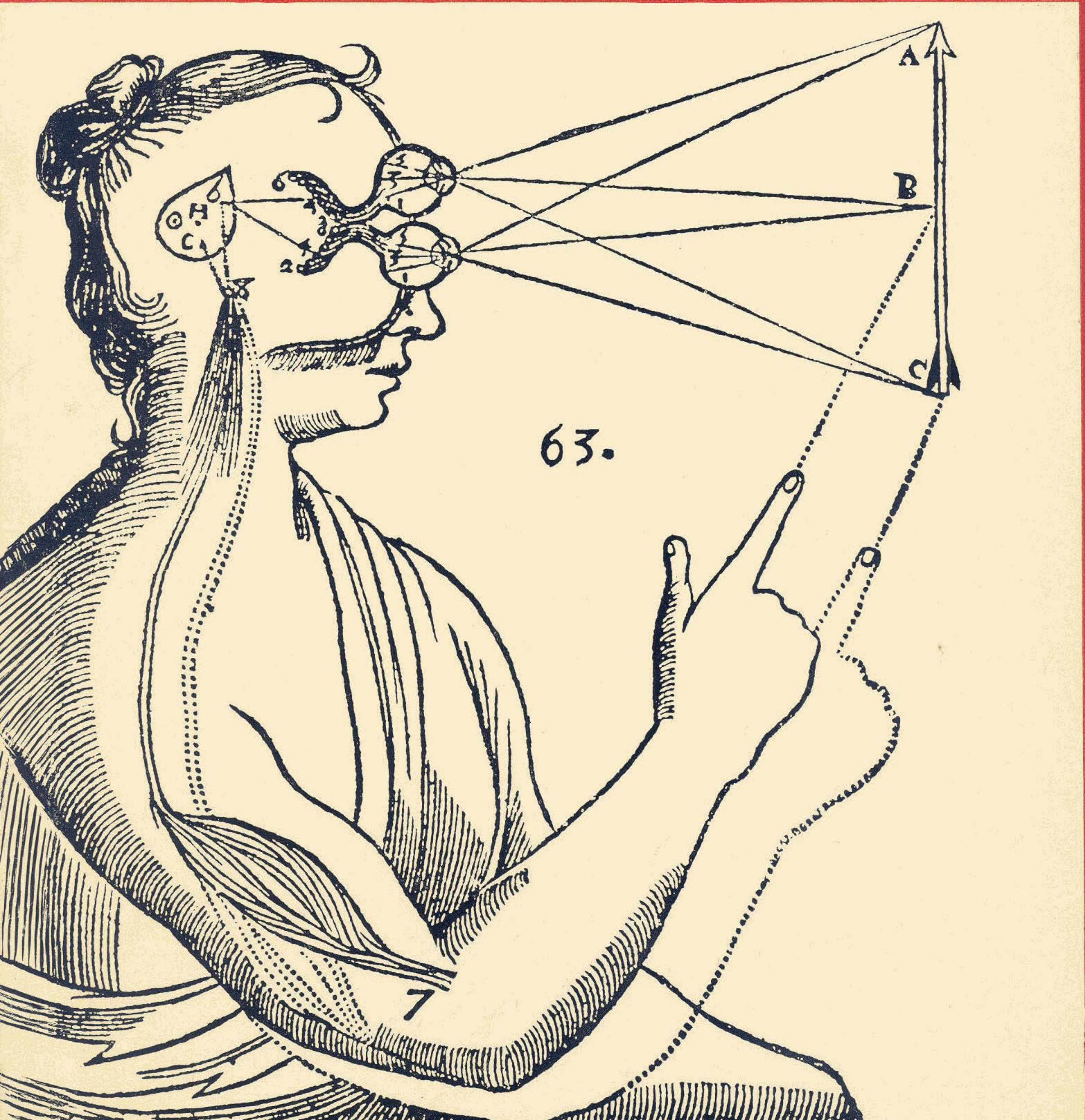
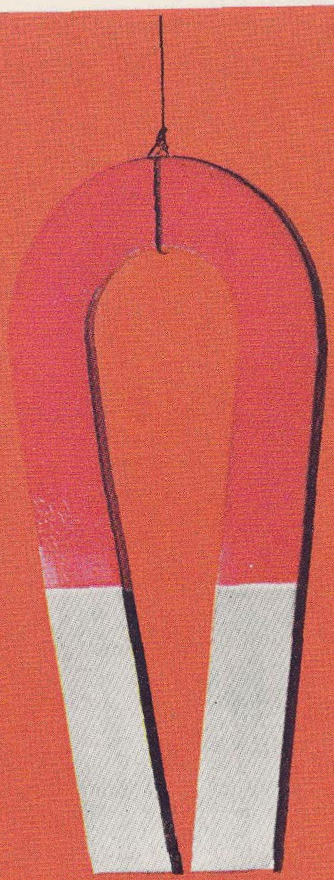
ENGINEERING | AND | SCIENCE

November 1962



Brain research . . . page 3

Published at the California Institute of Technology



Super magnets may help harness the power of the H-bomb

If the energy that makes an H-bomb could be released in a controlled flow, man would have an almost limitless source of electric power. But the "if" is a big one. It means, among other things, building a container to hold 100-million degree temperatures . . . hot enough to vaporize any known material. Theoretically, this container problem could be solved by holding the hydrogen reaction inside a powerful magnetic field, a sort of "magnetic bottle." But such a magnetic bottle would require a series of huge costly magnets consuming a powerhouse full of electricity. However, Westinghouse is already marketing a fist-sized super conducting magnet that runs on virtually no power, yet produces a field twice as intense as a conventional magnet weighing 20 tons. Scientists believe that future developments of these super magnets may provide the answer to the problem of harnessing the energy of a hydrogen reaction. Perhaps you would be interested in helping to develop this and many other challenging projects at Westinghouse, an equal opportunity employer. For more information, see our representative when he visits your campus, or write to L. H. Noggle, Westinghouse Educational Center, Pittsburgh 21, Pennsylvania.

You can be sure . . . if it's Westinghouse.

Westinghouse

IOWARD HUGHES DOCTORAL FELLOWSHIPS. If you are ıterested in studies leading to a doctor's degree in engineering or hysics, you are invited to apply for one of the several new awards ı 1963 on the Howard Hughes Doctoral Fellowship Program.

his unique program offers the doctoral candidate the optimum ombination of high-level study at an outstanding institution plus ractical industrial experience in the Hughes laboratories.

ach Howard Hughes Doctoral Fellowship usually provides about 8,000 annually. Of this amount approximately $1,800 is for tuition, ıesis and research expenses, other academic fees and books. The emainder is composed of salary earned by the fellow and a stipend.

oward Hughes Doctoral Fellowships are open to outstanding stuents. A master's degree, or equivalent graduate work, is essential efore beginning the Fellowship Program.

UGHES MASTERS FELLOWSHIPS. The Hughes Masters ellowship Program offers unusual opportunities for education leadıg to a master's degree . . . and, in addition, provides each fellow ith practical experience in the professional field of his choice.

ew awards will be made in 1963 to qualified applicants possessing bachelor's degree in engineering or physics.

he great majority of the award winners will be assigned to the **ORK STUDY PROGRAM** and will attend a university sufficiently ear a facility of the Hughes Aircraft Company to permit them to btain practical experience in a professional field of their choice, y working at the company at least half time. Those associated ith a Southern California facility usually attend the University of outhern California or the University of California, Los Angeles. An appropriate stipend will be awarded.

A small, highly selected group will be offered a **FULL-STUDY PROGRAM.** Participants in this program will receive fellowships that permit them to attend an outstanding university on a full-time basis during the regular academic year with a substantial stipend.

After completion of the Master's Program, fellows are eligible to apply for HUGHES STAFF DOCTORAL FELLOWSHIPS.

For both programs, typical areas of research and development to which fellows may be assigned while working for Hughes include: weapons control systems, guidance and control systems, infrared search and track systems, advanced propulsion systems . . . parametric amplifiers, masers, lasers, microwave tubes and devices, electron-tube and solid-state displays, semiconductor materials, digital computers, antenna arrays, aerospace vehicles and trajectories . . . plasma electronics; solid-state, atomic, nuclear and aerospace physics; propagation, mechanics of structures, chemistry and metallurgy . . . systems design and analysis, human factors and analysis, network analysis and synthesis . . . microminiaturization, communications, data processing and digital computers, information theory, simulation.

The classified nature of work at Hughes makes American citizenship and eligibility for security clearance a requirement.

Closing date for applications: February 1, 1963

How to apply: To apply for either the Howard Hughes Doctoral Fellowship or the Hughes Masters Fellowships write Dr. C. N. Warfield, Manager, Educational Relations — General Office, Hughes Aircraft Company, Culver City, California.

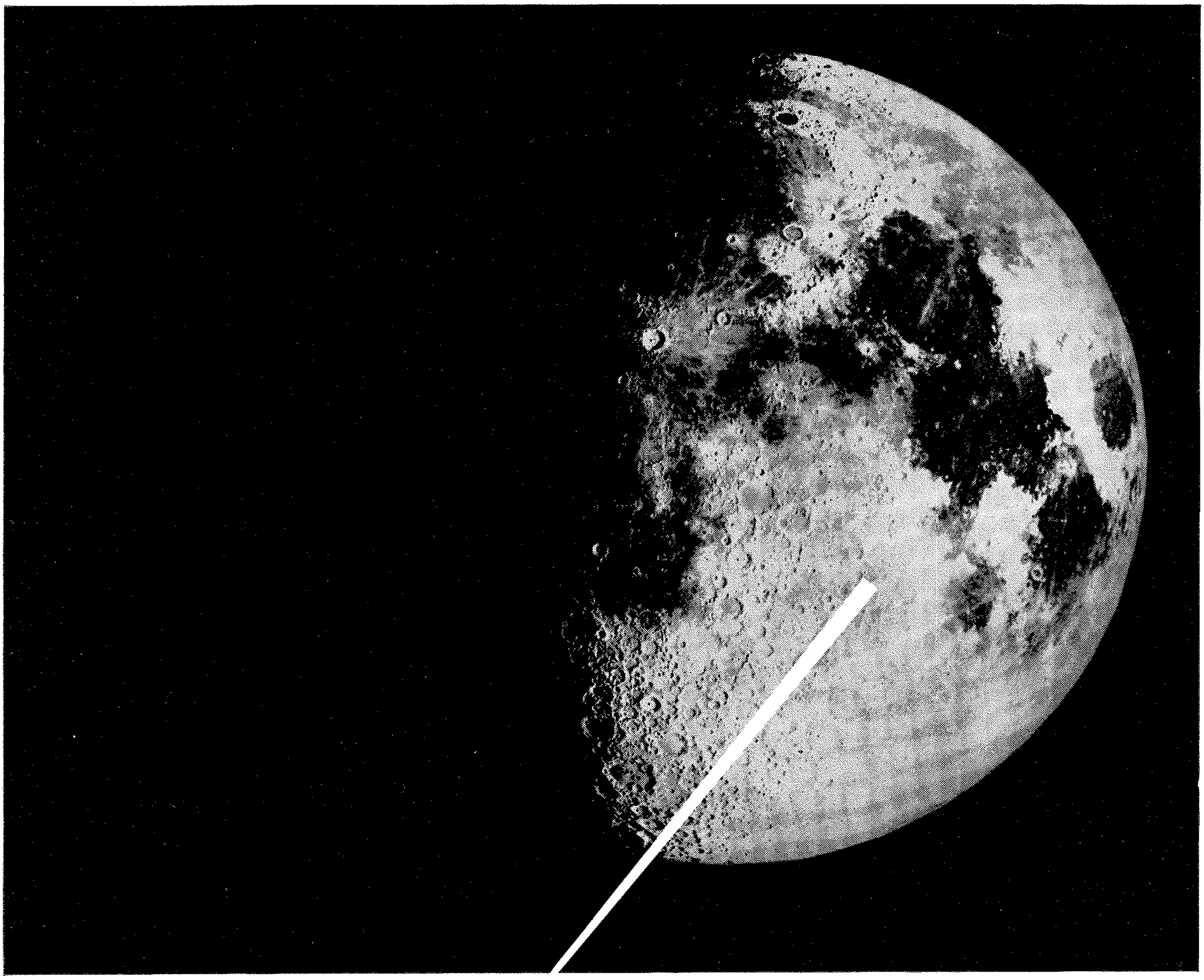
Creating a new world with ELECTRONICS

Hughes Fellowship Programs

HUGHES

HUGHES AIRCRAFT COMPANY

An equal opportunity employer.



Books

HIGH IN THE THIN COLD AIR

by Sir Edmund Hilary and Desmond Doig.

Doubleday *$6.95*

Reviewed by James Bonner

Everyone knows Sir Edmund Hilary, the conqueror – with Sherpa Tenzing – of Everest. Desmond Doig, the co-author of this book, is a newsman (Calcutta *Statesman*). He speaks the Sherpa Tibetan dialect, and – best of all – he is a perceptive observer and a fine writer.

High in the Thin Cold Air is the story of the Hilary expedition of 1960-61 to find the Abominable Snowman, the Yeti. They did not find the Yeti, but the expedition did spend ten months in the high Himalayas of east Nepal, including a full winter at 19,000 feet, the first winter stay by a party at so high an elevation in the Himalayas.

This book, wonderfully interesting throughout, is really three stories, the first of which is the story of the Yeti hunt, which ended in the well-known Yeti scalp incident. The scalp, an heirloom of a family of the village of Khumjung, was borrowed by Sir Edmund, spirited off to a succession of experts in various museums, unanimously declared to be a fake (made from the hide of a Tibetan blue bear or mountain goat), and chivalrously returned to its owner.

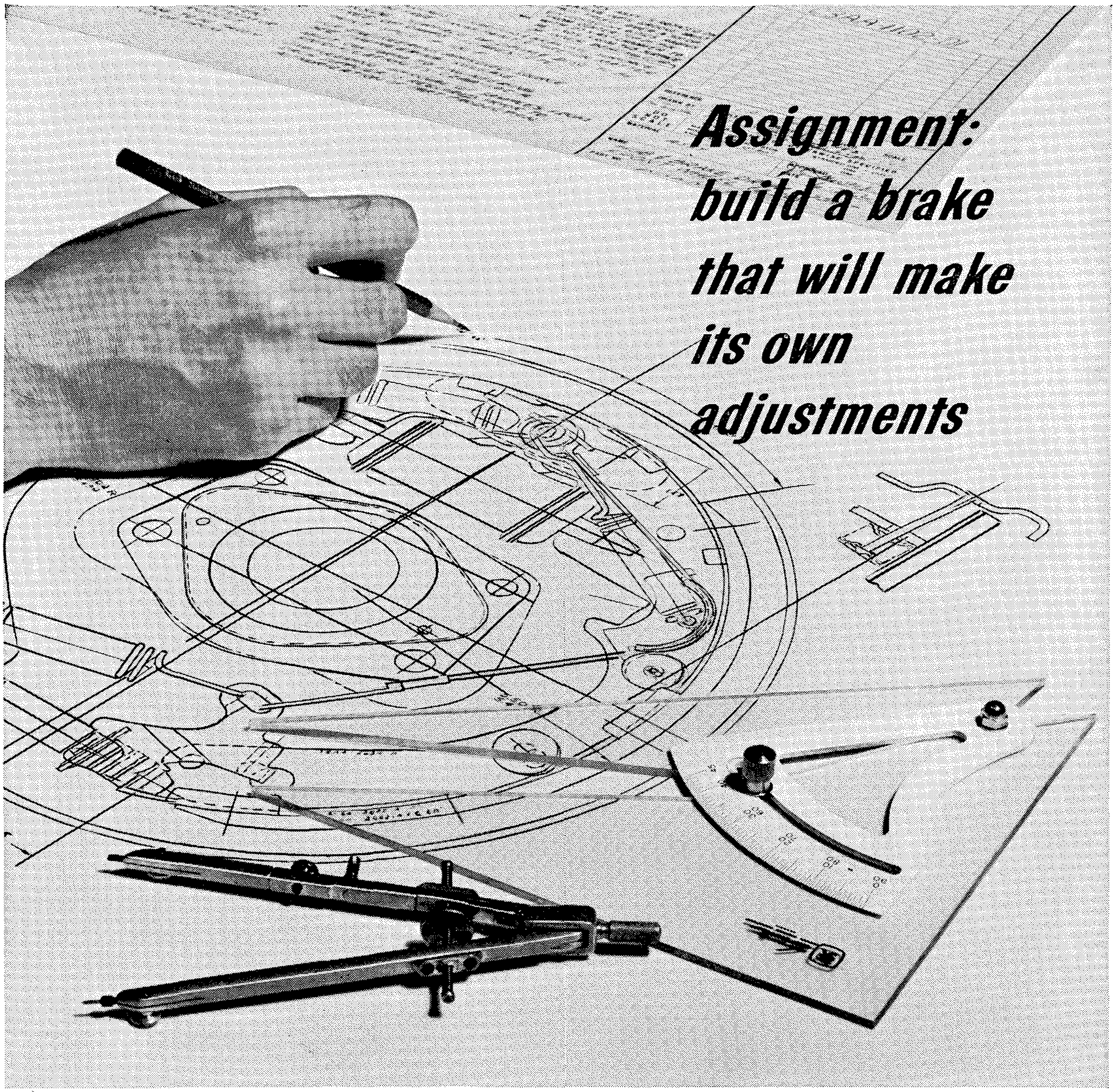
The second story, and perhaps the most engaging, is that of the daily life of the Sherpa people. The Sherpas, of whom I am a great admirer, live in the villages of Namche Bazar, Khumjung, Thyangboche and Pangboche – all at elevations of 15,000-plus feet – and at the foot of Mount Everest. Desmond Doig, with his ability to speak their language, has written one of the few, and one of the very best accounts of Sherpa customs and culture, illustrated with 88 pictures, many in color.

The third story is the mountaineering one – life at 19,000 feet during the Himalayan winter (easy except for the physiological tests conducted daily to follow the course of acclimatization of the mountaineers), the climb of Amadablam (technically a very difficult peak, and therefore hard), and the attempt on Makalu (impossible).

The World Book Encyclopedia supported the search for the Yeti, and a fine trip the search turned out to be. As for the existence of the Yeti, the Nepalese liaison officer of our own 1961 Himalayan expedition, knows the answer – which he would, I am sure, have given to the World Book Encyclopedia free of charge.

"Certainly," said he, in answer to the direct question, "there used to be lots of Yeti, but now they have all come down out of the mountains and turned into farmers."

James Bonner, professor of biology at Caltech, and an avid, international mountain-climber, made a Himalayan expedition of his own last year, on his way back from a biochemical congress in Moscow.



It's now a fact: every Ford-built car in '63 has self-adjusting brakes

"Give us a brake," Ford Motor Company engineers were told, "that will automatically compensate for lining wear whenever an adjustment is needed—and make it work for the entire life of the lining."

Tough assignment—but not insurmountable. Today, not only does every Ford-built car boast self-adjusting brakes, but the design is so excellent that adjustments can be made more precisely than by hand.

This Ford-pioneered concept is not complex. Key to it is a simple mechanism which automatically maintains proper clearance between brake drum and lining.

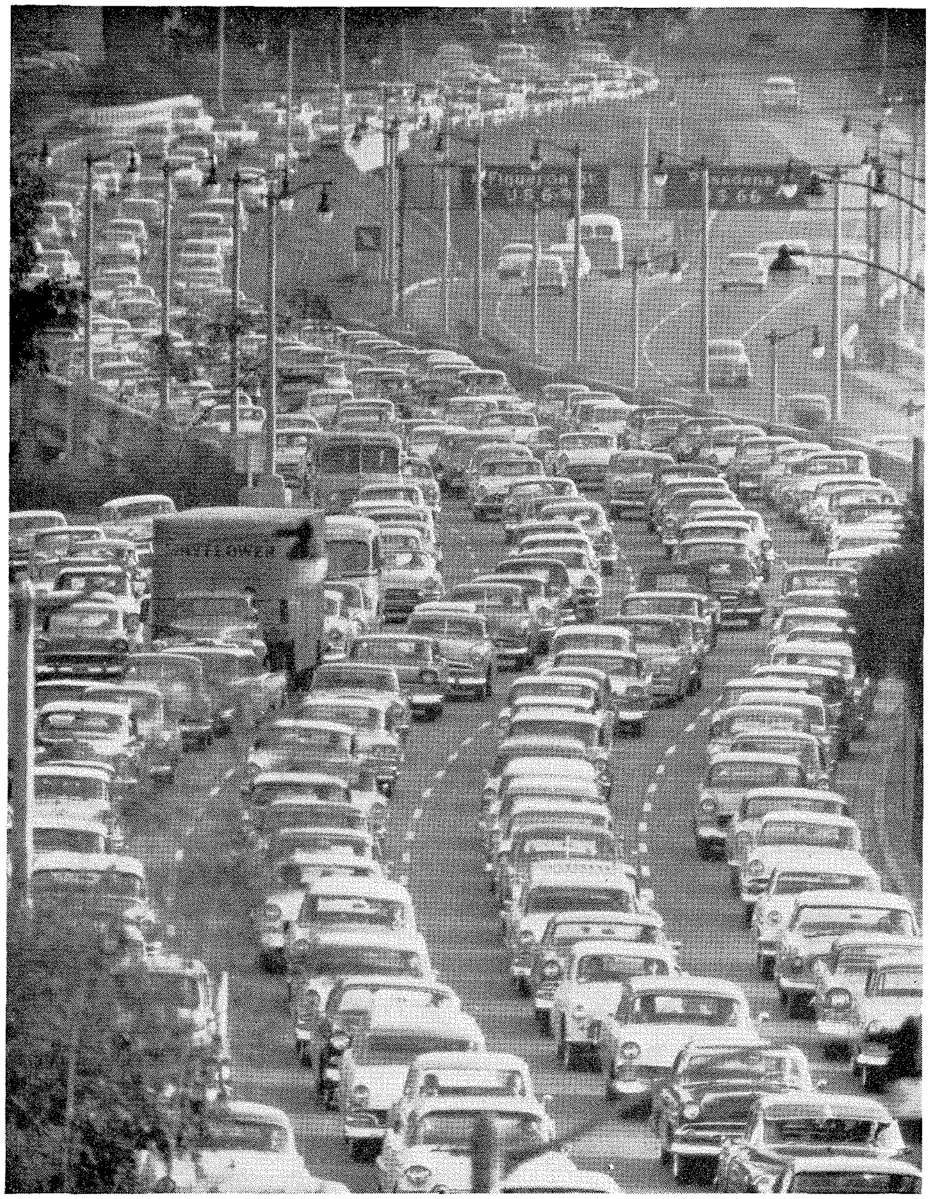
Self-adjustment takes place when the brakes are applied while backing up. This adjustment normally occurs but once in several hundred miles of driving. The brake pedal stays up, providing full pedal reserve for braking.

Another assignment completed—and another example of how Ford Motor Company provides engineering leadership for the American Road.

Ford MOTOR COMPANY
The American Road, Dearborn, Michigan

PRODUCTS FOR THE AMERICAN ROAD • THE HOME
THE FARM • INDUSTRY • AND THE AGE OF SPACE

ENGINEERING AND SCIENCE
November 1962, Volume XXVI, No. 2



SMOG CONTROL

— Is it just around the corner?

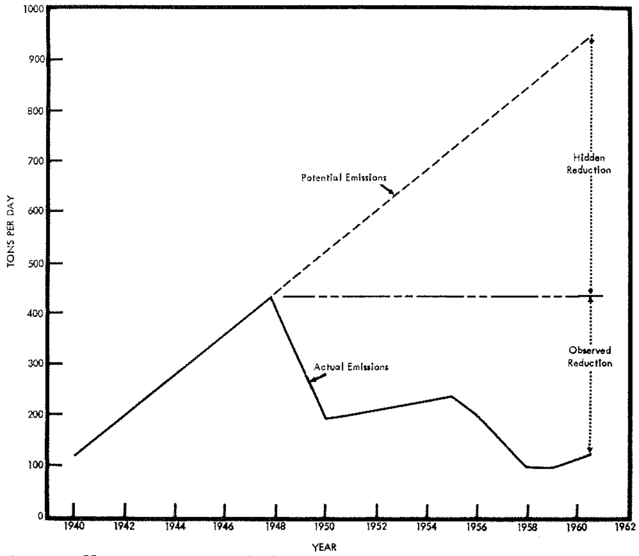
by A. J. Haagen-Smit

Old timers, which in California means people who have lived here some 25 years, will remember the invigorating atmosphere of Los Angeles, the wonderful view of the mountains, and the towns surrounded by orange groves. Although there were some badly polluted industrial areas, it was possible to ignore them and live in more pleasant locations, especially the valleys. The ideal climate and scenery started an influx of people which has now reached some 200,000 persons per year. But with this booming prosperity, the more subtle attractions began to disappear. Haze over large areas, limiting the view, became an everyday occurrence, and was the first indication that something was wrong with our atmosphere.

In 1942, just 20 years ago, the community was disagreeably surprised when the atmosphere was filled with a foreign substance that produced a strong irritation of the eyes. Fortunately, this was a passing interlude which ended with the closing up of a wartime synthetic rubber plant. However, this event clearly showed that it is not possible to emit unlimited amounts of foreign materials into the atmosphere without affecting the quality of the air. A few years after this first warning, the community was again stirred by serious complaints about strange-smelling, irritating clouds. These complaints resulted in the formation of the Los Angeles County Air Pollution Control District, which is governed by the County Board of Supervisors.

The APCD took on a big job, for by now the county's 4,003 square miles houses some 77 incorporated cities, the population has doubled since 1930, and industrial plants have boomed to more than 17,000 in 1962.

In its first years, the APCD placed special emphasis



Air pollution control has resulted in a reduction of dustfall in the Los Angeles basin to the 1940 level.

on the control of visible sources of pollution, smoke and fumes, and sulfur dioxide. By 1955 most of these were controlled and thousands of tons of pollutants were prevented from entering the air. Scavenger plants now recover several hundreds of tons of sulfur compounds originating from processing of crude oil at the refineries. Steel factories and foundries use electrostatic precipitators, bag filters, and scrubbers to collect their dusts. As a result, the dustfall in this area has decreased markedly (above).

Further reductions in the emission of sulfur compounds have been obtained by restricting the use of sulfur-containing fuel during seven months of the year, from April 15 to November 15, and during days in which atmospheric conditions would be likely to lead to higher smog levels. Monitoring of the atmosphere by chemical and spectrographic methods shows clearly the effect of burning sulfur-free gas instead of oil in power plants. The lowering of the SO_2 concentration in the air during the smog season is shown below.

To date, control efforts at a cost of more than 100 million dollars have resulted in preventing 5000 tons of air contaminants from entering our atmosphere each day.

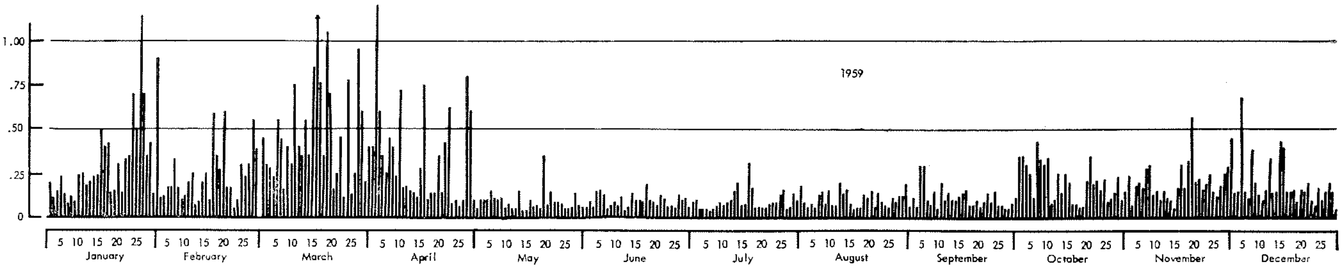
Although the stringent control did reduce dustfall and gave some improvement in visibility and local nuisance problems, it did not give relief from the regular smog symptoms – eye irritants, plant damage, excess cracking of rubber articles, and the peculiar odor. The control of the visible sources emphasized that there was something other than smokestacks which gave rise to the smog symptoms.

Through investigations initiated at Caltech, we know that the main source of this smog is due to the release of two types of material. One is organic material – mostly hydrocarbons from gasoline – and the other is a mixture of oxides of nitrogen. Each one of these emissions by itself would be hardly noticed. However, in the presence of sunlight, a reaction occurs, resulting in products which give rise to the typical smog symptoms. The photochemical oxidation is initiated by the dissociation of NO_2 into NO and atomic oxygen. This reactive oxygen attacks organic material, resulting in the formation of ozone and various oxidation products. Some of these products, peracyl nitrates and formaldehyde, are eye irritating. Plant damage is caused by peracyl nitrates and also by ozone. The oxidation reactions are generally accompanied by haze or aerosol formation, and this combination aggravates the nuisance effects of the individual components of the smog complex.

For smog control purposes, it is of importance that olefins, most saturated hydrocarbons, aromatics, and derivatives of these various types of organic material form ozone and one or more of the other typical smog manifestations. Control methods are therefore concerned with the emissions of volatile organic materials and with the other component of the smog reaction, the oxides of nitrogen.

These organics are emitted from the incomplete combustion and evaporation of gasoline in motor vehicles, from the losses of the petroleum industry, and from the use of solvents. A source survey conducted by the APCD in 1951 showed that the losses by the petroleum industry were quite substantial. Subsequent control, mainly at the refineries, has reduced these emissions by about 80 percent to 85 tons of organics per day, as determined in an elaborate survey by representatives of federal, state, and county government.

The significant reduction, however, was offset by



Monthly record of the concentration of sulfur dioxide in the air in the Los Angeles basin shows the reduction in the emission of sulfur compounds during the smog season, April 15-November 15.

an increase in the emission by motor vehicles. In 1940 there were about 1.2 million cars in the metropolitan area of Los Angeles. By 1950 there were 2 million. Today there are three and a half million. These three and a half million cars, including busses and trucks, burn about 6 million gallons of gasoline per day and emit 1300 tons of hydrocarbons, 600 tons of oxides of nitrogen, and 6500 tons of carbon monoxide per day. A glance at the table below shows that these emissions outweigh those of other sources.

Emission of Air Contaminants by Source in Tons per Day

		Organics	*Oxides of nitrogen*	*Carbon monoxide*	*Sulphur dioxides*	*Aerosols*
Transportation:						
automobiles	exhaust	750	450	5000	20	30
	blowby	150	—	50	—	—
	evaporation	150	—	—	—	—
trucks, buses	exhaust	150	150	1500	5	10
	blowby	30	—	10	—	—
	evaporation	50	—	—	—	—
diesel		10	10	2	2	2
aircraft		20	5	100	—	1
Moving Sources	subtotal	1300	600	7000	30	40
Petroleum Industry		250	1	50	40	5
Organic Solvent Uses		400	—	—	—	—
Combustion (Smog Months)		10	200	—	15	15
Miscellaneous Industries		50	15	200	50	25
Stationary Sources	subtotal	700	200	250	100	50
All Sources	TOTAL	2000	800	7000	130	100

It is clear that the five percent increase in emission from automobiles per year will make smog conditions worse unless something drastic is done to reverse this trend.

Emission of hydrocarbons occurs at several places in motor vehicles. Incomplete combustion of gasoline allows unburned and partially burned fuel to escape from the tailpipe. Seepage of gasoline, even in new cars, past piston rings into the crankcase, is responsible for "blowby" or crankcase vent losses. Evaporation from carburetor and fuel tank are substantial contributions, especially on hot days.

The exhaust gases of gasoline-powered motor vehicles consist mainly of nitrogen, oxygen, carbon dioxide, and water vapor. In addition, there are lesser quantities of carbon monoxide, hydrogen, hydrocarbons, partially oxidized hydrocarbons, oxides of nitrogen and of sulfur. The smoke particles contain carbon, lead salts, oil, and other non-volatile matter. In combustion a mixture of fuel and air is drawn into the cylinder. For complete combustion the relative proportion of air and gasoline, the air-fuel ratio, is around 15 to 1. To obtain smooth operation and maximum power, a mixture containing more gasoline is provided and consequently not all of the gasoline can be burned in the various operation cycles of the engine.

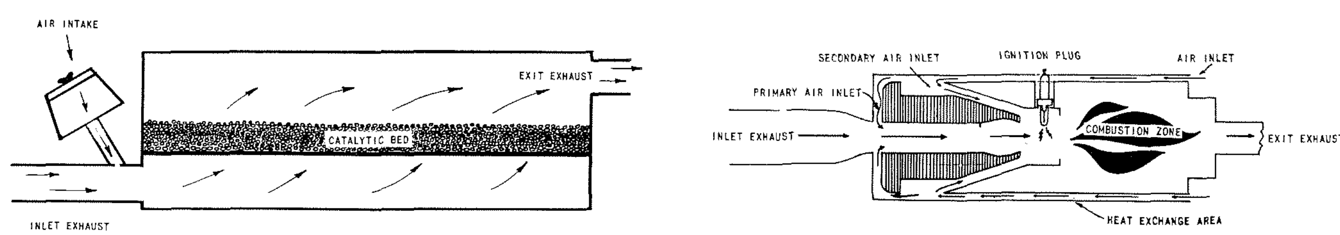
The greatest concentration of incompletely burned hydrocarbons occurs during the deceleration cycle. When fuel is drawn in but little or no air is supplied for combustion, unburned fuel is vented to the outside. However, to assess the actual contribution of each driving cycle, we have to know the exhaust volumes, which vary from a few cubic feet per second for idling and deceleration to 50 to 100 cft. per second for acceleration and cruising. In addition, we have to take into account the time spent in each of these cycles in town driving.

The table below gives the relative weights of exhaust emissions for the different operation cycles, on an average trip in Los Angeles County, for hydrocarbons, carbon monoxide, and oxides of nitrogen. The emission of oxides of nitrogen during these cycles is especially pronounced during acceleration and cruising since their formation is promoted by high temperature and increase of oxygen. We find low concentrations of oxides of nitrogen, therefore, in idling and deceleration, while high values are found during cruising and acceleration.

Relative Contributions of Exhaust Components in Operation Cycles in Weight Percentages

Driving cycle	*Hydrocarbon emission*	*Carbon monoxide emission*	*Oxides of nitrogen emission*
Idling	5	10	.5
Acceleration	55	60	80.
Cruising	15	15	20.
Deceleration	25	15	.2

The preferred method of control of the tailpipe hydrocarbon emission is a better combustion in the engine itself. (The automobile industry has predicted the appearance of more efficiently burning engines in 1965. It is not known *how* efficient these will be, nor has it been revealed whether there will be an increase or decrease of oxides of nitrogen.) Other approaches to the control of the tailpipe gases involve completing the combustion in muffler-type afterburners. The two main types are shown below.



Two methods of controlling hydrocarbon emission from automobile tailpipes through combustion of the exhaust gases—a catalytic afterburner (left) and a direct-flame afterburner (right).

One type relies on the ignition of the gases with a sparkplug or pilot-burner; the second type passes the gases through a catalyst bed which burns the gases at a lower temperature than is possible with the direct-flame burners. Additional equipment in these mufflers is a compressor for air supply and a temperature-actuated bypass to prevent overheating of the device.

A device which replaces the conventional muffler has to fulfill a number of conditions, such as long life and high efficiency of combustion. It should not adversely affect the operation of the engine by creating excessive back pressure, and it should not be a fire hazard. In addition, it should function as an ordinary muffler in eliminating noise. It is difficult to find a suitable place for an afterburner under the car or hood. This may be possible in new cars; for older ones the installation may be a costly engineering job, which adds to the estimated \$50-\$70 cost of the device. In the many cars with dual exhaust the price has to be doubled.

A partial answer to the price and space problem may be found in accepting less efficient combustion devices. Extensive investigations by automotive engineers have shown that reduction of unburned hydrocarbons and carbon monoxide can be obtained by modification of carburation — for example, by limiting the flow of gasoline during deceleration and by changing spark timing. Also, proper maintenance can reduce exhaust emissions, as has been shown in several motor laboratories. This reduction is on the order of 25 percent but may be as high as 50 percent, depending on the condition of the car.

Control of oxides of nitrogen

At present no control of oxides of nitrogen is contemplated. Several proposals have been made, such as water injection or return of a certain fraction of exhaust air in the intake manifold. Both methods actually work; they rely on a lowering of the flame temperature and consequent reduction in formation of the oxides of nitrogen. A promising approach was recently published whereby the exhaust air is admitted only during acceleration and cruising, when the emission of oxides of nitrogen is highest. Other methods involve enriching the combustion mixture; the excess fuel has then to be burned in an afterburner. There is the possibility that the newer type engines, which initially ignite a rich fuel mixture and subsequently supply the required air, will give a considerable reduction in the formation of the oxides of nitrogen. This is essentially a two-step combustion system, which has been developed and installed on a large scale in the Southern California Edison power plants, yielding close to a 50 percent reduction in the emission of oxides of nitrogen.

The crankcase vent is the second largest point of emission — 30 percent of the total. All new cars will be equipped with devices which rely on a closed system in which the gases are led to the air cleaner or to the inlet manifold and are burned together with the normal supply of fuel. Installation is simple and inexpensive (about \$5, factory installed). A valve preventing backflow and explosion is the only part which needs inspection or replacement and its cost is readily offset by a slight increase in mileage per gallon.

If the installation cost for used cars can be held within reason and if it is established that there is no extra wear on the engine from the introduction of blowby gases, then there is hope that this type of emission can be eliminated within a few years.

Proposals have been made for control of carburetor and tank losses through drainage of gasoline from the carburetor bowl to a heat-insulated tank. Progress in the control of these losses may have to wait until more accurate knowledge is available on their magnitude at temperatures and driving conditions prevailing in Los Angeles. Preliminary data indicate that on hot days these losses may amount to as much as 100 tons per hour. The release of material such as this may be significant as a contribution to the morning traffic exhaust.

What is being done

Air pollution control is always a balance between a desire to get the cleanest air possible and the price we are willing to pay to reach this goal. Theoretically, any amount of control is possible; in practice this complete control would be prohibitive because the engineering cost rises steeply with higher efficiency. This is true for the control of industry as well as of motor vehicles.

In modern concepts of air pollution control the first consideration is the establishment of acceptable levels of pollution for a community. Attempts can then be made to come as close to these levels as engineering methods and economic factors allow. The adoption of community standards for air quality by the California State Department of Public Health should be hailed as an event of great significance in giving a sound basis for an effective air pollution control program. The Health Department has developed a set of standards for most pollutants indicating adverse, serious, and emergency levels.

The adverse level is one at which eye irritation and plant damage begin to occur and is therefore of great importance to the control effort. An important gauge for Los Angeles smog conditions is the formation of oxidants, consisting largely of ozone produced in the photochemical smog reaction. Oxidants correlate well with symptoms of smog, and many years of observation have established a level of 0.15 parts per million of oxidant above which eye irritation will be noticed by a significant percentage of the population. The level of 0.15 ppm of oxidant was therefore chosen as an "adverse" level and as a basis for control of photochemical smog. It was stipulated that this level should not be reached on more than one percent of the days per year. In order to accomplish this goal for 1970 an 80 percent reduction of hydrocarbon emission would be necessary. In a similar manner the carbon monoxide reduction needed to bring its level down to the state standards has been calculated to require a 60 percent control.

Motor vehicle control

In July 1960 a state law was enacted which calls for such reduction in hydrocarbon and carbon monoxide emission from motor vehicles, and a Motor Vehicle Pollution Control Board was appointed and charged with the responsibility of testing and certifying emission control devices. Certification of a device requires its operation within the standards calculated by the State Department of Public Health. After certification of at least two devices, a schedule of application of the devices to new and old cars, busses, and trucks was made up with the intention of covering all cars in a period of three years.

A misconception has gradually developed that all we have to do now is to wait for the installations of exhaust control devices and the smog will disappear as scheduled. This is unfortunately not the case. At present there are no exhaust mufflers which will give an 80 percent reduction based on presently available emission data. The application of such devices to a car population would lead to an overall efficiency far short of expectation. Other difficulties arise from the limited life of most devices, which make periodic replacement and inspection necessary. Most experts in the field regard an effective inspection system on the performance of devices as practically impossible. In addition, installation costs on the many makes and models of old cars would be prohibitive.

The smog control calculations are based on the assumption that precursors responsible for various air pollution manifestations are simultaneously reduced by equal percentages. This does not hold true for at least one important participant in the photochemical reactions, the oxides of nitrogen. Their emission is increasing at a rate of 6 to 7 percent per year. These sources are generally of industrial nature and are already partially controlled. In most cases there is no practically feasible engineering method available for significant further control.

Considering these limitations, it is clear that control of emissions of our car population is a long way off if we insist on an 80 percent efficiency. It is therefore expedient to look for somewhat less efficient, less expensive, but more feasible approaches. With the present engineering knowledge in the development of control devices, it should be possible to make rapid progress in a partial control of both new and old cars.

The present motor vehicle pollution control law was a pioneering effort and it was expected that changes in the law would have to be made to cope with the experience gained in its practical application. Changes which should be considered are a revision of standards, which are presently based on concentrations, rather than weight of emission per mile in a prescribed driving cycle. The use of concentration as a standard has distorted the control effort and has diverted attention from the fact that busses, trucks, and large cars contribute far more pollution than economy cars, even though their exhaust concentration may be the same. By considering the weight of emission as criterium, the small car could be readily brought under control with relatively inexpensive means.

As a result of the rigidity of the law, the Motor Vehicle Board has had little opportunity to consider and to take advantage of the opportunities offered by the diversity of use and ownership of motor vehicles, or the uneven distribution of traffic in the basin, and the possibilities of simultaneous control of hydrocarbons and oxides of nitrogen. In a rapidly developing and new field, those responsible for control need a freedom of action to seek and apply the best available method which is the least burden on the community. The control of the car population will cost hundreds of millions of dollars, and the least we can do is to make a thorough analysis of all aspects of smog control to arrive at the best solution of this complicated problem.

Making up the deficiency in control

In accepting a more practical but less efficient control of the car, we have to make up the deficiency in control in some other way. A thorough search should be made on possible further control of stationary sources, and serious consideration should be given to the control of oxides of nitrogen. It is obvious that further gains can be made by use of public transportation, economy cars, better flow of traffic, and electric transportation, to name only a few of the many possibilities which reduce the amount of gasoline used. The control which the community can accomplish is unfortunately beset with many difficulties and it is therefore useful to elaborate on some of the advantages of control by means other than engineering control on the motor vehicle itself.

An inspection of the continuous readings of carbon monoxide concentrations at the downtown monitoring station clearly reveals a peak caused by morning traffic. A calculation shows that the carbon monoxide increase corresponds to about 200 tons, representing the emission of about 100,000 cars. This figure agrees quite well with actual counts of the early morning traffic into Los Angeles. The commuter cloud, containing not only carbon monoxide, but also hydrocarbons and oxides of nitrogen, moves slowly towards Pasadena and Burbank. Under the influence of sunlight, eye-irritating haze and ozone are formed and recordings at different stations reveal a slow movement of the cloud through the San Gabriel and San Fernando Valleys. By evening, the cloud, which is now considerably spread out, is carried by the east wind back to Los Angeles and it then stagnates, most frequently, west and southwest of the city.

In the meantime, the afternoon and evening traffic creates a new cloud of pollutants, but this time there is not enough sunlight to convert hydrocarbons and oxides of nitrogen to the typical daytime smog. This cloud moves slowly, first to the east a few miles and is then blown back west. This cloud, too, stagnates west and southwest of Los Angeles. As time passes and the cloud moves back and forth through the basin, it expands and covers a large area. The nature of the pollutants will be substantially the same as when they were released the previous evening and this cloud is ready for photochemical smog formation in the morning when the sun begins to shine.

One would not expect sharp peaks in pollutant concentration from this expanded, day-old cloud but rather a long-lasting background of carbon monoxide, oxides of nitrtogen, and oxidant. In the morning the expanded morning and evening clouds of the previous day move back to Los Angeles, joining with the new traffic cloud on its way to Pasadena and Burbank.

It is this combination of young and old traffic clouds with the extended one from traffic in the rest of the basin, and the older attenuated clouds from previous days, which form the base on which the morning traffic commuter peak rises. On its path through the basin, traffic continues to supply smog ingredients, hydrocarbons, and oxides of nitrogen. Further amounts of oxides of nitrogen are injected into these streams by power plants located at the entrances to the valleys.

The morning commuter cloud raises the average carbon monoxide level in Pasadena from a background of 10 to 15 ppm, a 30 percent increase. Oxides of nitrogen increase by about 15 percent, indicating the contribution from sources other than motor vehicles. By reducing the commuter peak through a public transport system a considerable improvement could be obtained in lowering the peak pollution values. Consequently, less efficient control on motor vehicles would be required for staying below the state health standards.

Temporary control

Clearly, the proposed 80 percent control methods for motor vehicle emissions are still a long way off. We should therefore consider a temporary control at lower levels of efficiency. It would then be possible to obtain significant reduction with less expensive devices which could also cover the old car population. These methods may consist in the use of afterburners which can readily replace the present muffler, or they may involve changes or alterations in engines and combinations of engine and carburetor adjustments leading to improved combustion. Serious consideration should be given to the prevention of hydrocarbon losses from carburetors and tanks.

Surveys conducted in several large cities have shown that a substantial percentage of commuters would switch to public transportation when it is good. The emphasis is on *good;* that is — frequent, rapid, extensive service, especially in the sprawling cities of the Los Angeles basin. There must be some radical changes in our ways of thinking about how this transportation should be organized and financed. We must get away from the idea that this is a direct profit-making business, and accept it as a public service paid in part by taxation.

A better flow of traffic in cities and on our freeway system contributes to air pollution control by eliminating the frequent idling, acceleration, and deceleration typical of stop-and-go traffic.

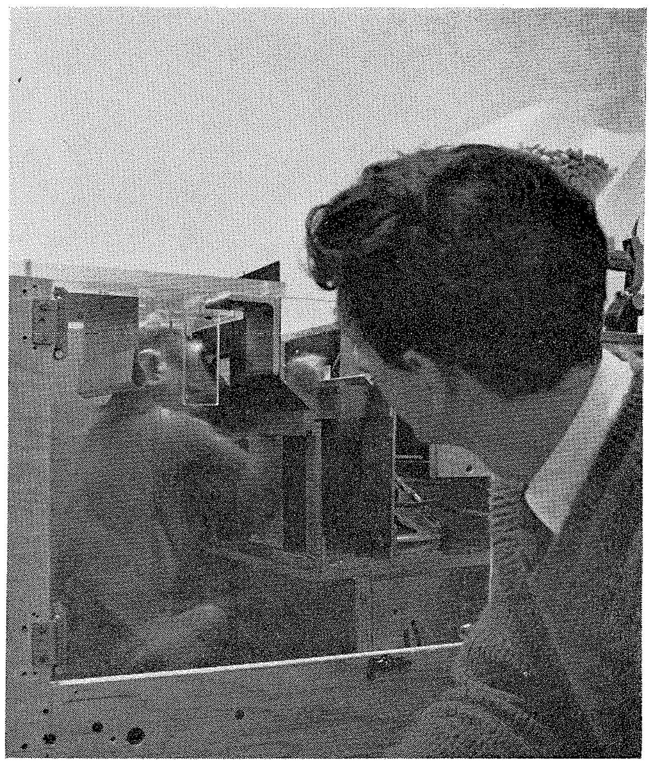
It should be clear to anyone that a car running 30 miles to the gallon produces less pollution than one which gets only 15. The concentration may be the same in both cases, but the exhaust volume — and therefore the total weight and emission — is considerably less than that of a bigger car. Perhaps some public-spirited individuals may consider this an additional reason for buying a small car, especially for town driving.

Proper maintenance of cars

In the same category of voluntary contributions is proper maintenance of cars. A survey has shown that 40 to 50 percent improvement in exhaust emission can be accomplished. It does not seem unreasonable to ask the individual motor vehicle owner to give his equipment the same care that industry is forced to give by law. The enforcement of such an approach may well be impractical; nevertheless, those who complain of smog would at least have their cars in proper shape. Since about 80 percent of the people don't like smog, this should make a considerable reduction.

It has become quite clear that controlling smog in Los Angeles is not just a matter of attaching a gadget to our cars. The problem is directly connected with the growth of our cities, and planning is necessary for an orderly expansion. Air pollution plays a vital part in this expansion, and a really effective control program must include efforts by the local community in addition to the engineering control of industry and motor vehicles.

The time has come for a critical appraisal of the smog situation and the development of a plan of action that takes into consideration technical, social, and economic factors. Such a plan, when actively supported by all levels of government, and backed by the community, can lead to clean air in Los Angeles.



Monkey at work in a training apparatus, under the supervision of Dr. Trevarthen, in Caltech's psychobiology laboratories.

Exploring the Neural Mechanisms of Mind

Psychobiologists look for answers to some of the intriguing questions raised by our present knowledge of the brain

by Colwyn Trevarthen

Medical knowledge of the brain depends upon careful study of the effects of injury or disease on human behavior. Centuries of observation have given us insight into the way different parts of the brain have specific functions. Now it is possible to relate certain intellectual functions with specific areas of the cerebral cortex. Visual, auditory, and touch perception; control of skillful movement; and the ability to understand language or communicate with words may all be located in particular parts of the cortex. Deeper parts in the brain stem seem to be more concerned with the passage of information to and from the cerebral cortex, or with the regulation of attention, posture, and the essential bodily functions.

In the last few decades, however, much that is dramatically new has come to us by way of experimental work where the brain functions are observed or altered precisely and directly. These experiments are rarely made with human subjects, though some startling observations have been made during brain surgery. Neurosurgeons, seeking to remove diseased or damaged parts of the brain, have exposed the active brain while the patient is fully conscious. The brain substance has no feeling of pain so the surgeon can carefully stimulate selected points electrically and ask the patient about the effects. Crude sensations can be produced. Fragmentary memories may appear, or the patient may observe that he is making unintended movements of parts of his body.

These, and much more extensive experiments upon animal subjects, have taught us in recent years that the brain has a pattern of coordination which does not quite fit the classical view. The cerebral cortex is a vastly important element of the working brain, but it collaborates at all times with the brain stem.

Lower parts of the brain have been found to regulate the activity in the cerebral hemispheres and to control the level of consciousness or wakefulness. It has been discovered that the flow of sensory excitations from sense organs into the brain can be modulated, and turned up or down in volume so that the brain can attend to messages of importance. Hearing can be sharpened for a moment, or visual attention can be focused on the fine detail.

An impressive expansion of brain research at the present time is directly attributable to these and other discoveries, and to the invention of powerful new techniques. The many intriguing questions raised by the knowledge we now possess must be answered by further careful experimentation. Now it is more necessary than ever to supplement our medical knowledge of human brain functions by carrying out careful studies of the behavior and brain-physiology of animals.

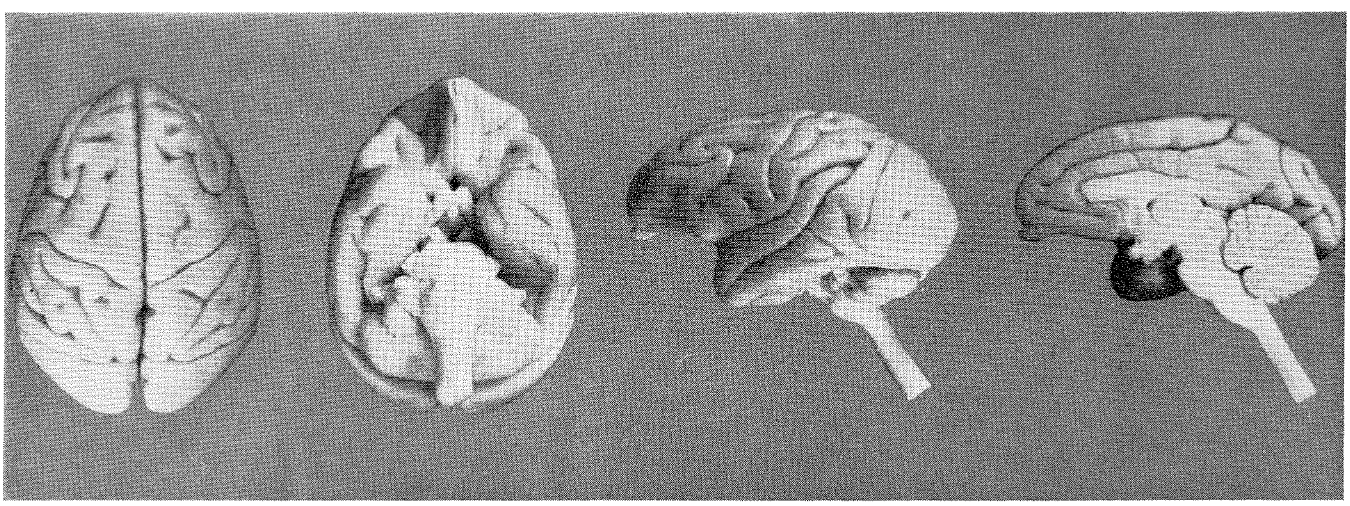
It is quite possible to study intelligence without considering the brain. In fact, it is only in the last two or three hundred years that the brain has been known to be an organ of intelligence. Now scientific knowledge has left us with no alternative but to seek out the mechanism of mind in the brain, and particularly since the methods of investigation are now so wonderfully improved, we may reasonably expect some very significant discoveries to come from a diligent exploration of the workings of the brain.

At Caltech we who call ourselves psychobiologists have been concerned with one particular kind of experimental alteration of the brain. This technique was developed by Dr. Roger Sperry, Hixon professor of psychobiology, and his students about seven years ago. I have been working with him these past five years. In our experiments we do not so much cut out parts of the brain as cut communication cables, and in this way separate selected parts. We modify the brain mechanism by dividing it into parts so that the parts can be studied separately, or at least more separately than was possible before.

Along with the evolution of intelligence in mammals there has been a dramatic relative increase in the topmost part of the brain called the cerebrum, so that one might well expect the cerebrum to be the seat of intelligence – the logical place to begin a search. Furthermore, the brain, like the body as a whole, is bilaterally symmetrical, with most of its centers represented twice – once on each side. At the largest development of all, in man, the cerebrum is a spherical mass filling the domed skull and the two mirror halves are called cerebral hemispheres. The brain of a monkey is very similar to that of man in general appearance, with two large cerebral hemispheres dwarfing the other parts.

Our surgery is called split-brain surgery. Under conditions of an aseptic technique such as is used in hospitals for human brain operations, and with even finer instruments, we carefully cut bundles of nerve fibers which form bridges between the cerebral hemispheres. We work under a binocular microscope and carefully avoid breaking blood vessels or bruising the delicate brain tissue.

After the anesthetic has worn off, the cat or monkey with the split brain wakes up with all direct connections between centers in the cerebral hemispheres cut through. He may feel a little strange, but there is little evidence of this, and the feeling soon wears off along with the weakness due to the anesthetic and the general surgical shock which accompanies any major operation. It is astonishing to see a monkey acting perfectly normal, seeing well, eating well, moving with perfect coordination, and even exhibiting all his old idiosyncracies just one or two days after the major connective fibers between right and left halves of his brain have been cut.



A monkey brain as it looks from above, from below, and from the side. At the right, a half-brain, showing the brain stem sliced through in mid-plane. In split-brain surgery the stem is largely undivided.

The purpose of this surgery is quite simple, really. We want to study the function of the cerebral hemispheres separately and to examine the relationship they have to the brain stem, the generally more primitive part, which remains largely undivided by the surgery. We want to test, for instance, more classical theories of brain function which say that intelligence works in the various parts of the cerebral cortex which have been located by surgical or electrical methods; that skillful voluntary movements are directed by "thought" in the motor area; and that higher functions of reasoning are taking place in the frontal lobes. We already have some new information which gives us opinions on these matters, and yet there are other facts which puzzle us and increase our curiosity in new ways.

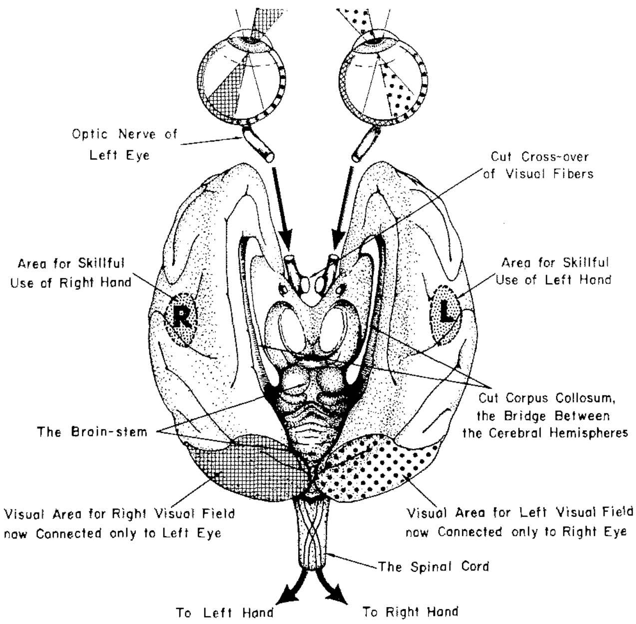
In order to test the hemispheres separately we need to have separate access to them through sensory pathways. Luckily, there are anatomical patterns which help us to separate the flow of visual information into the brain. In the case of vision there is a wonderfully orderly projection (like the projection of a slide onto a screen) of the retinal locations into the brain, and finally into the cerebral cortex. Half the retina of each eye projects to one hemisphere and half to the other. There is a crossing over of optic nerve fibers under the brain (the optic chiasm) which takes fibers from the left half of the right eye across to the left hemisphere, and vice versa.

We can cut this crossover of fibers in the midline and then each eye sends fibers from the outer halves of the retinas to the hemisphere of the same side only. The animal after this operation has a narrower visual field because he loses the parts of each retina which receive light from the sides of his view. He also loses the ability to make stereoscopic depth detection. But he learns quickly to overcome these difficulties and the operated cats or monkeys certainly see very well with both eyes. When the chiasm is sectioned, each eye has a private line to one cerebral hemisphere.

First experiments

The first experiments with split-brain cats showed that the two hemispheres could work independently in seeing, learning, and remembering tasks. When one hemisphere was given a visual task through one eye and it had learned to solve the task without errors, the other hemisphere acted with the other eye as if completely independent and ignorant, and had to start from scratch. If a special part of the main connecting bridge between the cerebral hemispheres (the corpus callosum) was left intact, the learning spread across from one hemisphere to the other and a new memory was imprinted on the other side.

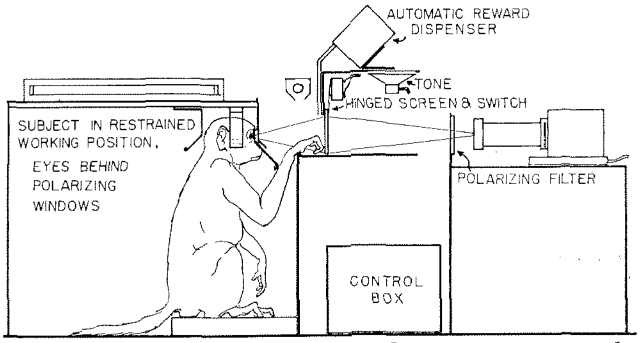
We wondered if these experiments were really final. Perhaps, because the tests were given sequentially, one eye and hemisphere – say the left – would be tuned in and attentive because of receiving the stimuli. It is possible that the right hemisphere could have been deliberately turned off because there was a mask over the right eye. Closely repeated tests seemed to indicate that the two half-brains were separate and independent. It was further shown that contradictory tasks could be learned without confusion. For example, one eye of a cat was taught to pick the pattern II and to avoid = . Then the other eye was taught to pick horizontal lines and to neglect vertical lines. These experiments were done by Dr. Donald Myers, working with Dr. Sperry.



A split brain, showing the separated cerebral hemispheres with their centers for vision and for control of skilled hand movements. After the optic crossover is cut, visual impulses from the inner halves of the retinas of both eyes cannot get to the brain.

If the half-brains are really independent, they should be able to work side by side without interference, each thinking its own thoughts. In order to test this intriguing possibility of double simultaneous intelligence, double visual perception, understanding, and remembering, we had to find a way of sending visual stimuli separately to the two eyes while the monkey subject was looking at, and responding to, an experimental test situation. We were at a loss to know how to do it until a geologist friend suggested that we use plane-polarized light.

A beam of light may be considered as composed of waves vibrating in all directions perpendicular to the direction of propagation of the light. A plane-polarizer inserted into the light beam absorbs selectively all waves vibrating in one plane, the plane of its absorption axis, and transmits light vibrating in a direction at 90 degrees to this in the transmission axis. Vibrations at angles between these two directions are absorbed in proportion to their orientation with respect to the absorption axis of the polarizer.



Apparatus used for controlling the use of eyes in the guiding of hand movements.

If the polarized beam now passes through a second polarizer whose transmission axis is parallel to the predominant direction of vibration of the beam, little further absorption results. If, however, the second polarizer is rotated to a "crossed" position with its axes at right angles to the axes of the first polarizer, it is almost completely absorbed. For us, the useful point is that polarizing filters (of the linear type) transmit light polarized in one direction best and fail to transmit light polarized in the direction at right angles to this.

One subject is trained to look through polarizing filters in a pair of spectacle-like openings at a screen on which polarized patterns are projected. When he is in position to work, the polarizing filters in front of his eyes are oriented so that they will transmit light polarized in two directions at right angles. Thus, light which the left eye-filter transmits best is not transmitted at all by the right filter, and vice versa. It is easy to see that two patterns of polarized light can be projected onto the screens so that one pattern is seen only by the left eye, and the other pattern is seen only by the right eye.

In order to test the independence of the cerebral hemispheres in the most rigorous manner, we decided to use opposite tasks for the two eyes. In each trial, one of the two screens was correct and a push on it would be rewarded by delivery of a peanut. The other screen would be incorrect and the monkey would go unrewarded. In one trial, for instance, the left screen might be the correct one.

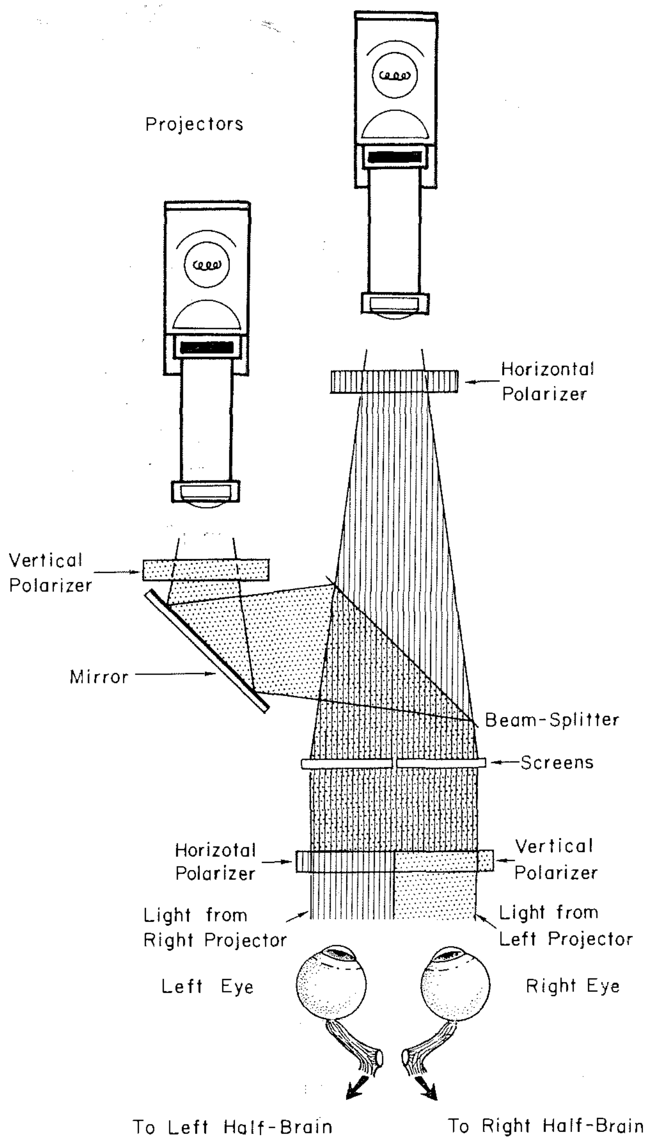
Let us say that in this trial the left eye sees **+** on the left screen and **O** on the right. At the same time we may project opposite patterns to the right eye — **O** on the left and **+** on the right. Over a series of trials in which the stimuli are changing in a *random* schedule as the reward is shifted from side to side, the left eye always finds the **+** correct and the right always finds the **O** correct. Could a split-brain monkey learn these two tasks in his brain at one time?

The answer is a qualified yes — and the qualifications are most interesting.

There have been a few cases in which the two half-brains seem to have learned side by side, simultaneously. As soon as the subject showed that he knew what to do by making correct choices a significant number of times, we found that both cerebral hemispheres knew their respective tasks.

This learning was well retained. There could be no doubt that both half-brains had learned. We had obtained dramatic indication that the two cerebral hemispheres were functioning separately in the perception and memorizing of the visual tasks. However, we could still not be sure that both halves could work at exactly the same time. We have reason to believe that they might be taking turns, quite quickly, and thus attaining the same average amount of learning.

We hope to know the answer very soon. So far we have proof that the two halves can both be ready to work at a moment's notice. But this is not the same as actually being *in* action simultaneously. The interesting point here is the possibility of a double awareness — two consciousnesses in one head. But



Technique used for projecting overlapping polarized light patterns. Each eye receives a different pattern.

there is a considerable amount of work to be done before we can say what the awareness of a split-brain monkey is really like.

While we were working along these lines, several serious complications arose which diverted our attention to the functions of the unsplit parts of the brain — the parts outside the cerebral hemispheres. There are two kinds of influence which throw the double learning off balance. One is due to the actual transfer or leakage of visual information through regions below the split. The other results from the need to read brain functions only through the response movements of the subject.

In the beginning of this work, about four years ago, we were fairly confident that the two halves of the visual system were separated completely by the split-brain surgery. Then there came definite proof of communication between the two halves of the brain. When split-brain monkeys were presented with a simple brightness discrimination task and its contradiction, the following events were observed:

First, with the two problems presented simultaneously, there was nothing particularly unusual about the learning. But then the monocular tests revealed that only one half knew its task securely; the other half behaved at first as if quite unsure, then suddenly it made a run of completely wrong choices.

Transfer of learning

This could mean only one thing; the learning by one side was being used by the other side, too. During the binocular training, the animal's second side had been inactive and when it was forced into use alone it was able to refer to the only memory in the brain — that of the other side. The wrong choices were not rewarded, and soon the misled half-brain made the necessary reversal of preference. At this stage the brain appeared to have retained the two opposite memories separately. The leakage between the halves had been prevented.

A similar but weaker transfer of learning was observed in the case of a simple discrimination between two colors. At about the same time, two workers at the University of Pennsylvania Medical School showed that split-brain cats could transfer a simple brightness discrimination task (but not a more difficult one, in which the brightness difference was reduced). We are certain now that either brightness differences are perceived and learned in low-level, unsplit parts of the brain, or else the split parts have lines of communication connecting them—loops which pass downwards and across at unsplit levels.

For some time there has been evidence from several studies that brightness discriminations may be made by parts of the brain outside the visual cortex of the cerebrum. In the lower vertebrates, fish for instance, the relatively small cerebrum is not necessary for visual learning. But the indications were that, at least in the more highly evolved mammalian brains, patterns involving more complex brain processes for their recognition were seen only in the cortex. However, we observed that when contradictory tasks were presented simultaneously to the two eyes, some kinds of pattern learning were *not* independent. The two half-brains were somehow still entangling at certain stages of the process of learning. There even seemed to be a hint of gradation from one kind of task to another, as though certain tasks were wholly cerebral, while others were partially dependent upon unsplit, brain-stem processes.

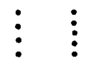
Attacking the question more directly

Lately we have been attacking this question more directly. The experimental method we use is related to the one for presenting two contradictory tasks, but there is one essential difference. Before, we were trying to detect the ability of the two halves to keep contradictory learning processes apart. We were forcing them not to work together. Now we are trying to make the two halves of the split brain join in the solution of one task.

In each trial of these experiments a different pattern is projected to each eye. A correct choice is certain only if the two visual processes are used in conjunction with one another. In one experiment we show two circles, one larger than the other. To be certain of choosing correctly, the monkey must compare the circle seen by one eye with the circle seen by the other, notice the size difference, and pick the larger. We have definite proof now that split-brain monkeys can do this task. In fact, they learn to be almost perfect and to make their choice quickly and confidently. One case has already learned to do all the following comparisons:

Pick the larger of two circles.

Pick the more tilted of two equal area black parallelograms.



Pick the one of two vertical rows of black dots with the smallest number of dots.

Pick the "screw head"-shaped figure which is rotated so that the crosssbar is more vertical.

In each of these sample pairs the pattern on the left is the correct one.

There is another experiment in which one eye sees a sample to which one of two stimuli presented to the other eye must be matched. One eye is told what to choose, the other does the choosing. Color tasks have been successful, and soon we may have data proving that patterns can be compared this way too.

continued on page 22

The second of the two kinds of complications standing in the way of balanced double learning in the split-brain is due to the fact that we have to detect the activity of the brain through the response movements of the subject. If, and only if, the two halves of the split-brain are equally in communication with the mechanisms which control the responses, then can we ask direct questions about the functions of the two halves. In an extreme case, if one half-brain had no connections to the response mechanism, how would we know what was occurring in it?

The first experiments

In the first split-brain experiments cats were used. They were required to respond by pushing a chosen door open with their noses. This response uses symmetrical muscle systems. We have every reason to believe that both halves of the brain would be used equally to control it. Later, cats were required to push aside labelled blocks or to push pedals with one or the other forepaw. The experiments failed to show any preferential linking of either paw with the learning processes of either half-brain, except when the discrimination was based upon the feel of the pedals instead of their appearance.

At first, the experiments with split-brain monkeys seemed to lead to the same conclusion. Monkeys were able to use either hand to perform tasks under visual direction by way of either eye. But then we noted that there was a tendency for the eye and hand of *opposite* sides of the body to be the best combination. I found in the double-learning experiments that whenever only one half-brain had learned, it was the one opposite to the hand which had been chosen by the subject for work. If the monkey chose to be left-handed, as many have done, then it would be the right half-brain which learned while the left half-brain remained naive.

I also noticed that when I forced the sleeping or inattentive half to work, by covering the other eye, there followed a clumsy period lasting several minutes, or even a day or two of training. Then the opposite hand was slowly brought into use. Finally, and usually before 100 trials had been presented, the new cross-combination was working smoothly and the learning of the aroused half-brain began. When there was transfer of learning, it coincided with continued use of the ipsilateral hand.

As an example, suppose that a monkey had been given contradictory stimuli to the two eyes simultaneously, and that he had learned by consistently working with the left hand. When I tested the eyes separately, I found that it was the right eye which knew its task. The left half-brain, when forced to work alone, could not direct movements at first, and they were random. The left hand continued to make the response, and soon negative choices, indicating transfer of learning, were being made. Then, at the same time as correct choices replaced the wrong ones, the right hand became active. The change to the second crossed combination of left eye with right hand seemed to be the signal for correct choices – for learning in the left half-brain.

The crossed combination in half-brain and hand is at first confusing. But neuroanatomists have long known that the so-called motor area of the left hemisphere sends fibers down to the brain stem, where they cross over to the other side of the body en route to the right hand.

Now we have plenty of evidence of the bias towards contralateral coupling. It has caused us to give up hope of obtaining freely balanced double learning unless we do something to control the bias to one side which a naturally-developed or inborn tendency to use one limb imposes. It is like trying to weigh on a balance with a varying force pulling down one side.

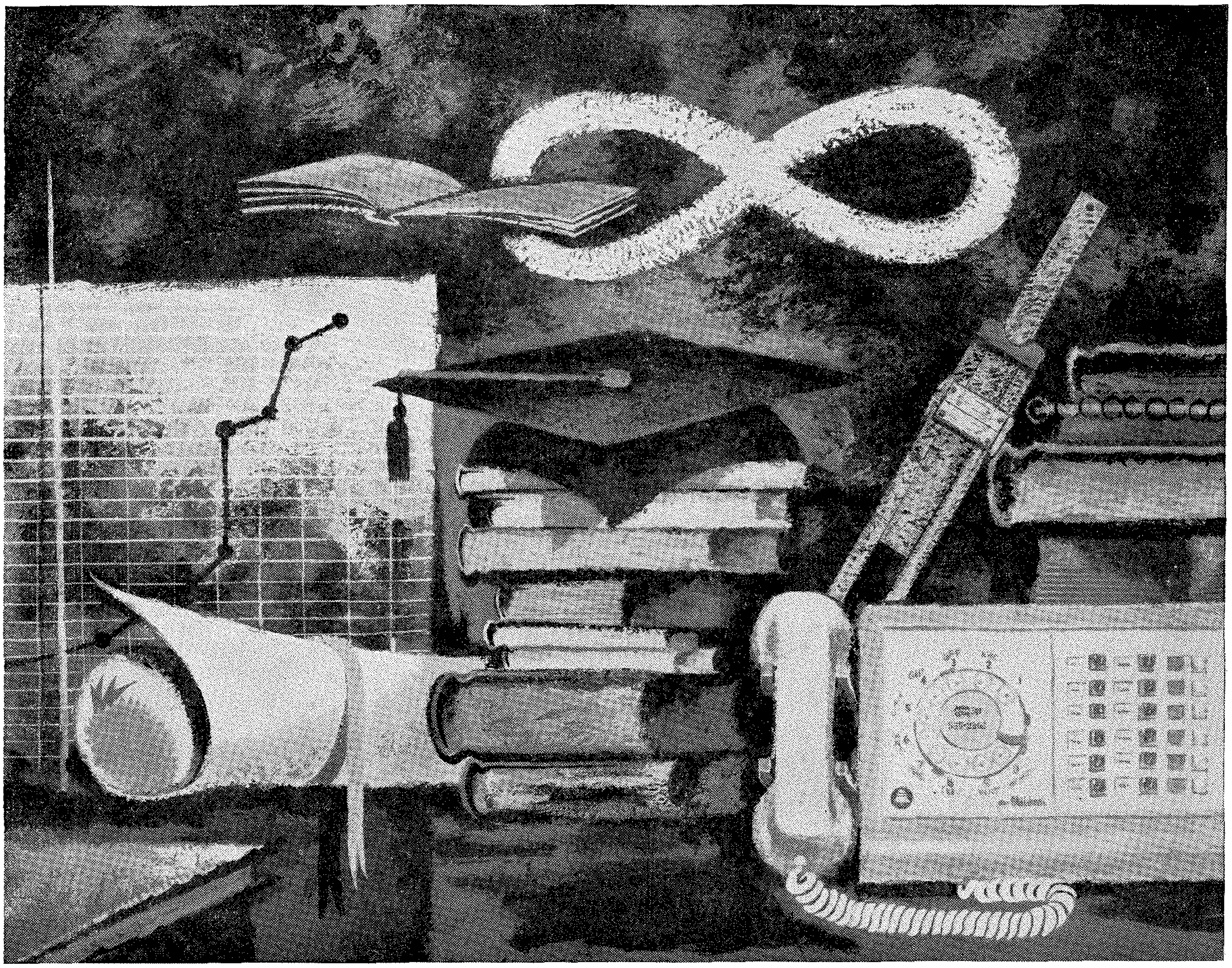
Fresh insight

But the complication, as is often the case, has given us some fresh insight into the problems of organization of the processes of intelligence.

With the right half-brain, a monkey may control swift and sure movements of his left hand. With right eye and left hand he seems as good as any monkey. But with the right hand he is much less skillful as long as his right eye is being used alone; that is, presumably, as long as his right half-brain is the one which is most active. Sometimes, perhaps mostly in older monkeys, the right brain-right hand combination is at first almost useless. The hand moves stiffly and seems almost to act blindly. But it is generally not nearly so bad as this. The hand is just vague and wooden. It is forgetful and makes blunders. Occasionally, it will go into a long blank period of quite unintelligent automatic responding. The monkey behaves as if he is a bit puzzled by the incompetence of the hand, but not very distressed. With the other half-brain, the left, the effect is reversed. Now the right hand is the most skillful.

When normally active in his cage or free in the laboratory, a split-brain monkey seems to be able to use both hands normally and he can coordinate them in complicated manipulation with great ease and smoothness. Furthermore, after practice in the experimental box, the superiority of crossed brain-hand combinations becomes less clear. The weaker combinations become quite quickly well-coordinated. A practiced monkey can work very well with any eye-

continued on page 24



Learning never stops for engineers at Western Electric

There's no place at Western Electric for engineers who feel that college diplomas signify the end of their education. However, if a man can meet our quality standards and feels that he is really just beginning to learn . . . and if he is ready to launch his career where learning is an important part of the job and where graduate-level training on and off the job is encouraged — we want and need him.

At Western Electric, in addition to the normal learning-while-doing, engineers are encouraged to move ahead in their fields by several types of educational programs. Western maintains its own full-time graduate engineering training program, seven formal management courses, and a tuition refund plan for out-of-hours college study.

This learning atmosphere is just one reason why a career at Western Electric is so stimulating. Of equal importance, however, is the nature of the work we do. Our new engineers are taking part in projects that implement the whole art of modern telephony from high-speed sound transmission and solar cells, to electronic telephone offices and computer-controlled production techniques.

Should you join us now, you will be coming to Western Electric at one of the best times in the company's history. In the management area alone, several thousand supervisory jobs are expected to open up to W.E. people within the next 10 years. And our work of building communications equipment and systems becomes increasingly challenging and important as the communications needs of our nation and the world continue to increase.

Challenging opportunities exist now at Western Electric for electrical, mechanical, industrial, and chemical engineers, as well as physical science, liberal arts, and business majors. All qualified applicants will receive careful consideration for employment without regard to race, creed, color or national origin. For more information about Western Electric, write College Relations, Western Electric Company, Room 6205, 222 Broadway, New York 38, New York. And be sure to arrange for a Western Electric interview when our college representatives visit your campus.

Western Electric

MANUFACTURING AND SUPPLY — BELL SYSTEM — UNIT OF THE BELL SYSTEM

Principal manufacturing locations at Chicago, Ill.; Kearny, N. J.; Baltimore, Md.; Indianapolis, Ind.; Allentown and Laureldale, Pa.; Winston-Salem, N. C.; Buffalo, N. Y.; North Andover, Mass.; Omaha, Neb.; Kansas City, Mo.; Columbus, Ohio; Oklahoma City, Okla. Engineering Research Center, Princeton, N. J. Teletype Corporation, Skokie, Ill., and Little Rock, Ark. Also Western Electric distribution centers in 33 cities and installation headquarters in 16 cities. General headquarters: 195 Broadway, New York 7, N. Y.

hand combination when he is forced to switch attention from one eye to the other rapidly during the testing. These facts have taught us to regard the split-brain monkey as a well-cordinated individual, and we have been impressed with the smooth integration of movement which is possible. Taken alone, this is evidence that skillful responses are controlled by a large, diffusely organized mechanism, much of which remains intact after the surgery.

However, even with highly practiced monkeys we have occasionally seen some strange things. Once, in the course of the experiment in which a split-brain subject is required to compare the sizes of circles seen separately by the two eyes, the two hands of an old pro came up together in a praying position, to push the screens. But this did not occur very many times. Eventually, only one hand was carrying out instructions based upon information sent to both halves of the brain. We might have expected uncoordinated effects like this to be more common after split-brain surgery. But they are merely instructive exceptions to the rule.

A number of questions

There are many questions to find answers for. We want to know in which particular brain centers a hand is readied for a response. Practiced monkeys reach out and push even when the apparatus fails and no stimuli are projected. The stimuli are expected, and the hand goes out automatically, thinking it will get the necessary visual cue at the last moment. We also need to know how an already moving hand is guided to the left or right by visual perception of the cues. Does the hand ask what the eyes have seen, or does the visual process give a push to the movement control centers and so cause a definite shape of response? We do not know. We do know this: When visual attention is restricted to the side of the brain which is on the same side of the body as the preferred hand, this hand becomes clumsy. After a few poor attempts, the other hand seems to wake up and to join in. Eventually the now more skillful partner steals all the trials and the weakened hand stops gesturing and is quiet.

We think that when the split-brain monkey is ready to respond with a particular hand, his brain is set to receive guiding sensations in certain of its parts through specific nervous pathways. For example, when in the habit of working with the left hand, the monkey is more expectant with the right eye and better able to receive visual impressions through it. We have seen (as in the drawing of the split brain on page 17) how the preference for the crossed combinations of eye and hand is definitely related to the way in which the centers for vision and skilled movement are located in the cerebral cortex.

If the right eye is now covered and cannot be used for guiding the responses, we observe that the left-hand movements become weakened. We suppose that this is because the brain has a built-in mechanism for suppressing or inhibiting action patterns which do not receive expected support. Then the other hand gradually assumes the task of responding.

Shift in activity

The shift from one hand to the other is probably caused by a change of the balance of activity within the nervous system which follows automatically from the inhibition of movements of the first hand. Now, with the right eye covered, the visual expectations of our left-handed monkey may be fulfilled if he pays attention more to the left eye. If we could visualize the patterns of impulses in the central nervous system we would probably detect a shift in the activity from the right cerebral hemisphere to the left as the movements of the hands and the direction of visual attention change.

With further study we have found that split-brain monkeys can be trained to attend to one eye even when the hand on the same side of the body is the only one which is allowed to be active. It is as if the brain can develop the art of expecting in two hemispheres rather than one.

The important point of our data at this early stage is that the patterns of nervous activity in the brain of a practiced monkey may be shifted in all the possible ways for the functioning of all possible eye-hand combinations. This integration of movements with sensation occurs in spite of the reduction in communication between brain halves which our surgery imposes. This must mean that the mechanisms for controlling voluntary movement of the hands, together with the mechanisms for directing attention to specific kinds of sensory cues, are still in communication within the split brain.

Intelligence is composed of things which have been the province of philosophers until very recently — the will, consciousness, the building of concepts and judgments in the mind, and the relationship between reality and what we personally experience to be true.

In an experiment, we choose to simplify these mysteries and pay attention only to the movements of the hand of a monkey under the guidance of his eye. Then we are quickly faced with problems which we cannot readily solve. In a small way we have been attempting to identify mind with brain. I think there is no doubt that the attempt is very successful because it brings quickly to light many new things. But as for the complete picture — we are very far away from that.

...suddenly, new hope in life

A man lies on the operating table, crippled with the exhausting tremors of Parkinson's disease. The surgeon guides a slender tube deep inside the patient's brain until it reaches the target area. Then liquid nitrogen, at 320 degrees below zero F., is fed to the end of the tube. Suddenly the trembling stops. The unearthly cold kills the diseased cells . . . and a once desperate human being has been given a new chance in life. ▶ Medical reports have indicated that not only Parkinson's disease but also other disorders causing tremor or rigidity have responded to this new technique in brain surgery. The operation has been described as easier on the patients than previous surgery, and they have been able to leave the hospital in a surprisingly short time. Also, encouraging results are reported on the use of cryosurgery, as it is called, to destroy diseased cells in other parts of the body. ▶ Through its division, Linde Company, Union Carbide was called upon by medical scientists for help in designing and making equipment to deliver and control the critical cold required in this new surgery. This dramatic use of cryogenics, the science of cold, is an example of how research by the people of Union Carbide helps lead to a better tomorrow.

A HAND IN THINGS TO COME

UNION CARBIDE

For information describing the work in cryosurgery done at the Neurosurgical Department of St. Barnabas Hospital, New York, write to: Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.

The Month at Caltech

Immunochemistry

The National Institutes of Health has allocated approximately $100,000 a year to Caltech for a broad seven-year program of research in immunochemistry, including studies of the basic mechanisms involved in allergic reactions.

While some new projects are planned, most of the funds will be used to support work already in progress under the direction of Dan H. Campbell, professor of immunochemistry, and Justine S. Garvey, senior research fellow, and a group of about 20 scientists and technicians.

The group is doing research in many of the basic problems in immunology. Research will continue in attempts to isolate pure antibodies so that their chemical structure and physical properties can be analyzed. Antibodies are proteins manufactured by the body to inactivate invading viruses and other foreign proteins.

Work will also continue in growing cells artificially in tissue culture and in developing techniques for harvesting antibodies from such cells.

Dr. Garvey will pursue her research with the tissue culture of liver because the artificial production of these cells offers the possibility of growing the hepatitis virus for the development of a vaccine against this disease.

Tissue culture is beginning to offer possibilities as a powerful tool in studying the synthesis of antibodies and the role of antigens in such synthesis. Antigens, which are the viruses and other foreign proteins that invade the body, have been detected in animals two years after infection, long after the symptoms they caused have subsided.

One of the grants is for research being done exclusively by Dr. Campbell. It will support continuation of his attempts to isolate the precise part or parts of ragweed pollen that cause allergic reactions. Similar work is under way on timothy hay. Another facet of Dr. Campbell's research is a study of soluble antigen-antibody complexes that are very toxic.

Several projected new studies involve the detection and behavior of antibodies, including work on their specificity, and an investigation into the role of the liver in gamma globulin formation.

An important part of the immunochemistry program at Caltech has been, and will continue to be, the research support of young physicians and PhD's who want advanced research experience. Caltech is one of the few institutions in the world where advanced training in immunology is possible.

James Edgar Bell

Dr. James Edgar Bell, professor emeritus of chemistry, died on October 15 in a Pasadena rest home. He was 87 years old. Dr. Bell was in charge of freshman chemistry classes at Caltech for 29 years, until his retirement in 1945.

Dr. Bell was born in Gettysburg, Ohio. He received his BS from the University of Chicago, and his PhD from the University of Illinois. He taught at the University of Washington before coming to Caltech in 1916, when the school was known as the Throop College of Technology.

After retiring from Caltech, Dr. Bell taught chemistry at Rollins College in Winter Park, Florida, until 1952.

Moessbauer Effect

More than 100 invited scientists and industrial representatives came to the campus on November 2 to discuss how the Moessbauer effect makes it possible to learn more about the interacting forces within atoms.

The effect is named for Dr. Rudolf Moessbauer, Caltech professor of physics, who was awarded the 1961 Nobel Prize in physics for discovering it.

The Moessbauer effect is a yardstick which makes it possible to measure the effects of natural forces such as gravity, electricity, and magnetism on photons and atomic nuclei with an unprecedented sensitivity. It has opened a great many new research possibilities in nuclear and solid state physics and relativity.

The one-day colloquium was sponsored by the Caltech Industrial Associates, consisting of about 40 companies associated with the Institute in support of teaching and research.

National Science Board

The National Science Board, composed of 24 of the country's leaders in research, education, and public affairs, held its 81st meeting at Caltech, November 15-17.

The Board is the governing body of the National Science Foundation, which was established by the Federal Government in 1950 for the purpose of developing national science policy. Empowered to give financial support to individuals and institutions engaged in basic scientific research, the Foundation's

Recent photographs of the Comet Humason, taken with the 48-inch Schmidt telescope on Palomar Mountain, reveal that it may have been involved in a collision with a large cloud of radiation from the sun. The swirling tail of the comet, 9,000,000 miles long, gives the clue to the collision. When this picture was taken the comet was well beyond the orbit of Mars, approximately 240,000,000 miles away from the sun. Normally, comets do not show the disintegrating effects of solar radiation until they approach much closer to the sun. The comet is named for Dr. Milton L. Humason, who discovered it in September 1961, shortly before his retirement from the staff of the Mount Wilson and Palomar Observatories.

budget for the fiscal year 1962-63 amounts to $360 million.

The Board normally holds nine meetings a year —eight in Washington, D.C., and one elsewhere. The meeting at Caltech is its first on the West Coast.

Mariner II

The Venus-bound Mariner II spacecraft established a new deep space measurement communications record on November 15 as it transmitted engineering and scientific data to earth from nearly 18 million miles in space, during the 81st day of flight.

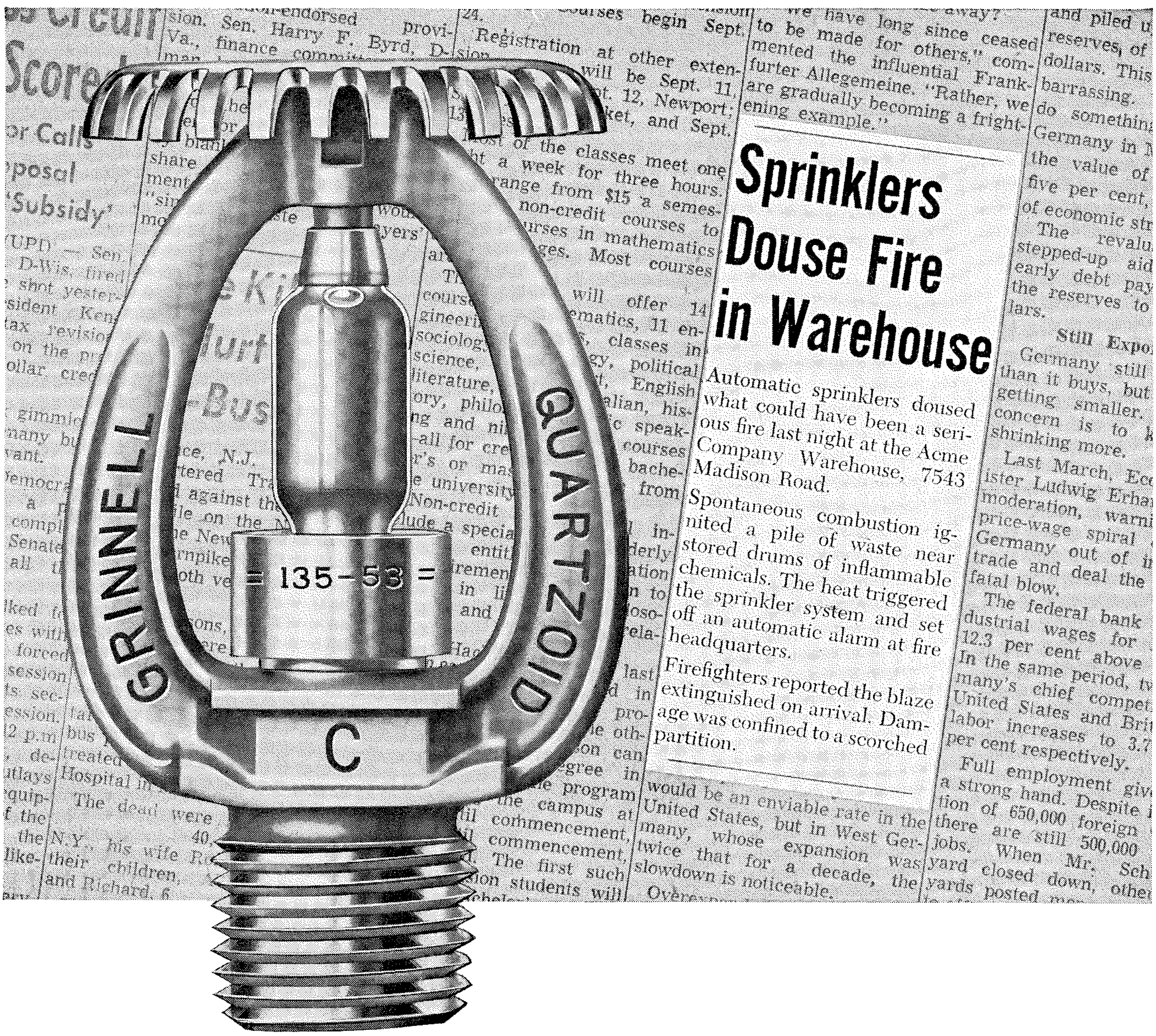
The earlier communications record was set by the Pioneer V space probe at a distance of 17.7 million miles. At that distance, on June 14, 1960, Pioneer V's signal strength dropped below the minimum for transmission of data.

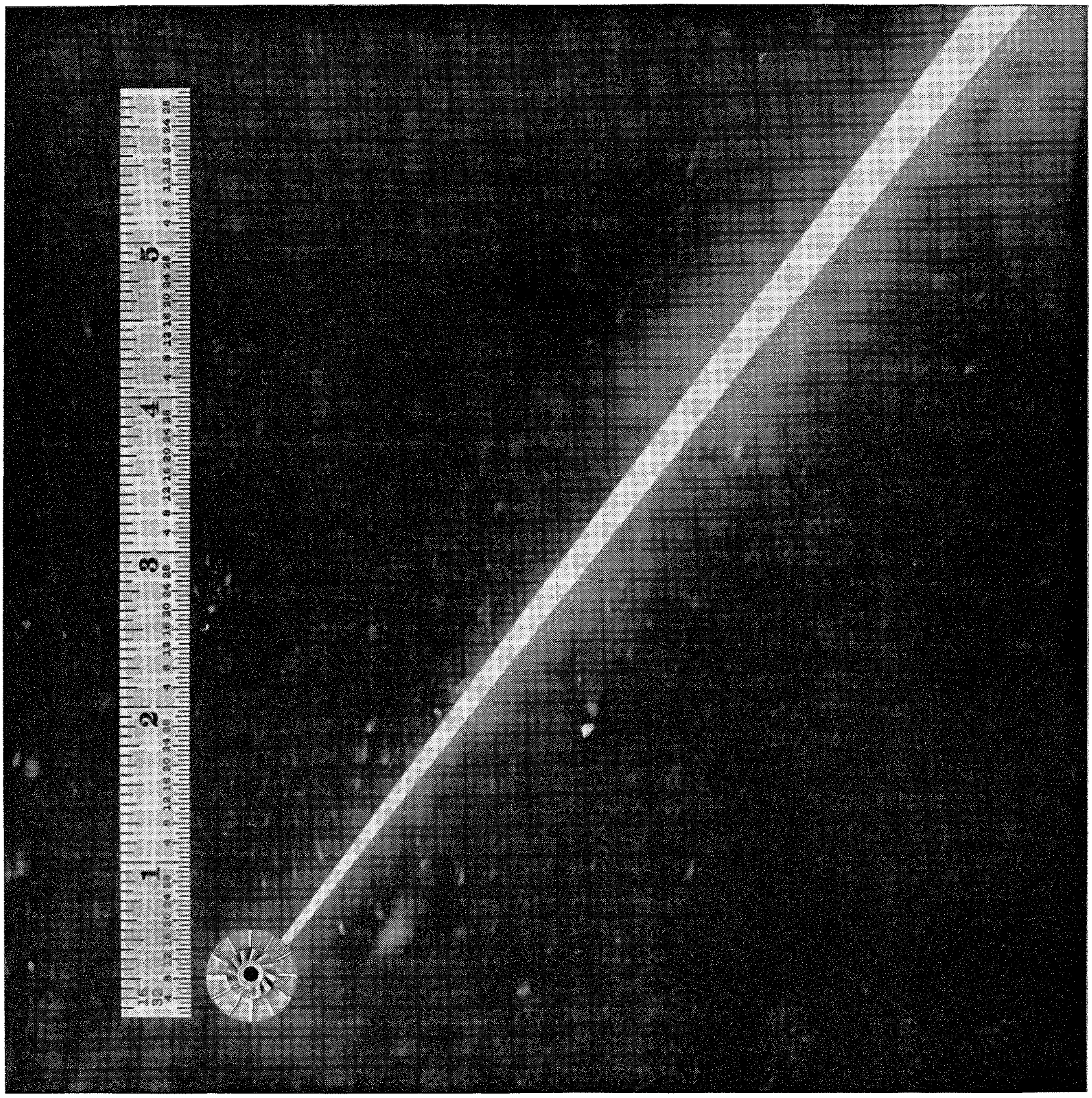
Mariner II has been transmitting engineering and scientific data continuously 24 hours a day, except for a period from October 31 to November 7, when the scientific instruments were turned off to reduce the power demand following an unexplained decrease in voltage supplied by the solar panels. The power level returned to normal on November 7 and the experiments were again turned on.

Engineering data — pressures, temperatures, voltages — report on the status of the spacecraft's various systems. Scientific data is collected by four interplanetary experiments carried aboard the spacecraft.

The mission of Mariner II is to fly by Venus, at a distance of 20,900 miles, and measure microwave and infrared emissions from the planet. The two planetary experiments will be automatically activated ten hours in advance of the fly-by. During the fly-by, all six scientific experiments will be functioning to supply data on the planet. They will answer such basic questions as whether Venus has a magnetic field, whether it has a belt of charged particles around it like the earth's Van Allen belt, and the presence or absence of cosmic dust.

The fly-by will occur on December 14, during the 110th day since the Mariner launch on August 27.


Sprinklers Douse Fire in Warehouse
Automatic sprinklers doused what could have been a serious fire last night at the Acme Company Warehouse, 7543 Madison Road.
Spontaneous combustion ignited a pile of waste near stored drums of inflammable chemicals. The heat triggered the sprinkler system and set off an automatic alarm at fire headquarters.
Firefighters reported the blaze extinguished on arrival. Damage was confined to a scorched partition.
GRINNELL
QUARTZOID
135-53
C



250,000 rpm/-452° F

Miniature turboexpander permits major breakthrough in cryogenics...Temperatures ranging from −200°F to −452°F are achieved by converting gases such as helium and nitrogen into a liquid state.

When cryogenic liquids circulate over an object, the moving molecules within come virtually to a stop. This abnormal condition makes some metals superconductive and extraordinarily sensitive to any form of electrical energy.

Military and commercial applications include increasing the effectiveness of ground and airborne detection, navigation and communication systems, shrinking the size of computers and solving specialized space cooling problems.

A leader in cryogenic cooling and lightweight turbomachinery, Garrett-AiResearch is now developing a closed cycle cryogenic system to compress and then expand (boil off) the low temperature gas into its supercold liquid state.

The tiny turbines within the system run on air bearings and eliminate all rubbing surfaces. Much greater system reliability and long life is the result... another major advance by Garrett in the exciting new science of cryogenics.

For information about other interesting projects and the many career opportunities with The Garrett Corporation, write to Mr. G. D. Bradley in Los Angeles.

Garrett is an "equal opportunity" employer.

GARRETT

THE GARRETT CORPORATION • AiResearch Manufacturing Divisions • Los Angeles 9, California • Phoenix, Arizona • other divisions and subsidiaries: Airsupply-Aero Engineering • AiResearch Aviation Service • Garrett Supply • Air Cruisers • AiResearch Industrial • Garrett Manufacturing Limited • Garrett International S. A. • Garrett (Japan) Limited

Personals

1916

Bernard E. Chamberlain retired in March 1962 from his position as assistant city engineer and superintendent of streets of the City of Pasadena, after 39 years of service. He and Mrs. Chamberlain recently returned from a trip to the Orient, where they visited their daughter who is a missionary in Japan.

1926

E. R. Peterson, financial vice president of the Southern California Edison Company, died on June 19 at his home in Los Angeles. He joined the company while still in college in 1923, as a substation operator trainee.

1927

James Boyd, president of the Copper Range Company of New York, and former director of the United States Bureau of Mines, has been named by the American Institute of Mining, Metallurgical, and Petroleum Engineers to receive its Charles F. Rand Gold Medal. The award is given for "distinguished achievement in mining administration." Jim will receive the medal on February 27 at the AIME's 92nd annual meeting in Dallas, Texas.

1930

N. D. Whitman, MS '32, and *Thomas G. Atkinson*, '42, have formed a new company, Whitman, Atkinson & Associates, with offices in Pasadena and San Diego. They are consulting engineers in structural, civil, and mechanical engineering. Whitman has been in private practice since 1945 and is best known for his work in the engineering of unusual structures. Atkinson has been in consulting structural engineering practice in San Diego since 1953, principally in the field of building design.

1933

Robert G. Macdonald, chief of the facilities branch in the Army Quartermaster General's Office in Washington, D.C., has received the Meritorious Civilian Service Medal from the Army. This is the Army's second highest civilian award.

Arnold Wilking, president of St. Mary Hardware Company, Inc., and St. Mary Supply Company, Inc., in Franklin, La., writes that his elder son, Phil, graduated from Tulane University in June, and is now in Pensacola, Fla., as "a Navy fly boy." Daughter Myrtle is now a junior at Reed College in Portland, Oregon, and the younger son, Dick, has just started the seventh grade. Arnold's wife, Martha, is working for her doctorate at Tulane University, and holds a full-time position as executive director at the Protestant Home for Babies in New Orleans.

Merrill Berkley, owner and operator of the Berkley Engineering and Equipment Company in Honolulu, Hawaii, recently started another business, the Rex Engineering Company, in Los Angeles, which represents the Electronics Corporation of America, makers of Fireye combustion safeguard systems and control components.

1936

Paul H. Hammond and *William H. Saylor*, '32, are playing important roles in the building of the Coleman Engineering Company in Los Angeles. Paul, who is executive vice president and a director, oversees the affairs of three operating subsidiaries: Beattie-Coleman, Inc., in Anaheim; Coleman Systems, Inc., in Santa Ana; and Coleman Electronics, Inc., in Gardena; as well as the Speed-D-Burr Division of the Coleman Engineering Company. Bill, a member of the Caltech Alumni Association Board of Directors, is serving as director of the development of new products for Coleman Systems, Inc. The most spectacular product is a new electronic vote-tallying system for Los Angeles County.

President of the company is *Ted Coleman*, '26, who founded it in 1950 as a small research and development firm working for military missile test centers. The company has now made a complete transition to the manufacture and sale of proprietary products in industrial photography, electronic controls, data handling, and metal finishing.

1941

Eben Vey, MS '42, CE '43, is professor of civil engineering at the Illinois Institute of Technology in Chicago, and also manager of soil mechanics research at the Armour Research Foundation at the Institute. The Veys have one son, 13.

1944

Hans Nuetzel, senior civil engineer for the Department of Water and Power, City of Los Angeles, died on September 29. He is survived by his wife, two daughters, and a son.

George F. Smith, MS '48, PhD '52, is one of three men who will direct the Hughes Research Laboratories at Malibu. He serves as manager of the material sciences laboratory, which inclndes the quantum physics, chemical physics, and space science departments. George has been at Hughes since 1952.

1949

Paul D. Saltman, PhD '53, associate professor of biochemistry at the University of Southern California, is serving as acting head of the biochemistry department for the academic year 1962-3.

1950

Robert V. Meghreblian, MS, PhD '53, is now chief of the space science division at JPL. He had been serving as chief of the physical sciences division since June 1960, and has been at JPL since 1947.

Almon E. (Bud) Larsh, Jr., electronic engineer at the Lawrence Radiation Laboratory of the University of California in Livermore, writes that he now has three children: Gerry, 7½, Sandra, 3, and Kevin, who was born on June 23.

1951

John Elliott writes that he is still working for the Douglas Aircraft Company and has recently been assigned as acting senior engineer in the aerostructural mechanics section in the engineering department at the Piaggio Project in Finale Ligure, Italy. His wife and three-year-old son are with him, and they expect to be in Italy for about six months.

David T. Manning, PhD '55, is now research scientist in the chemicals research and development department of the Union Carbide Corporation in South Charleston, West Virginia. The Mannings have two daughters; Teresa, 5, and Anita, 3.

1953

Carl A. Rambow, MS '58, resigned his position as assistant professor at Washington State University and is now an engineer with James M. Montgomery, Consulting Engineers, Inc., in Pasadena. The Rambows have three children; Mike, 5, David, 4, and Barbara, 2.

1954

Robert G. Morris, MS, is now professor and head of the physics department at the South Dakota School of Mines and Technology in Rapid City. He has been on the staff for four years.

1955

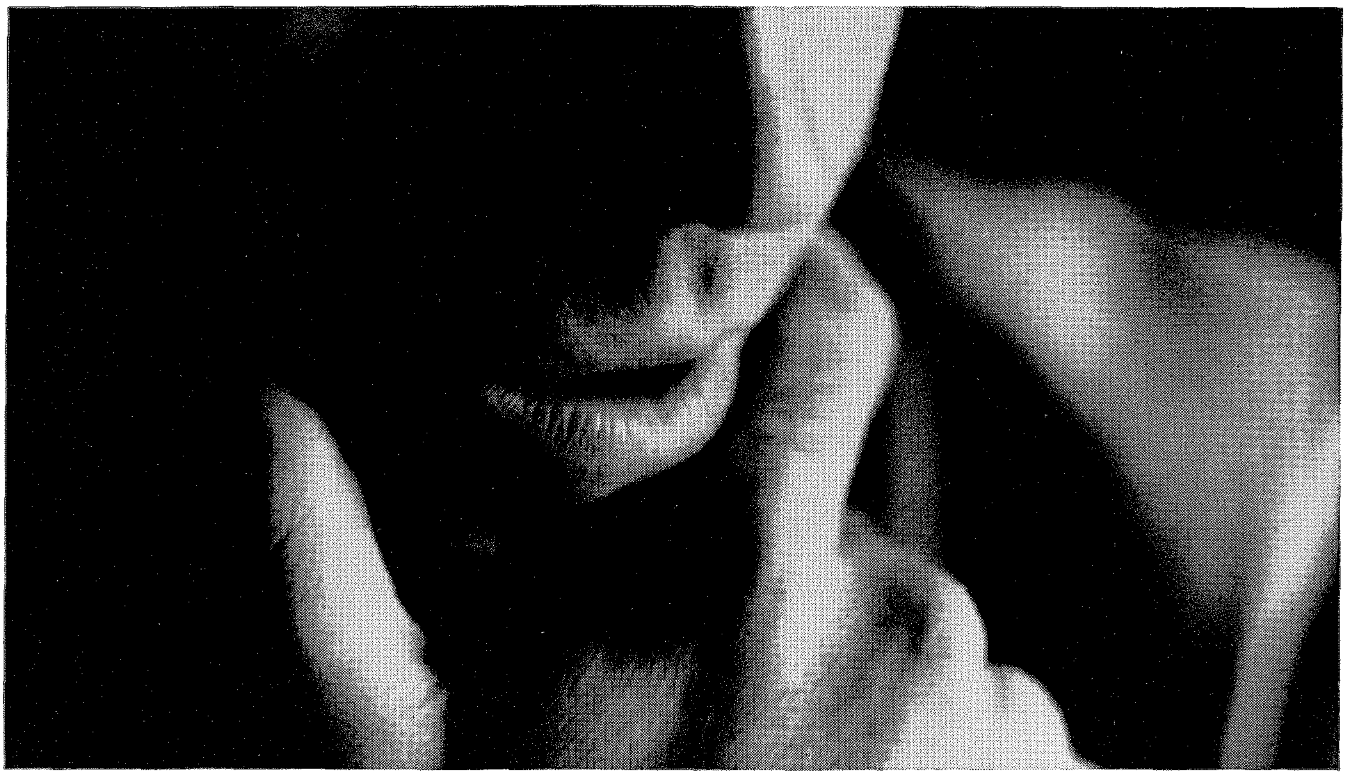
Richard Schmid, who is now half of a corporation (Williamson and Schmid, Civil Engineers, in Santa Ana) was married on July 29 to Pat Stanley, a school teacher. Dick formerly worked for fonr years with the Orange County Flood Control District.

1960

David S. Bailey is now on the staff of the theoretical physics department at UC's Lawrence Radiation Laboratory in Livermore, Calif.

1961

2nd Lieut. Douglas Shakel received his silver wings as an Air Force navigator last summer, and has been reassigned to the Mather AFB in California for navigator-bombardier training.



Alumni News

Manildi Memorial Fund

Friends of Joseph F. Manildi, BS '40, MS '42, PhD '44, who died September 7, 1962, have established a Caltech scholarship fund in his memory. Contributions to this fund may be made payable to California Institute of Technology – Manildi Fund, and mailed to the Institute.

Dr. Manildi joined G. M. Giannini and Company in 1944, serving as Director of Research and Chief Engineer until 1947 and as a consultant from 1947 to 1954. He taught engineering at the University of California at Los Angeles from 1947 to 1958, attaining the rank of full professor in 1958. He joined the Ramo-Wooldridge Corporation in 1954 as an engineering consultant and subsequently served that company and its successor, Thompson Ramo Wooldridge Inc., in posts including Director of Marketing for the Ramo-Wooldridge Corporation, General Manager of TRW Computers Company, member of the Corporate Products Planning Committee, and Director of Contract Research and Development Liaison for TRW Electronics.

He was the author of numerous technical papers and the holder of five patents. He was a member of the American Society of Mechanical Engineers, the Institute of Aerospace Sciences, the American Institute of Electrical Engineers, the American Rocket Society, and the American Marketing Association.

Dr. Manildi is survived by his wife Shirley and three children.

Caltech Astronaut

Major Frank Borman, who received his MS from Caltech in 1957, was one of the nine new astronauts chosen last month. The nine men have already been assigned to a comprehensive training program to prepare them for a possible flight to the moon, and for intermediate space trips Major Borman has been in the Air Force since 1950, when he graduated from the U.S. Military Academy.

BACK IN THE SADDLE

"Who? . . . Miss Johnson, I've asked you four times this week to find out who's calling. You know how busy I am. I haven't got time to talk to every guy who's tryin' to sell magnetic pothold . . .

"Sternmeyer? George Sternmeyer? But I *gave,* I *gave,* I know I gave! Didn't I? *Sure* I did. *Gimme* that phone!

"Listen George, doggone it, I *gave* an' I'm not givin' a second time this year so you haven't any right to keep pesterin' me 'cause I gave already an' I'm not fallin' for all that hoopla again, no siree, so don't keep callin' me on the phone 'cause I won't listen, an' if ya do I'll tell my girl to tell ya I'm not in 'cause I *gave* – I *gave* – I *GAVE ALREADY!* I've already given, George.

". . . Oh. . . . OK. . . . That's better . . . I thought you were tryin' to get me to give some more money to the ol' 'lumni Fund . . . guess I owe you an apology . . . Now . . . What's on your mind?

"I don't believe it . . . 1962? - 63? . . . A brand new year? You mean . . . No . . . Really? . . . We start all OVER again, huh? . . . What's the pitch this year? . . . Same thing, huh? . . . Increase the ol' endowment, huh? . . . Goal of seventy-five thousand, huh? . . . 75,000 WHAT! . . . DOLLARS? . . . Sheesh!

"Well, guess you're gonna hound – I mean – be after me all winter again . . . All spring too, huh? Well, there ya are . . . Back in the saddle again."

SURE WE ARE, WE'RE BACK IN THE SADDLE AGAIN

Lost Alumni

The Institute has no record of the present addresses of these alumni. If you know the current address of any of these men, please contact the Alumni Office, Caltech.

1906
Norton, Frank E.

1907
Miller, James C., Jr.

1911
Lewis, Stanley M.

1915
Soyster, Charles J.

1918
Lavagnino, John F.

1921
Arnold, Jesse

1922
Cox, Edwin P.
Cronin, John A.
Rose, Edwin L.

1923
Hickey, George I.
Neil, W. Harvey
Skinner, Richmond H.

1924
Henderson, William G.
Stearns, Charles F.
Tracy, Willard H.
Young, David R.

1925
Schlierbach, Louis T.

1926
Chang, Hung-Yuan
Kingsbury, William S., Jr.
McCarter, Kenneth C.
Yang, Kai Jin

1927
Evjen, Haakon M.
Riggs, Eugene H.

1928
Chou, P'ei-Yuan
Martin, Francis Crawford
Morgan, Stanley C.
Wingfield, Baker

1929
Briggs, Thomas H., Jr.
Burns, Martin C.
Lynn, Laurence E.
Nelson, Julius
Robinson, True W.
Wolfe, Karl M.

1930
Allison, Donald K.
Chao, Chung-Yao
Douglass, Paul W., Sr.
Forney, Morgan T.
Janssen, Philip
Mason, Harry S., Jr.
Moyers, Frank N.
Shields, John C.
White, Dudley

1931
Hall, Marvin W.
Ho, Tseng-Loh
Oaks, Robert M.
Voak, Alfred S.
West, William T.
Yoshioka, Carl K.

1932
Brass, P. D.
Patterson, J. W.
Schroder, L. D.
Schultz, William F.
Wright, Lowell J.

1933
Andes, Ammon S.
Applegate, Lindsay M.
Downie, Arthur J.
Koch, A. Arthur
Larsen, William A.
Lockhart, E. Ray
Michal, Edwin B.
Murdock, Keith A.
Shappell, Maple D.
Smith, Warren H.

1934
Harshberger, John D.
Liu, Yun Pu

1935
Huang, Fun-Chang
McCoy, Howard M.
McNeal, Don

1936
Chu, Djen-Yuen
Kelch, Maxwell
Nelson, Loyal E.
Van Riper, Dale H.

1937
Becker, Robert A.
Cheng, Ju-Yung
Easton, Anthony
Fan, Hsu Tsi
Jones, Paul F.
Lotzkar, Harry
Maginnis, Jack
Munier, Alfred E.
Odell, Raymond H.
Penn, William Lee, Jr.
Servet, Abdurahim
Shaw, Thomas N.
Wylie, Jean

1938
Ackerman, John B.
Gershzohn, Morris
Goodman, Hyman D.
Gross, Arthur G.
Kanemitsu, Sunao
Lentz, John Jacob
Lowe, Frank Clare
Rhett, William
Tilker, Paul Owen
Wang, Tsun-Kuei
Watson, James W.
Woodbury, William W.

1939
Aime, Edgar A.
Brown, William Lowe
Gombotz, Joseph J.
Hsueh, Chao-Wang
Jackson, Andrew M., Jr.
Oakley, Spencer W.
Townes, Charles H.
Tsien, Hsue-shen
Weinstein, Joseph
Wilson, Harry D.

1940
Abraham, Lewis
Batu, Buhtar
Compton, Arthur M.
Gentner, William E.
Gibson, Arville C.
Green, William Jeffrey
Hsu, Chang-Pen
Karubian, Ruhollah
Lovoff, Adolph
Menis, Luigi
Paul, Ralph G.
Tao, Shih Chen
Torrey, Preston C.
Wang, Tsung-Su

1941
Clark, Morris R.
Dieter, Darrell W.
Easley, Samuel J.
Geitz, Robert C.
Gould, Martin
Hardenbergh, George A.
Harvey, Donald L.
Hubbard, Jack M.
Noland, Robert L.
Robinson, Frederick G.
Standridge, Clyde T.
Taylor, D. Francis
Tiemann, Cordes F.
Vaughan, Richard
Wolfe, Samuel
Yui, En-Ying

1942
Bebe, Mehmet F.
Callaway, William F.
Devault, Robert T.
Emre, Orhan M.
Go, Chong-Hu
Hughes, Vernon W.
Johnston, William C.
Levin, Daniel
MacKenzie, Robert E.
Martinez, Victor H.
Proctor, Warren G.

1943
Angel, Edgar Penfield
Anspach, Kenneth E.
Bridgland, Edgar P.
Brown, James M.
Bryant, Eschol Alonzo
Burlington, William J.
Burnight, Thomas R.
Carlson, Arthur V.
Colvin, James Henry
Eaton, Warren V., Jr.
Gaffney, Thomas Alfred
Gould, Jack E.
Hamilton, William M.
Johnsen, Edwin G.
King, Edward Gerard
Koch, Robert Hal
Kong, Robert Wah
LaForge, Gene R.
Lee, Edwin S., Jr.
Leeds, William Lodowick
Ling, Shih-Sang
Lobban, William A.
Lundquist, Roland Edwin
McNeil, Raymond F.
Mixwell, Joseph W.
Mowery, Irl Holden, Jr.
Nesley, William Lewis
O'Brien, Robert Edward
Patterson, Charles Meade
Pearson, John Edwin
Rambo, Lewis
Scholz, Dan R.
Shannon, Leslie Arthur
Smitherman, Thomas B.
Tindle, Albert Wiley, Jr.
Vicente, Ernesto
Walsh, Joseph Russell
Washburn, Courtland L.
Wood, Stanley G.

1944
Alpan, Rasit H.
Baranowski, John J.
Barriga, Francisco D.
Bell, William E.
Benjamin, Donald G.
Berkant, Mehmet N.
Bertram, Edward A.
Birlik, Ertugrul
Burch, Joseph E.
Burke, William G.
Cebeci, Ahmed
Cooke, Charles M.
De Medeiros, Carlos A.
Fu, Ch'eng Yi
Harrison, Charles P.
Hu, Ning
Johnson, William M.
Labanauskas, Paul Julius
Leenerts, Lester O.
Lin, Chia-Chiao
Marshall, John W.
Mattinson, Carl O.
Onstad, Merrill E.
Pi, Te-Tsien
Pischel, Eugene F.
Rutland, David F.
Shults, Mayo G.
Stanford, Harry W.
Stein, Roberto L.
Sullivan, Richard B.
Trimble, William M.
Unayral, Nustafa A.
Wadsworth, Joseph F., Jr.
Wight, D. Roger
Williams, Robert S.
Wolf, Paul L.
Writt, John J.
Yik, George

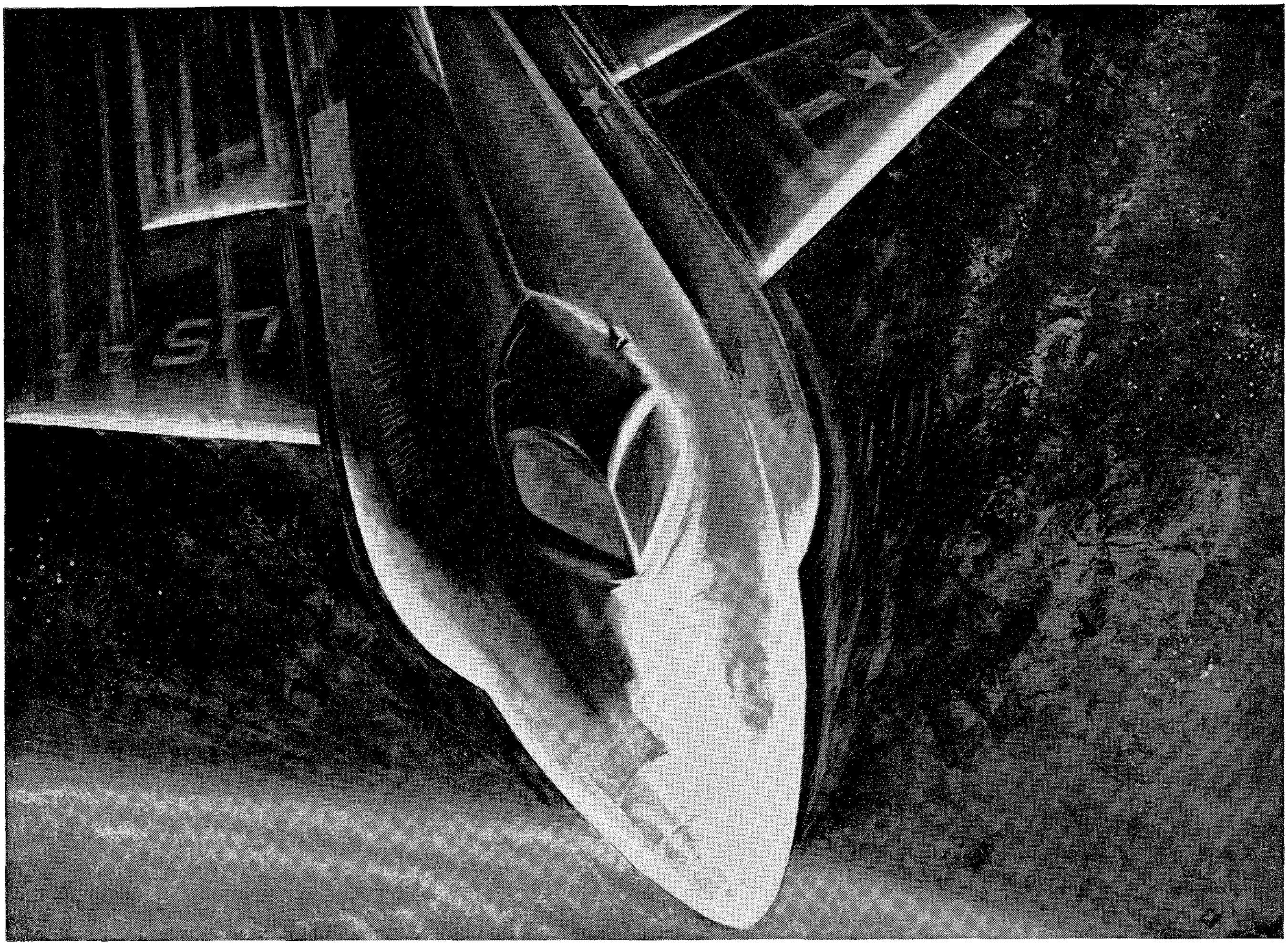
1945
Ari, Victor A.
Bryner, Dean L.
Budney, George S.
Bunze, Harry F.
Clementson, Gerhardt C.
Dixon, Thomas F.
Fanz, Martin C.
Fox, Harrison W.
Gibson, Charles E.
Grossling, Bernardo F.
Jenkins, Robert P.
Knapp, Norman E.
Kuo, Yung-Huai
Levy, Charles N.
Tseu, Payson S.
Yank, Frank A.

1946
Allison, Charles W.
Austin, Benjamin
Barber, John H.
Behroon, Khosrow
Bowen, Mark E.
Burger, Glenn W.
Dethier, Bernard
Dyson, Jerome Packard
Esner, David R.
Foster, R. Bruce
Gould, Edwin S.
Halvorson, George G.
Hoffman, Charles C.
Huestis, Gerald S.
Ingham, John S.
Ingram, Wilbur A.
KeYuan, Chen
Lewis, Frederick J.
Lowery, Robert H.
Maxwell, Frederick W.
Miller, Jack N.
Olson, Leslie R.
Parker, James F.
Prasad, K. V. Krishna
Rice, Jerry H.
Salbach, Carl K.
Shepard, Elmer R.
Simmons, George F.
Sledge, Edward C.
Smith, Harvey F.
Stephenson, Robert E.
Webb, Milton G.
Winson, Jonathan

1947
Asher, Rolland S.
Atencio, Adolfo J.
Clarke, Fredric B.
Clements, Robert E.
Collins, Hugh H.
Dagnall, Brian D.
Darling, Donald A.
Darling Rodney O.
Froelich, Jack E.
Flanders, Edward A.
Hammerle, William G.
Heppe, Ralph R.
Huang, Ea-Qua
Lane, James F.
Leo, Fiorello R.
Lim, Vicente H., Jr.
Lyon, George W.
MacAlister, Robert S.
Manoukian, John
McClellan, Thomas R.
Molloy, Michael K.
Moorehead, Basil
Olson, Raymond L.
Orr, John L.
Ramaswamy, Guruvayur S.
Rust, Clayton A.
Sanders, Lewis B.
Sappington, Merrill H.
Schroeder, Henry W.
Thompson, Russell A., Jr.
Torgerson, Warren S.
Wan, Pao Kang
Wellman, Alonzo H., Jr.
Wimberly, Clifford M.
Winters, Edward B., Jr.
Ying, Lai-Chao

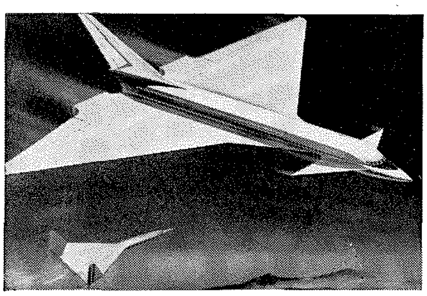
1948
Agnew, Haddon W.
Bunce, James A.
Clark, Albert R.
Collins, Burgess F.
Cotton, Mitchell L.
Crawford, William D.

continued on page 38

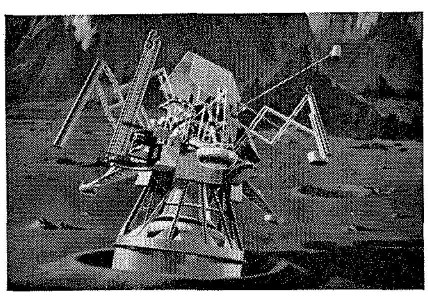


X-15—the famed research rocket plane that has reached speeds over 4000 mph and altitudes of 314,000 ft. Re-entering the atmosphere on the way back home, friction can make it glow like a red hot poker. The intense heat on the surface of the ship would soften and weaken materials normally used in aircraft construction. What kind of metal can be counted on to stay strong at the red heat of re-entry? Engineers found the answer to this difficult problem in a Nickel-containing alloy strong enough to resist sizzling temperatures of 1000 degrees, and more.

How Inco Nickel helps engineers make new designs possible and practical



2000 mph airliner—a supersonic jet that will fly from New York to London in just over 2 hours at speeds of 2000 mph, and at 70,000 ft. altitudes. What will hold her skin together? Logical choice: a brazing alloy containing palladium (one of the 14 elements produced by International Nickel), providing great strength at high temperatures—up to 630° F—caused by supersonic speeds.



Moon crawler. Sometime during 1964, this spider-like object—the "Surveyor" —is expected to land on the moon's surface and transmit information to earth on what the moon looks like and what it is made of. What metal will this machine need to withstand the extreme cold? Most likely a Nickel-containing alloy to provide toughness at sub-zero temperatures.

Today's engineer is aware of the advantages of Nickel-containing metals. He knows that Nickel, or one of its alloys, can make hundreds of new designs – from the strong, heat-resistant skin of a research rocket plane, to the complex parts of a moon surveyor – perform better and last longer.

You'll find Inco's List "A" helpful and informative. It has descriptions of 200 publications, covering applications and properties of Nickel and its alloys. Write: Educational Services,

The International Nickel Company, Inc.
67 Wall Street, New York 5, N. Y.

INCO INTERNATIONAL NICKEL

The International Nickel Company, Inc., is the United States affiliate of The International Nickel Company of Canada, Limited —producer of Inco Nickel, Copper, Cobalt, Iron Ore, Tellurium, Selenium, Sulfur and Platinum, Palladium and other Precious Metals.

Lost Alumni . . . *continued*

Herold, Henry L.
Holm, John D.
Hsieh, Chia Lin
Hsiao, Chien
Lambert, Peter C.
Latson, Harvey H., Jr.
Lawton, G.
Leavenworth, Cameron D.
Mason, Herman A.
Mooney, Harold M.
Oliver, Edward D.
Rhynard, Wayne E.
Stein, Paul G.
Swain, John Sabin
Voelker, William H.
Wenick, Robert L.
Winniford, Robert S.
Woods, Marion C.
Wray, Robert M.
Yanak, Joseph D.

1949

Abramovitz, Marvin
Barker, Edwin F., Jr.
Bauman, John L., Jr.
Baumann, Laurence I.
Bottenberg, William R.
Brown, John R.
Bryan, Whaton W.
Burkholder, Joseph F.
Clancy, Albert H., Jr.
Clendening, Herbert C.
Cooper, Harold D.
Felt, Gaelen L.
Foster, Francis C.
Galstan, Robert H.
Gilkeson, Fillmore B.
Hardy, Donald J.
Heiman, Jarvin R.
Hylton, Frank G.
Krasin, Fred E.
Leroux, Pierre J.
Lowrey, Richard O.
MacKinnon, Neil A.
McElligott, Richard L.
Merrell, Richard L.
Parker, Dan M.
Rinehard, Marion C.
Ringness, William M.
Saari, Albert E.
Sinker, Robert A.
Stappler, Robert F.
Weiss, Mitchell
Wilkening, John W.
Yu, Sien-Chiue

1950

Bryan, William C.
Edelstein, Leonard
Gimpel, Donald J.
Honda, Shigeru Irwin
Li, Chung Hsien
McDaniel, Edward Foy
McMillan, Robert
Montemezzi, Marco A.
Paulson, Robert W.
Petzold, Robert F.
Scherer, Lee R., Jr.
Soldate, Albert M.
Whitehill, Norris D.
Wong, Calvin

1951

Arosemena, Ricardo M.
Chong, Kwok-Ying
Davison, Walter F.
Denton, James Q.
Goodell, Howard C.
Hawk, Riddell L.
Lafdjian, Jacob Parseh
Li, Cheng-Wu
Merkel, George
Padgett, Joseph E., Jr.
Palmer, John M., Jr.
Pfeiffer, Walter F.
Sjodin, Raymond A.
Summers, Allan J.

1952

Abbott, John R.
Arcoulis, Elias G.
Bucy, Smith V.
Harrison, Marvin E.
Helmuth, James G.
Krause, Dale C.
Loftus, Joseph F.
Long, Ralph F.
Lunday, Adrian C.
Meyer, Robert F.
Primbs, Charles L.
Robieux, Jean
Robison, William C.
Schaufele, Roger D.
Shelly, Thomas L.
Sutton, Donald E.
Wiberg, Edgar
Van Hise, Albert Eugene
Wilson, Howard E.
Zacha, Richard B.

1953

Asakawa, Takeo
Daw, Edward H.
Elliott, David D.
Lennox, Stuart G.
Pilant, Walter L.
Ritter, Darrell L.
Robkin, Morris A.
Schroeder, Norman M.
Vidal, Jean L.
Wilburn, Norman P.

1954

Billings, John T.
Coughlin, John T., II
Feuchtwang, Thomas E.
Graves, Jack C.
Guebert, Wesley R.
Heiser, David A.
Mertz, Charles, III
Rogert, Berdine H.
Seele, Gordon D.
Sergeyevsky, Andrew
Von Gerichten, Robert L.

1955

Barmon, Mervyn, L.
Bryan, George E.
Campbell, Douglas E.
Crowe, Thomas H.
Gutierrez, Reinaldo V.
Lim, Macrobio
Negrette, Marco R.
Roman, Basil P.
Wolfe, John H.

1956

Ames, Lionel E., Jr.
Edwards, Robert W.
Garnault, Andre F.
Goldenberg, H. Mark
McAllister, Don F.
Morales, Daniel R.
Spence, William N.
Tang, Chung-Liang
Truong, Tran N.
Swindt, Joseph K.

1957

Bloomberg, Howard W.
Brust, David
Howie, Archibald
Kaufmann, Richard L.
Landrieau, Marcel
Leader, Elliot
Poggi, Jean Charles
Schwartz, Lowell M.
Stark, Richard D.
Stuteville, Joseph E.
Wong, Chi-hsiang

1958

Ackley, David A.
Chang, Berken
Donoho, Paul L.
Dundzila, Antanas V.
Jones, Laurence G.
Kern, William M.
Knight, Harold G.
Lange, Gordon D.
Saffouri, Mohammad H.
Wille, Milton G.

1959

Bodine, Alan G.
Bailey, John S.
Byun, Chai B.
Cribbs, Walter J.
Guillemet, Michel P.
Gustafson, Harold R.
Idrias, Izzat, M.
Monroe, Louis L.
Weber, Walter V., Jr.

1960

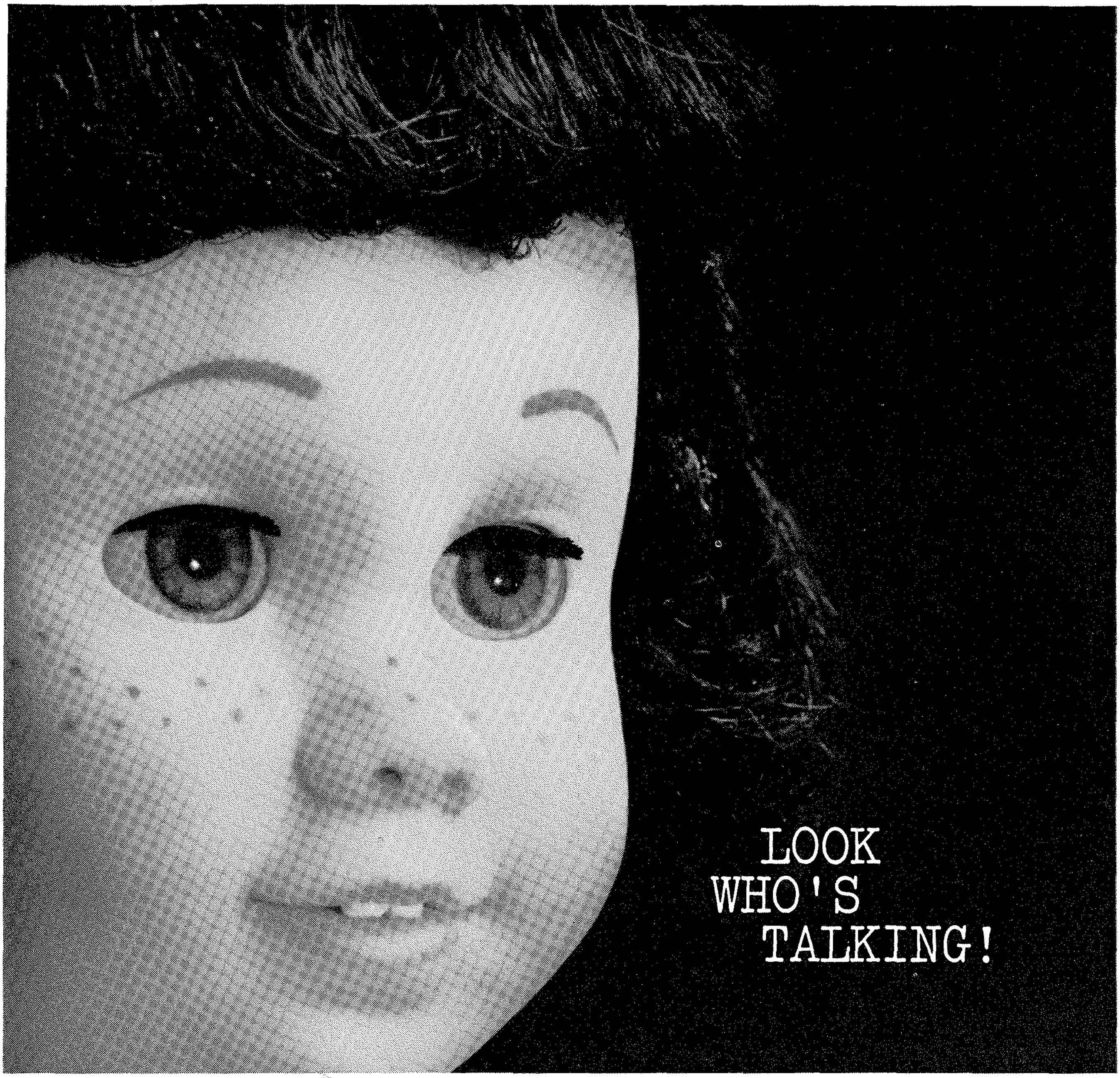
Baicher, Vladimir V.
Farha, Norman S.
Lindquist, David M.
Mauger, Richard L.
Meier, Karl L.
Nearing, James C.
Sawyer, Stanley
Sorrell, Furman Yates
Steinberg, Charles M.
Williams, Allen D.

1961

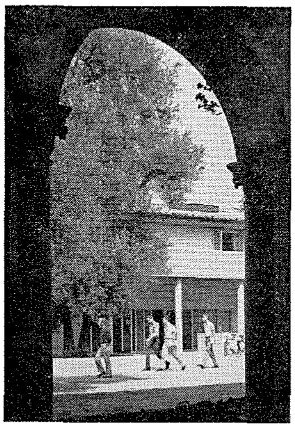
Schultz, Martin H.
Siegel, Charles
Richter, Rolf

1962

Gretsky, Neil E.
Lovell, Bruce A.
Moeck, Edward O.


LOOK
WHO'S
TALKING!

CALTECH CALENDAR



CALTECH YMCA ATHENAEUM LUNCHEON FORUM

Reservations by Tuesday noon

November 28
The Elections—1962 and 1964
—Barry Goldwater,
U. S. Senator from Arizona

December 5
Some Misconceptions about Disarmament
—Richard Schuster,
Staff Engineer, Arms Control and Disarmament Studies Group, JPL

FRIDAY EVENING DEMONSTRATION LECTURES

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

November 30
The Coming Search for Life on Mars
—Norman H. Horowitz

December 7
Formation and Evolution of Galaxies
—Halton C. Arp

December 14
The Strength of Metals—Hot and Cold
—David S. Wood

PUBLIC LECTURE

Culbertson Hall, 8:00 p.m.

November 27
Goals in a Free Society
—Barry Goldwater,

GIFT SUBSCRIPTIONS

This offer good through December 24, 1962

For a limited time, Caltech alumni who are already subscribers to *E & S* may enter one-year gift subscriptions at the special rate of $3.50 a year ($4.50 outside the U. S.).

Subscription to go to:

Name ______________________

Address ______________________

City ______________ State ______

Send bill to:

Your name ______________ Caltech Class ______

Address ______________________

City ______________ State ______

($3.50 enclosed............Bill later............)

ALUMNI ASSOCIATION OFFICERS

PRESIDENT
William L. Holladay, '24

SECRETARY
Donald S. Clark, '29

VICE-PRESIDENT
Peter V. H. Serrell, '36

TREASURER
John R. Fee, '51

BOARD OF DIRECTORS

Robert Boykin, '34
Patrick J. Fazio, '53
G. Russell Nance, '38
Richard W. Powell, '40
William H. Saylor, '32
William H. Simons, '49
Charles P. Strickland, '43

ALUMNI CHAPTER OFFICERS

NEW YORK CHAPTER

President Victor Wouk, '40
Electronic Energy Conversion Corp.
342 Madison Ave., New York 17, N.Y.
Vice-President Bruno H. Pilorz, '44
75 Echo Lane, Larchmont, N.Y.
Secretary-Treasurer Harry J. Moore, '48
590 Madison Avenue, New York 22, N.Y.

WASHINGTON, D. C. CHAPTER

Chairman Willard M. Hanger, '43
2727 29th St., N.W., Washington 8, D. C.
Secretary Cmdr. Joseph B. Deodati, '46
7933 Deepwell Dr., Bethesda, Maryland

SAN FRANCISCO CHAPTER

President Lee A. Henderson, '54
Spectromagnetic Industries
521 Lebanon St., Hayward, California
Vice-President Edwin P. Schlinger, '52
Scott-Buttner Electric Co., Inc., Mountain View, Calif.
Secretary-Treasurer Dallas L. Peck, '51
U. S. Geological Survey, Menlo Park, Calif.
Meetings: 13th Floor, Engineers Club, 206 Sansome St., San Francisco
Informal luncheons every Thursday at 11:45 A.M.
Contact Mr. Farrar, EX 9-5277, on Thursday morning for reservations.

CHICAGO CHAPTER

President Laurence H. Nobles, '49
Department of Geology, Northwestern University
Evanston, Illinois
Vice-President Philip E. Smith, '39
Eastman Kodak Company
1712 Prairie Ave.
Chicago, Illinois

SACRAMENTO CHAPTER

President G. Donald Meixner, Jr., '46
4416 Hazelwood Ave., Sacramento, Calif.
Vice-President Robert K. Breece, '47
4812 "I" St., Sacramento 19, Calif.
Secretary-Treasurer Dudley E. Bennett, '47
4535 Marble Way, Carmichael, Calif.
Meetings: University Club, 1319 "K" Street
Luncheon first Friday of each month
Visiting alumni cordially invited—no reservation

SAN DIEGO CHAPTER

Chairman Maurice B. Ross, '24
3040 Udal Street
Secretary Frank J. Dore, '45
Astronautics Div., Convair
Program Chairman Herman S. Englander, '39
U. S. Navy Electronics Laboratory

Dr. E. W. Hughes
131 Crellin

FV

AN INTERVIEW WITH G.E.'s DR. GUY SUITS, VICE PRESIDENT AND DIRECTOR OF RESEARCH

Dr. Suits has managerial responsibility for the General Electric Research Laboratory and as a member of the Company's Executive Office he is directly concerned with G.E.'s over-all research programs and policies. He joined G.E. in 1930 as a physicist, and holds 76 patents, is Chairman of the Directors of Industrial Research, member of the National Academy of Science, Director of American Institute of Physics, previous Chairman of Naval Research Advisory Committee and Fellow of the AIEE, AAAS, and IRE, and has been Vice President and Director of Research since 1945.

For complete information about these General Electric training programs, and a copy of Dr. Suits paper "The New Engineer And His Scientific Resources," write to: Personalized Career Planning, General Electric Company, Section 699-05, Schenectady 5, New York.

How Scientists and Engineers Work Together in Industry

Q. Dr. Suits, I've heard a good deal about the scope of your programs. Is your research mostly in physics and electronics?

A. This is a common misconception. The work of the many laboratories of General Electric "covers the waterfront" in science and in advanced engineering technology. Some laboratories specialize in electronics research, others in atomic power, space technology, polymer chemistry, jet engine technology, and so forth. Actually, the largest single field represented by the more than 1000 Ph.D. researchers in General Electric is chemistry.

Q. Is this research performed principally by people with Ph.D. degrees in science?

A. General Electric research covers a broad spectrum of basic and applied work. At the Research Laboratory we focus largely on basic scientific investigations, much as in a university, and most of the researchers are Ph.D.'s. In other Company laboratories, where the focus is on applied science and advanced engineering, engineers and scientists with B.S. and M.S. degrees predominate. Formal college training is an important preparation for research, but research aptitudes, and especially creative abilities, are also very important qualities.

Q. What are the opportunities for engineers in industrial scientific research and how do scientists and engineers work together in General Electric?

A. Classically, engineers have been concerned with the problem "how," and scientists with the question "why." This is still true, in general, although in advanced development and in technological work scientists and engineers work hand-in-hand. Very close cooperation takes place, especially in the increasingly important fields of new materials, processes, and systems. Certainly in General Electric, a person's interest in particular kinds of problems and his ability to solve them are more important than the college degree that he holds.

Q. What does it mean to an engineer to have the support of a large scientific research effort?

A. It means that the engineer has ready access to the constant stream of new concepts, new materials, and new processes that originate in research, and which may aid his effort to solve practical problems. Contact with research thus provides a "window" on new scientific developments—world-wide.

Q. How does General Electric go about hiring engineers and scientists?

A. During each academic year, highly qualified technical people from General Electric make recruiting visits to most college campuses. These men represent more than 100 General Electric departments and can discuss the breadth of G.E.'s engineering and science opportunities with the students. They try to match the interests of students and the Company, and then arrange interview visits. The result of this system is a breadth of opportunity within one company which is remarkable.

Experienced technical people are always welcome, and they are usually put in contact with a specific Company group. Where no apparent match of interests exists, referrals are made throughout General Electric. In all cases, one finds technical men talking to technical men in a really professional atmosphere.

Q. Are there training programs in research for which engineering students might be qualified?

A. There certainly are. Our 2-year Research Training Program at the General Electric Research Laboratory gives young scientists a chance to work with experienced industrial research scientists before carrying out research and development on their own.

In addition, there are seven Company-wide training programs. Those that attract the largest number of technical graduates are the Engineering and Science, Technical Marketing, and Manufacturing Training Programs. Each includes on-the-job experience supplemented by a formal study curriculum.

Of course, not all graduates are hired for training programs. In many cases, individuals are placed directly into permanent positions for which they are suited by ability and interest.

GENERAL ELECTRIC