. Our findings that there is a considerable difference in the ozone-forming capacity of different hydrocarbons suggest that investigation of the behavior of individual hydrocarbons might give a lead towards improvement in fuel composition. We should not forget, however, that the high temperatures which occur during the explosion change these compounds, and that the evaluation of their smog-forming character should be made not only on the fuel itself, but also on the products resulting from its incomplete combustion.

While engineering is in progress on the exhaust problem, everyone can help in the reduction of exhaust emissions by keeping his engine in good mechanical condition, by practicing the driving habits recommended when gasoline was rationed, by supporting the construction of freeways and by urging a greatly improved public transportation system.

PHOTOCHEMICAL OZONE FORMATION FROM AUTOMOBILE EXHAUST



Graph shows how far a sample of auto exhaust must be diluted to reach area where ozone-formation takes place.

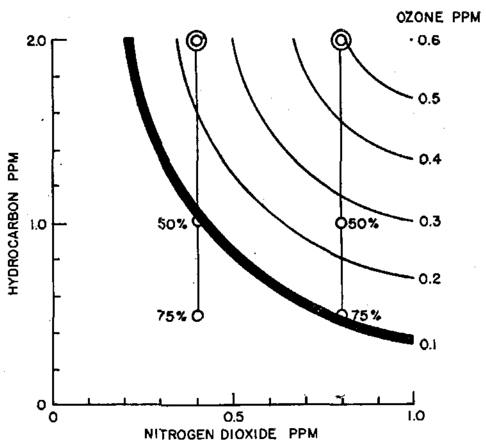
In order to evaluate the result of such reduction, we have to refer to our graph showing the ozone formation at different concentrations of hydrocarbon and NO_2. A more detailed view of the region of concentration measured during the smog is shown below. This graph shows the ozone level reached after four hours' irradiation with sunlight at varying concentrations of nitrogen dioxide and 3-methylheptane. Notwithstanding the use of a single hydrocarbon in these experiments, the values of ozone found seem to agree well with those found during smog periods, when not only the concentration of hydrocarbons, but also the concentrations of their oxidation products are used in the computation. This method of computation is necessary because the concentrations of hydrocarbon and NO_2 determined during a smog attack do not represent the initial concentrations. Oxidation is continuously going on, reducing the original hydrocarbon and NO_2 concentrations and increasing the concentrations of aldehydes, acids and other oxidation products.

Ozone formation

In the first place, we notice on our graph that the concentration of ozone formed is directly proportional to the product of the hydrocarbon and NO_2 concentrations. An increase of 20 percent in the hydrocarbon and NO_2 will therefore result in a 44 percent increase in the ozone formation, and this might well explain some of the increase in ozone levels during the last five years.

The graph also allows us to predict the effect that will be obtained by a reduction in the hydrocarbon. If the initial concentration of hydrocarbon is in the order of 2 ppm., and that of the nitrogen oxides 0.4 ppm., a reduction of 50 percent in hydrocarbon will enable us to remain just below the threshold of irritation of 0.1 ppm. of ozone. However, when the NO_2 concentration is 0.8 ppm., a quantity which has actually been found during severe smog, a 75 percent reduction in hydrocarbon (from the original concentration of 2 ppm.) would be necessary to reach the same threshold. Unfortunately, the tendency at present is towards a steady increase in the NO_2 concentration, which demands greater and greater efficiency in hydrocarbon recovery. The alternative is to reduce the NO_2 concentration as well as that of the hydrocarbons.

OZONE FORMATION WITH 3-METHYL HEPTANE AND NO_2



Concentration of ozone formed is directly proportional to the product of hydrocarbon and NO_2 concentrations. Graph shows potential effect of hydrocarbon reduction.

The sources of smog are well known, and there is general agreement that the control measures taken towards the reduction of dusts, smoke, sulfur dioxide and hydrocarbons were fully justified, and that this program should be continued with vigor.

Vigilance and planning needed

There is every reason to expect that the present difficulty will be overcome. The question is, however, how long will this improvement last? Every reduction in the harmful emissions from the industrial plants is but a partial one, and a small percentage of the pollutants still escapes into the air. The reduction in the emissions from the automobiles through exhaust devices or improvements in engine performance will probably be, in practice, not much better than 75 percent. The oxides of nitrogen, partners in the smog-forming reactions, have continued to increase at a rate of four to five percent per year without any practical means of their control in sight. This unfortunate fact, together with a renewed, gradually-increasing emission of organic materials, will eventually result in even higher concentrations of the irritants, such as ozone, than we notice today. This toxic agent may then exceed the level which conservative hygienists consider unhealthful. If the present trend continues, we might expect in ten or twenty years a repetition of our unpleasant experiences of today. At that time, however, a further reduction will be considerably more difficult and expensive, and will have to include the control of oxides of nitrogen.

To insure clean air for the future, the present control measures will have to be implemented by bold civic planning which will include not only the city of Los Angeles, but the entire Los Angeles basin. Plenty of breathing space in the form of spacious parks should be included in the plans, together with the creation of a badly needed rapid public transportation system. City planners and engineers may even have to scrutinize carefully such revolutionary proposals as the relocation of industries and power stations, community air purification plants, and other similar projects which may seem fantastic at this time.

Fresh air limited

We have now received two warnings that our fresh air supply is limited. The first, a wave of eye irritation during the war years, was controlled within a year through corrective measures at a single plant. The second attack of severe air pollution has lasted eight years and involves hundreds of industries and millions of people. We shall overcome our immediate problem, but only constant vigilance and thorough planning will assure a permanent solution.

Cooking class at Throop Polytechnic Institute at the turn of the century

LOOKING BACKWARD

Some memories of student life at Caltech's forerunner, Throop Polytechnic Institute

by IVY E. ARTHUR '01

Now that my grandson, Eric Arthur Johnson, has been enrolled as a student in the California Institute of Technology, it has been suggested that I write down some of my memories of Caltech's forerunner, Throop Polytechnic Institute, which I attended for two years—1899-1901. My older brother was a student there for five years and my younger sister for two years. I do not have at hand any of the Year Books or catalogues, so these jottings are merely from memory and should not be taken as authentic statistics.

The campus of TPI as I knew it took up less than a city block. It was bounded on three sides by Raymond Avenue, Chestnut Street, and Fair Oaks Avenue. There were two plain, substantial, red brick buildings, two stories high. In East Hall were the classrooms for the academic and collegiate studies, the art department and the science laboratories. Clay modeling and wood-carving were taught in the basement. The Assembly Hall was on the second floor. West Hall housed the manual training departments—the machine shops, art metal work quarters, woodwork shops, sloyd,* chemical laboratory, sewing room and cooking room.

Throop Polytechnic Institute was the first school west of Chicago to teach manual work. Amos G. Throop founded the Institute with the idea of uplifting the manual skills to the level of arts and sciences. A large oil-painted portrait of "Father" Throop hung on the wall above the platform in the Assembly Hall. The school was patterned after the Massachusetts Institute of Technology, so we were told—co-educational and non-sectarian. When the public schools took up the idea of manual training many of the graduates of Throop's

*A system of manual training which originated in Sweden, and was based on the use of hand tools in woodcarving.

Sewing, another course which was dropped from the Caltech curriculum, was a Throop favorite in 1900.

Normal Department were given key positions as instructors.

The tuition at TPI at the time I enrolled was $105 a year, and was later lowered to $75 a year. Extra fees were charged for materials used in the laboratories and domestic science classes. We purchased our own books and working materials.

The fare on the Pacific Electric cars from Los Angeles was 25 cents a round trip. Students could get 40-ride books of tickets for $3.00. The Pacific Electric carline terminated at the Throop campus. This was almost the outskirts of the city of Pasadena. Beyond, to the north, except for a few residences, were vacant natural fields stretching up to Altadena, then on up to the foot of the Sierra Madre Range.

In the springtime the fields were carpeted with brilliant golden poppies. The poppy fields were famous as a tourist attraction and could be seen for many miles. Permanent residents of the southland also enjoyed the wild flowers and the views of the mountains which seemed so close, as if the pure unpolluted air were a magnifying glass. There were no automobiles in those days. Horse-drawn vehicles, electric cars, or bicycles took people where they wished to go.

High on the mountain-side, and in plain view from the mountains to the sea, was a huge white or sandstone-colored letter "T", which had been carved out by the Throop boys. Perhaps the future surveyors or civil engineers did the work, clearing away the vegetation down to the bare rock.

Each of our school days began with a 15-minute, nonsectarian chapel exercise in the Assembly Hall. After a prayer, a song and a greeting from our president or other members of the faculty, we heard an address by some local clergyman, business man, benefactor of the college, or distinguished visitor to this community. One speaker that I remember clearly was "Buffalo Bill" Cody. He told of his thrilling experiences, but the theme and purpose of his talk was to stress the importance of temperance, morality, and the strength of character to say "no" in the face of temptation.

We had inspirational talks by such men as Dr. Norman Bridge, who did so much to make Throop and its ideals a success. There were two clergymen whose names were Reverend Socks and Reverend Stocking, (the spelling may not be correct but that is the way their names sounded when pronounced). One was short and broad, the other tall and thin. We always enjoyed their talks.

Throop Polytechnic Institute did not enter into sports events to any extent. Occasionally there was a track meet or ball game with some local high school or neighboring college. Sometimes there was a tennis match between the Pasadena High School and Throop, on the Throop Courts. On the Pasasena High School team were the three Sutton sisters, famous tennis champions. Throop never won against them.

West Hall was a building of many odors, as I remember it. On the south end where the sloyd was taught we smelled clean sawdust and sweet-scented shavings. I sniffed at the smell of baking bread, gingerbread, puddings, and savory meats and vegetables, from the cooking room on the floor above me. Down the hall a way was quite a change of smells. The chemistry room sent out the odors of foul gases which made us hurry past, holding our hands over our noses.

Ordinarily the machine shops and foundry were noticed by their noise from the lathes and heat from the furnaces, but on one occasion they sent out an odor to top all other bad odors. The boys of the biology department had found a dead horse out on the countryside. They brought the carcass back to the shops and placed it in a big vat of water over the fire and boiled it until the flesh dropped off the bones. When the bones were salvaged and the mess cleared away, the boys re-assembled the bones and proudly displayed the perfect skeleton of a horse.

A great day for Throop was the Tournament of Roses on New Year's Day. For weeks ahead we planned and worked on our entry in the parade. A horse-drawn tally-ho was filled with the prettiest girls of the school, and from among the boys were selected the bugler and the outriders. Volunteer workers spent many hours in the sewing room wrapping the harness for the six horses with strips of white sheeting. The wheels and detachable parts of the coach were also wrapped. The day before the parade the students scoured the area of Pasadena and other communities for donations of white and orange colored flowers—those were our school colors. In the early days of the Rose Parade locally grown flowers were used, and were plentiful. After the flowers were ready the workers were busy all night pinning and sewing the white chrysanthemums and deep yellow marigolds, calendulas, and roses onto the muslin-covered equipment and body of the tally-ho.

One year (1900, I believe) the girls were dressed as colonial ladies with powdered hair and large picture hats. They carried parasols that were covered with flowers. The bugler and outriders wore white satin colonial suits trimmed in gold, and had powdered wigs and tricorn hats.

The last Wednesday of each school year was Exhibition Day. The public was invited to view all the work and achievements of the year. Each department had its best work of students on display, and lectures explaining the school's training were given in the Assembly Hall. Domestic Science students served luncheon at noon, and throughout the day and evening they served punch. Other students were appointed to be guides and show the visitors about. Throngs of people filled the halls and classrooms from opening to closing of Exhibition Day.

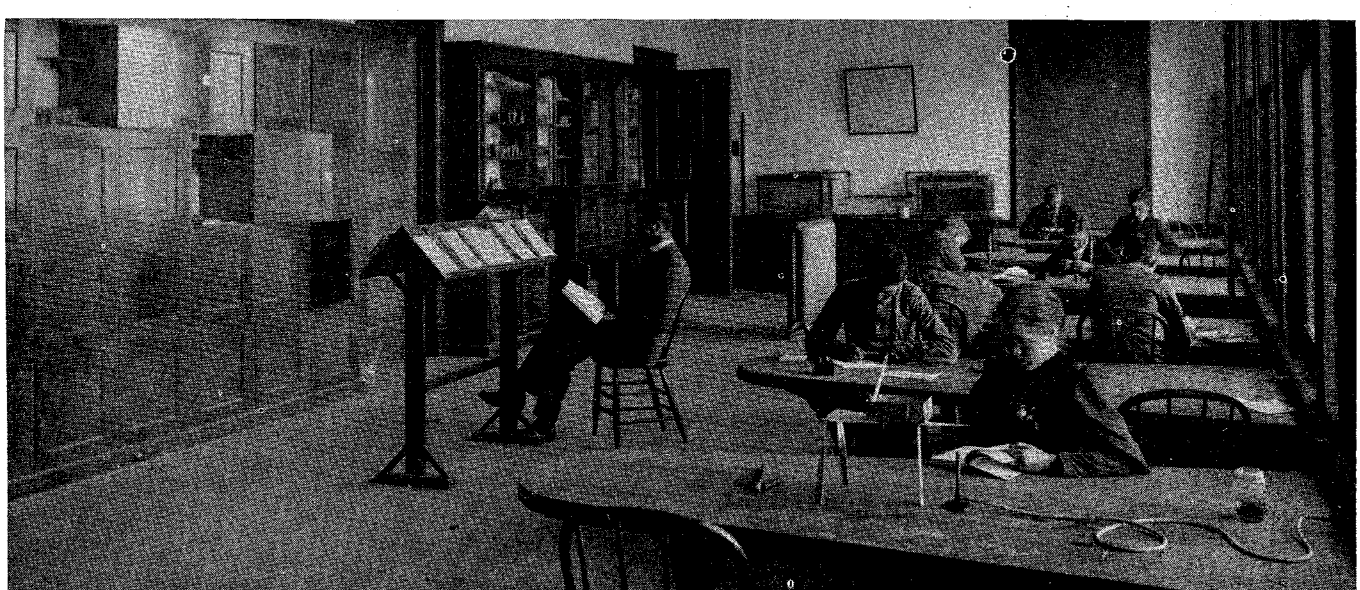
Throop had been attracting the attention of the very wealthy, the most successful, the famous and the cultured people of the local community, as well as the more distant places. These families sent their young people to Throop Polytechnic to get the practical training so needed in everyday life, along with the academic and collegiate education.

The middle class—well-known and professional people—entered their children in Throop because of its cultural and scientific education along with the manual arts. Then there were those parents who had very modest finances, but felt that no sacrifice was too great if their children could have the fine education and environment offered by Throop Polytechnic.

When the public schools began to establish manual training courses, it was then that the dream of Amos G. "Father" Throop to give equal opportunities to all children for this practical training was fulfilled.

Young Throop was now an adult and had to look to bigger and more advanced technical training for the more mature minds. Although the new Throop was not born until 1910, as early as the turn of the century the trustees and faculty were making plans and discussing the possibilities of an expanded but more concentrated program of technical studies, research, chemistry, astronomy, and other sciences. Looking forward to the new buildings, in 1900 the students in the Art Department were given the project of designing friezes, gargoyles, and other embellishments for the Throop Hall which was to be on the spacious campus on California Street.

We who knew and loved the parent Throop felt a little sad when its offspring decided to change its name to California Institute of Technology, but were somewhat appeased when told the big "T" on the mountainside would remain there and would stand for Technology as well as Throop. (I wonder if it is still there? Perhaps my grandson Eric can tell me, if he can see the mountains through the smog).



A group of industrious students in Throop Polytechnic's bustling, well-equipped biology laboratory

THE ROLE OF SCIENCE IN WARFARE OF THE FUTURE

A great military leader considers the possibility of war between East and West—and gives his own ideas on how such a war should be conducted.

by FIELD MARSHAL THE VISCOUNT MONTGOMERY OF ALAMEIN

THE WORLD IS SPLIT IN TWO and the aims of the two parts, East and West, are in direct conflict. In some areas the conflict is violent and has led to fighting. These local wars are part of what is called the "cold war". A better name would be the cold peace.

History records that from time to time evil men arise, seize power, and attempt to exert their will by force. Hitler was such a man. Therefore the possibility of the cold war turning to a hot war is always with us, and we must be prepared accordingly.

Both are global, the cold war *and* the hot war. In trying to win the cold war one side or the other may miscalculate and bring on a hot war, though neither side wanted it. So once again, war is a possibility.

But as we advance further along the road of development of atomic and thermo-nuclear weapons, guided missiles, and ballistic rockets, it will become increasingly clear that a *hot* war will be mutual suicide for the contestants. Therefore, the great problem regarding the cold war now in progress is how to win it without precipitating a hot war.

Local wars call for the use of conventional weapons, and for a readiness to use new weapons if the circumstances demand it. It is obvious that the use of atomic and thermo-nuclear weapons is going to have a profound effect on the conduct of war, on weapon systems, on strategical and tactical conceptions, and therefore on the organization of forces.

I want to make it absolutely clear that we at Supreme Headquarters Allied Powers, Europe are basing all our operational planning on using atomic and thermo-nuclear weapons in our defence. With us it is no longer: "They may possibly be used." It is very definitely: "They will be used, if we are attacked."

The reason for this action is that we cannot match the strength that could be brought against us unless we use nuclear weapons; and our political chiefs have never shown any great enthusiasm in giving us the number of men to be able to do this without using such weapons.

It all calls for a certain reorganisation of our forces, and in our strategy. We have reached the point of no return as regards the use of nuclear weapons in a hot war.

Field Marshal Viscount Montgomery, British hero of World War II, now serving as Deputy Supreme Commander of the Allied Powers in Europe, on a visit to Pasadena last month as guest of Caltech.

In our thinking ahead we need some realistic foundation. Let us therefore consider a war between two powerful groups of nations, and let us call them East and West. You can make any grouping within this broad statement that you think suitable. I would suggest that we include the NATO nations in the West.

We will assume that the West has at present a superiority in atomic and thermo-nuclear weapons together with the means of delivery, but that as the years pass that margin of superiority is likely to decline.

So far as we can see *today* we are not justified in depending on air bombardment *alone,* even with nuclear weapons, to bring a world war to a successful conclusion; still less a local war or disturbance. Wars *today* can be won only by fighting, and, in a hot war, fighting will continue in the air, at sea, and on land until one side loses the will to fight on.

On the other hand, the skillful employment and accurate application of superior nuclear fire-power *in combination* with the operations of streamlined land forces, can be a decisive factor in the battle on land. The problem will be, how to force the enemy to concentrate his armed forces sufficiently to offer a worthwhile nuclear target, without exposing our own forces to destruction by the enemy's nuclear attack.

I suggest that such a war will have three phases.

First Phase: A world wide struggle for mastery in the air and of the oceans. It will be vital during this phase to prevent enemy land forces overrunning and neutralizing Western bases and territories.

Second Phase: The destruction of the remaining enemy land forces.

Third Phase: The bargaining phase, when the enemy's homeland and all it contains is at the mercy of the Western air power. We will then carry the air attack to the point where the enemy accepts our terms.

The second and third phases may be concurrent.

Against the background of this overall strategy, let us consider the war under three headings: The War in the Air. The War at Sea. The War on Land.

THE WAR IN THE AIR

It is clear from the strategy I have outlined that the dominant factor in future war will be air power. And that is my very firm belief. But like so many things we do we too often pay only lip service to this great truth.

The greatest asset of air power is its flexibility. The main factors in determining the degree of flexibility are the methods of command and control, the range of aircraft and the mobility of supporting equipment.

Flexibility and centralized control of *all* the air forces in a theatre of war are vital to success. But the West has sacrificed much of its flexibility by basing the air command organisation on the requirements of "direct support" of the land forces, whereas it should be based on the organisation necessary to gain the greatest measure of control in the air.

Air power is indivisible. If you split it up into compartments you merely pull it to pieces and destroy its greatest asset—its flexibility. If we lose the war in the air, we lose the whole war and lose it quickly. We will never win the war in the air with the organisation for air command and control that we have at present. The present organisation is unworthy of a group of nations who claim to have some knowledge of war.

Now let us have a look at the war in the air.

If we maintain the ability to start a tremendous nuclear bombardment of the East *the moment we are attacked,* they cannot afford to do nothing about it.

It *must* affect the employment of their air forces. It *must* force them to devote a considerable effort of their long-range air forces and nuclear weapons to attempt to hit *our* strategical air forces and the installations on which they depend. It *must* force them to expend effort on air defence, no easy problem for them.

Against this background, I suggest there are three successive stages to consider in the War in the Air.

The first stage

This stage would be if war comes in the near future.

In this period, as I see it, both sides will rely principally on *piloted* aircraft in both the strategical and tactical fields. I see no sign, within this period, of either side being able to create an air defence system which could greatly affect the present balance in favour of the offensive in the air.

The results of this great battle for mastery in the air will have a tremendous effect on the whole war, and we must win it. But we cannot afford to rely on air resources which depend on mobilisation. The air forces we need, together with all the means necessary to keep them operational, *must exist in peace-time.* And by centralizing Air Command on the highest possible level we must restore to the air forces the flexibility they have largely lost.

The second stage

In the not too-far distant future, the East may create a sufficient stock of atomic weapons, and the long-range means of delivering them, effective enough for them to strike at the outbreak of war a devastating blow at *our* means of delivering offensive air power. At this stage, as far as I can see, both sides will still be relying principally on piloted aircraft, both for offence and defence.

Before this period arrives, it will be of tremendous importance that we should have developed, and have in being, a highly effective global early warning system, together with the best air defence that the scientists can give us; in order to prevent our offensive air power being crippled from the start by a surprise attack, and to minimize the effect of such an attack.

The third stage

Later on still, the East may have developed means of delivering their weapons with accuracy, both short-range and long-range, which do *not* rely on piloted aircraft, e. g., the ballistic missile.

Our ability to counter that threat by both offensive and defensive measures will be much reduced, because the targets will be far less vulnerable—whether they are launching sites, or the weapons themselves actually in the air.

We must ask ourselves seriously what, at that stage, are to be the targets of our offensive air power.

Will it then be true that offensive operations by our aircraft or missiles will directly affect the enemy's ability to deliver his weapons against us?

I do not see the aeroplane disappearing altogether. In the tactical field I am sure that there will always be tasks for piloted aircraft in support of land and naval forces. The enemy's aircraft used for these purposes, and their bases, will remain an important target for our aircraft and missiles.

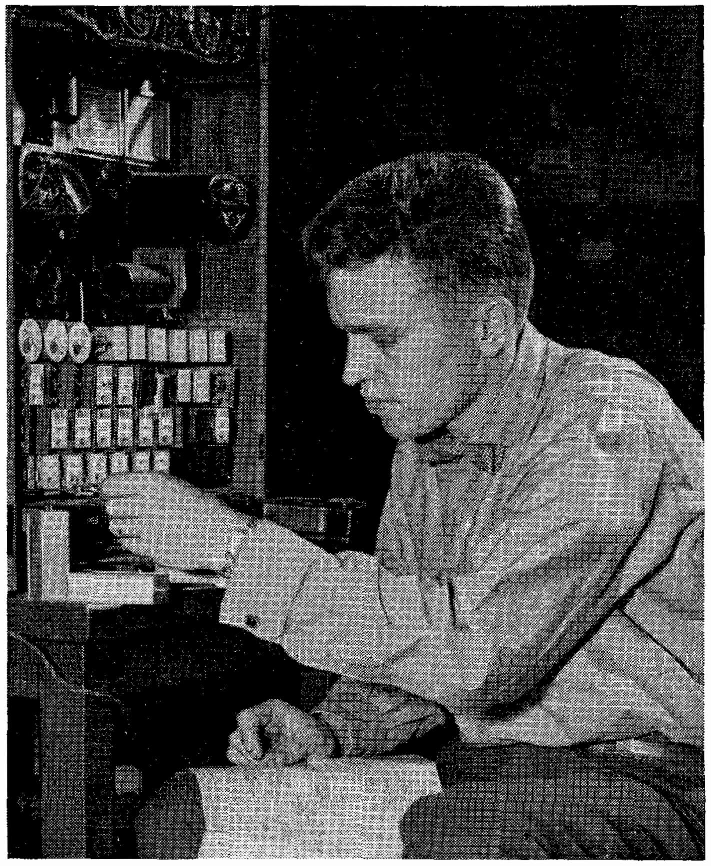
What are the conclusions?

Now that we have solved the problem of endurance in the air, and an aircraft can remain in the skies for prolonged periods and in all weathers, air power is becoming the decisive factor in warfare. We must therefore get organised accordingly. What we must do *now* is to organise the command and control of our air forces so as to retain the greatest degree of flexibility, centralizing command in the highest commander who can effectively exercise that command: so that he can wield the available air forces in a theatre of war as one mighty weapon.

If we are attacked, we must set in motion an *immediate* air offensive on the largest possible scale, directed at the enemy's air forces and at his homeland. The means of delivering an immediate air offensive must exist in peace.

A CAMPUS-TO-CAREER CASE HISTORY

"All the answers aren't in the book"



Here Don Garland makes noise distribution measurements with a Level Distribution Recorder

W. D. Garland, E.E. '52, Univ. of California, is working for the Pacific Telephone Company. We thought you'd be interested in what Don told us about his first assignment.

(*Reading time:* 45 seconds)

"My job is to help solve problems of noise and other interference on telephone lines due to power interference. Inductive co-ordination is the technical term for the work.

"First thing the Chief Engineer explained to me was that 'all the answers aren't in the book.' He was right. Most of the problems have required a combination of electrical engineering, a knowledge of costs and generous amount of ingenuity. *I like it that way.* It's given me an immediate opportunity to put into practice the theory I learned at school.

"In addition to this on-the-job experience, I have attended several special training courses conducted by the company. Now I'm breaking in a new man, just like when I started."

Don Garland's work is typical of many engineering assignments in the Bell Telephone Companies. There are similar opportunities for college graduates with Bell Telephone Laboratories, Western Electric and Sandia Corporation. If you'd like to get more details, see your Placement Officer. He will be glad to help you.

BELL TELEPHONE SYSTEM

We must develop an effective, and global, early warning system in order to have some chance of being able to take the offensive in the air should we be attacked. And we must study air defence urgently; I will say something on this subject later on.

It is vital that our air forces should be able to absorb nuclear attack, and survive to strike back. The principle of dispersion must be explored from every angle. We must get away from the enormous concrete runways of today, and develop aircraft which can land and take off from small pierced-steel-planking airstrips dispersed over the countryside. In this respect "vertical lift" aircraft have very great possibilities.

THE WAR AT SEA

Now let us discuss the war at sea.

As things stand today, it is my view that the West could not win if it lost control of the Atlantic. If we cannot deploy in Europe the power of the American continent, Europe could fall.

In the open seas the great threats are the submarine and air attack. In the narrow waters, the threat of the mine must be added and attack by aircraft will be more effective.

Naval forces of today require air support in the same way as do land forces. It is essential *in the conditions of today,* that navies called on to operate in the great oceans should have *their own air forces.*

The navies of those nations whose work lies entirely in narrow seas, such as the Mediterranean, or in European waters, are in a different situation; in my view, such navies do not need their own air forces. What I have said about the war at sea is applicable only for today and for the next few years. But the more one considers the future the more the problem of control of the seas becomes difficult to foresee. The question to be faced, and decided, is: "In the future, will the seas be controlled from the sea or from the air?"

When one considers the range and power of aircraft of the future, and the progress that is likely in radar and electronics, I am personally forced to the conclusion that the time will come when the major factor in the control of the seas will be air power.

I consider that the day of the large warship on the surface of the sea is over. The emphasis in the future is likely to be on the smaller type of vessel and on underwater craft.

If it is true that the seas will in the future be controlled mainly from the air, then it is for consideration whether this control would not be best exercised by national air forces and *not* by naval forces. If this is the case, then navies will not in the future require their own air forces.

That time has not yet come. But in my view it will come eventually. If this is true, then we should at once stop building any more aircraft carriers; because they are very expensive and will not produce a dividend. What it amounts to is that new weapons have not yet rendered the aircraft-carrier obsolete, but they will do so in the future. And I see control of the seas eventually passing to air forces.

THE WAR ON LAND

To fight successfully on land we need the following four essentials, as a minimum:—

First: We must have first-class forces "in being" in peace time, up to strength and ready at all times to act as our shield *without any mobilisation procedure.* These forces must be trained and equipped to the highest pitch: mobile, hard-hitting, offensive troops of magnificent morale, very highly disciplined, under young and active commanders. These are the troops and the commanders who have got to stand firm in the face of the horrors and terrors of the opening clashes of an atomic war, and they will stand firm only if they are highly trained and highly disciplined.

Second: We need reserve forces, well organised, capable of being mobilised in echelons, and each echelon receiving sufficient training in peace to ensure it is fit to fight at the time it is needed.

Third: Our forces, active and reserve, must be backed by a sound logistic and movement organisation, which should exist in peace to the degree necessary to ensure success in the opening weeks of war.

Fourth: We must have a sound Civil Defense organisation in each national territory.

The whole philosophy underlying these needs in land forces is, that the active forces "in being" in peace will make it impossible for the East to launch an attack successfully *without a preparatory build-up of their forces,* which we would know about; it would be difficult for the enemy to surprise us.

Our *active* forces will prevent the Eastern forces from reaching our vital areas, while we are assembling and moving forward our *reserve* forces.

Let us have a last look at the war in the air, at sea, and on land.

The war in the air

We have got to win the war in the air. We will not win it unless the air forces are allowed to regain their flexibility and unity, and unless air command is organised according. *It is vital that this matter be tackled at once on the highest political level.*

We *must* maintain in peace the ability to launch an immediate offensive in the air against anyone who attacks us.

The West is vulnerable to nuclear attack. Great offensive power is wasted unless it is married to defensive power and can be launched from a secure base.

As time passes and the offensive capability between East and West levels out, the advantage will go to that side which has the greater defence strength, which can protect itself against attack, and can survive to strike back.

There is at the present time no sure defence against the aeroplane or ballistic rocket. Indeed, so far as we can see today, trying to get a secure defence against air attack is rather like trying to keep the tide back on the sea shore with a picket fence. This situation must not be allowed to continue.

The best scientific brains we possess should be gathered in to help in the task, working in close cooperation with air forces. I say "air forces" because I hold the view that air defence should be organised and handled by air forces, and that Antiaircraft Commands should be handed over to that Service.

The war at sea

Today, the navies must handle this war. They must be given the minimum means to ensure control of the seas and of the approaches to essential ports, and no more. *It is essential that they should not dissipate those means on tasks which do not affect the war at sea.* But we must not be hide-bound by past traditions. I give it as my opinion that the time will come when the seas will be controlled from the air. If this is true, the future must be planned and organised accordingly.

The war on land

In the organisation of land forces the emphasis must be on strategical and tactical mobility, and on simplicity of weapons systems. We need Divisions that can be moved rapidly by air; this will necessitate suitable aircraft for the purpose.

To gain full advantage of the immense fire-power that nuclear weapons have provided, and to avoid destruction by enemy nuclear attack, armies must develop a more lively and opportunist type of battle leader than exists at present, in both junior *and* senior ranks. Such a leader must have the imagination, the daring, and the resource to seize fleeting local opportunities; he must be trained to act independently and immediately within the framework of a general plan, rather than on precise and detailed orders, or only after reference to a superior.

I should add that these qualities in a leader apply equally to navies and air forces.

Land forces must become *less* dependent on roads and *more* capable of cross-country movement. The supply system of land armies must be streamlined. They must become much less dependent on fixed lines of supply such as roads and railways, which involve frequent transfers of load.

Armies need a simple line of supply based on an air lift. Today, when supply lines are cut by enemy action, armies cease to operate efficiently. The system of the future should provide air supply to forward maintenance areas from Base Depots many miles to the rear, and well dispersed.

The air lift from Base Depots to forward maintenance areas must be by some type of "vertical lift" aircraft, which can take off and land vertically, and which fly at a fast speed like an ordinary aircraft in level flight. The air supply must be capable of being maintained in *all* weathers, and by day and night.

I see Base Depots being replenished by large freight-carrying aircraft which can land and take off from pierced-steel-planking airstrips.

There is clearly a tremendous future for "vertical lift" aircraft. It is my opinion that this vast air organisation for the land armies will be best handled by the air forces, since you cannot separate an air transport system from air operations.

Such a supply organisation would do away with the vast array of units and headquarters which today constitute the enormous "tail" of a modern army. It would be the first step in restoring to armies the "freedom of the countryside," and the tactical mobility, that have so largely disappeared. By simplifying the tail we shall get more bite in the teeth.

The armies of today have to a large extent lost their mobility; they are becoming road bound and are weighed down by a gigantic administrative set-up in and around them. Staffs are far too big; the amount of paper that is required to produce even quite small action is terrific. We seem to have lost the art of command, other than by paper. No ordinary man can read half the paper that is in circulation; I doubt if the other half is worth reading.

The gist of the whole matter

We stand today at the cross roads, not knowing which turning to take.

Absolute defence against air attack will be impossible in the future. A deterrent, the means with which to hit back instantly, and to give more than you receive—this is the surest way to make an aggressor think twice before he attacks. The West must build up such a deterent, capable of being delivered immediately by air forces which must be "in being" in peace time.

It is then vitally necessary to guard against a surprise attack, and against treachery, and to be able to hold such an attack long enough to enable nations to spring to arms behind the shield and mobilise their collective strength.

The Western nations must also retain the ability to absorb atomic and thermo-nuclear attack, and must ensure that their means of instant retaliation are not compromised by surprise or treachery.

Political, financial, and economic considerations will make it impossible for armed forces to have all they want, or do all they would like. It will become more

important than ever to concentrate on essentials and to have our priorities right.

In the scientific age into which we are moving, which is also an age of ever-increasing costs, Governments have got to ensure that their armed forces and security measures are built up within a framework of economic realities and against a background of sound inter-Service responsibilities.

If what I say has validity, then the priorities will call for the following:

(a) Bigger air forces.

(b) Smaller and more immediately-ready regular armies with great strategical and tactical mobility. Better organised and more efficient reserve armies.

(c) Smaller navies.

(d) The organisation of the three fighting Services based on more atomic and thermo-nuclear power, and less manpower.

(e) A Civil Defence organisation which exists in peace to the degree necessary to ensure it can operate in top gear in an emergency. It must be understood in this respect that while great destruction may be caused at the point of burst of a nuclear weapon, tremendous saving of life and property will be possible on the fringes.

CONCLUSION

I would like to put some points to you in conclusion.

1. We are living today in an age of great scientific progress. The possibilities that lie ahead are almost limitless. If ever war should come again to this distracted world, which God forbid, the key to our success will lie in your hands. I would put forward the following points for your consideration.

The scientific advances of today in civilian life, and in the realm of defence, are creating a demand for highly trained technicians and engineers in ever-increasing numbers. Most nations are falling behind more and more in the attempt to meet this need.

I have been told that Russia is producing more of these technicians than the United States. It is not important whether you produce more technicians than Russia. It *is* important that you have enough to meet your needs for defence and to keep ahead in new developments. And your needs are also the needs of the free world.

I believe there is a further problem in the field of science that needs to be watched. Your nation has earned a great reputation as a mass producer and for your ability to take an idea and improve on it. I suggest that you want to have the same reputation in basic research. Basic research has given us some near-miracles in the past, and we want more in the future. I suggest you concentrate on this and lend your assistance, so that you gain for the United States a reputation in basic research that matches your reputation for production and applied techniques. The survival of the free world may well depend on your success in this vital matter.

2. What is needed today in every nation is a clarion call and a roll of drums. That call must be one to discard out-of-date doctrines and methods of past wars, and to organise our affairs to take full advantage of the progress of science.

We see today the rise of air power and the emergence of the Air Forces as the decisive arm in warfare. We see the big warship disappearing from the seas. We see the day of the aircraft carrier approaching its end.

It is no good trying to fight against the inevitable, as some people do. Do not let us be mesmerised by what worked in past wars; it will not work again. We must take off our hat to the past and roll up our sleeves for the future.

Service chiefs must cooperate closely with the scientist, put their problems clearly and simply to them, and give them all possible help in solving those problems.

We require a fighting machine which is backed by a sound logistic organisation. Both of these, the fighting machine *and* the logistic organisation, must be planned in full accord with scientific progress. There will be much opposition.

The citadels of vested interests must be swept away; out-of-date procedures and techniques must be discarded. All this will require courage, and decision.

And the first courageous decision will be to acknowledge the dominance of air power, and to place air forces in the position of being able to play their part as the decisive weapon in future war. This decision must be taken at once; delay will be dangerous.

3. In the past the defence programme of a nation has often been decided as a result of compromise decisions by Chiefs of Staff. If this practice is followed in the future we shall fail.

The vital thing today is to produce a military weapon which is in all respects adequate for the national needs and for the collective security system of the free world.

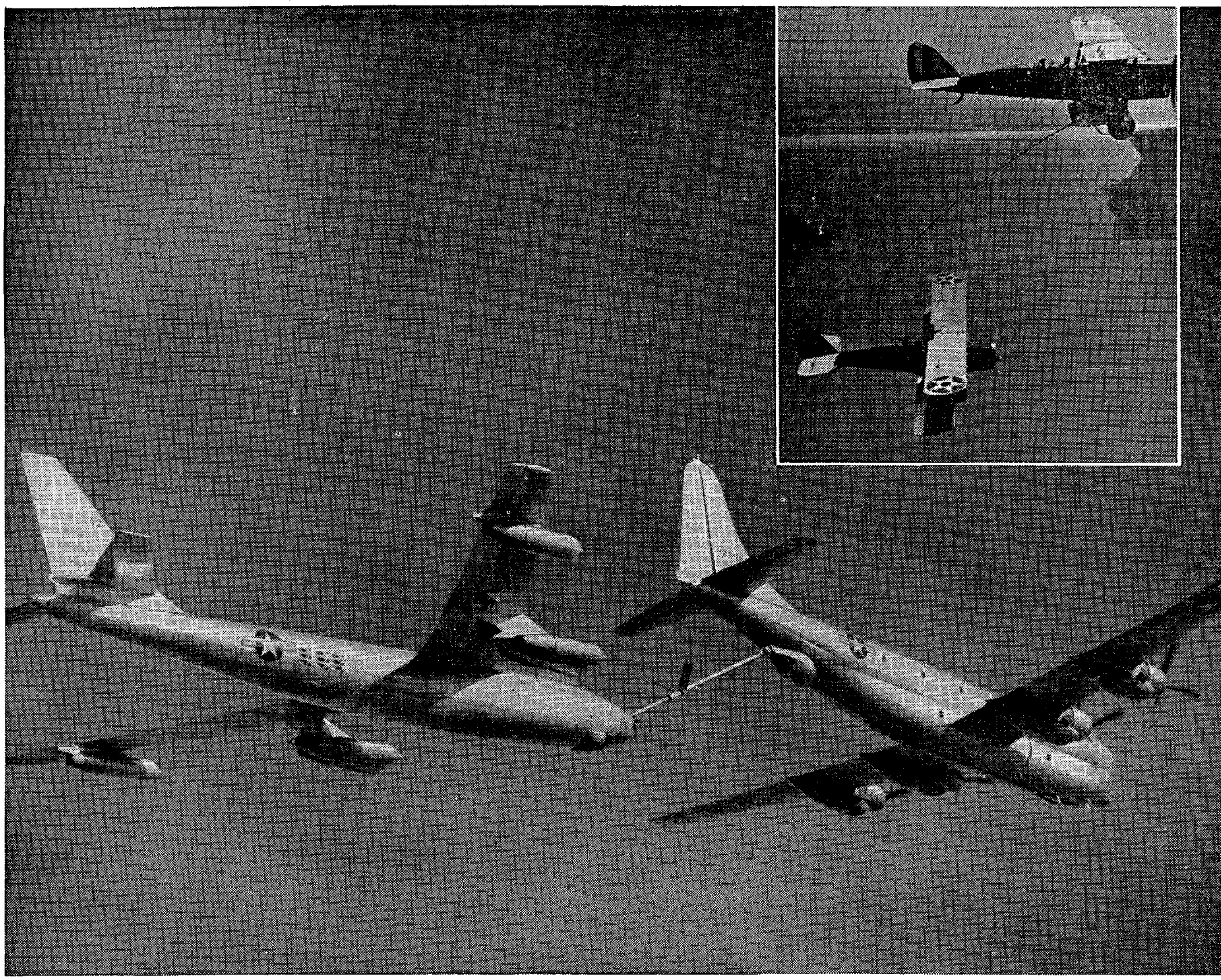
In the Navy, the Army, and the Air Force each nation has a team. By themselves the individual members can achieve little. The team can achieve victory if it is properly constituted. The progress of science is likely to change the former responsibilities of the three members in certain directions. Parts of the load are shifting from the shoulders of one Service to the shoulders of another.

In particular, the air is coming to the front as the dominant factor in war and the decisive arm, as I have already said. This is going to introduce difficult problems and in solving them do not let us bother unduly about the colour of our uniform: dark blue, light blue, khaki.

What is vital is to find the right answer and the one which is best for the nation, and to reach that answer without ill-feeling and inter-Service quarrels.

Finally—The key to the future lies in the hands of the scientists, and in Institutes of Technology such as yours. I am confident you will not fail us.

1923—first aerial refueling

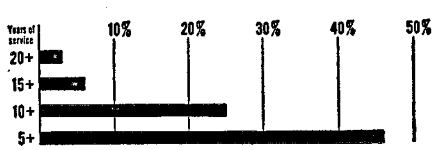


1954—Boeing KC-97 tankers completed 16,000 refuelings last year

30 years of progress in aerial refueling

The small picture shows the first aerial refueling by the Air Force. The large picture shows a Boeing KC-97, today's standard Air Force tanker, transferring 600 gallons of fuel a minute to a Boeing B-47 Stratojet bomber.

Boeing pioneered aerial refueling tankers and equipment. Further, during its 38 years, it has constantly pioneered trend-setting designs in commercial and military aircraft. This has meant such continuous growth that Boeing now employs more engineers than ever before, including the World War II peak. Boeing offers *stable* careers to engineers of virtually EVERY type: civil, mechanical, electrical and aeronautical. The company employs draftsmen and engineering aides for routine work, thus freeing engineers for more creative assignments.



Boeing engineers enjoy long-range careers—46% of them have been at Boeing 5 or more years, 25% have been here 10 years, and 6% for 15 years.

In addition to stability, Boeing offers an unusual variety of research, design and production opportunities, including work with new materials, guided missiles, jet bombers and transports, and research in nuclear-powered aircraft and supersonic flight.

Boeing makes it possible for engineers to take graduate studies while working, and reimburses them for all tuition expenses.

For further Boeing career information, consult your Placement Office, or write:

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

BOEING

SEATTLE, WASHINGTON WICHITA, KANSAS

THE MONTH AT CALTECH

James R. Page Retires

JAMES R. PAGE, retiring after 11 years as chairman of Caltech's Board of Trustees, was honored at a dinner given by the Trustees and Associates of the Institute at the California Club in Los Angeles last month.

Mr. Page was one of the 100 original members of the California Institute Associates when they organized in 1926. He was elected their president in 1931.

"It was the Associates," said President DuBridge, in his speech at Mr. Page's retirement dinner, "whose moral and financial support was the decisive element in converting a small engineering college into the great center of pure and applied science that we know today."

Mr. Page retired officially on November 1, and was succeeded by Albert Ruddock. (*E&S*, November 1954). He will continue to serve on the Board as chairman of the finance committee.

Mr. Page became a Trustee of the Institute in 1931, and in 1943 he succeeded the late Allan C. Balch as chairman of the Board.

"Since then," said Dr. DuBridge, "he has occupied the chair with grace, with good humor, with friendliness, with firmness or with any other mood which seemed to him appropriate for each particular occasion."

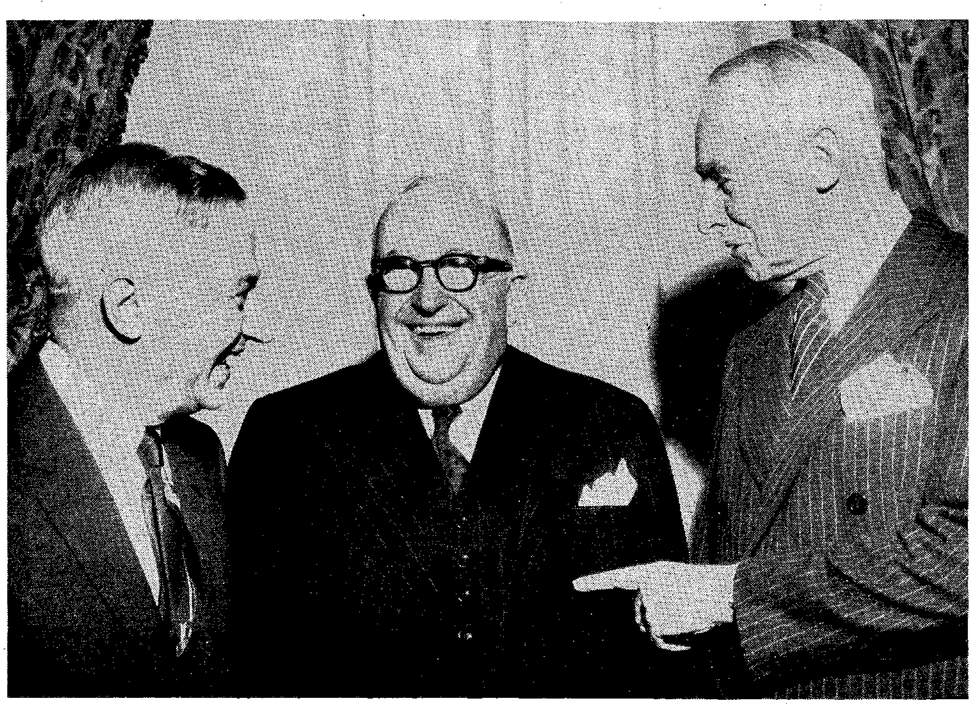
A native of Memphis, Tennessee, Mr. Page came to California in his youth and over a period of sixty years has been active in the business, cultural, civic and religious affairs of the Los Angeles community.

He is currently a director of the I. N. Van Nuys Building Company, the Gladding McBean Company, the Southern California Edison Company, the First Safe Deposit Company and the Union Oil Company of California. He is also a trustee and the treasurer of the Henry E. Huntington Library and Art Gallery.

For five years he was president of the California Bank. He served four terms as president of the All-Year Club of Southern California. From 1923 to 1929 he was secretary of the Greater Los Angeles Harbor Committee of 200, which employed the engineers and experts who designed the Los Angeles harbor as it is today.

Mr. Page has been a leading figure in the Community Chest for more than 20 years and was its president for four years. An active churchman, he served as a vestryman and warden in the Episcopal Church for more than 30 years. He is a trustee of the Good Samaritan Hospital, the Barlow Sanatorium and the Santa Barbara School in Carpenteria.

Reviewing Mr. Page's career, William C. McDuffie of the Caltech Board of Trustees, said: "This impressive list of activities was possible only because Jim was doing the things he really liked best to do. He did not play golf, own a boat, horses or a country home. His one big hobby has been his work and this community has greatly profited thereby."



President DuBridge, James R. Page, and William C. McDuffie, member of the Caltech Board of Trustees, at the testimonial dinner honoring Mr. Page on his retirement as chairman of the Board of Trustees.

Honors from France

DR. ALFRED STERN, Associate Professor of Languages and Philosophy at Caltech, received the insignia of a Knight of the Legion of Honor, one of France's highest awards, at a ceremony on the Caltech campus last month.

The Legion of Honor was established by Napoleon Bonaparte in 1802 for recognition of distinguished civil and military service. By recent decree of the President of France, Dr. Stern was proclaimed a Knight of the order for his outstanding scholarly contributions to French culture and the valuable service he rendered the cause of France during World War II.

Lt. Col. Hubert de Pazzis, chief of staff for General De Castries at Dien Bien Phu, presented Dr. Stern the insignia of the order, a star with five two-fold rays surmounted by an oak and laurel crown and bearing the inscription, *Honneur et Patrie*.

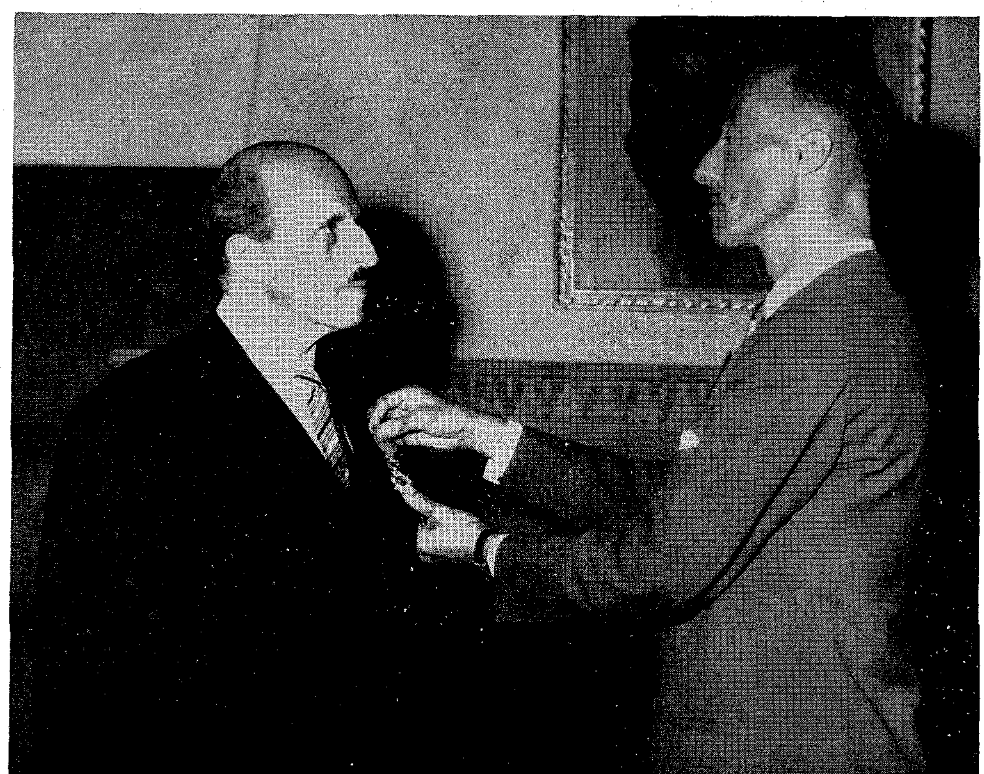
Dr. Stern has published a number of books and articles in French, English, Spanish and German, many of which deal with French philosophy and literature. Among his best-known works are *The Philosophy of Values*, *The Philosophy of Laughter and Tears*, and his latest book, *Sartre—His Philosophy and Psychoanalysis*. Dr. Stern also wrote the basic article on French science and philosophy for the current edition of the *Encyclopedia Americana*. He has lectured frequently in this country in French philosophy and literature.

Dr. Stern came to Caltech in 1947. In addition to teaching here, he also lectures at the University of Southern California. He came to the United States from Mexico City, to which he had escaped when France was overrun by the Nazis in World War II. At that time he was a volunteer in the French Infantry. Soon after arriving in Mexico City in 1942 he became active in the Comité National Francaise, headed by General Charles de Gaulle. As a writer for this committee, Dr. Stern published in the next three years a book and hundreds of articles in support of the cause of Free France.

Dr. Stern has taught at the University of Paris, the New University of Brussels, the National University of Mexico, the French College in Mexico City and the French University in New York. He holds a PhD from the University of Vienna. He is a contributor to many scholarly journals in the United States, France and Latin America. In France he holds the "Academic Palms" and the title, "Officer of the Academy."

"What I have done for France," said Dr. Stern, after receiving his award, "is much less than what she has done for me. I owe France an immense enrichment of my life in the realms of intellectual, moral and artistic values.

"When, in 1933, still five years before the annexation, I had to leave my native Austria because of her growing totalitarian intolerance which prevented me from continuing my academic career, France opened for me the doors of her first university, the Sorbonne. The years I had the privilege of teaching philosophy there belong to the proudest and happiest of my life. Thus, I had every reason to love France, and what is done from love is always beyond merit. In recognizing as a merit what was only the result of the impulses of my heart, France gives a new proof of her generosity."



Dr. Alfred Stern receives the insignia of a Knight of the Legion of Honor, one of France's highest awards, from Lt. Col. Hubert de Pazzis, right, chief of staff for General DeCastries at Dien Bien Phu.

ALUMNI NEWS

Dinner Meeting

THE NEXT Alumni Dinner Meeting, to be held on January 12, will have Elmer S. Nelson, economic consultant, as speaker of the evening. Mr. Nelson will discuss "Business Conditions and the Industrial Trend in Southern Californa for 1955-56."

Now a consultant to private business on economic, financial, and trade problems, Mr. Nelson was appointed Trade Expert and Economic Advisor to the U. S. government under President Woodrow Wilson in World War I. He later served on the World Trade Board, the War Industries Board, the U. S. Food Administration and the U. S. Shipping Board. During World War II he served with the Office of Price Administration and the War Assets Administration. In 1947 he went with the U. S. Department of Commerce, and in 1951-52 he was Supervisory Economist for the Office of Price Stabilization. He has also been on the staff at UCLA, giving courses in economics, money, banking, foreign trade, and transportation.

The dinner will be held at the Carolina Pines Restaurant, 7315 Melrose Avenue, Los Angeles. The time is 7:00 p.m. Wives are welcome. And the committee promises that the tariff will be $3 or—if possible—under.

Alumni Picnic

THE ANNUAL ALUMNI PICNIC will be held this year on Saturday, June 25 at the Marineland of the Pacifiic located on Palos Verdes Peninsula. The Oceanarium, picnic areas, restaurant and parking space will be available to alumni. Save this date for your visit to this exciting marine display—and for an organized picnic with your family and friends.

Continued Story

COLONEL JOHN K. ARNOLD, '41, MS, command pilot of a B-29 shot down over Korea in January, 1953, was listed as "missing in action" until October, 1954, when word was received that he had been located as a prisoner of war. An AP dispatch from London, dated November 23, gives further details on Colonel Arnold.

> "Thirteen Americans who dropped out of sight on *aerial missions against the Communists* in the Korean war were sentenced by a Red Chinese military court today to prison terms ranging up to life on spy charges . . .
>
> "Colonel John Knox Arnold, Jr. of Silver Spring, Md., was the highest ranking of the prisoners listed . . . the commander of a B-29 shot down January 12, 1953, he drew 10 years.
>
> ". . . By the Peiping account, Col. Arnold was the

commanding officer of the 581st Supply and Communications Wing of the U. S. Air Force, 'charged with the task of carrying out espionage in the service of the U. S. Central Intelligence Agency' against Red China and the maritime areas of the Soviet Union in the far east.

"Against American reports that his B-29 fell over North Korea, the Chinese said it was shot down 'after intruding into China's territorial air space over Liaoning Province' of Manchuria, across the Yalu.

"News of the court action came out only a few weeks after delivery of some letters from the Air Force prisoners to their relatives in the United States through Chinese Red Cross Channels. These lifted a blanket of silence lowered by the Reds almost two years ago."

A later newspaper dispatch quoted the Chinese as saying that Colonel Arnold had confessed that the mission of his wing was to "bring in, supply, evacuate or recover underground personnel." The U. S. story is that his group was engaged in psychological warfare, dropping leaflets—and that Colonel Arnold and his operations officer merely went along for the ride on the day that they were shot down.

Open House

ALUMNI LITERALLY went back to campus life recently when Caltech's eager football squad met Oxy's Tigers in the classic contest November 12. Not about to be overwhelmed by the adverse combination of a halftime score of 0-27 and an especially damp Patterson Field, the pigskinning Beavers provided alumni and students alike a great second half by outscoring Oxy 13-12.

Appropriately enough, a "victory" celebration had been planned at Dabney Lounge on campus, at which the Alumni Association played host to old grads and present students. Thanks to a warm hall, coffee, and a band, the evening proved to be a success for all—including the twenty-some men who put up such a determined battle earlier in the evening.

1915

Earle A. Burt has been 40 years with the Los Angeles County Road Department. As Chief Deputy Road Commissioner, his job keeps developing new aspects almost daily, due to the expanding needs for highway facilities. Earle also proudly reports that he now has two grandsons and one granddaughter.

1925

Robert W. Fulwider, a partner in the Los Angeles law firm of Fulwider, Mattingly and Huntley, reports that they have recently opened a branch office in San Diego for the practice of patent law. *Walter Huntley* '32, and *Warren Patton*, '34, are also members of the firm.

1926

Allen L. Laws, District Manager of the Southern California Edison Company in Los Angeles, was elected President of the San Marino City Club at the November elections.

Joachim F. Voelker was recently promoted Chemical Engineer for the Pennsylvania-Dixie Cement Corporation, with headquarters at the company's general office in Nazareth, Pa. Before this advancement, he was superintendent of one of the plants. He has been with the company since 1950.

1928

Tomizo Suzuki joined the Japan Construction Agency in January of this year as a civil engineer and special consultant, and is acting as field inspector at one of the U. S. Army bases near Tokyo. Before this, he worked four years for the Okinawa Engineer District. Tomizo writes that in general the people of Japan have a hard time, due mostly to the deflationary policy of the government. The Suzukis have three children, all busy in school.

1929

Leonid. V. Leonard has been with the Shell Oil Company (Pacific Coast Area) as an Area Gas Engineer for 20 years, and has been working on the design and construction of gasoline and gas processing plants. In the last few years he has visited both South America and Canada in connection with gas processing problems.

Thomas Clements, MS, PhD '32, has just completed 25 years on the faculty of the Department of Geology at USC (21 years as head of the department). He just published a booklet entitled *Geological Survey of Death Valley*, and has been elected president of the Death Valley 49'ers.

1930

Roscoe P. Downs is now project manager on the Demirkapue Dam, 60 miles out of Izmir, Turkey. Roscoe and his wife spent three and a half months in Europe this summer, when he was first called to Turkey to act as consultant on the dam. While Roscoe was in Turkey, Mrs. Downs did a bit of sight-seeing throughout Europe, and in September they returned to Los Angeles together. Roscoe returned to Turkey in October, and Mrs. Downs should be joining him very soon, as they plan to spend the holidays in Jerusalem. Roscoe is employed by Entreprises Metropolitaines et Coloniales, a French company.

1932

Millard V. Barton is a research engineer with the Ramo-Wooldridge Corporation in Los Angeles. Before joining the company he was chairman of the Department of Engineering Mechanics at the University of Texas.

1937

Lawrence Fleming recently resigned from the Diamond Ordnance Fuze Laboratories in Washington, D. C.—where he was chief of the Instrumentation Section, Electronics Division—to devote full time to activities as a consultant and patent agent. He has served as a project engineer in acoustic instrumentation and on proximity fuzes at the Naval Ordnance Laboratory, and on fuzes in the Ordnance Division of the National Bureau of Standards, as well as in the Electron Tube Laboratory at NBS. Lawrence is now living in Falls Church Virginia.

George F. Francis, MS, sends a postcard from South America with news of recent activities: "Returned in September to Punta Areanas, Chile (the world's most southerly city, with the most southerly golf course and race track) for a second two-year contract as party chief for the United Geophysical Company. Work is with Empress Nacional del Petroleo (government) . . . seismograph prospecting for oil on the mainland and on the island of Tierra del Fuego, both sides of the Straits of Magellan. There are about 20 Americans working in, and training local people in geology, seismology, drilling, production, and refining.

"Weather is generally cool, sometimes -10°F in winter, and very seldom 65° in summer. Also rates as the world's windiest area. Life is generally calm. No night clubs, two or three picture shows, a few parties. People generally pleasant."

1939

Charles MacKintosh, MS, a partner in the consulting engineering firm of MacKintosh and MacKintosh, Los Angeles, has developed a new line of compact and comfortable nesting chairs and tables, which is now being manufactured commercially.

Harry O. Davis has become assistant project engineer on the new C-130A turboprop cargo airplane that Lockheed is building at its Marietta, Ga., plant. Harry started with Lockheed in 1940, and before his new appointment was assistant project engineer on the B-47 project.

1940

Kiyou Tomiyasu, engineering section head for Microwave Research at the Sperry Gyroscope Company in Great Neck, New York, delivered a paper at the National Electronics Conference held in Chicago in October. His paper, which was prepared with another engineer at Sperry, was on Microwave Components for Double Ridge Waveguide.

Ellis Lapin, MS '41, is assistant supervisor of the Aerodynamics Research Group at Douglas Aircraft in Santa Monica.

1942

Fred Bauer is living in Amsterdam, Holland, as the Foreign Field Representative for the AiResearch Manufacturing Company of Inglewood, California. Fred's work involves getting U. S. equipment on European airplanes.

Enver Murqdoglu is president of Yol ve Yapi, Ltd., a Turkish contracting firm now engaged in three NATO airfield constructions (in Turkey) and two highway projects, costing four to five million dollars.

S. Kendall Gold, formerly president of the New York chapter of the Caltech Alumni Association, resigned when he was recently transferred to England as Chief Engineer of the United Overseas Petroleum Company, Ltd.

1943

Robert M. Benson has been appointed vice president of Gyromechanisms, Inc., in charge of the West Coast Division, with headquarters in Los Angeles. Bob will coordinate sales and engineering activities for the company's western customers—mostly manufacturers of aircraft and missiles.

1945

John L. Stern has opened a real estate and insurance office in Los Angeles. He has taught real estate at UCLA and was previously sales engineer for the Walter Leimert Company.

Walter L. Hunter, PhD, is vice president in charge of engineering for the Lamson Aircraft Company of Seattle. The company designs and manufactures special-purpose airplanes. Walt mentions that one of their planes is a crop dusting-spraying plane; another, an "air tractor", was ready for flying last month. Walt was with Boeing before joining Lamson.

Ralph D. Winter received his PhD in general linguistics from Cornell University in September, '53, and is now taking further graduate study. The Winters have one child, and are living in Somerville, N. J.

1946

John A. Anderson reports "Escaped from the Navy in March after two years in Japan at Yokosuka Naval Base. The first six months were interesting, but the last year and a half boring as hell. First born, Susan Elaine, arrived August 19. At present am with North American Aviation in Industrial Engineering Department. While in Japan *Bill Libbey, Don Meixner,* and *Howard Jensen,* all class of '46, came sailing through."

1947

David Caldwell thinks he's in a rut—at any rate, he can't seem to get away from Institutes of Technology. He just returned from Europe, where he studied at the Swiss Federal Institute of Technology on a National Science Foundation Postdoctoral Fellowship, and is now in the Physics Department at MIT.

Le Val Lund received his MS in civil engineering last June from the University of Southern California.

1948

Conway Snyder, PhD, decided to leave industry and go into the teaching field this fall. He is now Assistant Professor of Physics at Florida State University. He resigned from the Fairchild Engine and Airplane Company, where he had been since 1949. As senior physicist he worked on the Nuclear Energy Propulsion Aircraft Project, set up research programs, conducted nuclear research at Oak Ridge, and travelled for the company, giving lectures on atomic energy at various universities.

Philip Blenkush, MS, PhD '49, is employed by the Radioplane Company in Van Nuys as chief of their Preliminary Design Engineering Division. Before this last promotion, Phil was project engineer of the Weapons Systems Division.

Robert G. Stokeley, senior design engineer of the Guided Missile Division at Convair, is now coaching the Convair basketball team. Bob thinks today's Beavers are going to have an easier time of it than they did when he was in school—a recent look at the new gym on campus, he says, brought back a flood of memories of the long daily trips to Muir and the Armory for basketball practice.

1949

Paul Saltman, PhD '53, Assistant Professor of Biochemistry at USC, has received a $7,776 grant from the Tobacco Industries Research Committee. Paul will use the grant to study the dark-fixation of carbon-dioxide in the leaves of the tobacco plant.

William Moellering is now at Heidelberg, Germany, studying at the Physikalisches Institut.

William N. Harris will join the Navy in January, and has been accepted for the OCS class at Newport, Rhode Island.

Edward P. Fisk and wife Mary report the birth of their second daughter, Donna Lee, born on September 20. Ed is working in Los Angeles for the Bell Petroleum Company as manager of drilling production.

Hugh C. Carter became a father on November 18th when John Clendenin was born.

1950

Andrew G. Fabula, MS, and his wife (the former Connie Triesch of Glendale) announce the arrival of a son, David, on November 15th. Since leaving Caltech, Andrew has been with the Pasadena Annex

of the U. S. Naval Ordnance Test Station, working on hydro-dynamics and ballistics.

Michel Gossot, MS, studied two years in Paris after leaving Caltech. Now living in Brest (Finistère), France, he gives a run-through of his recent activities: "Was married in April, 1953, and have a nice baby named Dominique, born February 2, 1954. Am now working for the Navy—a very fine job where one can actually build things and make them work. The job is connected with most branches of industry and is both scientific and practical. Been traveling since I left school—39 states in the U. S., France, Germany, Italy, Switzerland, Spain, England, Belgium, Holland, Denmark, Norway, Sweden, and Austria. Have also been aboard ships. I sail on weekends on a little sail ship, or learn to play the cello, or polish my Spanish. Still interested in non-representative photography. I have a nice wife, a nice home. All is well."

1951

William R. Smythe was married on November 27 to Carol Evelyn Richardson of Pasadena. Carol attended UC at Santa Barbara.

John G. Elliot was married on October 17 to Ann James, of Tucson, Arizona, a graduate of the University of Arizona and the Huntington Memorial Hospital School of Medical Technology.

John H. Walter received his PhD from the University of Michigan last June, and is now an instructor at the University of Washington, in Seattle.

1952

Henry B. Keswick joined the Aramco Oil Company as area engineer in the Abqaiq District of Saudi Arabia—and look what happened: "Am engaged to an Australian girl I met in Madrid last winter, and am going to marry her on Bahrain Island, in the Persian Gulf, and then bring her here to Abqaiq. Became engaged while on a three months vacation from the company. Took this fatal step in England. Incidentally, while in Copenhagen, a Caltech classmate, *George B. Cooke*, '53, and I just missed two other classmates, *Augustus Soux* and *John McCourt*, both '52."

Joseph J. Picornell, MS, is now in Manila as production engineer with the Industrial Textiles Manufacturing Company of the Philippines, Inc., which has 830 employees. The work is mostly concerned with the introduction and adaptation of modern production methods to local requirements. Off-hours, Joe gets in a lot of sailing and swimming. Still single, he says—so far.

Jose Luis Reissig, PhD, is another '52 bachelor, now a research worker, studying the behaviour of enzymes in the Instituto de Investigaciones Bioquimicas, a privately supported Buenos Aires Institution.

1953

Morris Robkin is now working in the physics department of the Westinghouse Atomic Power Division and, at the same time, going to graduate school (physics) at Carnegie Tech in Pittsburgh.

1954

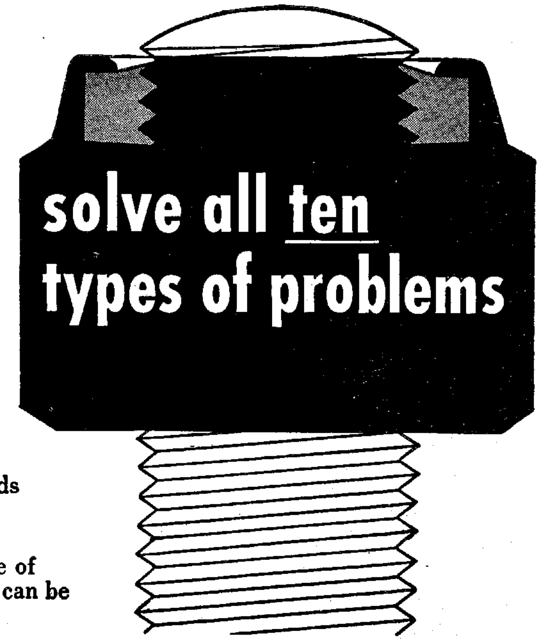
David A. Heiser, MS, a private in the Army, has been assigned to the Chemical Corps at Muscle Shoals, Alabama.

Richard Hodges and *William Nevill*, PhD, have accepted positions with Procter and Gamble. Dick is working in factory management at P&G's Long Beach factory, and Bill is in research and development at the new company laboratories just outside Cincinnati.

Paul Concus spent an interesting summer working at the Bell Telephone Labs, and enjoying the wilds of New York City. Now he's joined the rest of the Caltech delegation at Harvard graduate school, where he is majoring in physics.

Richard F. Dondanulle is now in the Army Air Force, stationed at Lowry Air Force Base in Colorado.

elastic stop nuts



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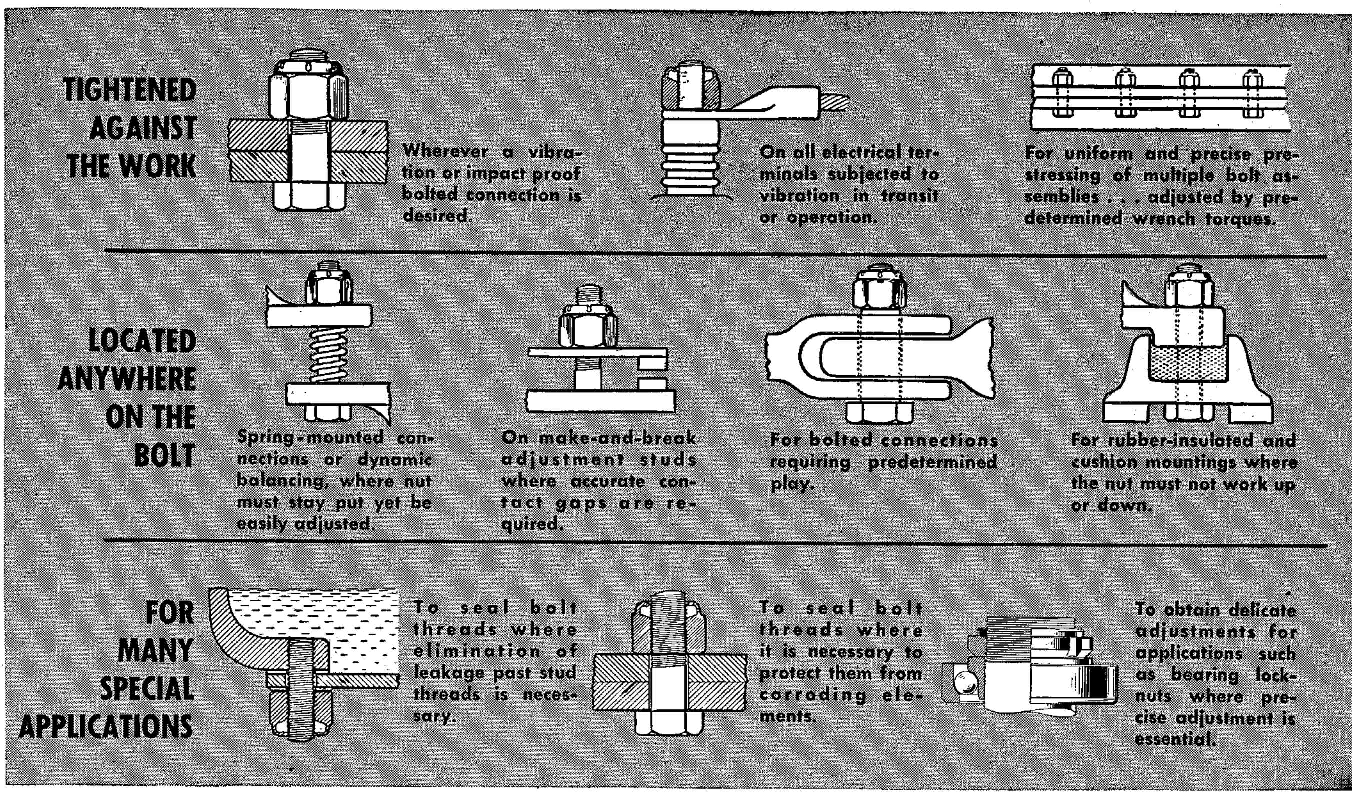

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1906
Norton, Frank E.

1911
Lewis, Stanley M.

1912
Humphrey, Norman E.

1918
Pease, Francis M.

1922
Beman, Willard J.
Cox, Edwin P. MS

1923
Skinner, Richmond H.

1924
McKaig, Archibald
Miller, Palmer

1925
Bailey, Emerson
Smith, Dwight O.

1926
Barnes, Orrin H.
Chang, Hung-Yuan
Higman, Arch
Hsaio, C. Y.
Huang, Jen Chien
Huang, Y. H.
McCarter, Kenneth C.
Schueler, Alfred E.
Yang, Kai Jin

1927
Langer, R. Meyer, PhD
Peterson, Frank F.

1928
Chou, P'er-Yuan, PhD
Hicks, Hervey E. PhD
Martin, Francis C. MS
Morgan, Stanley C. MS

1929
Briggs, Thomas H. Jr. MS
Nagashi, Masahiro H.
Nelson, Julius (Espinosa)
Robinson, True W.
Sandberg, Edward C. MS

1930
Chao, Chung-Yao PhD
Janssen, Philip
Moyers, Frank N.
Russell, Lloyd W.
White, Dudley
Wilkinson, Walter D. Jr.

1931
Crossman, Edward B.
Ho, Tseng-Lo MS
Matison, Harry
Newby, Oscar M.
Voak, Alfred S.
West, William T.
Woo, Sho-Chow PhD
Yoshika, Carl K.

1932
Fraps, A. W. MS
Harshman, E. Nelson
Marshall, Donald E. MS
Schroder, L. D. MS
Wright, Lowell J. MS

1933
Applegate, Lindsay M. MS
Ayers, John K.
Hsu, Chuen Chang MS
Kitusda, Kaname MS
Larsen, William A. MS
Lockhart, E. Ray
Michal, Edwin B.
Murdock, Keith MS
Pauly, William C.
Rice, Winston H.
Schlechter, Arthur H. MS
Shappell, Maple D. PhD
Smith, Warren H.

1934
Core, Edwin J.
Hooper, Duncan L. MS
Liu, Yun Pu PhD
Lutes, David W.
Magden, John L. MS
Marmont, George H.
Radford, James C.
Read, John PhD

1935
Becker, Leon
Ehrenberg, Gustave Jr.
Gelzer, John R.
Harney, Patrick J. D. MS
Huang, Fun-Chang MS
Huang, Hsia-Chien MS
Jackson, Oscar B. MS
Koons, Harry M.
McCoy, Howard M. MS
McNeal, Don MS
Obatake, Tanemi
Rivas, Dagoberto

1936
Bassett, Harold H. MS
Chu, Djen-Yuen MS
Creal, Albert
Hartlein, Robert L.
Kelch, Maxwell
Kurihara, Hisayuki
Ohashi, George Y.
Onaka, Takeji MS
Van Riper, Dale H.
Weber, Bruce T.

1937
Burnight, Thomas R.
Cheng, Ju-Yung MS
Easton, Anthony MS
Fan, Hsu Tsi MS
Jones, Paul F. MS
Lotzkar, Jack MS
Maginnis, Jack MS
Miller, Shirley S. MS
Moore, Charles K. MS
Munier, Alfred E. MS
Murphy, Joseph N. MS
Nojima, Noble
Park, Noel R. MS
Parry, H. Dean
Penn, William L. Jr.
Rechif, Frank A.
Servet, Abdurahim MS
Shaw, Thomas N.
Smith, Joe M.
Tsubota, George Y. MS
Yin, Hung Chang PhD
Yuan, Shao-Wen MS

1938
Ackerman, John B. MS
Gershzohn, Morris MS
Goodman, Hyman D. MS
Hughey, Albert H. MS
Kanemitsu, Sunao MS
Koch, Walter L. MS
Lowe, Frank C.
Ofsthun, Sidney A. MS
Okun, Daniel A. MS
Scoles, Albert B. MS
Shanahan, Edmond F.
Stone, William S. MS
Tilker, Paul O.
Tsao, Chi-Cheng MS
Velasquez, Jose L.
Wang, Tsun-Kuei
Watson, George G.
Watson, James W.

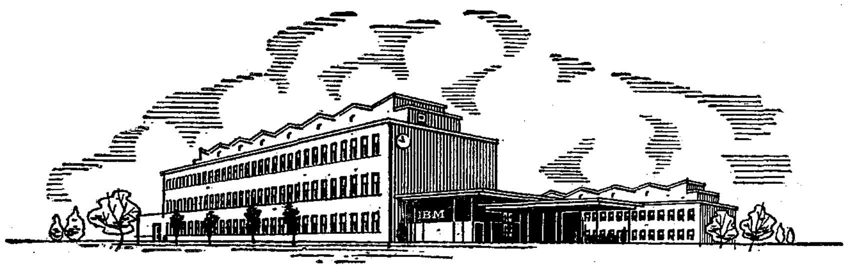
1939
Asakawa, George
Brown, William Lowe
Burns, Martin C. MS
Carter, Robert T.
Coates, Leonidas D. MS
Jackson, Anderw M. Jr. MS
Jones, Winthrop G. MS
Kyte, Robert M.
Liang, Carr Chia-Chang MS
Neal, Wilson H. MS
Poon, Yuk Pui
Robertson, Francis A.
Sinclair, George W.
Tatom, John F. MS
Yood, Bertram MS

1940
Batu, Buhtar MS
Green, William J. MS
Heywood, Harold E. MS
Hofeller, Gilbert W.
Pai, Shih-I PhD
Paul, Ralph G.
Tajima, Yuji A.
Tao, Shih Chen MS
Wang, Tsung-Su MS
Wild, John M.

1941
Blake, Charles L. MS
Bruce, Sydney C. MS
Clark, Morris R.
Damberg, Carl F. AE
Dieter, Darrell W. MS
Frank-Jones, Glyn
Green, Jerome
Jones, John W.
Kuo, I. Cheng PhD
Robinson, Frederick G.
Shelton, Edward E. MS
Skalecky, Frank H. Jr.
Taylor, D. Francis
Truesdell, Clifford A.
Vartikian, Onick
Waigand, LeRoy G. MS
Whitfield, Hervey H. MS
Yung, En-Ying MS

1942
Bebe, Mehmet F. CE
Bergh, Paul S.
Callaway, William F.
Gayer, Martin R.
Go, Chong-Hu MS
Levin, Daniel MS
MacKenzie, Robert E.
Martinez, Victor H. MS
Sternberg, Joseph

1943
Angel, Edgar P. MS
Bethel, Horace L. MS
Bridgeland, Edgar P. MS
Brownson, Jackson C. MS
Bryant, Eschol A. MS
Burlingtin, William J. MS
Carlson, Arthur V. MS
Colvin, James H. MS
Daniels, Glenn E. MS
Dewdney, Harold S.
Edelman, Leonard B. MS
Gould, Jack E. MS
Hamilton, William M. MS
Hewson, Lawrence MS
Hillyard, Roy L. MS
Hilsenrod, Arthur MS
King, Edward G. MS
Koch, Robert H. MS
Kong, Robert W. MS
Leeds, William L. MS
Lundquist, Roland E. MS
Mampell, Klaus PhD
Mataya, Jack L. MS
McNeil, Raymond F. MS



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Mixsell, Joseph W. MS
Moore, Paul R. MS
Mowery, Irl H. Jr. MS
Nesley, William L. MS
Neuschwander, Leo Z. MS
Newton, Everett C. MS
O'Brien, Robert E. MS
Patterson, Charles M. MS
Pearson, John E. MS
Rambo, Lewis
Rhoades, Walter F. Jr. MS
Rivers, Nairn E. MS
Roberts, Fred B. MS
Rupert, James W. Jr. MS
Scholz, Dan R. MS
Shannon, Leslie A. MS
Stewart, John T. D. MS
Tindle, Albert W. Jr. MS
Vicente, Ernesto, MS
Walsh, Joseph R. MS
Washburn, Courtland L. MS
Weis, William T. MS
Wood, Jesse A. MS
Wood, Stanley G. MS
Yung, Chiang H. MS

1944

Ahuza, Victor B. MS
Alpan, Rasit H.
Baronowski, John J. MS
Barriga, Francisco D. MS
Beek, Barton B.
Bell, William E. MS
Birlik, Ertugrul MS
Burch, Joseph E. MS
Burke, William G. MS
DeMedeiros, Carlos A. MS
Ditman, Keith S. MS
Estrada, Neil S. MS
Fu, Ch'eng Yi PhD
Harrison, Charles P. MS
Hu, Ning PhD
Johnson, William M. MS
Kern, Jack C. Jr. MS
Labanauskas, Paul J. MS
Leenerts, Lester O. MS
Ling, Shih-Sang MS
Lobban, William A. MS
Lockhart, William H. MS
Maier, Mark MS
Parker, Theodore B. MS
Pearce, Rufus B. Jr. MS
Shults, Mayo G. MS
Stanford, Harry W. MS
Stein, Roberto L. MS
Sullivan, Richard B. MS
Sunalp, Halit MS
Taylor, Garland S.
Trimble, William M.
Wilson, John H.
Writt, John J. MS
Yik, George

1945

Bade, William G.
Bunze, Harry F. MS
Fanz, Martin C.
Gibson, Charles E. MS
Jenkins, Robert P.
Knox, Robert V.
Lien, Wallace A. MS
Nesbitt, Mason W. MS
Romney, Carl F.
Tatlock, William S.
Tiernan, William F. Jr.MS
Werme, John V.

1946

Anderson, John B. MS
Barber, John H. MS
Burger, Glenn W. MS
Conradt, Robert H.
Dethier, Bernard
Dyson, Jerome P.
Esner, David R.
MacKinnon, Neil A. AE
Hoffman, Charles C. MS
KeYuan, Chan MS
Lewis, Frederick W. MS
Libbey, William H.
Lowery, Robert H. MS
MacDonald, Norman J.
Miller, Jack N. MS
O'Meara, Donald J. MS
Siltanen, John C. MS
Simmons, George F.
Srinivasan, Nateson MS
Tung, Yu-Sin MS
Uberoi, Mahinder S. MS
Vincent, Harry L. Jr.
Weitzenfeld, Daniel K. MS
Williams, Ralph C. MS

1947

Atencio, Adolfo J. MS
Baen, Spencer R. MS
Dagnall, Brian D. MS
Das, Subodh C. MS
Hauger, Harry H. Jr.
Hsueh, Chi-Hsun MS
Hso, Chi-Nan MS
Huang, Ea-Qua MS
Hutchison, Paul T. MS
Kamath, Mundkur V. ID
King, Emmett T. ID
Lawrence, Harvey
Leo, Fiorello R. MS
McClellan, Thomas R. MS
Monoukian, John MS
Moorehead, Basil E. A
Rosell, Fred E. Jr. MS
Sappington, Merrill H. MS
Schroeder, Henry W.
Shackford, Robert W. MS
Swatta, Frank A. MS
Vadhananahich, Charoen
Vanden Heuvel, Geo. R. MS
Veale, Joseph E. MS
Wan, Pao Kang MS
Wellman, Alonzo H. Jr. MS
Ying, Lai-Chao MS

1948

Agnew, Haddon W. MS
Barker, William A. II MS
Bingham, Andrew T. MS
Blue, Douglas K. MS
Browne, Charle I. Jr. MS
Crawford, William D. MS
Holditch, James E.
Hoyer, Horst W. MS
Hsiao, Chien MS
Hsieh, Chia Lin MS
Lambert, Peter C.
McCollam, Albert E. MS
Metzler, David E.
Mitchell, Edward E.
Morehouse, Gilbert G. MS
Oberman, Carl R.
Roberson, Harvey L.
Staros, Basil MS
Stewart, Robert S. MS
Strand, Torstein MS
Swain, John S.
Swan, Walter C. ME
Swank, Robert K. MS
Walters, James W. Jr. MS
White, Harvey J. ID
Winniford, Robert S. MS
Yanay, Joseph D. ChE

1949

Atkins, Douglas C. MS
Barish, David T. MS
Bauman, John L. Jr. MS
Bauman, Laurence I.
Blazina, Thomas D. MS
Clancy, Albert H. Jr. AE
Clendining, Harbert C. MS
Craighead, Emery M. MS
Darrow, Robert A.
Davis, Raymond E.
Foster, Francis C. ID
Hughes, Richard F. MS
King, Daniel W.
Krasin, Fred E.
Lamb, William E. AE
Linderman, Harold J.
Matteson, Robert C. MS
McElligott, Richard H. AE
Petty, Charles C. MS
Wallace, Richard A. ID
Yu, Sien-Chiue PhD

1950

Bryan, William C. AE
Coons, Thomas P.
Crossley, Harry E. ME
Curtis, Robert N.
Li, Chung Hsien MS
Ludwig, Rubin W. MS
McDaniel, Edward F. MS
McIntyre, Richard M.
McLaughlin, Jack E. PhD
McMillan, Robert MS
Pao, Wen Kwe PhD
Porcher, Calvin E. Mc
Roberts, Morton S. MS
Roddick, James A. MA
Shen, San Chuin PhD
Vivian, James A. MS

1951

Carter, Cevil V. MS
Carter, Joseph M. MS
Davison, Walter F.
Lafdjian, Jacob P. MA
Ostrander, Max H. AeE
Rodriguez, Sergio E.

1952

Abbott, John R. MS
Gehrels, Ernst
Lamar, Donald L.
Long, Ralph F. MS
Lunday, Adrian C. MS
Parnes, Basil R.
Price, Edgar P. MS
Robbins, Howard M. PhD
Sutton, Don E.
Wiberg, Edgar MS

1953

Einwohner, Theodore
Rankin, Fred W. MS
Vidal, Jean L.

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Department of Geology, Northwestern University

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California Board of Equalization

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

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U. S. Navy Electronics Lab., San Diego 52

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San Diego City Schools, 22nd and J Sts.

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

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

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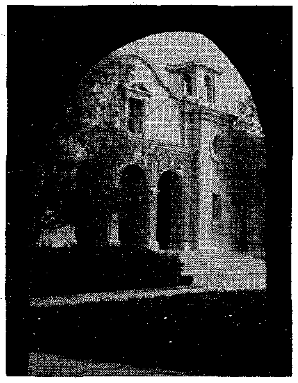

CALTECH CALENDAR

December, 1954

ALUMNI CALENDAR

Jan. 12	Dinner Meeting
Carolina Pines Restaurant	
Feb. 5	Dinner Dance
Oakmont Country Club	
April 16	Seminar Day
June 25	Annual Picnic

ATHLETIC SCHEDULE

Varsity Basketball

Jan. 8	Caltech at Chapman
Jan. 11	L.B. State at Caltech
Jan. 14	Caltech at Occidental
Jan. 15	Caltech at Cal Poly
Jan. 18	Pomona at Caltech
Jan. 21	Whittier at Caltetch

ANNUAL ALUMNI DINNER DANCE

Oakmont Country Club, Glendale Saturday, Feb. 5, 8 p.m. Bring your wife and enjoy a wonderful evening. The bar opens at 7, dinner at 8. Dancing to the rhythms of the La Verne Boyer orchestra. The cost? Little. Don't miss it!

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