ENGINEERING | AND | SCIENCE

JUNE/1958

Smog control . . . page 5

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

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from Donald W. Douglas, Jr.

President, Douglas Aircraft Company

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ENGINEERING AND SCIENCE

IN THIS ISSUE

ON OUR COVER is a graphic demonstration of what makes smog. The hand belongs to Dr. A. J. Haagen-Smit, Caltech professor of bio-organic chemistry. He has just applied a stream of ozone to a mixture of hydrocarbons cupped in his hand—which results in a dense cloud of smog.

Dr. Haagen-Smit has been conducting research on smog since 1949. For a 1958 progress report, see page 5.

"WHAT'S HAPPENING to Engineering Education," on page 16 of this issue, has been adapted from a talk given by Frederick C. Lindvall at the annual Alumni Seminar Day held on the Caltech campus on April 12. Dr. Lindvall is professor of electrical and mechanical engineering at Caltech, and chairman of the division of civil, electrical and mechanical engineering and aeronautics. He is also currently president of the American Society for Engineering Education, whose purpose is the advancement of engineering education, research and teaching.

PICTURE CREDITS

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Progress in Smog Control

by A. J. Haagen-Smit

Since the war, the influx of people to California has been one of the greatest mass migrations in history. Today, some 200,000 people settle in the Los Angeles area per year. This explosive growth is not always an undivided pleasure when orange groves rapidly disappear to make room for real estate developments and transportation facilities begin to fail in their task of moving people to and from work. During the past ten years another unpleasant discovery was made when we began to notice that something was the matter with our supply of air.

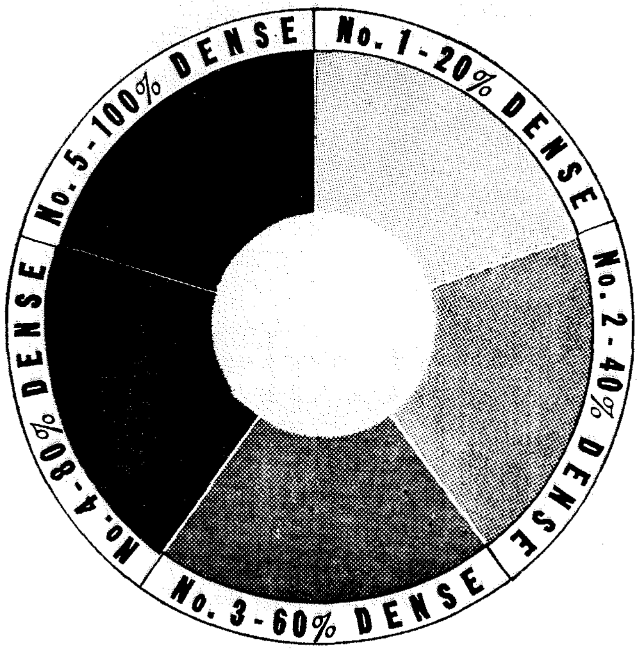
We may tolerate considerable self-made air pollution in our homes and in buildings where we gather daily, but when the outside air becomes polluted the telephone exchanges in the police and fire departments and the Air Pollution Control District are swamped with calls. This happened a few times when Pasadena residents were surprised at night by a strong odor of mercaptans. While somewhat unpleasant, and objectionable from an esthetic point of view, this type of pollution is rather harmless, and is limited to areas close to the source. A more serious situation developed during the war years when an eye-irritating wave of pollution moved across the valley. Its origin was soon located and found to be a synthetic rubber plant. After suitable measures were taken to eliminate air pollution from this source, the symptoms disappeared, and the excitement died down.

A few years later, the population of this area was again disagreeably surprised by foreign odors and eye irritation. This time it wasn't easy to find the culprit, and numerous committees were formed to demand action. This resulted in the formation of an Air Pollution Control District, in 1948, under an enabling act which authorized the Board of Supervisors of Los Angeles County to act as an Air Pollution Control Board in the County of Los Angeles. At the present time, similar control districts have been set up in the adjacent counties of Orange, Riverside and San Bernardino. A close cooperation between these districts is, of course, necessary, for air pollution does not recognize any city or other administrative limits.

The Los Angeles County Air Pollution Control District has recently celebrated its 10th anniversary. During this time, under the able directorships of Dr. Louis C. McCabe, Mr. Gordon P. Larson and the present director, Mr. S. Smith Griswold, much progress has been made in abolishing the sources of visible smoke, as well as sulfur dioxide.

It is perhaps typical of the early period of smog control that the District employees gave the name, "Ringelmann Club" to their newly-formed employees organization. The name "Ringelmann" is intimately connected with degrees of smoke density. Ringelmann invented a chart indicating by five equal steps between white and black, varying shades of gray to which smoke plumes could be compared.

Although not the official chart, a handy observation card (see page 6) illustrates the principle used in smoke measurement. Most air pollution authorities who use the card agree that the real measure of objectionable stack emissions has to be indicated by weight of dust per unit as well as the distribution of the particles according to size. This is even more true of non-black plumes, such as steam or aerosol types from condensations of vaporous materials, which are dependent on factors such as wind, humidity, temperature, cloud background and others.



The Ringelmann chart is used to determine whether emissions of smoke are within legal limits or standards of permissibility. The card shown here, adapted from the official Ringelmann chart, has a viewing hole in its center, and is frequently used for quick reference.

In this early period many important emissions were controlled. These include the effluents from two large steel mills, some 120 foundries and open burning dumps. Also, while the control program was under way, research was carried out which established that the eye irritation and typical plant damage, as well as the odor observed during smog attacks, were due to a photochemical oxidation of organic material, mostly hydrocarbons, in the presence of oxides of nitrogen.

The acceptance of these findings led to a drastic control of hydrocarbon emissions at the refineries. Oil-water separating tanks were covered, open-vented tanks were converted to closed systems, and the general supervision of air pollution problems in the petroleum industry is now well taken care of, day and night, by specially appointed personnel responsible directly to the refinery manager.

With the considerable reduction in the refinery hydrocarbon emission, attention was directed to the major smog source—the automobile. Studies were initiated on the exhaust gases of the automobile—a phase of engine studies which had received practically no attention in the past. Both in Detroit and in Los Angeles the surprising discovery was made that the automobile engine is not as efficient as its smooth performance might lead one to believe. Seven to eight per cent of its fuel leaves the exhaust incompletely burned.

The study of the operation of the automobile has shown that most of the hydrocarbons are released during acceleration and deceleration. Devices are being developed which shut off the flow of gasoline during deceleration, when no power is required anyway, and much work is being done on after-burners of different types. Some work with a catalyst bed; others utilize a spark plug to ignite the gases before they leave the exhaust.

The most desirable way of controlling the hydrocarbon losses would be to have a more complete combustion in the engine itself, but we may have to wait for the introduction of the turbine engine to passenger cars —a matter of at least ten years. Others are seeking a cure by modification of the fuel. At present, opinions are divided on the effectiveness of such a change, and research is under way to resolve these differences.

It is clear that the development of a satisfactory control device for the automobile emission is many years away. The Air Pollution Control District, primarily an organization charged with enforcing the law with regard to objectionable emissions, has stimulated a great deal of engineering research and development work of this type, but it could not very well be expected to take over the task of the automobile industry to meet this challenge. During this waiting period, the District has started with renewed vigor to give attention to sources other than the automobile.

Under the efficient guidance of Captain Louis J. Fuller, formerly of the Los Angeles Police Department, some 40 inspectors are roaming the 400-mile-square Los Angeles area. Their cars are equipped with two-way radio, and they are at all times in touch with headquarters and can investigate reports of objectionable emissions in the matter of a few minutes. Aerial observation, integrated with this system, facilitates their work. As a result, the number of violations cited during the past three years was about 11,000, compared to 700 for all the eight previous years of the District's existence. The nature of the violation varies from the smoking automobile to stacks of industrial operations.

Now that private backyard incinerators have been banned, there are relatively few sources of smoke left. Among these are some municipal incinerators, the Hyperion sewage disposal plant, and most of the municipal and privately owned power plants—which include those of industry, as well as those of utility companies.

In almost all of these cases the quantities by weight of dust or chemicals leaving the stacks are well within the limits prescribed by law. Nevertheless, the opacity of the smoke plume is greater than that designated as permissible on the basis of the Ringelmann chart.

For example, a typical analysis of the stack emission from one of the large oil-burning plants (capacity, 350,000 kw) shows a stack gas concentration of 1,000 parts per million of sulfur dioxide, while 2,000 ppm is the legal limit. The dust load is 0.05 grains per standard cubic foot, as compared to the legal limit of 0.3 gr./scf. or 770 lbs./hr., calculated to 12 percent CO_2 at standard conditions (60° F., 14.7 lbs./sq.in. absolute). The capacity, on the other hand, varies from 20 to 100 percent, depending on weather conditions, while 40 percent is considered a violation.

On the basis of previous experience with oil-burning plants, the Air Pollution Control District had not much choice in denying the Southern California Edison Company a permit to operate its newly erected El Segundo steam station, although it was built according to specifications approved by the Control District. While a solution could have been found by abandoning the burning of fuel oil, the always rather critical fuel supply made this impossible.

The difficulty in keeping up with the demand of the growing population for more fuel is also felt in the necessary construction of electric generating stations. Every new plant gives a respite of only a few years, and presently new units are being built or are on the drawing board to follow the upswing in electrical demand. It is clear that this building and operating schedule cannot be interrupted without serious consequences for the community. This embarrassing situation was solved by the Air Pollution Hearing Board, a judicial body created by the Governor of California to arbitrate matters of air pollution.

This board, consisting of three members—our own R. L. Daugherty, emeritus professor of mechanical and hydraulic engineering, together with Mr. William A. Sherwin and Mr. Delmas R. Richmond, both representatives of the legal profession—permitted the Southern California Edison Company to operate under a variance with the proviso that an investigation be made to determine the possibility of reducing the opacity of the plume. The scope of the research program instituted by the Edison Company was considerably broader than just reducing the opacity of the plume to the legal limits, and has considered the emission of dust, and of oxides of sulfur and nitrogen, as well.

These investigations, and those conducted by other power-generating organizations in this area, are of much more than local importance, and have a direct bearing on similar problems in other parts of the country. Combustion of various kinds, whether in automobiles or in industrial furnaces, is by far the largest chemical operation, and is responsible for most of the air pollution problems.

The amount of fuel burned in the United States is tremendous. The total energy produced from all fuels and water power is on the order of 100 quadrillion Btu's, or 300 trillion kilowatt hours per year. (It is difficult to imagine what such a figure represents in comparison to a man's energy expenditures of approximately ½ kwh per day.)

In the area of southern California, approximately 3 to 4 percent of this total energy is produced in the burning of local oil supplies and natural gas. In addition, huge dams, such as Hoover Dam, which supply hydropower to areas some 400 miles away, have been built. Even today this development continues, and one of the most interesting modern hydropower systems is in our own backyard—the Big Creek water power project of the Southern California Edison Company.

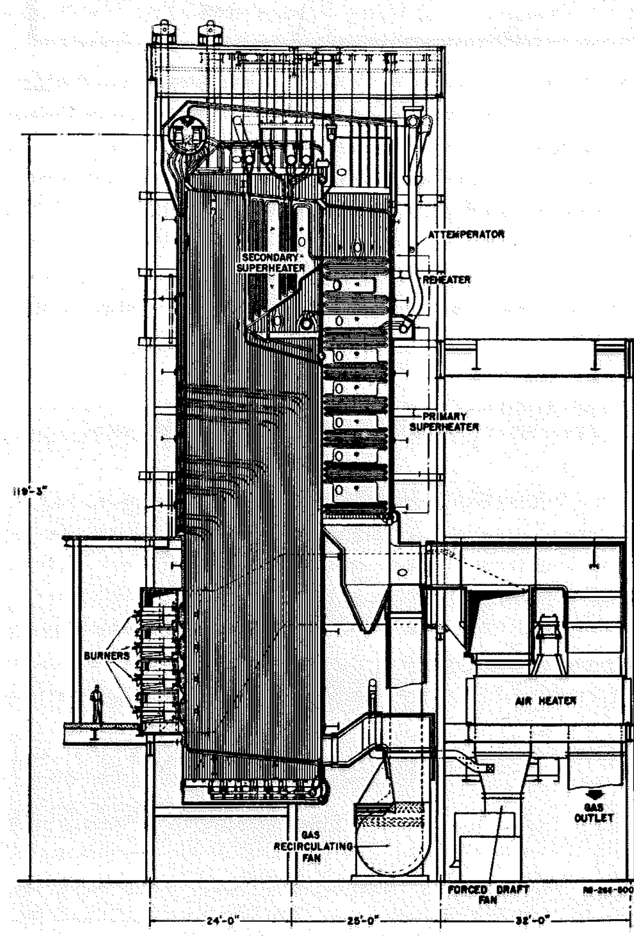
Through a succession of dams interconnected with miles of tunnels, the water of the San Joaquin River is reused several times to produce electrical power before it is finally distributed as irrigation water. In this process it has generated 500,000 kw of electricity. With the energy derived from Hoover Dam, the hydropower represents about 25 percent of the total energy need of this area.

Unfortunately, this cleanest source of power is limited, and the rest has to be supplied by combustion of fossil fuels, oil and gas. The gas is burned in kitchens and household furnaces, and in the production of electric power. The utilization of oil is much more complex. It is converted at high temperatures in hydrogenation and reforming processes to gasoline and other petroleum products, and the residual oil is used for power production. The daily consumption of these different fuels is as follows:

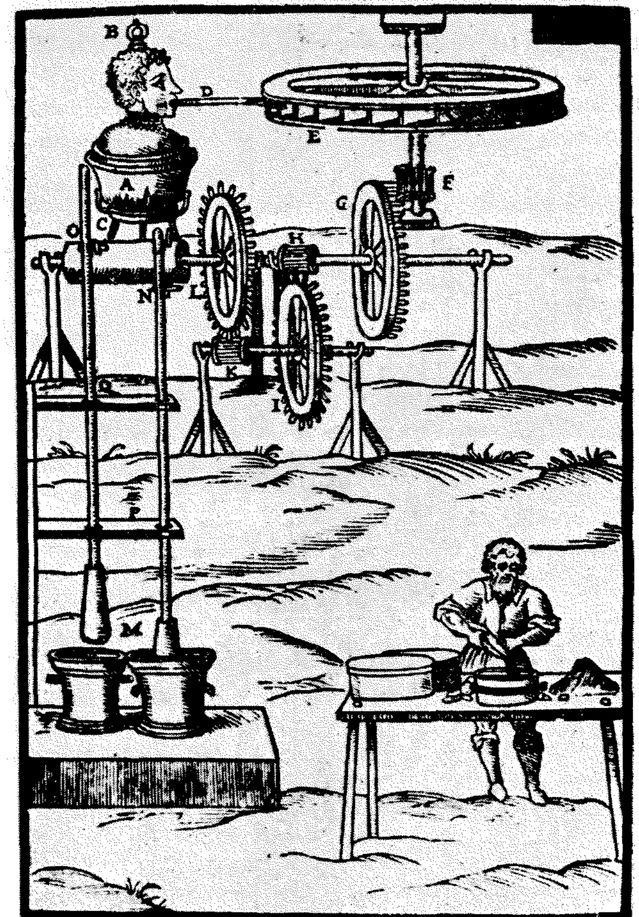
Daily Fuel Consumption in the Los Angeles Area

	Quantity	*Equivalent Bbls. of Oil*
Gasoline	5,500,000 gallons	110,000
Oil	65,000 barrels	65,000
Gas	1,000,000,000 cubic feet	167,000
Hydropower	891,000 kw	30,000

All hydropower is converted into electricity and, in addition, 3,000,000 kw are produced in oil and gas burning, chiefly by the Southern California Edison Company



Cross section of a modern steam generation unit, showing a single boiler with its necessary equipment.



The modern process of power production doesn't differ much from one of the first simple steam engines, illustrated above, developed after an idea of Leonardo da Vinci. In both cases, the force of expanding steam is converted into mechanical energy.

and the cities of Los Angeles, Pasadena, Burbank and Glendale.

The El Segundo steam station, where most of the Edison Company's air pollution research is conducted, accounts for 350,000 kw—or about 1/12 of the total production in this area. To produce this much electricity, equivalent to one-half million horsepower, 12,000 barrels of fuel oil are consumed per day. When gas is available, three million cubic feet per hour are burned in the two units.

One must visit such a plant to really grasp the magnitude of these operations and the tremendous power developed. In principal, the process of power production is quite simple, and doesn't differ much from one of the first steam engines (illustrated above) developed after an idea of Leonardo da Vinci.

Essentially, we have a boiler producing steam, which turns a turbine. The process has become more complicated, however, as attempts have been made over the years to increase the efficiency. This is one reason why the temperature of the steam is raised to 1,000° F (538° C.) and the pressure as high as 2,000 lbs./sq. in. (136 atmospheres).

This operating steam temperature is continuing to rise at the rate of about 12° F. per year, and is expected to reach 1,400° F. in 1980. The same is true for the pressure, which is doubled about every 12 years, and should by 1980 be in the order of 7,000 pounds per sq. in. absolute.

Boiler tubes and turbine blades have to withstand the action of this nearly red-hot water and steam. Much engineering research went into this problem before the efficiency of today was obtained—and the efficiency is still going up.

The power plant engineer is an expert in obtaining the maximum efficiency in the combustion of his fuel, and tests of the stack gases reveal the virtual absence of hydrocarbons and carbon monoxide. This is in sharp contrast to the automobile performance, where the CO concentration amounts to several thousand parts per million (0 - 3.6%). Unfortunately, the oil, because of its origin from living organisms, contains ash and sulfur. The ash contains an appreciable proportion of vanadium, nickel and iron. It is generally held that this vanadium has come from fossil marine organisms. Even at the present time we find some sea animals such as *Ciona*, the sea squirt, and certain *ascidia*, with a vanadium content of ½ to 1 gram per kilogram dry weight. Nickel is a common though minor constituent of plants and animals.

Compared to other dusty operations, the amount of solids coming from an oil-fired burner is a hundred times smaller.

In most dusty operations, the escaping materials are rather coarse, and the particle size ranges from several microns to big cinders. Settling chambers, baghouses and cyclones are now extensively used in sawmills, foundries and incinerators. Unfortunately, these do not take care of ultrafine dust, such as that produced in the burning of oil. The particle size of this ash is in the order of 0.5 - 2 microns, and its behavior is more like that of cigarette smoke.

Quite effective in this small particle field is the electrostatic precipitator. In this device, a charged particle passing through an electric field will be attracted to one of the electrodes. The electrodes are usually in the form of plates or tubes, and on these the dust will accumulate. It can be easily removed in simple mechanical fashion, such as rapping or purging with a blast of air. While the particle is travelling at high speed through the precipitator, its sideways motion towards the plates takes many seconds. For this reason a high voltage, from 15,000 to 40,000 volts is used to speed up this movement.

At the El Segundo steam station, 350,000 cubic feet of gas leaves the stack every minute, carrying with it 1.5 lbs. of dust. The removal of this extremely small quantity must take place in a very short time, because every minute one is faced with the assignment of processing a new batch of 350,000 cubic feet of gas.

The lack of previous experience on the application of precipitators to oil-burning power plants required the building of pilot precipitators. To make intelligent decisions in the extrapolation to a large-scale boiler, the pilot installations were quite large—with capacities for handling 1/50 and 1/200 of the total effluent.

After extensive testing, the conclusion was reached that the plume is largely due to dust, and only during exceptional periods of unfavorable weather does the sulfuric acid play an important role. In the 350,000 cu. ft./min. of effluent gas from one unit, only 2 ounces of dust will remain after passage through the precipitator, which means a collection efficiency of greater than 90 percent. The removal of dust also results in some removal of sulfuric acid, assuring an additional safety factor.

The electrostatic precipitator to be installed by the Southern California Edison Company has been designed in such a way that even the slowest particles most responsible for the plume will reach the collecting plates while they are passing through the system. This, of course, requires a long path, and makes the collection apparatus quite large and expensive. The full-scale unit which will be built this year will measure about 100 feet long, 30 feet high and 34 feet wide. With this large chamber, approximately 20 seconds will be required for the passage of 350,000 cu. ft. of gas.

The material collected is quite corrosive, and extensive experiments have been carried out on the addition of neutralizing reagents such as dolomite and ammonia. The removal of the acid lowers the condensation point and it is now possible to consider the release of the stack gases at a temperature lower than the present 300° F. A further study of this potential heat is in progress.

In our control efforts the oxides of sulfur and nitrogen have to be considered. The oxides of sulfur have always stood in bad repute, and consequently conditions in other industrial areas are often extrapolated to the Los Angeles area without any real basis. Sulfur dioxide does not irritate the eyes at concentrations observed in our atmosphere (from 0.0 - 0.20 ppm) and its concentration is about 100 to 200 times less than the threshold limit value of 10 ppm adopted by industrial hygienists.

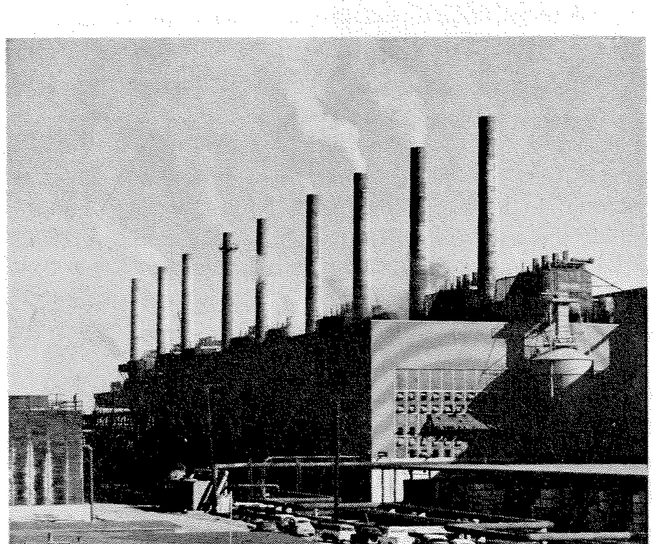
No plant damage attributable to sulfur dioxide has been found in recent years since oil refineries and sulfuric acid manufacturing plants have adopted recovery processes for most of the sulfur previously released into the air.

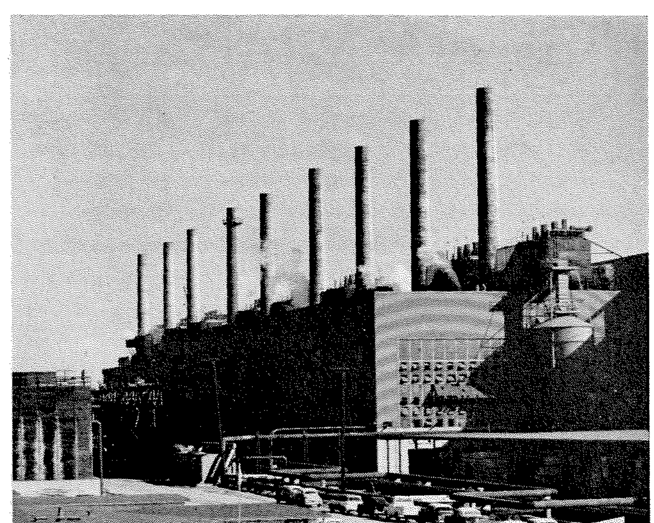
Sulfur dioxide control merits consideration from a long range point of view since the expansion of industry will gradually raise the SO_2 level. Also, from a public relations standpoint, it is expedient to give attention to a possible reduction of sulfur dioxide. For this reason, experiments have been conducted with the object of checking the economic feasibility of reducing the SO_2 content of the flue gas. The low concentration of SO_2 in stack gases, in the order of 1,000 ppm, makes recovery extremely difficult and expensive.

The Bureau of Mines has considered some 60 means of removing SO_2 from flue gas. Only a few seem to warrant laboratory investigation. In our research efforts we have added two more processes. One consists of an adsorption process and subsequent release of SO_2. The other manufactures concentrated sulfuric acid by passing the flue gas over a vanadium catalyst. The latter process, especially, has some appeal, since the dust itself contains large quantities of vanadium.

These processes have been carried out far enough to enable a reasonable engineering estimate to be made of the cost of a full scale installation. The cheapest and simplest process, which consists of scrubbing with water and subsequent neutralization of the water washings, costs \$3,000,000 for one unit, and in addition, \$1,000,000 per year for its operation and maintenance.

The results obtained are undesirable because a new





These two pictures of the Kaiser Steel Company plant in Fontana, taken within minutes of each other, demonstrate the effectiveness of smog control. The picture at the left was taken with all the smoke-control units temporarily shut off. At the right, just minutes later, the equipment is back in operation against a clear sky.

problem of disposing of the tremendous quantities of salts formed is created. When chemical manipulations such as catalytic conversion or adsorption are added to the scrubbing process, the price increases considerably. For example, a process using ozone plus manganese chloride will cost initially more than the construction of the entire power plant, and in addition, $3 - 4,000,000 per year to operate. Any hope that the process would pay for itself evaporates when it is realized that the Edison Company could sell sulfuric acid made from stack gas at $175/ton to compete with the usual price of $22/ton.

The idea of removing sulfur, as well as metals, from the oil before it is burned seems quite attractive. After all, we have in that case to deal with only 6,000 barrels per unit, or with a volume of approximately 25,000 cubic feet per day, as compared to half a billion cubic feet per day of stack effluent. Unfortunately, both metals and sulfur form an integral part of the constitution of the oil, and simple washing, unpleasant as it may be, is not going to remove either one of these components. For a successful removal, the oil has to be cracked and hydrogenated at higher temperatures. The total cost of this process which, by the way, is not yet available, has been estimated to add approximately one dollar per barrel of fuel, which raises the annual fuel cost by about $2,000,000.

Economic conditions would have to change considerably, and also the arguments for the control of oxides of sulfur in this area would have to be more convincing before serious thought can be given to adding the cost of the removal of SO_2 from flue gas, to the existing production costs.

A more healthy solution for both dust and sulfur problems in populated areas is the use of natural gas, which contains practically no mineral or sulfur compounds, and hence can form no dust or oxides of sulfur. The Edison Company has been diligent in obtaining the maximum amount of gas. Research has made it quite clear that in highly populated areas the burning of gas is the best remedy for air pollution nuisances, even though it must be transported from sources as distant as Mexico or Texas.

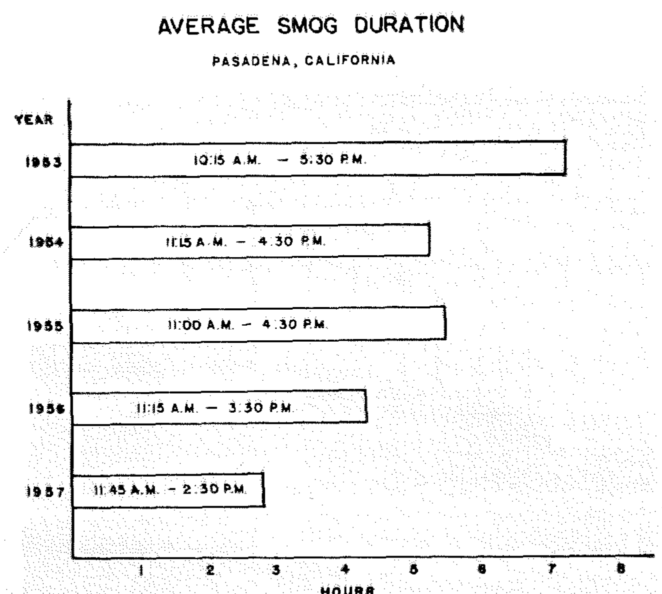
Up to this point we have discussed only those ingredients of the flue gas which might lead to the formation of haze. Although this is one of the aspects of Los Angeles smog, neither oxides of sulfur or dust could possibly be held responsible for the eye irritation and plant damage typical of Los Angeles smog, or the intense rubber cracking observed during smog periods.

As mentioned earlier, it has been well established by now that these effects are due to the oxidation of organic material under the influence of sunlight. In this reaction the oxides of nitrogen play a dominant role. Their origin is in a fixation of atmospheric nitrogen and oxygen during high temperature combustions in automobile engines and in burning of gas and oil. Stack gas from power plants contains from 300 - 700 ppm of oxides of nitrogen. This means that, per 175,000 kw unit, 10 - 15 tons of oxides of nitrogen are produced daily. The total amount produced in the Los Angeles basin is estimated to be about 600 - 700 tons per day.

Many attempts have been made to reverse the reaction by which oxides of nitrogen are formed, by trying to split the compound back to its original components— harmless nitrogen and oxygen. For this purpose some 40 different catalysts were tested without significant success. We have to realize that even when a catalyst is found, it would be necessary to apply engineering methods similar to those used for the removal of oxides of sulfur, and any one of those processes would turn out to be quite expensive.

Since the formation of the oxides of nitrogen is highly dependent on the temperature, any reduction in the combustion temperature would lead to a reduction in the oxides of nitrogen. Here a conflict of interests develops between those who would like to see the furnace as hot as possible, and the air pollution experts who would like to see it as cold as possible. In a systematic study of burning conditions, several ways have new been found to reduce the temperature without too severe a curtailment of efficiency. Joint studies with engineers of the Babcock and Wilcox Company are now under way on a two-step burning of the incoming fuel oil. The intake air is reduced at the burner site, and an equivalent amount is introduced through the rear wall of the furnace. Four large ports have been constructed along the upper wall of the firebox, and dampers permit the regulation of the air admitted.

Although these full-scale experiments are still in the initial stages, it has already been shown that predictions based on preliminary work were correct. The infrared analyzer monitoring the concentration of nitric oxide (NO) in the flue gas registered a decrease of approxi-



The result of air pollution control measures can be seen by the decrease in the average duration of smog in Pasadena over the past few years, in spite of a constantly increasing population.

mately 25 percent. This reduction, if applicable to other oil and gas burning installations, would be equivalent to a reduction of 75 tons of nitrogen oxides per day in the whole basin.

Similar studies on automobiles and diesel engines should lead to a substantial reduction in NO emissions from these sources.

The air pollution control work by the Edison Company has been accomplished with the cooperation of several agencies—the Bechtel Corporation, Truesdail Laboratories, Standard Oil Company of California, Babcock and Wilcox and others. The technical skills and knowledge of all power-generating organizations in this area, as well as the air pollution control districts of San Bernardino, Orange and Los Angeles Counties have been made available through the formation of a Joint Research Council. Its regular meetings have been a forum of discussion on any progress made.

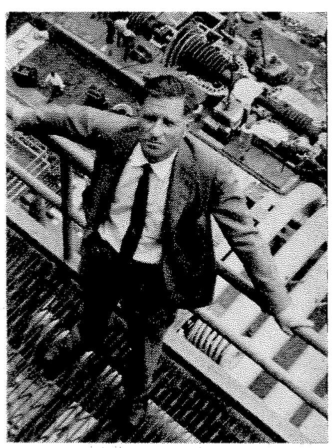
The Edison Company's decision to change its program from one of research to that of predominantly engineering by building a full-scale electrostatic precipitator and executing the recommendations based on the research findings is a most significant step towards ultimate control of Los Angeles smog, for it points the way for reduction of power stack emissions in general, of privately owned as well as municipal plants.

When, in addition, the plumes of city-owned incinerators have disappeared, the problem of the automobile will stand out even more clearly. The nature of this problem and the cures which are needed are such that they require that all industrial sources be under control before we can think of attaching hundred dollar mufflers to three million automobiles.

In the meantime, we are enjoying improved smog conditions which can only be attributed in part to the favorable weather. The oxidant, the typical manifestation of Los Angeles smog, is decreasing on the average, both in maxima reached and in duration. When the smog rolls in now, its duration is a few hours, compared to daylong sieges a few years ago; rubber cracking and dustfall values have decreased, and visibility has improved.

It is not possible to point to the control of one source as the cause of this improvement. Air pollution control in a complex area can be achieved only by the tenacious, step-by-step control of numerous sources. There is no magic wand.

About the author



Arie Jan Haagen-Smit, professor of bio-organic chemistry at Caltech, is a native of Utrecht in the Netherlands. After receiving his PhD from the University of Utrecht in 1929 he taught chemistry there until 1936, when he was appointed to Harvard University as an instructor in chemistry. The following year he came to Caltech as an associate professor of bio-organic chemistry and became a full professor in 1940.

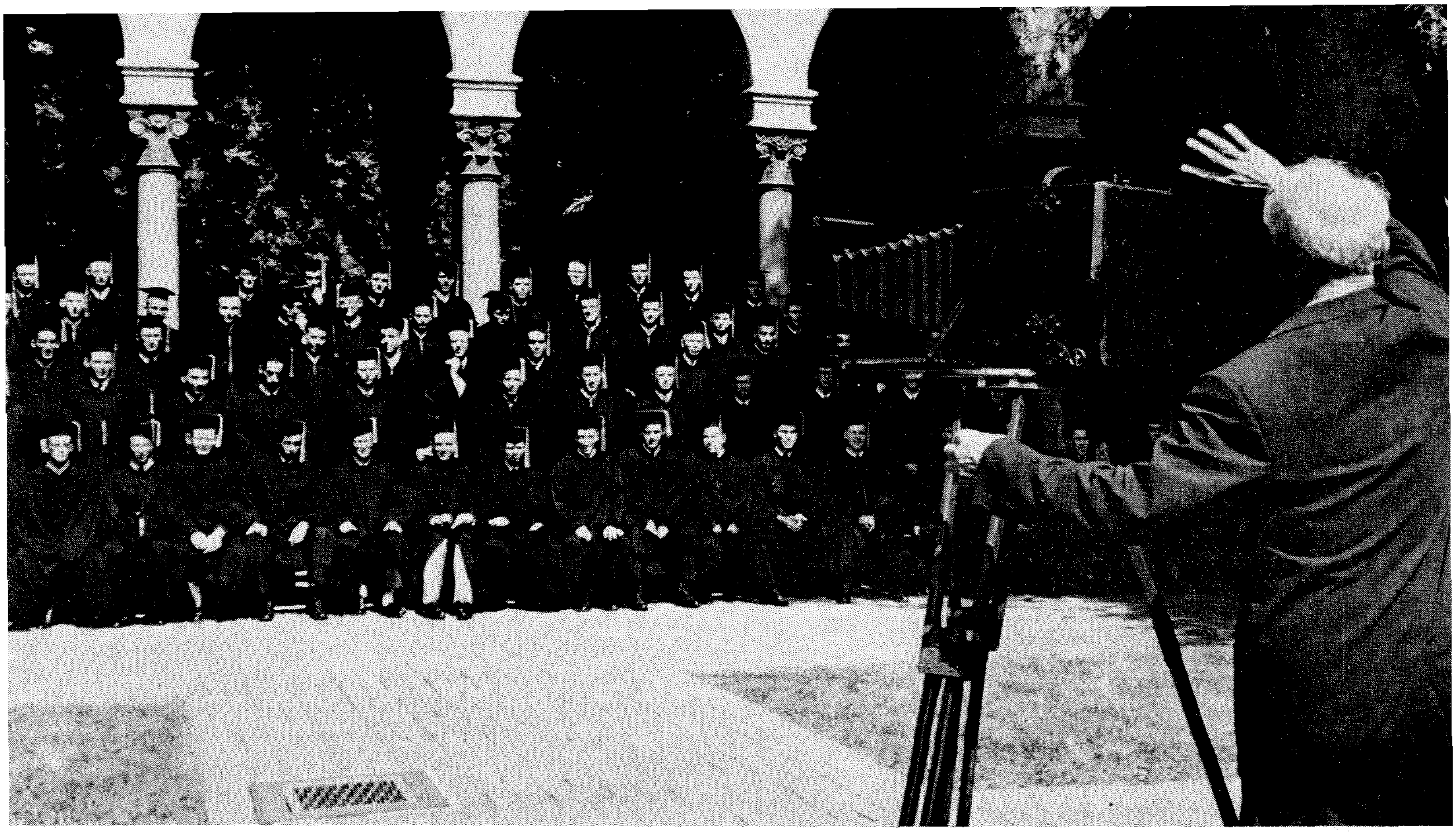
Although Dr. Haagen-Smit's name is now synonymous with smog research, he's known internationally for his work in flavor chemistry and the isolation and structure determination of various plant substances as well as investigations of food flavors, wine and milk. Applying the technique he had developed for flavor studies, he was able to identify smog in his laboratory in 1949.

In 1950 Dr. Haagen-Smit was granted a leave of absence from Caltech to direct full-time research on smog for the Los Angeles County Air Pollution Control District. During this time, he discovered a new type of modern air pollution formed from the photochemical oxidation of hydrocarbons in the presence of sunlight and oxides of nitrogen.

In 1956 Dr. Haagen-Smit received another leave of absence to serve as director of research for the Southern California Edison Company. His work there has been concerned with curbing the effluents from stacks on central power stations. By determining the composition of the effluents, he has been able to learn about their contribution to smog and has developed corrective processes. His specially-designed equipment has been used successfully at Edison's El Segundo and Etiwanda plants. Much of the work he has been doing there is described in the accompanying article.

On May 27 Dr. Haagen-Smit was awarded the 1958 Frank A. Chambers Award by the Air Pollution Control Association, an international smoke-control organization. In 1957 he won the Los Angeles County Clean Air Award.

This year two other Caltech professors received the Clean Air Award—Royal W. Sorensen, emeritus professor of electrical engineering, in recognition of his outstanding services in the pioneering and the application of electrostatic precipitators and the control of particulate emissions in industry; and Frits W. Went, professor of plant physiology, for his research in Caltech's Earhart Laboratory which has established a connection between air pollution and plant damage.



After receiving their degrees, 125 Bachelors of Science pose for a group picture on the steps of the Athenaeum.

The Month at Caltech

Commencement

At Caltech's 64th annual commencement on June 13, a total of 325 students received degrees—125 Bachelors of Science, 140 Masters of Science, 10 Engineers and 50 Doctors of Philosophy.

Of the 45 men who graduated with honors, 4 received both academic honor and Student Body Honor Keys: Glen L. Converse, Michael W. Konrad, David B. Leeson and Donald Stern. Honor Keys were awarded to 12 seniors in all.

The Frederick W. Hinrichs, Jr., Memorial Award for the most outstanding senior this year went to Richard L. Van Kirk. The award consists of $100, a certificate and a memento. The Sigma Xi Award for research of exceptional quality by a graduate student was presented to Peter Crawley, who received his PhD in mathematics.

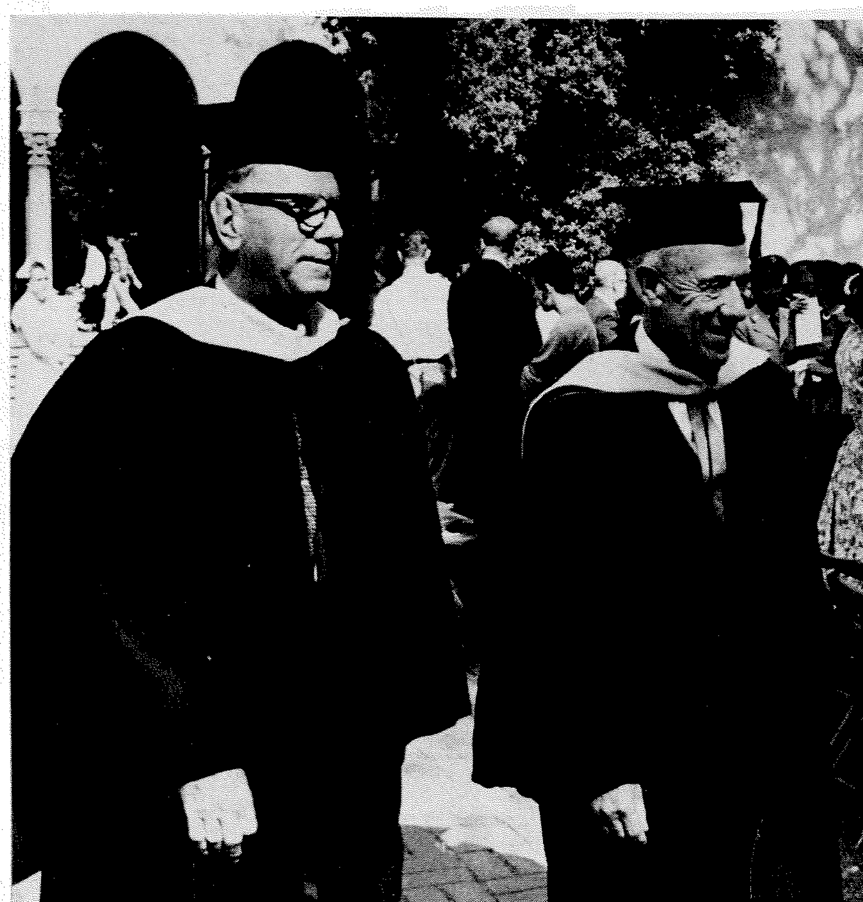
The commencement address, "The Challenge of Change," was given by Dr. Detlev W. Bronk, president of the Rockefeller Institute for Medical Research and president of the National Academy of Sciences.

Five buildings

Though the Caltech Development Program has just gotten under way, President L. A. DuBridge reported at the 1958 commencement ceremonies on June 13 that "substantial progress" has already been made.

Of the total goal of $16,100,000, in fact, more than $4,000,000 has been subscribed to date.

"Of the 13 buildings in our Campus Development plan," said Dr. DuBridge, "5 have now been assured by specific gifts: A laboratory of molecular biology from Dr. Gordon Alles, a Caltech alumnus, and from the U.S.



Albert B. Ruddock (left), chairman of Caltech's board of trustees, who presided at the ceremonies; and commencement Speaker Detlev W. Bronk, President of the Rockefeller Institute for Medical Research and president of the National Academy of Sciences.

Public Health Service; a new laboratory of plant research from the Campbell Soup Company; a new student activities center from Mr. P. G. Winnett; and two anonymous givers have assured a graduate house and an undergraduate house, respectively.

"In addition, other funds are coming in at such a rate that it will be possible to begin construction this summer of a new home for our plant maintenance department to be located across San Pasqual Street from the present campus. We hope to complete this building by next spring and begin then the long-anticipated pleasure of tearing down the temporary buildings which now occupy the northeastern part of the campus. On this portion of the campus there will then be erected the new undergraduate student houses and the new student activities center.

"Our goal of 16 million dollars, though large, is not an extravagant one. The needs for additional undergraduate living facilities, for a student activities center, for additional laboratories for teaching and research in engineering, physics, mathematics and biology, the need for a new library and a new auditorium—all these have long been felt, and for many years our campus planning has envisaged the construction of these facilities. It became apparent a few years ago that only a concentrated drive would allow us to acquire these facilities in time to pursue our program of education and research on the campus without serious interruption.

"The financing of such plans means extraordinarily generous giving on the part of the friends and supporters of this institution," Dr. DuBridge said. "The campus facilities which will be made possible by this drive will fill our foreseeable needs, but the $16,100,000 will by no means be adequate to fulfill all the other needs which we will face for annual income, to finance our program, and to pay adequate faculty salaries during the coming years. Our efforts to secure new income will have to be unceasing in the future as they have been in the past. The new campus facilities which we now hope to finance will go a long way toward assuring the continuity and excellence of our program."

Nuclear weapons talks

Robert F. Bacher, chairman of Caltech's division of physics, mathematics and astronomy, is one of the three-man team of U.S. nuclear scientists chosen by President Eisenhower to discuss ways of policing a nuclear weapons test ban with Russian scientists in Geneva, Switzerland, this month.

The other members of the U.S. delegation are Ernest O. Lawrence, director of the University of California Radiation Laboratory; and James Brown Fisk, executive vice president of the Bell Telephone Laboratories. Dr. Bacher and Dr. Fisk are members of President Eisenhower's Science Advisory Committee.

Nuclear physics has been Dr. Bacher's chief interest throughout his career. A graduate of the University of Michigan, he received his PhD there in 1930, taught at Columbia University, then, in 1935, joined the physics

Walter Baade, staff member of the Mount Wilson and Palomar observatories.

department at Cornell University, where he remained until 1949.

On leave of absence from Cornell from 1941 to 1943 he worked at the Radiation Laboratory, the radar project set up at the Massachusetts Institute of Technology which was headed by L. A. DuBridge.

From 1943 to 1945 he worked on the atomic bomb project at Los Alamos, as head of the Experimental Physics Division, and head of the Bomb Division.

At the end of the war he returned to Cornell to become the first director of the university's Laboratory of Nuclear Studies and, in 1946, doubled as scientific advisor to Bernard Baruch, who was then head of the United Nations Atomic Energy Commission. When the United States Atomic Energy Commission was established in that same year, Dr. Bacher was appointed a member of it—the only scientist in the group. He served as an AEC Commissioner for three years, and left in 1949 to take his present position at Caltech.

Scientist of the Year

William A. Fowler, professor of physics, was named co-winner of the first annual Science Award presented by the California Museum of Science and Industry on June 5. He thereby shares the title of "California Scientist of the Year" with Heinz Fraenkel-Conrat, biochemist in the Virus Laboratory at the University of California.

Dr. Fowler's research involves the studies of nuclear forces, the structure of light nuclei, thermonuclear sources of stellar energy and element synthesis in stars *(E & S—March, 1956)*. Specifically, he received the Science Award "in recognition of his outstanding contributions to enlarging our understanding of the nuclear processes that take place in the stars, thereby clarifying the manner in which the chemical elements have been synthesized from primordial hydrogen, revealing the history of the birth, life and death of the stars themselves, and thus extending man's knowledge of the universe in which he lives."

Dr. Fraenkel-Conrat (with Dr. Robley Williams, a colleague at the Virus Laboratory) achieved the first historic reconstitution of a virus; the men separated the tobacco mosaic virus into its protein and nucleic acid parts, then put the components back together again.

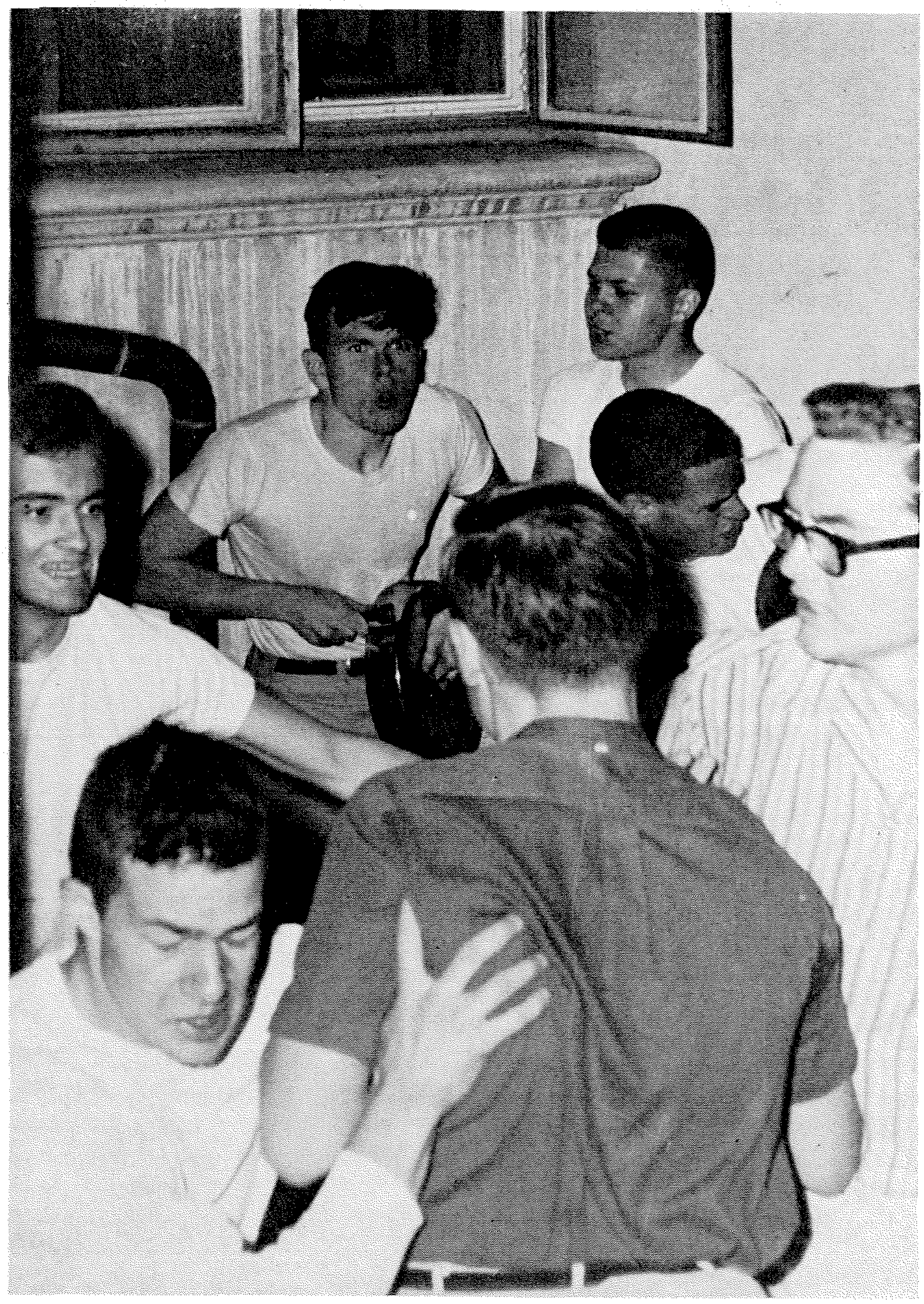
Retirement

Walter Baade retires from the staff of the Mount Wilson and Palomar Observatories on June 30. He has been a staff member for 27 years.

Dr. Baade introduced the concept of population types in stars—Population I, whose most prominent features are the blue giant stars; and Population II, characterized by the red giants. Studies of these two populations provided the observational basis for present theories of stellar evolution which suggest that the difference between the population types is primarily one of age.

After the completion of the 200-inch Hale telescope, Baade's studies of the cepheid variable stars (distance

William A. Fowler, professor of physics, receives award as California Scientist of the Year from President DuBridge, chairman of the award jury.



No spring is complete without a brakedrum riot at Caltech, when Ricketts House freshmen and sophomores battle for possession of this chrome-plated heirloom. The class in possession of the brakedrum brings it out of hiding and attempts to ring it noisily for 20 seconds—like the freshman at the right. All he had to do after this was outrun the sophomores and hide the drum.

P.S. He didn't make it.

indicators in the Andromeda Galaxy and elsewhere) led to the discovery that all objects beyond the Milky Way were more than twice as far from us as we had supposed before—the observable universe was more than twice as large as we had supposed.

Dr. Baade also collaborated with Rudolph Minkowski in the identification of radio sources with optically observed objects, and in the physical interpretation of the nature of these sources.

A native of Schrœttinghausen, Germany, Baade studied at the University of Muenster and Gœttingen—where he received his PhD degree in 1919. He served as an assistant and later as an observer at the Hamburg Observatory, before joining the Mount Wilson Observatory in 1931.

Dr. Baade is a member of the American Astronomical Society and an associate of the Royal Astronomical Society. In 1954 he received the Gold Medal of the Royal Astronomical Society and, in 1955, the Bruce Gold Medal of the Astronomical Society of the Pacific.

AEC nominee

John A. McCone, chairman of the ways and means committee of Caltech's board of trustees, was nominated as a member of the Atomic Energy Commission by President Eisenhower on June 6. He will succeed Lewis L. Strauss, who is resigning as chairman of the AEC. Mr. McCone is president of the Joshua Hendy Corporation in Los Angeles.

What's Happening to Engineering Education

by Frederick C. Lindvall

With the space age rapidly emerging from science fiction into reality a new dimension is being added to technology. No longer are we constrained to move and to think within the thin confines of our earth's atmosphere. Space has become the new frontier. Space ships and space islands intrigue the imagination and challenge our inventive genius. At the same time we find ourselves ignorant of much basic information on which to build ideas and to design their engineering embodiment. We lack materials, energy sources and guidance systems to carry us beyond the limited capabilities of current missile developments. We must expand the engineering system concept—and with it our techniques of analysis and synthesis—far beyond our present skills, because space is not merely a new dimension; it is a wholly new environment for man and his machines.

Progress into the wild blue yonder will be slow, frustrating and expensive. The utility of such enterprise is certain to be questioned at every turn, and every effort will be challenged on economic, moral and even religious grounds. Nonetheless, man with his insatiable curiosity and indomitable urge to conquer the unknown will ultimately break the technical bonds which tie him to earth and will project himself into outer space. Some rocket experts predict this dramatic moment as soon as fifteen years hence!

But before the first adventuresome spacemen batten the hatches of their ship and take off for a trial run, step by step explorations will be made. More and more elaborate satellites will be put in orbit to give us scientific data on the environment in increasing detail. Sounding rockets will probe to greater and greater distances beyond the point of no return, telemetering back results of physical and biological measurement and experiment.

Engineering problems of unique character and complexity will challenge the best of our abilities, and collaboration with scientists and specialists in aviation medicine will dramatically expand engineering interests and influence.

New knowledge, instrumentation and materials will flow from such work, and engineering imagination will quickly direct them into novel applications and devices useful for more mundane purposes. In short, the engineer has a key role to play in this dawning age of space.

An exciting field which challenges engineering education is that of computers and their application. Let us examine the implications of this challenge in some detail. As an example, we are being urged to offer courses in computer fundamentals, logic, design, components, applications and use—not to speak of complete curricula leading to degrees in computer engineering.

Some schools have strong research interests in modern computing and may be justified in offering such instruction. At the same time, other customers for our graduates give equally convincing arguments for more or less specialized instruction in, for example, control systems, instrumentation, automation, system engineering, operations research, nuclear engineering and information theory. Needless to say, we are somewhat confused and bothered beyond mere professorial petulance over these challenges to comfortable academic routines.

Formal instruction pertinent to computing can have specific as well as general aspects. Of general character are computer fundamentals, including logical design; applied mathematics that incorporates a new philosophy and approach to problem formulation for computer solution; related mathematics, such as Boolean algebra, probability and statistics, group theory, matrix algebra; and a mathematics "laboratory" for numerical methods, iteration procedures and relaxation methods.

Engineering education is being pulled into new and different directions. Shall we concentrate on fundamental education or go in the direction of specialized training?

More specific instruction could include computer circuitry, components, storage devices, input and output systems, programming and coding, laboratory experience, checking routines and trouble shooting. However, from the educational point of view, such instruction should be watched critically lest it be too specific to particular computers, devices, and those systems subject to a high rate of technological obsolescence. The significant generalizations can easily be obscured in such instruction by a horde of details which may be only of transient value in the hustling computer art.

The computer's challenge to engineering education is properly in the area of fundamentals. Fortunately, some of the significant basic factors implicit in modern computation underlie other developments in engineering science as well. Probability and statistics, general concepts of reliability and generalizations from information theory, for example, permeate modern engineering—particularly instrumentation and control.

Systems study, as contrasted with component study, is the coming approach to involved engineering problems. Computers or simulators of varying degrees of sophistication are likely to be parts of such systems. The science of decision-making may eventually become a recognized engineering science taught in the colleges, implemented by the power of high-speed computing, analysis and synthesis. Engineering cybernetics (the more generalized aspects of servos and control) also leans heavily on concepts that are basic in modern computation.

The implications of high-speed computing in our classical engineering science subjects are a bit frightening. For example, structural design, whether applied to bridges and buildings or to aircraft, could be completely different in approach if high-speed computing were generally available. Rapid iterative methods, optimization procedures, and even incorporation of nonlinear properties would give an engineer freedom to explore new design concepts.

Engineering economy could be greatly extended in scope by computers, in that alternative choices could be examined quickly and tested for the effect of many parameters. In short, the whole approach to a physical problem may be different if high-speed computing is available. The problem formulation would be derived directly from basic physics into machine terms, without necessarily going through a mathematical formulation. We would then be less inclined to warp the physical system into formal mathematics which we can solve. This would be particularly true if nonlinearities are involved—and most of nature is nonlinear!

Students will become aware of these new horizons in basic thinking which modern computing suggests. However, the great new day is only dawning and we will fumble along for quite a while with analyses and techniques that later may be displaced. Existing methods of engineering will apply indefinitely to thousands of unglamorous but essential problems, and these the students must be prepared to solve realistically. So our education in engineering won't suddenly be coded and programmed for the computer art, but it will eventually include the fundamental subjects that are pertinent and will develop those broader methods of analyses and thinking that computers will make possible. We welcome the computers with their challenges, but we are not quite ready to throw away our slide rules!

Reliability is another new factor which has come to represent an important quality of equipment and its performance. This quality is rapidly assuming an almost paramount importance in many systems. The simple and innocent-sounding reliability criterion presents some extremely difficult problems—first, of stating sensibly the expected reliability, and, second, the synthesis of the system to achieve it. Some of the methods of analysis and synthesis resemble those of information theory. Statistical methods have their place, also, in determining a degree of confidence that a given system will perform as desired.

Some engineers, whose work in weapons systems and missiles has made them acutely conscious of the importance of reliability, believe that there is a new field of analysis and synthesis to be developed under this term "reliability." This new field involves concepts and methods of thinking which are now only vaguely understood. Here, again, for its educational implications, "reliability" appears not as a likely subject for a course in itself, but rather as a pervading idea which threads through many aspects of our engineering analysis and design.

Reliability, of course, is not a new thought, but the problems of missile guidance and control give it a prominence of first magnitude. Similarly, other engineering features of design, production and performance are brought into sharper focus for space age vehicles than for less exotic devices and applications.

Technical sophistication

Nonetheless, these new problems are catching up with us in many other areas as we seek improved performance, greater efficiencies and extended applications at higher levels of technical sophistication. We must design uncomfortably close to ultimate limits in many instances, but we can do so with more assurance because of better instrumentation, more knowledge of material properties and refined design methods.

Nuclear energy is another vital subject of great engineering significance which can pull engineering education into still different directions, with exciting new details to stimulate the student. The fact of radiation itself introduces unique problems which complicate the application of older principles of analysis, design, materials and heat transfer. Some schools have responded with nuclear reactor engineering curricula, but others have taken the position that, because nuclear reactors are specialized devices which involve so many engineering fundamentals common to other applications, only a few substitutes are required rather than a separate curriculum.

In the colleges we cannot, and, I believe, should not attempt to meet these challenges by detailed specialization in all the areas of current interest and importance. We must, instead, do the more difficult job of examining each new development for those features that are truly basic, extracting the concepts that are new and fundamental, and synthesizing the important generalizations that have lasting value. This exercise of self-discipline, of sticking to fundamentals, is not easy. The other way —that of following avidly in the classroom the exciting new developments, the intriguing applications, and the fascinating new details—is more fun, has high entertainment value for the student, and is an easy, pleasant way to teach. But it has the elements of a phony gold brick—the superficial appeal and the form, but little substance—and the values in such instruction are apt to be transient.

Thus engineering colleges must evaluate critically the fundamental character of these new advances so that curricula and course content of the basic sciences and engineering sciences may be improved to serve better as fundamental education for future professional application. We must always be critical of that instruction which is specialized training rather than comprehensive education.

On this point Alfred North Whitehead, the mathematician and philosopher, has some apt remarks. "A well-planned University course," he says in *The Aims of Education*, "is a study of the wide sweep of generality. I do not mean that it should be abstract in the sense of divorce from concrete fact, but that concrete fact should be studied as illustrating the scope of general ideas.

"This is the aspect of University training in which theoretical interest and practical utility coincide. Whatsoever be the detail with which you cram your student, the chance of his meeting in after-life exactly that detail is almost infinitesimal; and if he does meet it, he will probably have forgotten what you taught him about it. The really useful training yields a comprehension of a few general principles with a thorough grounding in the way they apply to a variety of concrete details. In subsequent practice the men will have forgotten your particular details; but they will remember by an unconscious common sense how to apply principles to immediate circumstances."

Key to success

To these remarks of Whitehead, I should like to add that, from an engineering point of view, the ability to apply fundamentals to new situations is the key to successful professional practice. As a corollary, versatility, or the skill in moving from one field of technology to another, marks the outstanding practitioner, and, in fact, such ability is virtually a test of understanding of the fundamentals.

These ideas should sound familiar to alumni of Caltech, where fundamental education rather than specialized training has been the objective for many years. Caltech can also take pride in its leadership in recognizing early the importance of the humanities as a vital part of science and engineering education. Now all engineering schools include some, and seek to add more of history, English and social science by displacing so-called professional subject matter. But this change is not coming easily and as someone has said wisely, "Reorganizing an academic curriculum is like trying to move a graveyard."

This trend toward breadth is now well accepted and moving ahead. At the same time (even before our recent dramatic satellites) engineering has been challenged in many areas—some military, some civilian—to new achievement in research, design, and production. Many of these areas involve materials, techniques and methods not presented in text books or even in public discussion.

A sampling of the advertising in professional journals, alumni magazines and college publications gives a feeling for this climate of modern engineering in phrases such as, "A career that requires creative thinking, utilizes all your skills and talents, offers the chance to learn the latest techniques" . . . "Want to grab the atom by the tail and put it to useful work?" . . . "Want to dig in and really get down to the basics?" . . . "Start today and plan tomorrow" . . . "Up to two years of theoretical and practical training are offered" . . . "You will push beyond existing limitations into new concepts and new products" . . . "Today more and more new ideas come from men trained to an awareness of that which is yet to be accomplished" . . . "The door to electronic wonders is only slightly ajar. The greatest discoveries lie ahead."

The emphasis is on the new, the undiscovered ideas, devices and systems. Creative thinking is an ideal eagerly sought and carefully nourished. Advanced ideas and methods intensify the need for a basic engineering education which has extensive scope and depth in the fundamental sciences and the engineering sciences. This basic education is a foundation for professional work to be learned in practice, and for graduate study which is becoming increasingly a necessity.

An initial degree

Admittedly, a four year curriculum with this orientation must omit some of the engineering details which we have all been accustomed to present in our teaching, and which have some immediate value to the young graduate if he happens to fall into work in the general area he has studied. But if our engineers of the future are to be identified with the highest levels of effort in technology, the advanced designs and the new materials and processes, we must accept the fact that a Bachelor's degree program is insufficient for the highest level of professional engineering practice. In the same way, our colleagues in physics and chemistry expect the Bachelor's degree to be an initial rather than a terminal degree.

We are all well aware of the fact that during the war many scientists distinguished themselves in work which was quite foreign to their professional experience, and which they regarded as essentially engineering in character—but a type of engineering which had never been studied before. In fact this experience has led to a certain arrogance among some scientists with respect to the competence of engineers. However, this invidious comparison overlooks the fact that at the time of World War II very few engineers had had graduate education, and even fewer held the Doctorate degree—whereas these useful scientists were, for the most part, exceptionally able people who were also PhD's. Their additional education, together with maturity and research experience, was of great value, but most important of all, it was sufficiently fundamental and general to be applicable to new situations and new developments.

Such strength should also mark the education of our best engineers so that they may function truly as engineers in advanced development, synthesis and design, with no handicap of a shallow base of fundamentals or weakness in analysis. Obviously, not all engineers will work at this high level, but their basic education should not exclude them from the opportunity. Indeed, the opportunities and challenges are unlimited in all areas of technology. The space age with its "new dimensions" clearly dramatizes the future for us and for the public, and establishes a favorable climate and receptive attitude which will be of enormous help in our efforts to strengthen engineering education.

Teacher shortage

It is in the achievement of this improvement that we are in most serious difficulty. We have not enough competent teachers in our engineering colleges to meet the needs of increased enrollment and higher quality of instruction. Evidently, with more graduate work there will be a greater demand for more teachers with advanced degrees.

The Caltech staff in engineering, with its very high proportion of Doctorates, is far from typical, and throughout the country a large number of advanced degree men ought to enter the teaching profession. A special study for the American Society for Engineering Education by its Committee for the Development of Engineering Faculties reveals that during the next ten years, due to the normal growth of engineering student enrollment, faculty retirements, loss to industry and for other reasons, about 9500 new teachers of engineering will be needed, or some 1000 per year.

Last year a national total of 590 PhD degrees in engineering was reported. A few of these new PhD's entered teaching, but if all of them had done so the number would still have been too small. Next year will not be significantly better.

Thus our problem is, first, to encourage more of the best students to enter graduate school to prepare for careers in engineering teaching and research; second, to make a teaching career as attractive as possible, with reasonable pay and good basic research opportunities; and third, to do everything possible to assist existing engineering faculties to develop professionally in new technological directions and improve in effectiveness in their teaching. For it is only from superior teachers that we can expect to obtain superior graduates. There is no substitute for quality, and it is the improvement of quality that is now pertinent in engineering education.

I earnestly hope that Caltech can make a conspicuous national contribution to this strengthening of engineering education—not only by example, but as an important source of teachers of high quality.

Personals

1924

E. Dale Barcus, head of the toll service transmission engineering organization of the Pacific Telephone Company, was appointed chairman of the Los Angeles section of the American Institute of Electrical Engineers this month. He has been with the telephone company for 34 years and has been concerned with such projects as the Los Angeles - San Francisco microwave relay system and the transcontinental coaxial cable used for television programs and telephone conversations. Dale lives in San Marino.

1926

Robert W. Moodie is now supervising structural engineer for the State Division of Architecture in the Los Angeles office of the design and planning section.

1927

W. Layton Stanton, PhD '31, has moved from Arcadia, California, to the Denver headquarters of the Union Oil Company, where he is now serving as general manager of the Rocky Mountain district.

Robert B. Vaile, PhD '36, is now chairman of the physics department in the division of physical sciences at the Stanford Research Institute in Menlo Park, California. He has been with S.R.I. since 1948. The Vailes have two children and live in Palo Alto.

L. Sprague de Camp, free lance writer and contact man for the Gray & Rogers advertising agency, has a new novel, *An Elephant for Aristotle*, published by Doubleday & Company.

Nathan D. Whitman, Jr., MS, '32, who is in business for himself as a construction engineer in Pasadena, writes that he's keeping busy—last year as president of the L.A. Section of the American Society of Civil Engineers, and this year with the design of a test facility to load structural members with simulated atomic blasts.

1929

Duane E. Roller, PhD, professor of physics at the Harvey Mudd College in Claremont, is the editor of a book, *Foundations of Modern Physical Science*, just published by the Addison-Wesley Company. His son, Duane, of the University of Oklahoma, is co-author of the textbook.

Maurice F. Hasler, PhD '33, president of Applied Research Laboratories, Inc., in Glendale, received the 1958 Beckman Award in Chemical Instrumentation last month. The award is given for outstanding achievement in the development of new instruments for chemical analysis and in the application of analytical instruments for chemical process measurement and control. Selection of the winner is made by the American Chemical Society.

Maurice plans to use the money from the Beckman Award to set up a series of annual awards, in the name of the Applied Research Laboratories, Inc., to be administered by the Southern California Science Fair, an annual exhibit of the scientific work of high school students.

1932

Fred Foulon, in charge of a group handling electronic research at the Douglas Aircraft Company in Los Angeles, is 1958-59 vice chairman of the American Institute of Electrical Engineers, Los Angeles Section. Fred, who took office this month, has been with the Douglas Aircraft Company for 15 years.

1933

Moses B. Widess, MS '34, PhD '36, is now Division Geophysical Technical Supervisor for the North Texas-New Mexico Division of Pan American Petroleum Corporation. He is living in Fort Worth, and has two children.

1935

H. M. A. Rice, PhD, writes from Ottawa, Ontario, Canada, that "shortly after getting my PhD, I joined the staff of the Geological Survey of Canada and am still with them. I hold the rank of senior geologist in charge of processing of maps and reports."

"While in Pasadena I married a local girl, Lorna MacDonnell, and we have two boys. The elder is working at the map compilation division of the Topographic Survey of Canada—and the younger starts university in the fall. As for hobbies, mine are landscape painting, golf (handicap 100) and studying fossil insects."

1938

Darrell W. Osborne, PhD, senior chemist at the Argonne National Laboratory in Lemont, Ill., has received a 1958 Guggenheim Fellowship to conduct research at Oxford University on the properties of liquid and solid helium-3 at a very low temperature. He will be accompanied to England by his wife and daughter.

Byron L. Havens, MS, is now resident manager of the new IBM Research Laboratory in Yorktown, N.Y. For the past 12 years he has been a senior staff member of the IBM Watson Laboratory at Columbia University, where he has led a research team working on the technology of high speed electronic computing with particular emphasis on very large machines.

The Havens and their three daughters live in Closter, New Jersey.

1939

Jack Goodell writes that, "After graduation I spent approximately 8 years with the General Electric Company and 1 with

Personals . . . *continued*

the Essex Wire Corporation. For the past 10 years, I have been with the Bechtel Corporation in Anaheim. I am now assistant manager of engineering in the power division. My most recent responsibility was the engineering of the Huntington Beach and Mandalay steam electric generating stations (each 400,000 kw) for the Southern California Edison Company. My family includes two boys—15 and 13—and a daughter 9."

John J. Browne, assistant to the superintendent of the General Petroleum Corporation's production department in Taft since 1952, has been transferred to the Los Angeles home office as a special assistant. He has been with the company since 1939.

1940

Frederic M. Brose writes from Monrovia, California, that "I am now employed by the Datex Corporation, a subsidiary of G. M. Giannini & Company, Inc. I am assistant operations manager and production engineer. Datex produces shaft position encoders and digital data handling equipment and systems. Familywise, I am specializing in girls (three daughters—aged 8, 6 and 1½)."

1941

Donald F. J. McIntosh, assistant superintendent of the General Petroleum Corporation's production department at Ventura, has been transferred to the San Joaquin division, with headquarters in Taft.

1942

William T. Holser, MS '46, assistant research geophysicist at UCLA, has taken a new job as research mineralogist at the California Research Corporation, a subsidiary of the Standard Oil Company of California in La Habra. The Holsers have two sons now—one 2 years old, and one 2 months.

Comdr. Forest M. Clingan has been transferred from the Naval Torpedo Station at Keyport, Washington, to Washington, D.C., where he is still in industrial control work.

Peter L. Nichols, Jr., PhD, chief of the propellants division at JPL, was appointed a member of the National Advisory Committee for Aeronautics (NACA) Subcommittee on Rocket Engines last December. Recently he received another appointment—to serve on the Propulsion Subgroup of the Ad Hoc Polaris Panel, which is sponsored by the Department of Defense. Peter's division was responsible for the initial propellant development which led to the propulsion system for the Navy's "Polaris" missile.

To top it all off, Peter's also been appointed chairman of an Ad Hoc Panel on Propellant Performance Calculations and Thermodynamic Data sponsored by the

Joint Army, Navy, Air Force (JANAF).

1943

John E. Cushing, PhD, associate professor of bacteriology at UC in Santa Barbara, has received a Guggenheim fellowship for 1958. He plans to work at the University of Tokyo, where he will serve as a visiting lecturer and also continue his research—identifying blood groups of fish, whales and fur seals. Only three American and three Japanese scientists are engaged in this area of biological studies. Among the interesting applications of such findings is to distinguish the origin of salmon populations to provide information for establishing fishing treaties with Japan.

1944

Albert T. Spaulding has announced the formation of a new firm, the Eckels-Spaulding Company, engineering representatives, in San Francisco. They began operations on March 1st, representing the Fluor Products Company of Whittier in Northern California and the Pacific Northwest. The Spauldings live in Mountain View and have two children—Anne, 5, and Edward, 2.

1945

Charles W. Hunt and a partner have opened new offices in Calgary, Alberta, as consultants in petroleum exploration. The Hunt family was increased by a third child, Mary Melinda, in May. The other two children are Lucile, 7, and Malcolm, 4.

1947

James S. Smith is now a project engineer (Minute Man ICBM) at the Space Technology Laboratories division of the Ramo Wooldridge Corporation in Los Angeles. The Smiths have three children—twins Susan and James, 2, and four-month-old Claire Ann. A two-year-old prize (?) boxer completes the family.

1949

Stanley C. Pace, MS, assistant manager of the newly-formed Tapco Group of Thompson Products, Inc., in Cleveland, has been elected assistant secretary of the board of directors of the company. The Tapco Group was formed in March to combine the company's specific work in the fields of astronautics, electronics, nuclear power and advanced weaponry into a separate unit. Stan, who was formerly manager of the Jet Division, has been with the company since 1954.

1950

Jerome K. Delson, MS, PhD '53, has received a post-doctoral Fulbright Fellowship which will enable him to work at the Weizmann Institute of Science at Rehovoth in Israel. He writes: "I visited there in 1956 and was impressed with the many similarities to Caltech—the buildings and grounds are similar and there is a fine atmosphere for research."

1953

Bruce Holloway, PhD, writes from the department of bacteriology at the University of Melbourne in Victoria, Australia, that he will be visiting Caltech in August, on his way to the International Genetics Congress in Montreal.

1954

Edward J. Gauss is president of a newly-formed firm, the Gauss Development Company, with offices in Denver and Los Angeles, which will market a kit for making etched circuits, called the DRAW-N-ETCH kit—a simplified process for the making of prototypes.

1955

Robert S. Christian writes that "since leaving Tech I have been with the Air Force and am presently stationed at March AFB in Riverside, California, where I expect to remain until my discharge in December. We now have a second daughter, Kelly Marie, born in April. Our first daughter, Tracy Lynn, is now 1½."

IF college has sharpened your urge to know more...

Stick-force reversal, a problem of reverse elevator response occurring at sonic speeds, was solved by this sensitive AiResearch air data system incorporating transducer, computer and actuator. Engineers taking part in its development included mathematicians and specialists in analog computation, preliminary design, fractional hp motors and gears.

Your formula for advancement in present day technological industry is growth in knowledge and ability.

Applying this principle at Garrett, engineers are achieving outstanding reputations for excellence in the following aircraft, missile and industrial fields: air conditioning and pressurization; heat transfer; cryogenic and nuclear systems; pneumatic valves; controls and air motors; system electronics; computers and flight instruments; gas turbine engines and turbine motors; prime engine development and industrial turbochargers.

Upon employment, you may choose either a direct assignment or enter a 9 month orientation program which permits you to survey Garrett engineering activities to aid you in selecting your field of interest. With company financial assistance you can continue your education at neighboring universities.

Typical project work is done in small groups where opportunities for learning, added responsibility and advancement are enhanced. To receive full information write to Mr. G. D. Bradley

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Alumni News

President's Report

During the past year all the activities engaged in by the Caltech Alumni Association were highly successful, due almost entirely to the help and cooperation of Institute personnel and a great number of alumni. We wish to thank all those people who were so generous.

Most exciting was the Board's decision to join the Institute in its $16,100,000 Development Program, directed by Dr. Arnold Beckman. Dr. Simon Ramo enthusiastically agreed to serve as chairman of the Alumni Committee of the Development Program, aided by Alumni Association Directors Ed Fleischer, John Fee, Nick Ugrin and myself. Dr. Don Clark has been invaluable as this Committee's secretary and Grice Axtman was assigned by the Institute to work full time as Alumni Program Director.

Caltech and the Association suffered a great loss in the passing of Howard B. Lewis. Howard was a past president of the Association, was instrumental in the establishment of the Caltech Alumni Fund, and at the time of his death was making further contributions of his time, serving as chairman of the Alumni Fund Council. Needless to say, the benefit of his advice, based on many years of experience in fund activities, will be missed.

The Board of Directors, after several years of pro and con deliberations, unanimously voted to increase yearly Association dues from $4 to $5 starting with the fiscal year 1958-1959. The cost of a life membership will increase from $75 to $100 effective at the close of the annual meeting. These increases in membership fees are to be applied directly toward more fully allaying the cost of publishing one of the most outstanding alumni magazines in the country today, *Engineering and Science*.

Most interesting to the younger graduates is the preparation of the supplement to the 1957 Alumni Directory. This activity was under the directorship of Junior Board Member John Fleming.

Social Program Director Frank Bumb, who was helped by General Program Chairman Bill Haefliger and his committee of six, gave alumni a change of scene and sound at the annual dinner dance and provided speakers at the two dinner meetings who attracted record attend-

ance. In addition, all arrangements for this annual meeting and for the picnic later this month have been well taken care of. I would like to think that some small credit should go to these people for Tech's overdue gridiron victory over Oxy last fall, since a great many alumni rooters witnessed this sports phenomenon as a prelude to enjoying post-game dancing and refreshments.

The Seminar program was overhauled this year by Director Fort Etter, General Chairman Ralph Jones, and Program Chairman Owen Johnson. To say that their efforts were rewarded would be the understatement of the year, since attendance soared into four figures—1,185 to be exact, an increase of some 77 percent over last year's attendance.

Senior Directors Chet Lindsay and Jack Osborn convinced 3,105 annual dues-paying alumni of the benefits in belonging to the Association, and life members numbered 664—making a membership total of 3,769. This membership met the budget nicely, indicating a 4.7 percent increase over 1956-57, when memberships totaled 3,570. It is gratifying to report that at this time more than 50 members of the class of '58 have joined the Alumni Association.

Retiring Directors this year are John Fee, Chet Lindsay and Jack Osborn. On behalf of the alumni, I would like to thank these men for their several years of service.

Mr. Joe Lewis was appointed Chairman of the Alumni Fund Council subsequent to the death of Howard B. Lewis.

Four capable men join the Board as junior members. All of them have already contributed to the success of a number of Association activities. They are Frank Alderman, Bill Haefliger, Ralph Jones and Francis Odell.

—*Willis R. Donahue*
President

ALUMNI ASSOCIATION OFFICERS

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SECRETARY
Donald S. Clark, '29

VICE-PRESIDENT
Edward P. Fleischer, '43

TREASURER
George B. Holmes, '38

BOARD OF DIRECTORS

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L. Fort Etter, '35
John R. Fee, '51
John E. Fleming, '46
Chester W. Lindsay, '35
John E. Osborn, '39
Nick T. Ugrin, '34

ALUMNI CHAPTER OFFICERS

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Armed Forces Special Weapons Project

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Applied Physics Laboratory, Johns Hopkins University
Silver Springs, Maryland

SAN FRANCISCO CHAPTER

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Shell Oil Company, Martinez

Vice-President Jules F. Mayer, 40
Chemical Division, Standard Oil Co., Richmond

Secretary-Treasurer Norman Bulman, '52
Shell Oil Company, Martinez

Meetings: Informal luncheons every Thursday
Fraternity Club, 345 Bush St., San Francisco

CHICAGO CHAPTER

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Vice President Philip E. Smith, '39
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Secretary-Treasurer Thorne J. Butler, '51
245 Latrobe Avenue, Northfield

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State Division of Architecture, 1120 "N" St.

Vice President Kenneth M. Fenwick, '28
State Division of Highways, 1120 "N" St.

Secretary-Treasurer Joseph A. Dobrowolski, '49
Portland Cement Association

Meetings: Luncheon first Friday of each month.
University Club, 1319 "K" St., Sacramento

SAN DIEGO CHAPTER

Chairman Maurice B. Ross, '24
3040 Udal Street, San Diego 6, Calif.

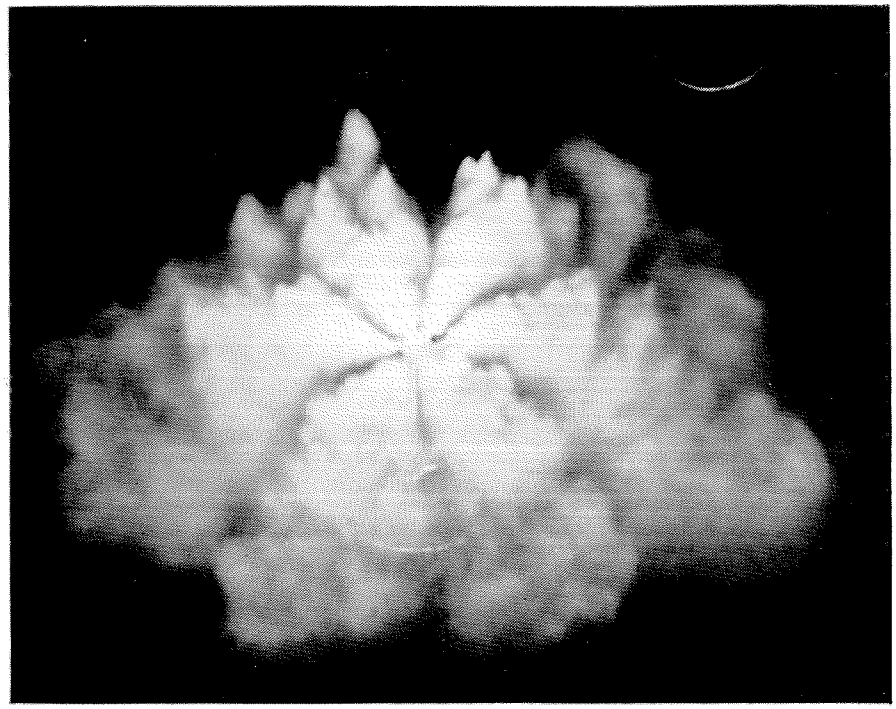
Secretary Frank John Dore, Jr., '45
Consolidated Vultee Aircraft Corp., San Diego

Program Chairman Herman S. Englander, '39
U. S. Navy Electronics Laboratory

PHOTOGRAPHY AT WORK
No. 33 in a Kodak Series

The Army's first operational rotor-tip propelled jet helicopter—built by Hiller.

The camera has caught the fuel spray pattern within the rear end of the ram-jet engine even though passing by at about 450 miles per hour.



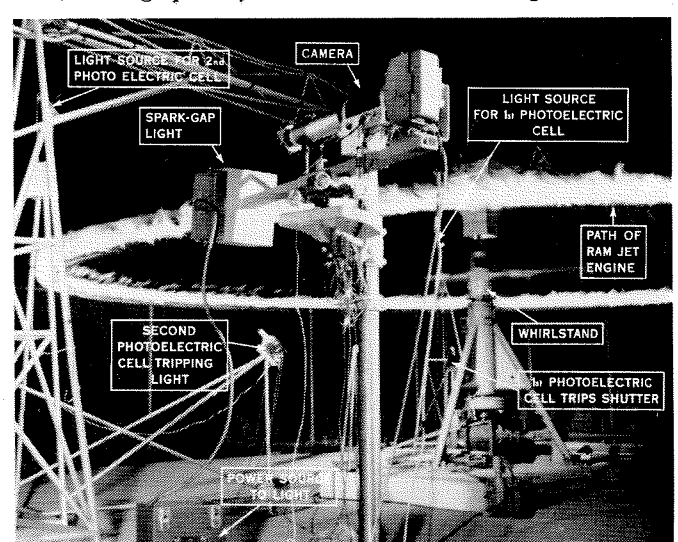
Project:
Inspect rotor tip jets for a whirlybird

Hiller Helicopters wanted facts on the fuel spray pattern of a ram-jet engine whirling at speeds up to 700 feet per second. Photography got the job.

WHEN HILLER HELICOPTERS of Palo Alto, Cal.—a pioneer in vertical take-off aircraft—developed a rotor-tip ram-jet engine, they knew the fuel spray would be subject to high air velocity and centrifugal force up to 1200 G's. Would the fuel spray be deflected outward and cause the jet to lose thrust? They wanted to know. So they set up the camera with its fast eye to catch what otherwise couldn't be seen. And they learned the right angle of air intake and nozzle to obtain the greatest power.

Using photography in research is an old story with Hiller—just as familiar as using it for improving public relations. It's an example of the way photography plays many important roles in modern-day industry.

In whatever work you do you will find that photography will play a part in improving products, aiding quality control and increasing sales.



This is all the human eye could have seen of the whirling ram-jet engine as camera takes its picture.

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