ENGINEERING | AND | SCIENCE

May 1961

Essential Oils . . . page 7

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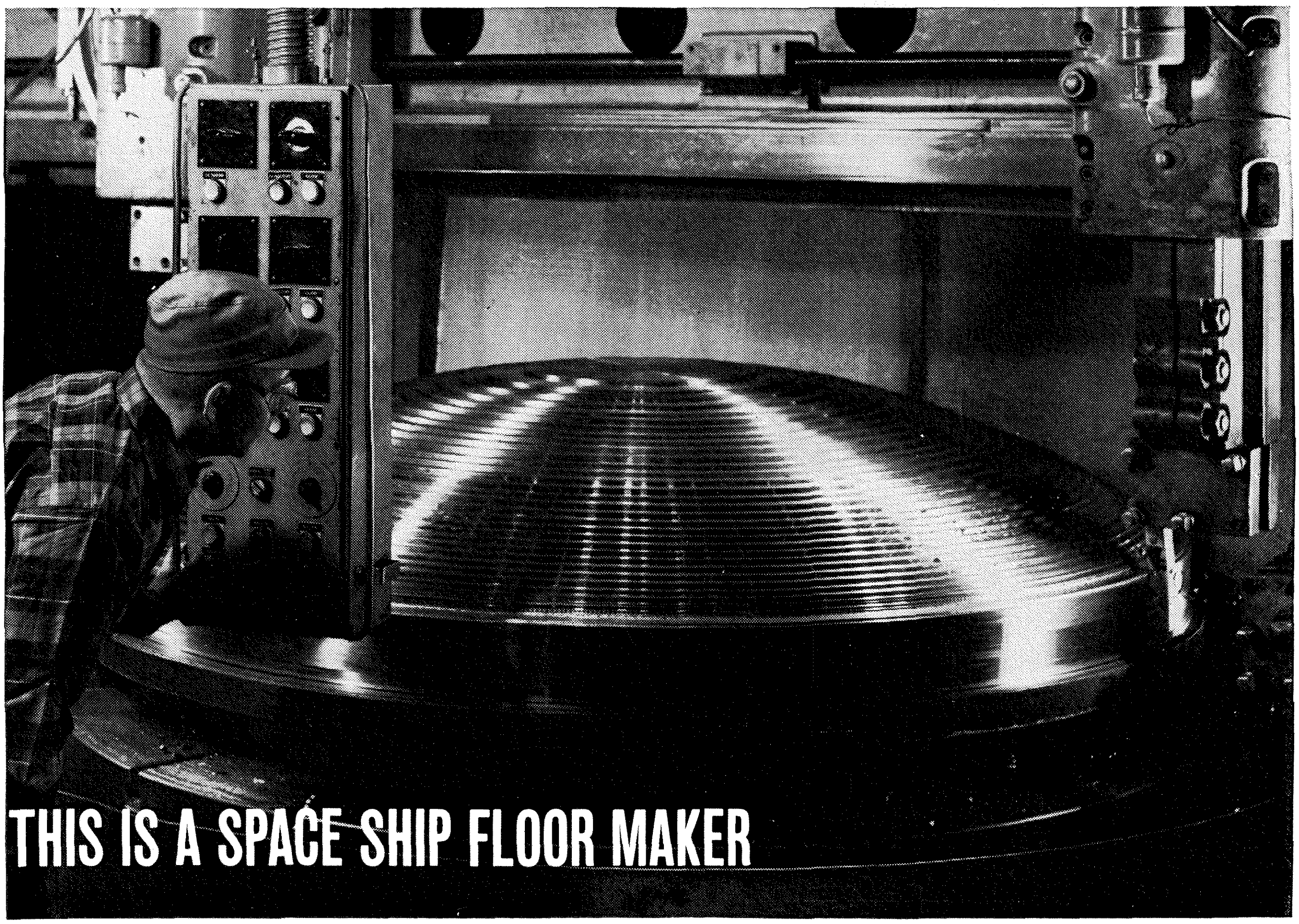
THIS IS A SPACE SHIP FLOOR MAKER

FACTS ABOUT AIR FORCE OFFICER TRAINING FOR ENGINEERS

Who is eligible?

College graduates, with a degree from an accredited college or university, who are U.S. citizens 20½ to 27½ at time of application. Male applicants may be married or unmarried; female applicants must be single and have no dependents. Applicants must complete written and physical examinations for commissioning.

What kinds of engineers are needed most?

Aeronautical, electrical, mechanical, civil, architectural, industrial. (Also graduates with any degree who majored in nuclear physics, engineering physics or meteorology.)

What is Air Force Officer Training School?

A precommission training course of 3 months' duration at Lackland Air Force Base, Texas. Officer trainees upon graduation receive a commission as second lieutenant. They are then assigned directly to duty or additional training.

Does the Air Force offer career opportunities?

Yes. Technically trained officers have a particularly bright career outlook. They have good opportunities for graduate study.

How can further information be obtained?

Write to OTS Information, Box 7608, Washington 4, D.C., or inquire at any Air Force Recruiting Office, listed in the telephone directory under "U.S. Government—Air Force."

Civilian Career Opportunities

The Air Force also offers challenging jobs for engineers as civilians. Write to Directorate of Civilian Personnel, Hq. Air Force Systems Command, Andrews Air Force Base, Washington 25, D. C., concerning opportunities for individuals with degrees in aeronautical, electrical, electronic, and mechanical engineering. Write to Directorate of Civilian Personnel, Hq. Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio, concerning opportunities for individuals with degrees in industrial engineering.

ENGINEERING AND SCIENCE

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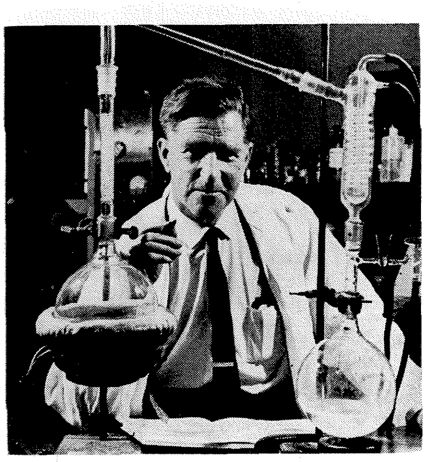

On Our Cover

A. J. Haagen-Smit, professor of bio-organic chemistry, with the distillation apparatus used in the investigation of essential oils — a continuing project in Caltech's biology laboratories, and the subject of Dr. Haagen-Smit's article on page 7.

Dr. Haagen-Smit, a native of Utrecht in the Netherlands, has been on the Caltech faculty since 1937. He has an international reputation for his work in flavor chemistry and the isolation and structure determination of various plant substances, as well as investigations of food flavors, wine and milk. Applying the same techniques he had developed for flavor studies, he was able to identify smog in his laboratory — and is now one of the leading experts in smog research.

Albert R. Hibbs,

chief of the Division of the Space Sciences at Caltech's Jet Propulsion Laboratory, reports on the extensive lunar and planetary probes planned for the future on page 14. Dr. Hibbs, who received his BS from Caltech in 1945 and his PhD in 1955, has been with JPL since 1950. As chief of the Space Sciences Division, he is responsible for coordinating all scientific experiments in JPL's space program.

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Books

Popular Science

Man's View of the Universe
by R. A. Lyttleton

Little, Brown *$3.95*

A small, tightly-packed, and well-illustrated book about what we know of the astronomical universe today. The British astronomer, Raymond Lyttleton, is as good a popularizer as his colleague, Fred Hoyle, and his book makes an ideal introduction to modern astronomy.

Man and the Moon
by Robert S. Richardson and Chesley Bonestell

World *$6.50*

A large and lavish book about the moon which includes everything from descriptions of various features of the moon by modern astronomers (up to the Russians' account of the moon's other side), to details of how man will get to the moon and what he will do there – by such writers as Arthur C. Clarke, Wernher von Braun, and Fred Whipple.

Robert S. Richardson, former staff member of the Mount Wilson and Palomar Observatories, and now associate director of the Griffith Observatory, serves as editor and commentator. Chesley Bonestell provides plenty of his dramatic illustrations, along with numerous photographs.

The Fifteen Wonders of the World
by Rene Poirier

Random House *$5.95*

A French writer tells the stories of 15 of the greatest engineering feats of all time – the Tower of Babel, the Pyramids, the Great Wall of China, the Roman Roads, the Palace of Versailles, the Transatlantic Cable, the American Transcontinental Railway, the London Underground, the Tay and Forth Bridges in Scotland, the Eiffel Tower, the Panama Canal, the Simplon Tunnel, the Reclaiming of the Zuyder Zee, the Volga and Tennessee Hydro-Electric Dams and the Oak Ridge Atomic Power Project.

This should be an engineer's delight, though there's no heavy engineering emphasis. An impressive piece of scholarship – and even better journalism.

Science Fiction

The Voice of the Dolphins and Other Stories
by Leo Szilard

Simon & Schuster .... *Hardbound $3*
Paperback $1

Five science fiction stories by the famous physicist, Leo Szilard, who seems to have been writing these things for his own amusement since at least 1947 – and writing them, as you might expect, like a pro. This is the kind of science fiction to win over people who never touch the stuff.

The Sirens of Titan
by Kurt Vonnegut, Jr.

Houghton Mifflin *$3.50*

A wildly-swinging but engrossing science-fiction satire that, reversing the usual trend, first appeared as a 35-cent paperback book, and now appears in dignified hard covers. Almost deserves them too.

Alumni Books

Gas and Air Compression Machinery
by Lyman F. Scheel

McGraw-Hill *$12*

A comprehensive analysis of the selection and application of all types of gas compressors by Lyman Scheel '26, consulting engineer.

Elementary Concepts of Topology
by Paul Alexandroff

Dover *$1*

An English translation, by Alan E. Farley '57, of an introduction to topology originally published in Germany in 1932. Paperback.

ENGINEERING AND SCIENCE
May 1961, Volume XXIV, No. 8

Oils were used abundantly in daily life in ancient times. In this early Egyptian painting from the tomb of Senejem, a son presents a libation of fragrant oil to Senejem and his wife.

ESSENTIAL OILS

by A. J. Haagen-Smit

More than a million different species of plants and animals have already been described by taxonomists, and new species are discovered every day. Even in densely populated areas it is still possible to discover some new species, as George MacGinitie, Caltech's emeritus professor of biology, proved in our time by digging up a nearly-one-foot-long animal, the *urechis caupo,* on a California beach.

What has the chemist done with this wealth of material? In handbooks on chemistry we find listings of fat, carbohydrate, and protein content of many organisms, and in addition some 10,000 miscellaneous compounds which are found in individual species. When we realize that only a small fraction of all known organisms (less than half of one percent) have received little more attention than a label from taxonomists, it is clear that much work still has to be done. Nevertheless, the study of natural products has played an important role in the development of organic chemistry, and has given us products of great commercial and medical importance.

The present revival of interest in these compounds from natural products continues to give evidence of the astounding synthetic abilities of living organisms. Through a revolution in analytical methods, as well as progress made in biochemistry, new research avenues have been opened for such classical problems as those of alkaloids and pigments. These compounds no

The study of essential oils has had an exciting past.
Now, with improved analytical techniques, it has an equally exciting future.

longer stand by themselves as freaks of nature, but have become expressions of general metabolic processes.

The same is true of another group of natural products known as essential oils. This name is a very old one and refers to the alchemists' idea of the most sublime extractive, the *Quinta Essentia.* This material was, in general, the active ingredient of pharmacologically important drugs. Later the name was applied to volatile materials responsible for the fragrance of plants. The manifold aspects of these materials have been studied by chemists, plant physiologists, and pharmacologists as well as historians.

One could write a world history on the basis of essential oils. These highly valued products have played a very important role in the economy of many countries — especially in classical times.

In the ancient countries of the Orient, in Greece, and in Rome the essence of flowers and roots was extracted by placing them in fatty oils. The glass bottles containing these mixtures were warmed in the sun, and finally the odoriferous oils were separated from the solid materials. Sometimes the flowers or plants were macerated with wine, and the product obtained by digestion was then filtered and boiled to a syrup.

These fatty oils and syrups containing the fragrance of flowers and leaves and the oleoresin of trees — such as labdanum, myrrh, and incense — were some of the most valuable products of commerce in ancient history.

Relics of the Egyptian period, several thousand years ago, show evidence of the use of these products. Even the one-room exhibit of Egyptian art in the L.A. County Museum contains many items relating to the abundant use of odoriferous oils and ointments in daily life, and in religious ceremonies. The empty mummy case in the corner of the Egyptian room has in the bottom of the case a life-size painting of the deceased which shows an oil jar at his right containing odoriferous oil. The mummy itself was preserved with cedar oil and other resins such as myrrh and cinnamon.

In the Bible *(Exodus 30:63 and 64)* we find some detailed recipes for the preparation of an ointment with which the altar, its vessels, candlesticks, and even the priest, should be anointed. The exact composition is also given for a perfume (a name used in the old original sense, meaning that which is produced by burning). In many places it mentions the use of spices and odoriferous oleoresins such as myrrh, cinnamon, and labdanum.

Caravans from India and China brought many of these products to Egypt. As the Bible tells us in *Genesis 37:25*, after Joseph was cast into a pit by his brothers:

> ". . . they sat down to eat bread: and they lifted up their eyes and looked, and behold, a company of Ishmaelites came from Gilead with their camels bearing spicery and balm and myrrh, going to carry it down to Egypt."

Often the fragrant oils were endowed with mysterious properties and it is said that Helen of Troy possessed a secret perfume, revealed to her by Venus, which was responsible for her fabulous beauty. While the secret of such magic perfumes has been lost, later generations tried to make up for this in quantity. Laws were even passed in England during the reign of King George III, in 1774, which forbade women to "seduce and betray into matrimony any of His Majesty's subjects by the use of scents, cosmetics and other artificial means." Penalties were the same as those used against witchcraft and upon conviction the marriage would be null and void.

Our present Federal Food and Drug Administration may not go quite so far. It has stated repeatedly that it does not believe in the cure-all properties of fragrant oils, nor in the radio and television claims of irresistible effects of perfumes and ointments on males and females. Everyone can readily agree, however, that the fragrance of flower oils is pleasant, and the industry is hardly to blame if it has supplied us with an abundance of the volatile odoriferous products. Today, as thousands of years ago, natural as well as artificial scents accompany us from early morning to late at night.

These odors take many forms. The eucalyptus trees in the center of the Caltech campus give off the odor of a well-known brand of cough drops. On the other hand, the eucalyptus at the entrance to the Athenaeum smells quite different and resembles lemon; in fact it has been called *E. citriodora,* in distinction to

Distillation in the 16th century: "In fire the juice of all bodies, by means of art, becomes a vigorous liquid."

the more common *E. globulus*.

Each plant has its peculiar odor, and this odor is most frequently the property of the oils secreted in special cells, or in intercellular spaces in the plant. These oil-filled spaces can readily be observed in an orange peel. By bending the peel, the cell walls of the container are torn and the droplets of orange oil form a spray, which can be seen by the light of a candle. The simple process of release of the oil by pressing is the basis of a large industry producing orange and lemon oil in the nearby towns of Ontario and Corona.

The old way of producing this oil was to press by hand and collect the oil in a sponge. When the sponge was saturated, the oil was squeezed out. This process is still used in Italy and Spain. An operator can collect from one to two pounds of oil per day from 200 pounds of fruit.

Our California lemon and orange byproducts industry solves this problem by mechanically reproducing the work of the individual hand presser. In this way the orange byproducts plant in Ontario supplies 400,000 pounds of orange oil per year. The lemon industry in Corona produces 650,000 pounds of lemon oil per year.

The oils so obtained are practically insoluble in water, just like fatty oils; however, unlike these, they are volatile. A drop of volatile oil on filter paper disappears after a time, while a fat gives a lasting spot. Turpentine can be used to remove the fat spot. This fat solubility has been recognized for a long time and forms the basis for a process called *enfleurage* still practiced chiefly in the south of France. Flowers are spread on glass plates covered with fat. These are held in a wooden frame and stacked one on top of the other so that the flowers are surrounded by fat. While the odors are given off by the flowers they dissolve in the fat and afterwards the fat is collected and extracted with alcohol. In this way the perfume industry obtains the highly valued and very expensive *absolutes* of *enfleurage*.

This process doesn't fit too well into our present day economy and is gradually being replaced by solvent extraction with low-boiling petroleum fractions. The oils obtained by pressing oranges or lemons, or those obtained by fat extraction, are volatile by themselves, or they can be distilled over with steam.

In areas far from civilization these distillations are carried out in very much the same way that was described in the books on distillation printed in the 16th century.

In essential oil centers, on the other hand, we find the most modern stills, capable of handling large quantities of oil. American oil of turpentine is produced in this way in Georgia and Florida by steam distilling of the oleoresins from the pine trees. When the mixture of water vapor and the volatile material is condensed, two layers are formed. The top layer, above the water, is an oily liquid, which is the turpentine. What remains in the distilling flask is rosin. In this country 300,000 barrels of turpentine are processed every year (with 50 gallons in each barrel).

The same process is used in the preparation of oil of peppermint. In Michigan, Indiana, Oregon, and Washington, 1.5 million pounds a year are produced, largely for chewing gum flavoring. In addition, huge quantities are imported from Japan to satisfy the demands of the flavor industry for candy, dental cream, ice cream, and numerous other products.

The public demand for these products has established an essential oil industry with a yearly turnover of an estimated $50,000,000. Far greater, however, is the turnover of the finished products that go to the consumer. Most of these finished goods, such as perfumes, require only a small amount of the oils, and this business runs into many billions per year.

The modern perfumer draws on thousands of odoriferous compounds to compose perfumes and flavors. The walls of his studio are lined with shelves filled with bottles of natural oils, individual fractions of the oils, and synthetics. None of the individual compounds would be satisfactory as a perfume, and it requires a great deal of skill and good taste to blend these so that they become acceptable.

Stimulated by the desire of the perfume and flavor industry to substitute synthetic odors for the natural ones, considerable work has been done on analysis of natural products, and the establishment of the correct chemical structure of the individual pure components. Only 200 years ago a PhD candidate at a university in Jena, Germany, could successfully defend the thesis that the ingredients of the distilled oils consisted of sulphur or phlogiston, earth, and salt. Now it is possible to indicate the exact structure of most of the molecular species of distilled oils, and synthetic methods allow the duplication in the laboratory of most of these molecules.

The terpenes — many and varied

The hundreds of pure chemical compounds isolated from oils form a heterogeneous lot from a chemical point of view, and we find among them hydrocarbons, alcohols, aldehydes, acids, esters, open-chain and cyclic compounds. Biochemically, however, most of them are associated in some way with fundamental life processes. Normal heptane from the turpentine of *Pinus jeffreyi* as well as decyl aldehyde from orange oil is linked to fat metabolism. The odoriferous indole produced during the evening by the night blooming jasmine is related to the amino acid metabolisms of all organisms.

By far the most frequent and diverse group of compounds from oils are the terpenes, named after their first isolation from turpentine. The odor from the eucalyptus leaf is due to a typical representative of this group. The cough-drop-smelling material is cineol, while the lemon type contains a large percentage of citronellal. Numerous members of this group are found in herb gardens and among many desert plants such as sage.

Interesting terpenes with strong pharmacological action are found in trees growing in southern California canyons. Anyone who has hiked through Monrovia Canyon, or climbed up to Sturtevant Falls, has rested in the shade of some large trees which spread a peculiar aromatic odor. This odor comes from the leaves of the California bay tree, *Umbellularia Californica*. In small amounts the odor is rather pleasant. Try, however, to inhale deeply the odors of a crumpled leaf and you will experience, for a second or so, a bursting headache, caused by the inhibitory action of one of the components of the volatile oil on the vagus of the heart, with a resulting temporary increase in blood pressure.

For the isolation of the compound the leaves are distilled with steam, and, after fractionation of the volatile oil, several pure compounds are obtained.

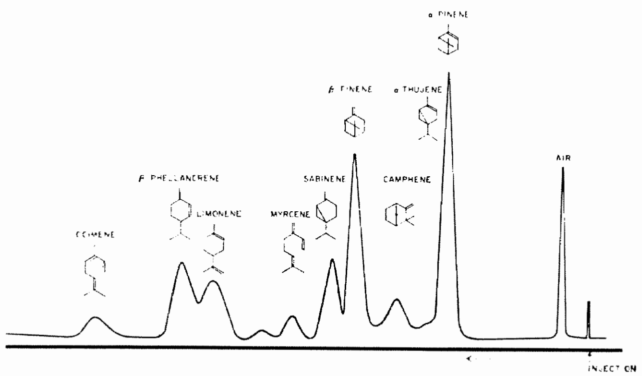
Umbellulone, the blood-pressure-raising substance, is apparently the major component and is typical for this oil. The other components occurring in small quantities in this oil are major products in others. For example, safrole is the major flavor compound of the oil of sassafras, and consequently of root beer. (It has been coming in for some unfavorable publicity lately, since some attribute carcinogenic properties to this compound.) Eugenol is typical for oil of cloves, cineol is typical for eucalyptus oil, and pinene is the main ingredient of oil of turpentine.

Duplicating natural products

Perfume and flavor industries have for many years tried to make a complete analysis of essential oils with the intention of duplicating natural products. Only in recent years have the main difficulties towards this goal been overcome. Through the application of gas chromatography — aided by spectroscopic methods — tremendous progress has been made in the isolation and identification of oil compounds. This revolution is well illustrated by comparing present day analytical results with those obtained only a dozen years ago.

During the war years, an interest developed in the product of home grown rubber. One of the best sources was a desert shrub, *Parthenium argentatum*, commonly called guayule. This shrub is a most efficient rubber manufacturing plant and strains have been developed which contain up to 16 percent rubber. In addition, it contains ½ percent of volatile products essentially similar to ordinary turpentine. The presence of alpha-pinene, beta-pinene, limonene, and a sesquiterpene alcohol, was established. This research took several months and a hundred pounds of leaves, which were carefully fractionated.

The new separation techniques are essentially based on difference in affinity. The gas mixture to be analyzed is pressed through a glass tube packed with a solid inert material coated with a solvent such as diethylene glycol. The high-boiling compounds with greater affinity to the solvent will move more slowly through the column than the more volatile components, and will separate in distinct fractions. With a sensitive detector, the organic materials which come through are measured and nicely separated peaks appear in the recorder of the gas chromatograph.



Chromatogram showing nine different pure compounds was produced in one day, with less than an ounce of leaves from the rubber-producing plant, guayule.

In a day's work the chromatogram shown above was produced, showing nine distinct peaks, each indicating a different pure compound. Infrared spectra of these fractions showed that we were dealing with nine terpenes. This identification was accomplished by using less than an ounce of leaves, in a fraction of the time needed for the classical procedures. In addition to confirming the presence of the previously found terpenes, six new components were found and their identity established.

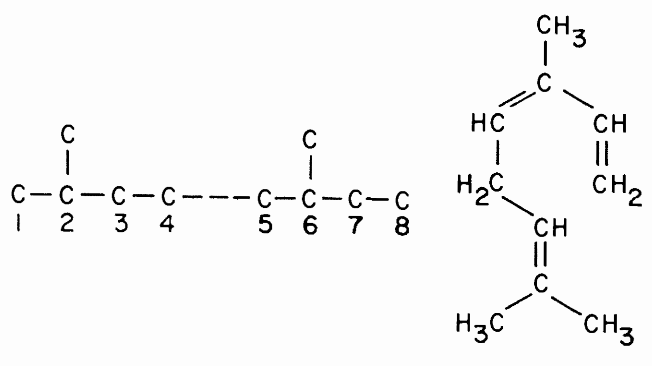
A look at the structures of the terpenes isolated from the guayule oil shows a common characteristic. They are all built of a chain of eight carbon atoms which has two methyl groups. This branched chain of carbon atoms is typical for the whole terpene group and can be constructed of two isopentane units, as shown at the right. All the other terpenes present in volatile oils can be constructed from this chain by connecting different carbon atoms and forming cyclic structures. For example, from plants and animals more complicated related structures containing many multiples of 5-carbon atoms have been isolated. Among these we find saponins, steroids, plant pigments, and rubber.

The recurrence of the isopentane unit in all these compounds has led in the past to much speculation about unit origin in plants or animals. Only in the last few years, through the work of many investigators in different countries, have we reached a better understanding of the biochemical processes in terpene formation. A key role in these syntheses is played by a 2-carbon unit – the acetate group. Through a coupling of three of these units with loss of one carbon atom the fundamental unit of 5-carbon atoms is formed. Two of these units in the form of their phosphate esters combine to form the terpenes present in the oils. When more of these units are coupled higher terpenes are formed, and this coupling culminates in the formation of rubber, which has several hundred of the isopentane building blocks.

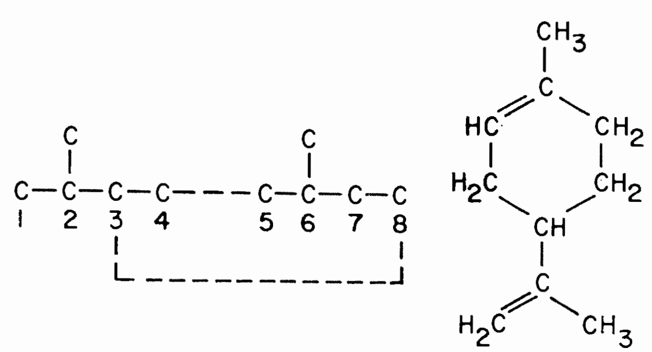
Although, in the last few years, there has been tremendous progress in the knowledge of the nature of oil components, and in the biochemistry of their formation, much remains to be done. The improved analytical techniques allow us, for the first time, to make complete analyses of food flavors. This is of great importance to the food industry, which turns more and more to drastic processing of food, where often the desirable flavors are lost. An exact knowledge of these lost flavors becomes of decisive importance in the reconstitution of foods so that they regain most of the original quality.

Then there is the problem of what function these oils have in plants. Many theories have been proposed. All components of the oils are connected with major metabolic processes and it is possible that in many cases the oils could be byproducts in the numerous reactions carried out by the plant. Some of these products could serve a useful function and may, for example, serve as an attraction for insects, while others may act as repellants. We know that, especially among the higher terpenes, we find substances of great importance for the animal world as well as for the plant itself, such as hormones and vitamins. In general, however, we are completely in the dark about their function.

Finally we have to look into the genetic aspects – and into the enzymatic reactions which lead to the formation of hundreds of different complicated organic structures. The study of essential oils has had a most exciting past and is bound to hold many surprises in the future.



OCIMENE



LIMONENE

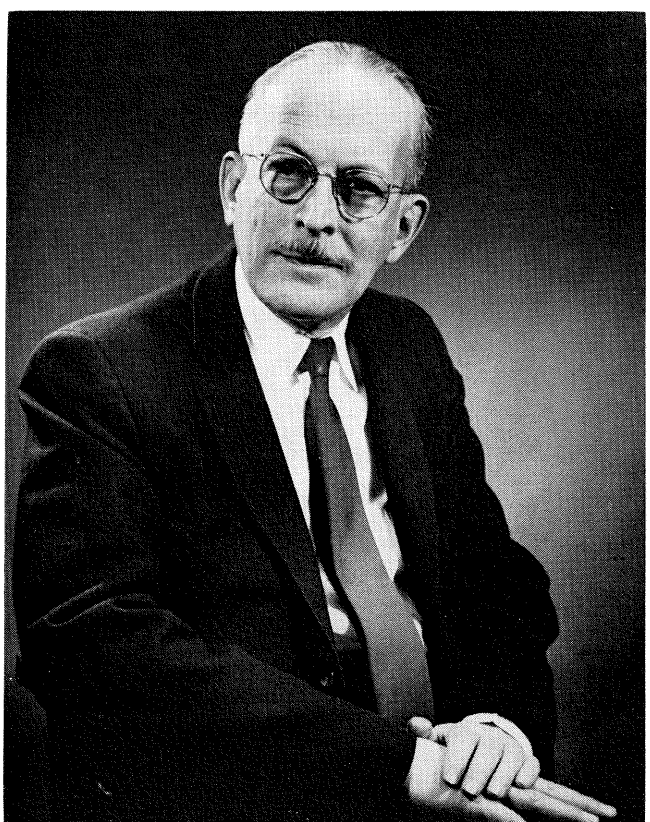
The structures of ocimene and limonene, showing their formation from two isopentane units.

The Month at Caltech

Frank Press, director of the Seismological Laboratory.

Scientist of the Year

Frank Press, director of Caltech's Seismological Laboratory, was named scientist of the year this month by the California Museum of Science and Industry and its educational affiliate, the California Museum Foundation. Dr. Press received the award of $5,000 for proving that the earth is thrown into free oscillations and actually rings like a deep-toned bell for from one to two weeks after an earthquake or other shock. The award was presented by Dr. Glenn T. Seaborg, chairman of the Atomic Energy Commission and chief of the judges in the science selection, at a banquet at the Beverly Hilton Hotel on May 11.



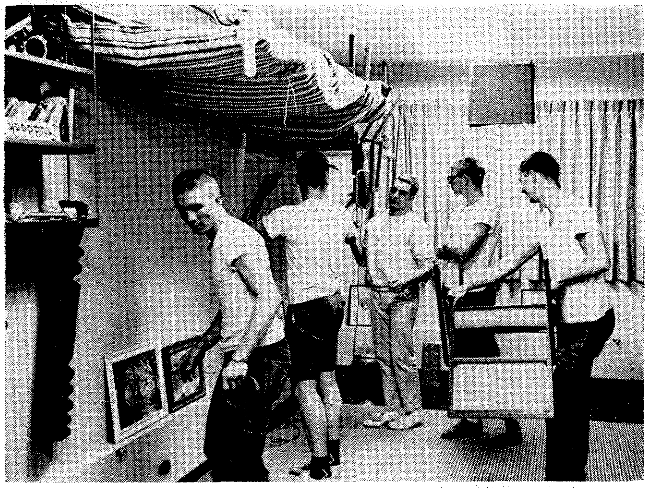
Richard M. Badger, professor of chemistry.

American Academy of Arts and Sciences

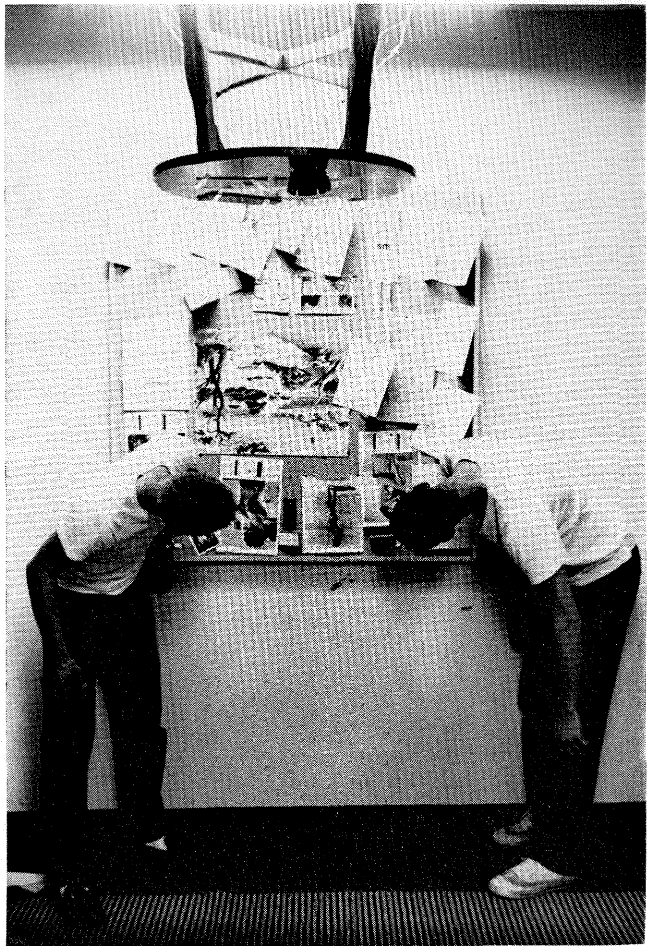
Richard M. Badger, professor of chemistry, has been elected a Fellow of the American Academy of Arts and Sciences. Also this month Dr. Badger was named recipient of the Manufacturing Chemists' Association Medal and Citation for his superior work as a teacher in the field of chemistry. This, the highest honor in the education field which the Association can bestow, consists of a medal, a citation, and $1,000. It is given annually to six chemistry teachers, chosen for outstanding success in "awakening in students a genuine interest in chemistry." Presentation of the award will be made at the annual meeting of the Association in White Sulphur Springs, West Virginia, on June 8.

Dr. Badger has taught undergraduates at Caltech for 32 years. A Caltech graduate himself (1921), he received his PhD here in 1924, then spent four years on the staff as a research fellow. After a year at Goettingen and Bonn, Germany, as an International Research Fellow, he returned to Caltech in 1929.

Dr. Badger is currently doing research on the structure of molecules by infrared spectroscopy at Caltech on a Guggenheim Fellowship.



SENIOR DITCH DAY — *It's that time of year again. Caltech seniors took a day off to go to the beach this month, and Caltech juniors, sophomores and freshmen spent the whole long day redecorating the seniors' rooms.*



Birthday Celebration

Theodore von Karman, professor of aeronautics, emeritus, and director of NATO's Advisory Group for Aeronautical Research and Development, was honored on his 80th birthday on May 11 at an all-day celebration at the Park-Sheraton Hotel in Washington, D.C., attended by representatives of scientific and military organizations in America and Europe. Joseph V. Charyk, undersecretary of the Air Force, was the speaker at an evening banquet, and Edward Teller, director of the Radiation Laboratory of the University of California, was toastmaster. Dr. von Karman was director of Caltech's Guggenheim Aeronautics Laboratory from 1930 to 1949.

Frontiers in Science

Frontiers in Science, the book made up of articles from *Engineering and Science*, has just been selected by the American Booksellers Association as one of the 200 outstanding books published over the past four years. It will be presented to President Kennedy during the ABA Convention Week in June, and will remain in the White House library for the Chief Executive's family and guests.

Royalties of over $21,000, received from sales of *Frontiers in Science* since it was published in 1958, have gone to Caltech's Faculty Salary Fund.

1961 Swimming Championships

Climaxed by a record-breaking effort in the 400-yard Freestyle Relay, the Caltech varsity swimming team swept to its third consecutive Conference swimming championship on Friday, May 5, at the Alumni Pool. The relay team members – Larry Daubek, Gary Mitchell, Gary Tibbetts and Bruce Chesebro – swam to a time of 3:33.9 compared to second-place Occidental's 3:34.1.

Caltech first places were scored by Gary Turner, a junior, in the 200 Individual Medley and 200 Backstroke; Pete Mayer, a senior, in the 200 Breast Stroke; and by the 400 Medley Relay team of Gary Turner, Alan Huber, Bill Howard, and Gary Mitchell.

Gary Tibbetts, a senior, established new Caltech records in two events, though winning neither. His time of 2:12.5 in the 220 Freestyle was good for third, and his 4:49.0 was good for second in the 440 Freestyle. New Conference records were established by the winners in both events.

Bruce Chesebro, a sophomore, placed second in the 50 and 100 Freestyle events. His times of 23.7 in the 50 and 53.6 in the 100 established new Caltech varsity records.

The Caltech victory was very much a team effort, as points were scored in every event, and in almost every case Tech men turned in their best performances of the year. The final team scores were Caltech – 115, Occidental – 68, Redlands – 56, Claremont-Harvey Mudd – 20, and Whittier – 7. Pomona did not enter the meet this year.

Caltech finished third in the frosh division behind Occidental and Claremont-Harvey Mudd. Dave Seib established new Caltech school records of 2:20.9 in the 220 Freestyle and 5:11.3 in the 440 Freestyle.

Albert R. Hibbs, director of the Division of Space Sciences at Caltech's Jet Propulsion Laboratory.

by Albert R. Hibbs

The National Program for Lunar and Planetary Exploration

The Jet Propulsion Laboratory of the California Institute of Technology was established more than twenty years ago to undertake research and development of guided missiles. Until 1958, the end products of these activities were military weapons systems. For example, the Corporal — the nation's first operational guided missile — and the Sergeant — now entering operational status as a second-generation successor to the Corporal — were the products of research and development efforts of JPL. In the pursuit of its objectives, the Laboratory was responsible for numerous fundamental developments in rocketry, guidance, communication, and instrumentation.

These skills, which the Laboratory had developed as the founder of American guided missile technology, were used in the design and construction of this country's first successful artificial satellite, Explorer I. At the time of launching of Explorer I, on January 31, 1958, the Laboratory was under contract to the United States Army, and it joined with its companion organization, the Army Ballistic Missile Agency (ABMA), under the technical leadership of Dr. Wernher von Braun, in the launching of this satellite.

In addition to a series of successful launchings of artificial satellites, JPL and ABMA launched two probes intended for lunar exploration, Pioneer III and IV. Neither of these came sufficiently close to the moon to merit the label of lunar probe; nevertheless, Pioneer IV successfully escaped from the gravitational field of the earth to take up its independent orbit around the sun as this country's first artificial planet.

This successful launching occurred in March of 1959, three months after the Laboratory had been transferred from the direction of the United States Army to the direction of the National Aeronautics and Space Administration (NASA). For more than two years, the Jet Propulsion Laboratory has been one of the three space flight centers of the National Aeronautics and Space Administration.

The successful team which launched the Explorers and the first successful Pioneer has been kept intact. Dr. Wernher von Braun's group at Huntsville, Alabama, also has been transferred to the auspices of NASA and named the George C. Marshall Space Flight Center. The third center has been organized by NASA in Greenbelt, Maryland, under the name of the Goddard Space Flight Center.

The NASA has assigned to each of its three space flight centers their particular roles in the space flight program. Goddard Space Flight Center is constructing payloads for the earth-satellite and sounding-rocket program. The Marshall Space Flight Center in Huntsville, Alabama, is developing and operating the launching rockets. The Jet Propulsion Laboratory in Pasadena is developing the spacecraft for lunar and planetary exploration.

The lunar program is characterized by a steady increase in the complexity of exploring spacecraft. The program begins in 1961 with spacecraft development flights and continues in 1962 with "rough-landing" missions. Next, lunar orbiters, capable of photographing the moon from a few hundred kilometers above it, and lunar soft-landers, capable of exploring their immediate environs, are scheduled in the period from 1963 to 1965.

In the second half of the decade, more complicated and larger lunar vehicles are employed. These vehicles are capable of returning samples of lunar material to the earth and roving over the surface to extend the exploration program to a much more diversified type of lunar material and surface.

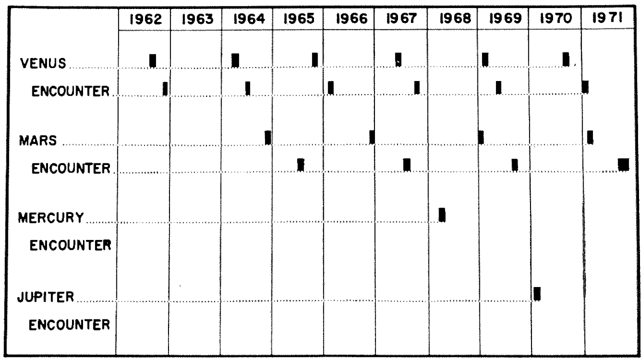
The flight schedules to the planets are limited by the motions of the planets in their orbits. The planetary program will begin in 1962 with a Venus fly-by passing close enough to the planet to obtain better resolution in planetary measurements than could be obtained either from the earth or from an earth satellite in this same time period. The second flight, later in 1962, will gather only interplanetary data. Similar flights will be made past Venus in 1964 and possibly in 1965.

In 1963, a Mars spacecraft will be flight-tested and in 1964 will be flown on a mission to observe Mars.

JPL's Lunar Program

	61	62	63	64	65	66	67	68	69	70
SPACECRAFT DEVELOPMENT	2									
RANGER ROUGH LANDING		3								
CENTAUR SOFT LANDING			2	2	3					
CENTAUR LUNAR ORBITERS				1	1					
SATURN SOFT LANDINGS							2	2	2	3

Flight Schedules to the Planets



Scientific-Experiment Plan: Ranger 1 and 2

Experiment	*Sponsoring agency/Experimenters*
Triple-coincidence telescopes	University of Chicago C. Y. Fan, P. Meyer, and J. A. Simpson
Integrating ionization chamber	Caltech and JPL H. V. Neher and H. R. Anderson
Medium-energy particle detectors (a) Geiger tubes and CdS detectors	(a) State University of Iowa J. A. Van Allen (b) University of Chicago C. Y. Fan, P. Meyer, and J. A. Simpson
Electrostatic analyzers	JPL/M. Neugebauer and C. W. Snyder
Magnetometer	NASA Goddard Space Flight Center J. P. Heppner
Lyman-Alpha telescope	Naval Research Laboratory and JPL T. A. Chubb and R. W. Kreplin
Cosmic-dust detectors	NASA Goddard Space Flight Center W. M. Alexander

Scientific-Experiment Plan: Ranger 3, 4, 5

Experiments	*Instruments and measurements*	*Cognizant agency and scientist*
Capsule: Seismology	seismometer capsule temperature measurement	Caltech/Columbia U. F. Press/M. Ewing
Bus: Photography of small lunar area	vidicon television	JPL/E. F. Dobies
gamma-ray spectroscopy	gamma-ray spectrometer	U of Calif./LASL/JPL J. R. Arnold/M. A. Van Dilla E. C. Anderson/A. Metzger

Availability of the Saturn booster in the second half of the decade will permit experiments with spacecraft put in orbit around the target planets and landed on the surface of Mars, and possibly on Venus, if continued temperature measurements indicate that this is practical.

The increased capability of Saturn vehicles will provide spacecraft flexibility in the exploitation of new discoveries and will allow such special missions as fly-bys of Mercury and Jupiter and a flight considerably out of the plane of the ecliptic to be flown near the end of the decade.

Only the very earliest spacecraft involved in the lunar and planetary programs can be described here since only for these is sufficient design detail available to make such a description valuable.

Two vehicles, Ranger 1 and 2, will be launched during the last half of 1961 to begin the interplanetary exploration program. The trajectories for these two spacecraft, and the trajectories for Ranger 3, 4, and 5, are shown above.

Ranger 1 and 2 will be sent on a long elliptical trajectory whose apogee is approximately one million kilometers from the earth, which means that they will be launched with a speed only slightly less than escape speed. They will spend about one or two months measuring the characteristics of space at the order of several hundred thousand to a million kilometers from the earth.

Ranger 3, 4, and 5 will be sent on trajectories toward the moon and will carry with them a capsule containing a seismometer. This capsule will be detached from the main bus of the spacecraft, slowed by a retrorocket, and landed on the surface at a speed of a few hundred miles an hour.

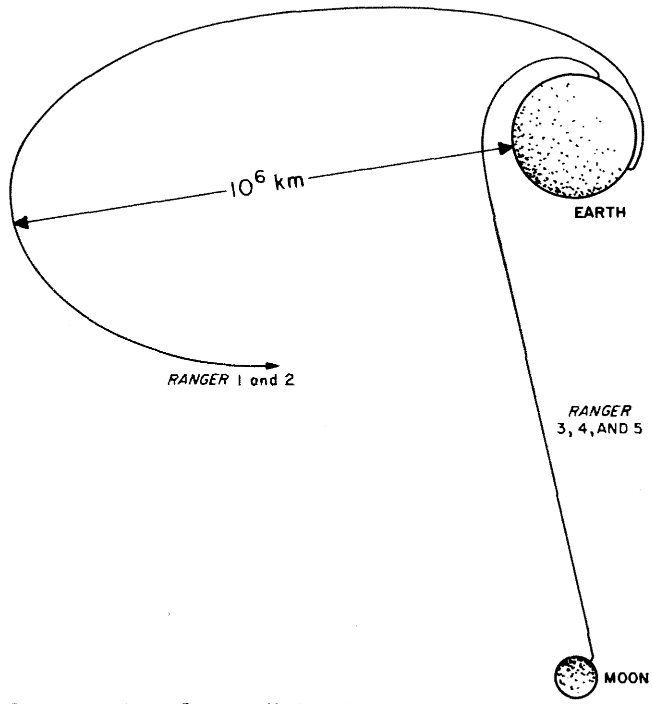
Most of the scientific experiments which will be carried out by the first two Ranger spacecraft will be directed toward the objective of measuring interplanetary fields and charged particles. There are two exceptions to this category; namely, a measurement of density of interplanetary dust, and an observation of the neutral hydrogen geocorona.

The charged-particle measurements will be carried out by instruments covering a range of energies. At the lowest energy range, there are electrostatic analyzers capable of examining the spectrum of protons from 0 to 5000 electron volts and the spectrum of electrons up to a few hundred electron volts. These analyzers will thus be the first ones flown which extend their measurements into this very low region, characteristic of the hypothesized solar wind. Medium-range particles will be detected by a group of counters relying both on the solid-state property of semi-conductors and on traditional geiger tubes. Ionization chambers such as those flown on balloons in the earth's atmosphere, and triple-coincidence telescopes, such as those which were used on Pioneer V, will complete the charged-particle measurements by covering the highest energy range in the neighborhood of 10 to 100 mev for protons.

Closely associated with the behavior of charged particles is, of course, the behavior of the interplanetary and magnetic field. This will be measured with a rubidium vapor magnetometer.

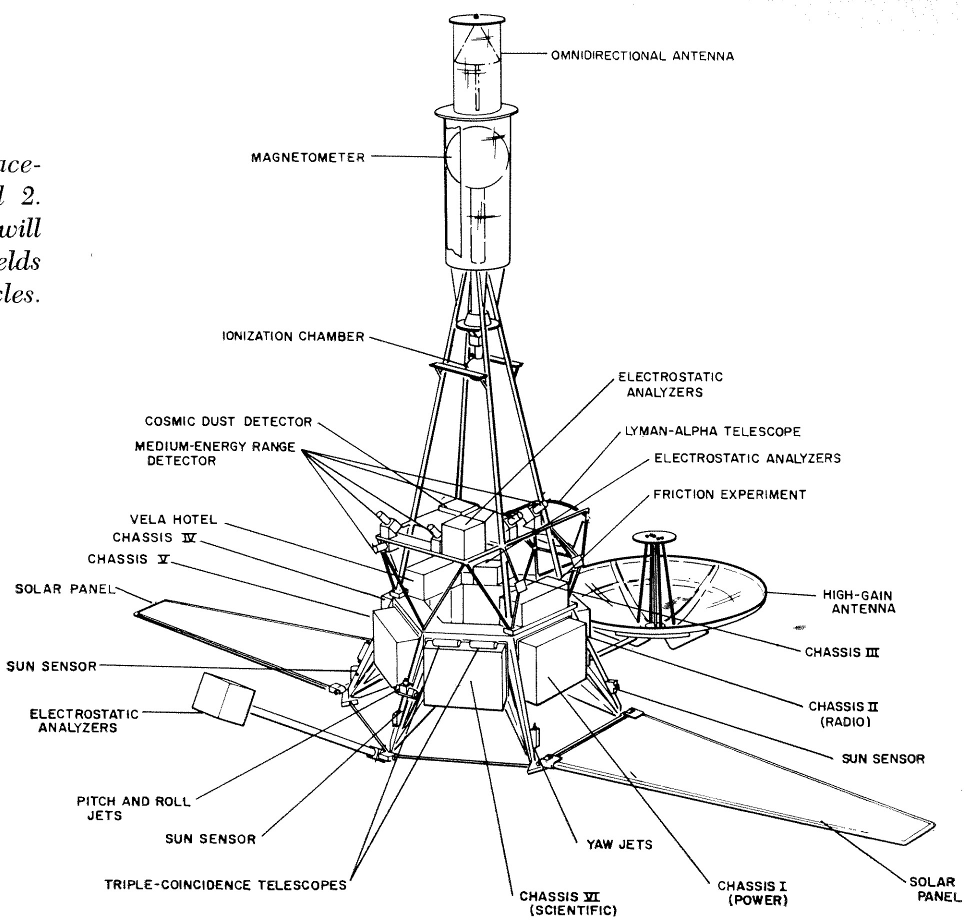
The neutral hydrogen cloud around the earth will be observed by a scanning telescope which detects scattered radiation of the Lyman-alpha frequency. As the spacecraft recedes from the earth, this telescope will repeatedly scan the vicinity of the earth, including in its successive pictures a larger and larger field of view.

The micrometeorite detectors on the Ranger will give information on both the energy and momentum of the particles striking it.



Rangers 1 and 2 will hurtle to approximately one million kilometers from the earth to explore interplanetary space. Rangers 3, 4 and 5 take a path to the moon to drop seismometers on its surface.

The model of the spacecraft for Rangers 1 and 2. These probes will measure interplanetary fields and charged particles.



The spacecraft for Ranger 1 and 2 (above) has the rubidium vapor magnetometer located near the front end, where it is as far removed as possible from those parts of the spacecraft which may introduce a spurious magnetic field. The ionization chamber is below it, located in a position where it will be shielded as little as possible by the structure of the spacecraft. The six electrostatic analyzers are positioned so that they can see freely along opposite directions of each of three coordinate axes.

The spacecraft itself is powered by solar panels which operate after the attitude-control system has successfully aimed the spacecraft directly at the sun. The attitude-control system will thereafter maintain this aiming direction throughout the lifetime of the experiment. The directional parabolic antenna will be aimed at the earth with the same attitude-control system by means of rolling the spacecraft around its longitudinal axis after the sun direction has been fixed. In this way, and by hinging the antenna out from the spacecraft to the appropriate angle, the antenna can be made to point at the earth.

The Ranger 3, 4, and 5 spacecraft is similar in many ways to that used for Ranger 1 and 2. However, the superstructure containing the scientific instruments has been replaced by a superstructure supporting an omnidirectional antenna and surrounding the lunar capsule which together with its retromotor is being developed by the Aeronutronic Corporation under sub-contract to the Laboratory. This spacecraft is also powered by solar panels and communicates with the earth by means of a directional parabolic antenna.

As the spacecraft approaches the moon, a succession of photographs will be taken by a vidicon camera which is aided toward the lunar surface. The vidicon tube will employ a 200-line scan, and the optics will be such as to take a picture measuring approximately 40 kilometers on a side at the initiation of the picture-taking sequence and decreasing steadily to 600 meters on a side for the last picture expected to be successfully recovered from the data.

While the vidicon is in operation, a gamma-ray spectrometer, positioned far from the spacecraft so as to avoid the effect of secondaries, will measure the ambient radioactivity in the region of the spectral line associated with the decay of potassium 40. This experiment has been so designed that, even if the moon is composed of material as low in natural radioactivity as the chondritic meteorites, the detector will observe the lunar potassium 40 gamma rays above the background expected from interplanetary and cosmic-ray sources.

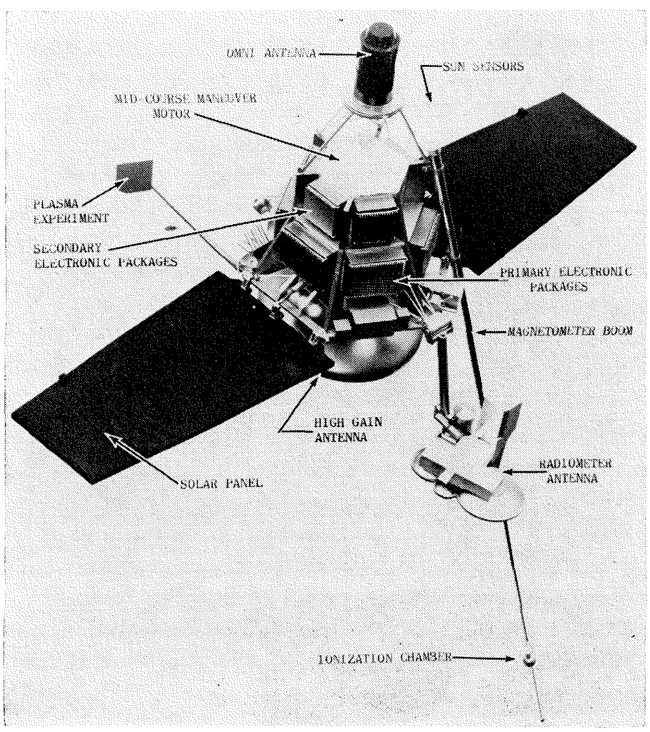
Approximately 30 kilometers above the lunar surface, after the spacecraft has been properly positioned, the capsule, together with its retromotor, will be detached from the parent spacecraft.

The capsule is spun to maintain its aiming direction. Thereafter, the retrorocket is ignited, which slows down the capsule to a zero speed relative to the lunar surface at an altitude of about 400 meters. The capsule then falls freely from this altitude to impact with a speed of about 30 meters per second.

Variations in retromotor performance will, of course, result in a variation of landing speeds. The expected standard deviation of landing speeds is approximately 30 to 40 meters per second. The landing capsule and all of the instrumentation within it – that is, the seismometer, its amplifier, transmitter, and antenna, power supply, righting mechanism, temperature control device, zeroing motor, and automatic calibration device – have all been designed to withstand several thousand G's of impact acceleration.

The seismometer carried in the capsule of Ranger 3, 4, and 5 is designed to operate thereafter for a period of 30 to 60 days. Even if no internal seismic activity occurs on the moon, it is likely that the impact of meteorites on the moon will create sufficient seismic disturbances to be detected by this device.

Detailed lists of experiments for the first flights in the planetary exploration program have not all been fully formalized. However, committees of the National Academy of Sciences' Space Science Board, as well as groups of consultants working with NASA personnel to advise the Space Science Steering Committee of NASA Headquarters, have considered in some detail the most pressing problems of planetary science which should be investigated with our earliest probes. A listing of experiments for the first Venus flight, the Mariner A, is now available.



The Mariner A, designed to make the first exploratory flight to the near vicinity of Venus.

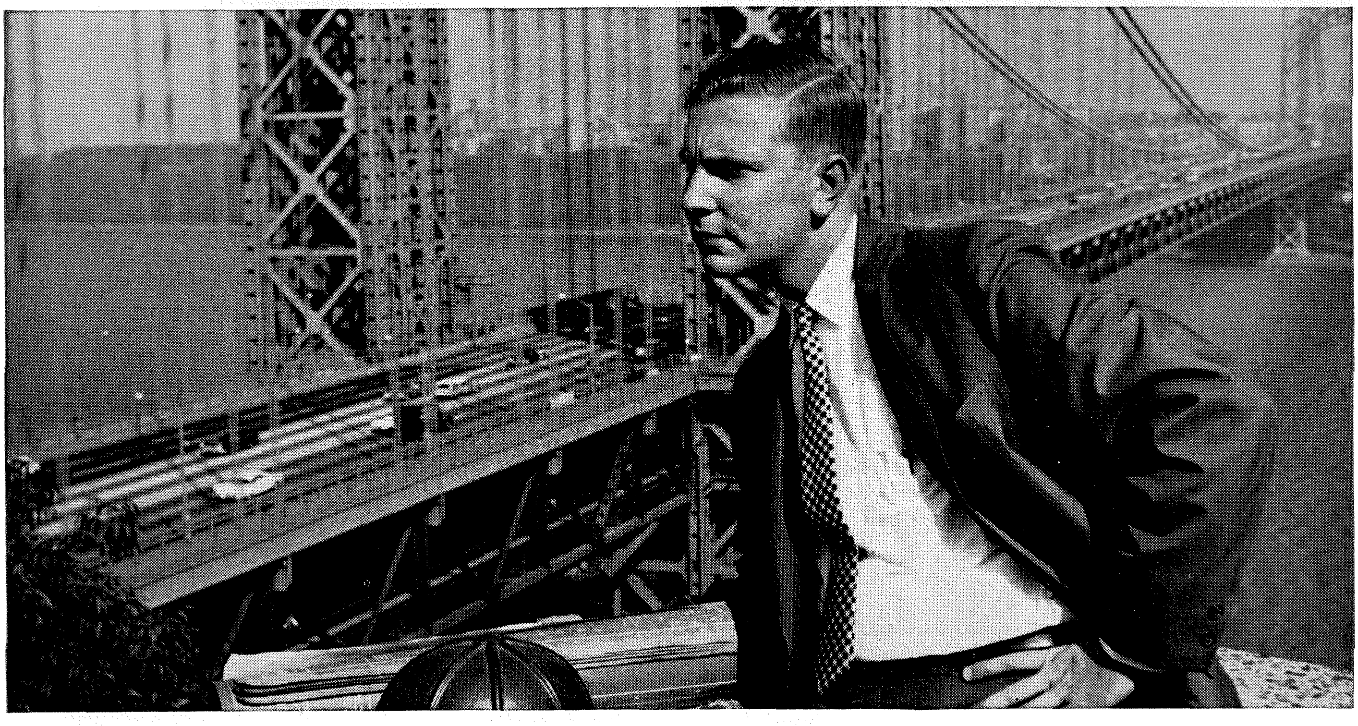
This spacecraft, designed to make a single pass in the near vicinity of Venus, will measure the temperature of the planet's surface, atmosphere, and ionosphere, evaluate the atmospheric composition of Venus; measure its magnetic field and the interplanetary magnetic field; and investigate the dust and charged-particle spectrum near Venus and in interplanetary space. Some of the instruments for these experiments will produce their results only during the period of the near-pass of the planet. Others will operate all the way from earth to Venus. The magnetometer, for example, is in this latter class and consequently must be designed to measure not only the fields of the order of a few gammas which are expected to occur in interplanetary space, but also fields of the order of a gauss which may occur in the close vicinity of Venus.

A spacecraft designed to pass close to the planet Mars would carry very nearly the same instruments; however, their order of priority would differ. A difference which obviously affects the selection of instruments is the fact that the surface of Venus is not available to optical instruments, as is the surface of Mars.

Although the selection of experiments to be carried out by the first spacecraft to be soft-landed on the moon is not final a number of design studies of possible instruments have been completed. These studies have considered such devices as drills, geophysical instrument packages for both down-hole and surface measurements, and instruments for chemical and mineralogic analysis of surface material and material recovered from the drill hole.

In addition to these devices, the spacecraft will contain several television cameras with the total capability of a complete panorama sweep of the vicinity of the spacecraft as well as close-up observation of the material in the immediate neighborhood of the spacecraft. This Surveyor spacecraft is now being developed by the Hughes Aircraft Corporation under a subcontract with JPL.

The instrumentation and the spacecraft described here will initiate this nation's program for the exploration of the moon and planets. The successful development of this exploration program will yield, for example, geophysical and geochemical information about the moon which will help us to understand not only the nature of our sister planet but perhaps also something of the origin of the solar system, since the moon may still retain on its surface the five-billion-year-old record of these early processes. It is possible that the biologic exploration of Mars may reveal extraterrestrial life forms. The chemical analysis of such life, developing in an ecology completely separate from the earth, may bring us closer to the understanding of the origin of life. But even the excitement inherent in such possibilities as these will undoubtedly be surpassed by the reality of the discoveries which lie before us.



THIS YOUNG ENGINEER IS ON THE ROAD TO MANAGEMENT

Dick Cotton knew he wanted to take the engineering route into management long before he joined New Jersey Bell Telephone Company. In fact it was his goal when he was working for his engineering degree at Rutgers.

When he graduated, he had his lines out to eleven other companies. He came to New Jersey Bell because: "I didn't feel I was just a number to these people. There was no doubt in my mind that this job would be the best for the long pull."

His first assignment was a tough one. A complex of major telephone cables lay in the path of the approach to the new traffic level of the George Washington Bridge on the Hudson. Dick's job was to find the most practical and economical way to reroute these cables, and at the same time to provide for future telephone growth in the area around the bridge approach.

Dick ironed that one out and got a crack at another tough job.

Next stop: New Jersey Bell Headquarters Engineering Staff, Special Studies Group. Here Dick was a member of a four-man team whose job was to find ways to eliminate some of the routine work of field engineers to give them "more time to think." Dick also helped plan and control a $100,000,000 annual telephone construction budget.

Presently, Dick is responsible for telephone equipment engineering projects in the Camden, New Jersey, area.

How does Dick look at it? "This is a growing business. I work with this growth every day. And growth means more room at the top. Of course, I don't figure I'll get there overnight—but on my jobs so far I've had a chance to take a good look at how this business is run. And I think the sky's the limit for a man who really wants to work for it."

If you're a guy who can tackle a tough job and deliver the goods—then you're the kind of man who should find out more about the Bell Companies. Visit your Placement Office for literature and additional information.

"Our number one aim is to have in all management jobs the most vital, intelligent, positive and imaginative men we can possibly find."

FREDERICK R. KAPPEL, *President*
American Telephone & Telegraph Co.

BELL TELEPHONE COMPANIES

Caltech Alumni Endowment Fund

The April issue of *Engineering and Science* carried a brief statement about our Alumni Fund and its new and important purpose, the raising of funds for unrestricted endowment.

How did the Alumni Fund Council decide upon this particular use for the Fund? Some weeks ago the Council invited representatives of Institute management to suggest Fund purposes. Previous decisions launched the gymnasium-swimming pool fund, the scholarship fund and the alumni phase of the Development Program. These purposes had basic common principles. They were all *timely* and the need was *urgent*. With these principles in mind the suggestion was made to concentrate alumni vitality on the securing of unrestricted endowment funds.

What about an Endowment Fund? Is it timely? Is it urgent? Consider these facts:

Just three years ago endowment income represented almost a third (32%) of the total current income for campus expenditures. In 1958-59 the figure had dropped to 28%. Last year it was down again to 25%.

Additions to endowment have always been dependent upon the bequests from the estates of individuals interested in Caltech. The Balches, the Eagles, the Robinsons, the Ricketts', the Flemings – all have given generously through their bequests. We cannot wait, however, for fortunes to be made and disbursed. But when "live" endowment additions are counted the amounts are discouraging – $37,720 in 1958-59; and $38,306 in 1959-60.

Our contributions to endowment can help the Institute in several ways. First, these contributions will produce unrestricted income. Second, the present level of endowment additions by live donors could well be *tripled* through thoughtful alumni giving. Third, alumni contributions will emphasize the importance of endowment gifts as a stable and secure method of financing the growth of the Institute.

There is a fourth point which also has appeal. As donors we will have the satisfaction of knowing that our contributions will produce annual income *forever*.

Institute management has pointed to the problem. We hope that you will feel as we do that it is now up to us to help see that it is solved.

– Howard B. Lewis, Jr. '48
Co-director, Alumni Fund

Caltech Varsity Game Scores

	Baseball			
April 19	Redlands	13	Caltech	4
April 26	Redlands	16	Caltech	4
April 28	Pasadena College	24	Caltech	7
May 3	Chapman	12	Caltech	7
May 6	Claremont-Harvey Mudd	11	Caltech	1
	Claremont-Harvey Mudd	14	Caltech	1
May 8	Azusa College	17	Caltech	10
May 10	Occidental	13	Caltech	2
	Tennis			
April 29	Caltech	7	Claremont-Harvey Mudd	2
May 2	Occidental	5	Caltech	4
May 6	Pomona	5	Caltech	4
	Swimming			
April 22	Caltech	57	UC Riverside	38
April 26	Caltech	65	Occidental	29
May 5	All-Conference Swimming Meet held at Caltech Alumni Pool			
	SCIAC Championship won by		Caltech	115
			Occidental	68
			Redlands	56
			Claremont-Harvey Mudd	20
			Whittier	7
	Track			
April 22	Redlands	103½	Caltech	23½
May 5	All-Conference Track Meet held at Occidental			
	SCIAC Championship won by		Occidental	111¼
			Redlands	55¼
			Whittier	28½
			Claremont-Harvey Mudd	14
			Pomona	11¼
			Caltech	4¾
	Golf			
April 21	Redlands	37	Caltech	17
April 28	Pomona	44	Caltech	10
May 3	Redlands	50	Caltech	4
May 5	Claremont-Harvey Mudd	38	Caltech	16
May 8	Whittier	36	Caltech	18

Personals

1925

Thomas P. Simpson, general manager of engineering and operations analysis at the Socony Mobil Oil Company, has retired after 35 years of service. He was one of the developers of the thermofor catalytic cracking process, which was vital in the manufacture of high-octane gasoline for the armed forces during World War II.

Tom joined the company as a chemical engineer and in 1933 he became process laboratories supervisor of the General Petroleum Corporation, a former West Coast affiliate. He was transferred to Socony Mobil in New York in 1935 as chief development engineer, became assistant director of research in 1944, and manager of research and development in 1947. He assumed his engineering and operations title in 1959.

1926

Sterling B. Hendricks, PhD, chief scientist at the Mineral Nutrition Laboratory for Pioneering Research in the Agricultural Research Service of the U.S. Department of Agriculture, is one of six career civil servants to be given the 1960-61 Rockefeller Public Service Award for distinguished achievement as an employee of the Federal government. The awards were presented in Washington last month. Each winner was given a $3,500 honorarium and the privilege of applying for an additional grant to permit time for lecturing, writing, research or some educational endeavor which would extend the benefit of his experience to others.

A federal career employee since 1928, Sterling has won many awards for his investigations into the genesis and nature of soils. He was educated at the University of Arkansas, the University of Iowa, and the Kansas State Agriculture College as well as Caltech.

1928

Sydney B. Ingram, PhD, director of technical employment at the Bell Telephone Laboratories, has been elected chairman of the EJC Engineering Manpower Commission for 1961. He has been with Bell since 1930 as electronic research engineer, director of education and research and industrial training.

1929

Anthony Larrecq is president of Power Generators, Inc., and Design Engineering, Inc. He is living in Yardley, Pa. The Larrecqs have three children; the eldest graduates from Vassar this year.

1931

Gen. Benjamin G. Holzman, MS '33, is commander of the Air Force Cambridge Research Laboratory, where some 650 research scientists are working in areas which range from satellite communications to Arctic investigations. The Holzmans and their 17-year-old daughter, Katherine, a senior at Concord-Carlisle Regional High School, live in Bedford, Mass.

1932

Patrick B. Lyons writes that "I'm currently checking on our Eastern branch as a member of the ten-week program for senior executives at MIT. I'm still with the Western Electric Company, and am an assistant works manager of the Columbia Works in Ohio where we make central office switchboards and associated apparatus, primarily for the Bell Telephone System."

1935

Charles F. Thomas is now manager of marketing and planning of RCA's major defense systems in New Jersey. He was formerly corporation director of military sales for the Lockheed Aircraft Corporation. Charles has two married daughters living in California, and a 14-year-old daughter and a 4-year-old son at home.

1936

E. V. Watts was named vice president of exploration and producing at the Mobil Oil Company in Houston, Texas. He has been with the company since 1936.

1938

Verner Schomaker, PhD, interim project director of Union Carbide's Research Institute in New York, has been named vice president of the American Crystallographic Association for 1961.

1939

L. G. Borgeson, MS '40, has been division vice president in charge of consumer products service of the RCA Service Company in New Jersey for the past two years. He has been with RCA since 1940.

Charles H. Townes, PhD, was appointed Provost of MIT last month. He will assume his new duties in the fall. He is now on leave from his post as professor of physics at Columbia University to serve as vice president and director of research for the Institute for Defense Analysis in Washington, D.C.

Rear Adm. Leonidas D. Coates, MS, is now Chief of Naval Research in Washington, D.C. He was formerly director of development planning in the Office of the Chief of Naval Operations.

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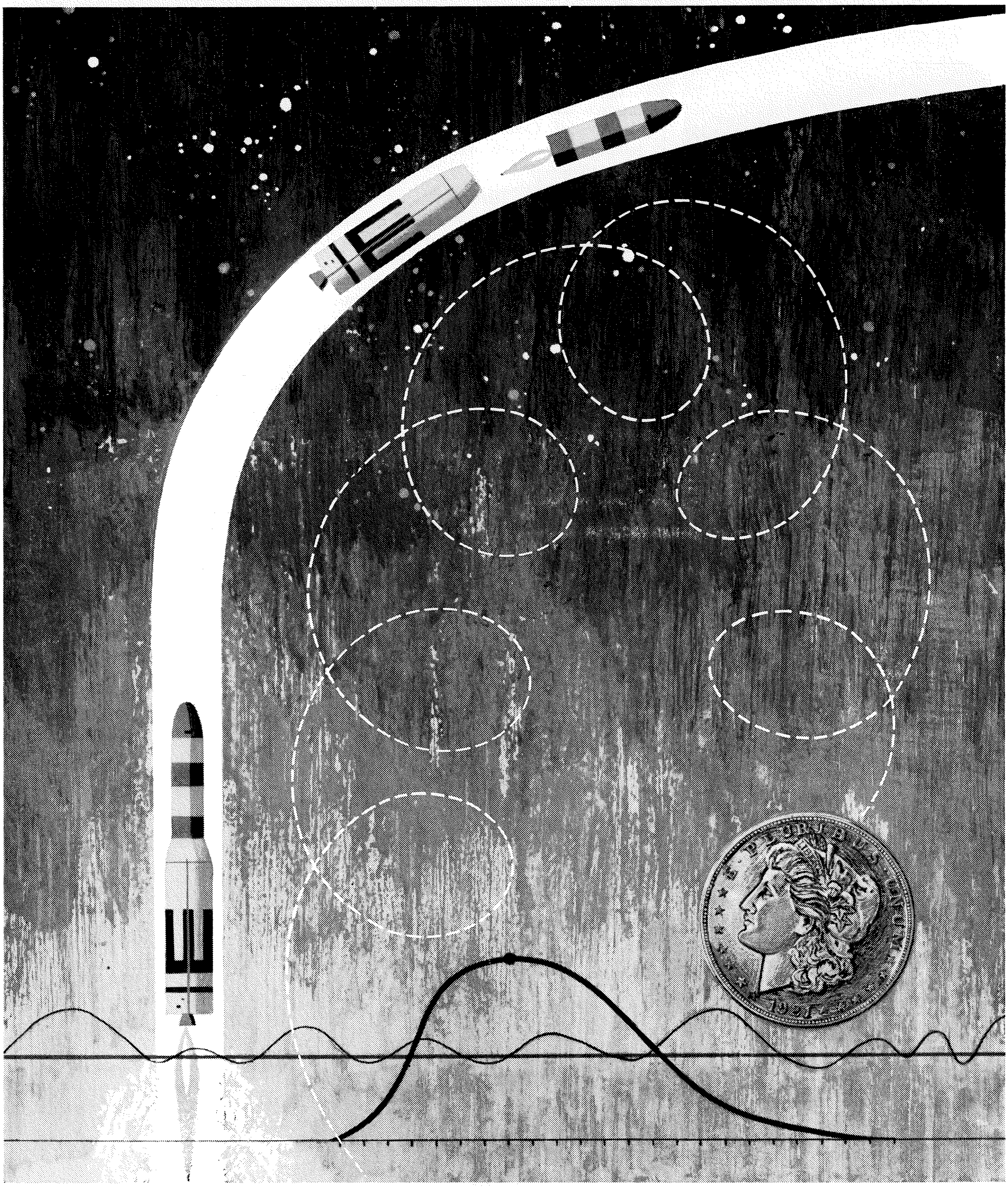

Personals . . . *continued*

1939

Lloyd R. Zumwalt, PhD, is now senior research advisor at the General Atomic Division of General Dynamics in La Jolla. He has been with the company since 1956.

1940

Frederick C. Brunner, MS '41, is head of all chemical engineering work at C. F. Braun & Company's new eastern office in Murray Hill, N.J. The office is currently engaged in the design of two plants – a polybutadiene plant in Kentucky, and a urea plant in Spain.

A. M. Zarem, MS, PhD '44, president of Electro-Optical Systems, Inc., in Pasadena, has been named a Fellow in the Institute of Radio Engineers. The honor was awarded at the group's annual banquet in New York City in March, and was given to Dr. Zarem for his contributions in the application of millimicrosecond electronic instrumentation techniques.

1946

L. Wayne Mullane, MS, AE '47, has been elected vice president of the Downey plant of Aerojet-General. He has been manager of the plant since 1959 when Aerojet-General acquired it from the Rheem Mfg. Company.

1948

Stuart Butler, vice president of the western division of the Fruin-Colnon Contracting Company, has been transferred to their Burlingame office. He was formerly in the company's division at Kirkwood, Mo.

1950

Marvin C. Brooks, PhD, was recently transferred from his position as department head of the U.S. Rubber Research Center in Wayne, N.J., to quality control manager of the main plant in Detroit.

Warren E. Krum writes that he's still making chicken feed (for chickens) at his Artesia and San Marcos plants.

1951

Steve Pardee, MS '52, writes that he left the Bell Laboratories in 1959 and is now working for the TRW Computers Company as manager of a study team that is assisting the research division of the FAA in carrying out real-time simulation studies of terminal area air traffic control systems. The work is being done at the Bureau of Research and Development Center near Atlantic City. The Pardees (including David, 4, and Stephanie, 2) have rented a house about a block from the ocean.

1952

Jose Luis Reissig, PhD, has spent the last six years in Europe (Scotland, Denmark, and France) doing research in genetics. He is finally back home in Buenos Aires, where he is now professor of genetics at the School of Sciences at the University of Buenos Aires. Jose has one daughter.

William A. Kemmel, Jr., MS '53, is now associated with the patent law firm of Miketta, Glenny and Poms. After he left Tech, Bill worked for the Goodyear Atomic Corporation and then served in the U.S. Army. For three years he worked as an examiner in the U.S. Patent Office while attending night law school at George Washington University. He passed the California bar examination shortly after that. Bill is married and has two children.

1955

Stephen F. Crumb, PhD, is now professor of electrical engineering at Arlington State College in Texas. From 1945 until he joined ASC, he worked for Convair at Fort Worth. His most recent position there was as assistant project engineer.

1957

W. H. Dietrich was released from service last August shortly after he had received his MS in industrial engineering at Ohio State University, and is now working as an industrial engineer at Norton Air Force Base in San Bernardino. Bill has a nine-month old son, David.

1959

Wilfried Stockmair, AE, writes from Germany that, "Having received my degree from Caltech in June, I returned to Germany where I received the degree of Diplom-Ingenieur in November. I am now employed at the German Research Council as a research assistant at Technische Hochschule Munchen in the Institute of Mechanics and Testing Materials."

Robert J. Kwik, MS, is now a student pastor at Princeton Seminary and is enjoying his studies in theology. Last year he worked part-time on magnet design at Princeton University's Forrestal Research Center with the BEV synchrotron.

1960

Richard E. Bradbury, MS, is a physicist in the spectroscopy department of the quantum electronics division at Electro-Optical Systems, Inc., in Pasadena. He was formerly a research assistant at JPL.

Carleton B. Moore, PhD, formerly assistant professor of chemistry at Wesleyan University in Middletown, Conn., has been appointed director of the Nininger meteorite laboratory at Arizona State University.

ANNUAL ALUMNI MEETING

June 7, 1961

Reunion of the Classes of
1906, 1911, 1916, 1921, 1926, 1931, 1936, 1941, 1946, 1951, 1956

A Special Talk to Caltech Alumni by
John L. Burns, President, Radio Corporation of America
and
Report to the Alumni by Lee A. DuBridge, President
California Institute of Technology

Cocktails at 6:00 – Dinner at 6:30

Rodger Young Auditorium
936 West Washington Blvd., Los Angeles

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Ralph W. Jones, '38

VICE-PRESIDENT
Holley B. Dickinson, '36

SECRETARY
Donald S. Clark, '29

TREASURER
John R. Fee, '51

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Claude B. Nolte, '37

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Secretary-Treasurer — Harry J. Moore, '48, 590 Madison Avenue

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

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Vice-President — G. Donald Meixner, Jr. '46, Dept. of Water Resources, State of California
Secretary-Treasurer — John Ritter '35, Division of Highways, State of California
Meetings: University Club, 1319 "K" Street
Luncheon first Friday of each month
Visiting alumni cordially invited—no reservation

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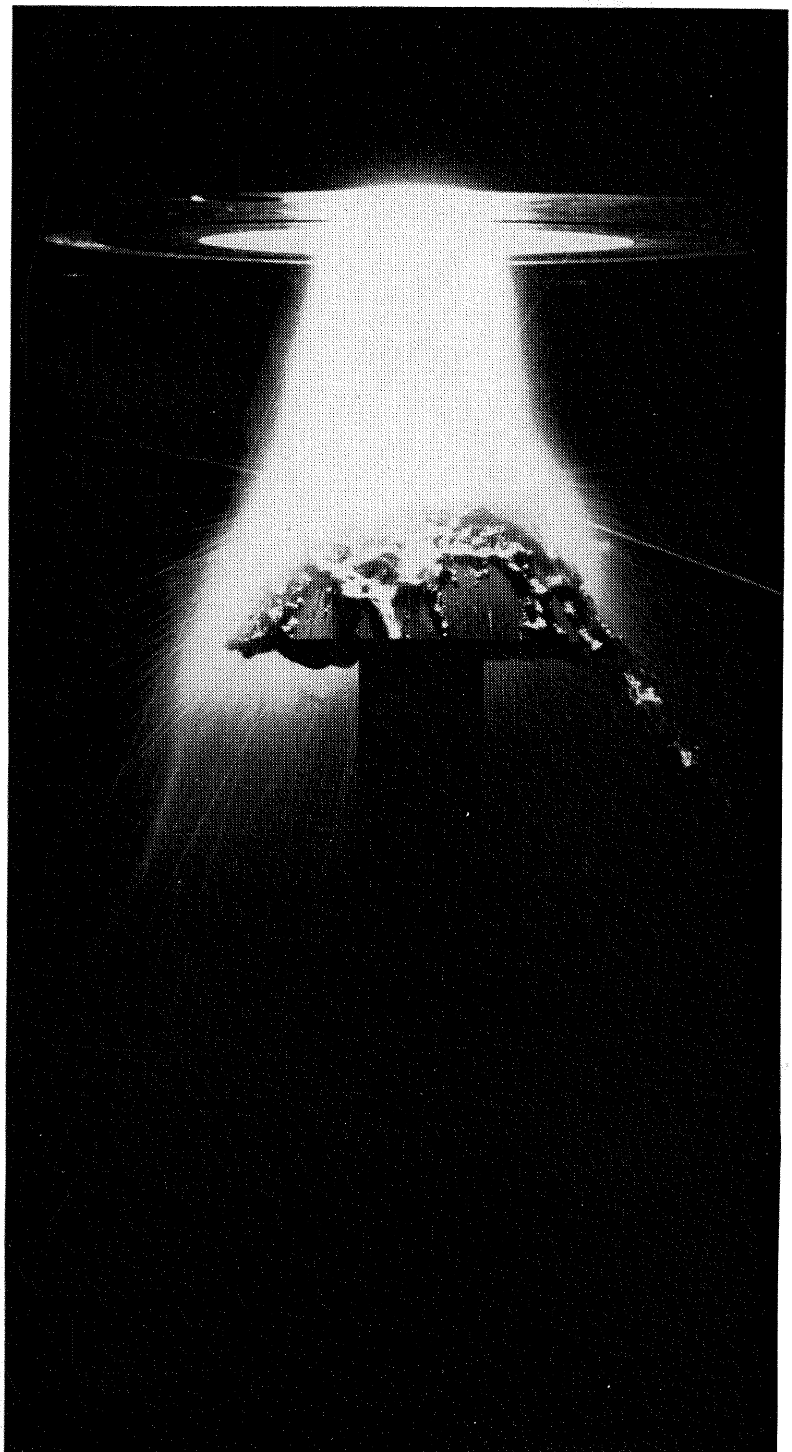
Secretary — Frank J. Dore, '45, Convair
Program Chairman — Herman S. Englander, '39, U.S. Navy Electronics Laboratory

If your sights are set on  research and development–



Jet heat blast of more than 15,000 degrees Fahrenheit flares over surface of an experimental nose cone shape in a physics laboratory of Avco Research and Advanced Development Division, Wilmington, Mass.

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