NOVEMBER 1965

ENGINEERING AND SCIENCE

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Ford Motor Company is:

challenge

Dale Anderson
B.A., Wittenberg University

At many companies the opportunity to work on challenging projects comes after many years of apprenticeship and a few grey hairs. Not so at Ford Motor Company where your twenties can be a stimulating period. There are opportunities to prove your worth early in your career. Dale Anderson's experience is a case in point.

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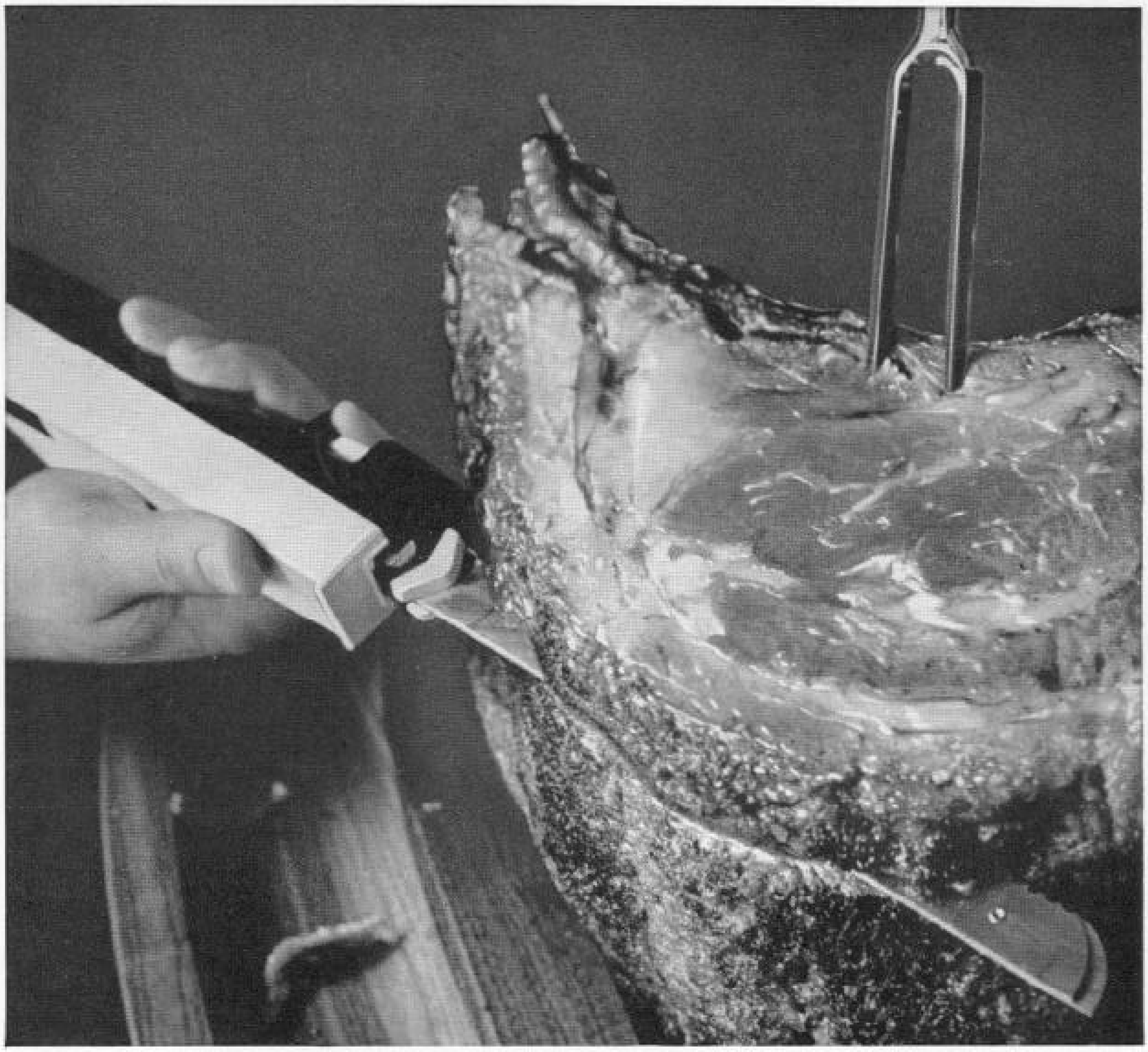

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On Our Cover

Carl Anderson, chairman of the division of physics, mathematics, and astronomy, and Nobel Prizewinner in physics in 1936, leads a rousing cheer for Caltech's newest Nobel Laureate, physicist Richard Feynman, who is swallowed up in the crowd of colleagues, students, and friends helping him celebrate. The place—the Physics Library on the Caltech campus. The time—October 21, 1965. More about that day, and about the man and his work—page 10.

Peter Lissaman,

assistant professor of aeronautics, provides an exciting glimpse into the future of air travel in "The Winds of Change in Aeronautics" on page 14, as he discusses the role of modern, subsonic aeronautics in the space age, and shows how new developments in the subsonic region could revolutionize human transportation. Work in this area, pioneered at Caltech in the 30s and 40s — but passed by as faster aircraft were built — has taken on new importance as it becomes apparent that ways will have to be found to get large, very fast aircraft on and off the ground safely and within reasonable runway lengths.

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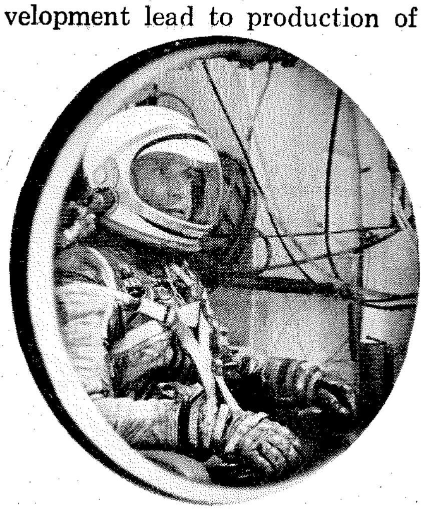

The product lines at AiResearch, Los Angeles Division, are environmental systems, flight information and controls systems, heat transfer systems, secondary power generator systems for missiles and space, electrical systems, and specialized industrial systems. In the Phoenix Division there are gas turbines for propulsion and secondary power, valves and control systems, air turbine starters and motors, solar and nuclear power systems.

In each category AiResearch employs three kinds of engineers.

Preliminary design engineers do the analytical and theoretical work, then write proposals.

Design engineers do the layouts; turn an idea into a product.

Developmental engineers are responsible for making hardware out of concepts.

Whichever field fits you best, we can guarantee you this: you can go as far and fast as your talents can carry you. You can make as much money as any engineer in a comparable spot – *anywhere.* And of course, at AiResearch, you'll get all the plus benefits a top company offers.

Our engineering staff is smaller than comparable companies. This spells opportunity. It gives a man who wants to make a mark plenty of elbow room to expand. And while he's doing it he's working with, and learning from, some of the real pros in the field.

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IDEA MAN

How thirty-six words Paid off to the Tune of Six Thousand Dollars!

No, he didn't dream up a better mousetrap. But he's the kind of person who probably could if he put his mind to it. As the old maxim implies, though, if you figure out a way to do *anything* worthwhile more efficiently, chances are you'll be rewarded. It was certainly true of this ingenious General Motors employe, who recently collected $6,000 for a valuable suggestion that took just thirty-six words to describe—more than $166.00 per word!

The GM Employe Suggestion Plan has paid out more than $70,000,000 and produced more than a million usable suggestions since its inception in 1942. It is worth noting that a great many awards go to conscientious employes who would have submitted their suggestions even if there had been no monetary reward involved.

Whatever their jobs, these are among the real stars of the General Motors team—people who are truly interested in finding ways to make products and processes safer, better and more efficient.

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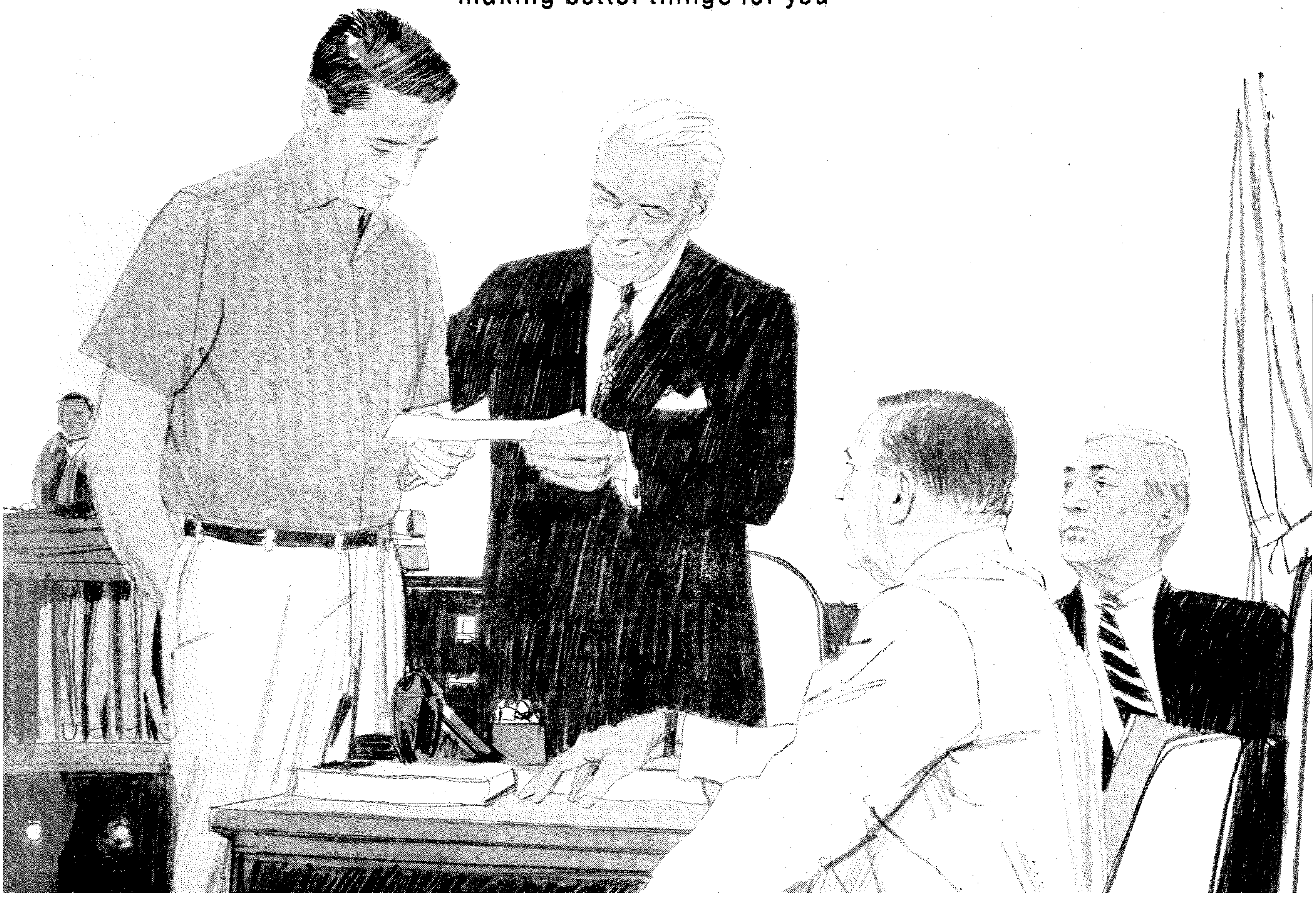


Books

Of Men and Galaxies
by Fred Hoyle
University of Washington Press $2.95

Galaxies, Nuclei, and Quasars
by Fred Hoyle
Harper & Row $3.95

Reviewed by Joel N. Franklin, professor of applied science

Fred Hoyle, visiting associate in physics at Caltech, is Plumian Professor of Astronomy and Experimental Philosophy at Cambridge. His *Of Men and Galaxies* is based on three lectures given at the University of Washington in 1964.

Part I, "Motives and Aims of the Scientist," is a galaxy of Hoylean opinions. Some samples:

Scientists are not responsible for weapons; society is to blame.

Everything radically new is produced in a democracy.

The physical sciences have been on the wane since 1925 because of the creation of the bad attitudes of big science.

BIG is BAD: Big buildings are bad; big budgets are bad; big administrative responsibility is bad.

Inefficiency in unimportant matters is necessary for efficiency in important matters.

No first-rate scientist is in government because, after six months away from science, no one can be a first-rate scientist.

Brilliant minds are always around, but great scientists will emerge only in the proper cultural milieu.

"An Astronomer's View of Life" talks about science: There is no sharp difference between living and non-living things. There are intelligent beings scattered throughout the universe. To reach them by space-travel is "not merely difficult but impossible." But to communicate with them is possible and is important. "What is needed (from these beings) are the big thoughts, not the daily baseball scores . . . an interchange of messages could influence the future development of human culture, and for this it is by no means necessary to gabble continuously across the interstellar spaces." There is a galactic telephone directory for intercommunicating intelligent beings. "My guess is that there might be a million or more subscribers to the galactic directory. Our problem is to get our name into that directory."

Of the three parts of the book, "Extrapolations into the Future" is the deepest and the most personal. "It is curious," writes Hoyle, "how much attention we all pay to the immediate future and how little to the more distant future." Since the decline of the small town and the rise of the megapolis, there has been a decreasing intimacy, an increasing aimlessness. As the isolation of the individual grows in ever larger and more affluent cities, the principal personal motive will be status seeking. As meaning ebbs, diversion will become essential; and the brightest possible future is foreseen for the entertainment industry. Unimportant problems, like domestic communism, are always more fun to argue about than important, tough problems, like overpopulation. Man is not in charge of his future. The most important factor in our environment is our state of mind. Scientists produce technology, but they can exercise no political control over it. The author makes ". . . a religious hypothesis – that the emergence of intelligent life is not a meaningless accident." The big ideas in the universe can and must be obtained by communication with extraterrestrial intelligent beings. We might learn from these beings "what policies lead to nuclear war and what policies avoid it."

Either you like opinion, or you don't. Professor Hoyle has had the courage to be subjective, speculative, sometimes superficial, sometimes profound, and always honest. This reviewer felt privileged to spend a few hours reading the inner thoughts of one of the world's distinguished minds.

The book *Galaxies, Nuclei, and Quasars* would have to be labeled "for astrophysical cosmologists only" if it were not laced with gossip, sentiment, and tales of scientific adventure. Gorgeously illustrated with photographic plates from the Mount Wilson and Palomar Observatories, packed with formulas, graphs and charts, the book would be hard to master in detail; but it can be skimmed pleasurably and informatively. Caltech readers will note frequent references to the names Bolton, Fowler, Greenstein, Matthews, Minkowski, Oke, Sandage, Schmidt, Fowler, Fowler, and again Fowler.

Chapter I, "Galaxies," states that the biggest problem in present-day astronomy is to understand why there are different kinds of galaxies and how galaxies originate. There is a discussion of the red shift and an exposition of some cosmology.

"Radio Sources" talks about radio astronomy. Immense, concentrated, fluctuating sources of energy have been discovered by radio reception. These energy sources, which are too large to be stars, too concentrated and fluctuating to be galaxies, have been named quasars. One observation in Australia was considered so important that "Hazard and Bolton carried duplicate records back to Sydney, on separate planes."

"X-Rays, Γ-Rays, and Cosmic Rays" contains this comment on our space program: "I find it ironic that doubts are being cast as to whether sums of the order of 100 million dollars can be afforded for the construction of new accelerators; ironic because sums of many *tens of billions* are being afforded to set a man afoot on the ruined slag heap we call the moon. This comparison, between what can be afforded and what cannot, shows the remarkable degree to which man's cortical activity is still dominated by his lower-brain centers. It is exactly because social decision-making is controlled almost entirely by the lower centers, while science and mathematics are controlled by the cortex, that the never-ending moan is raised that science is fast outstripping man's social sense."

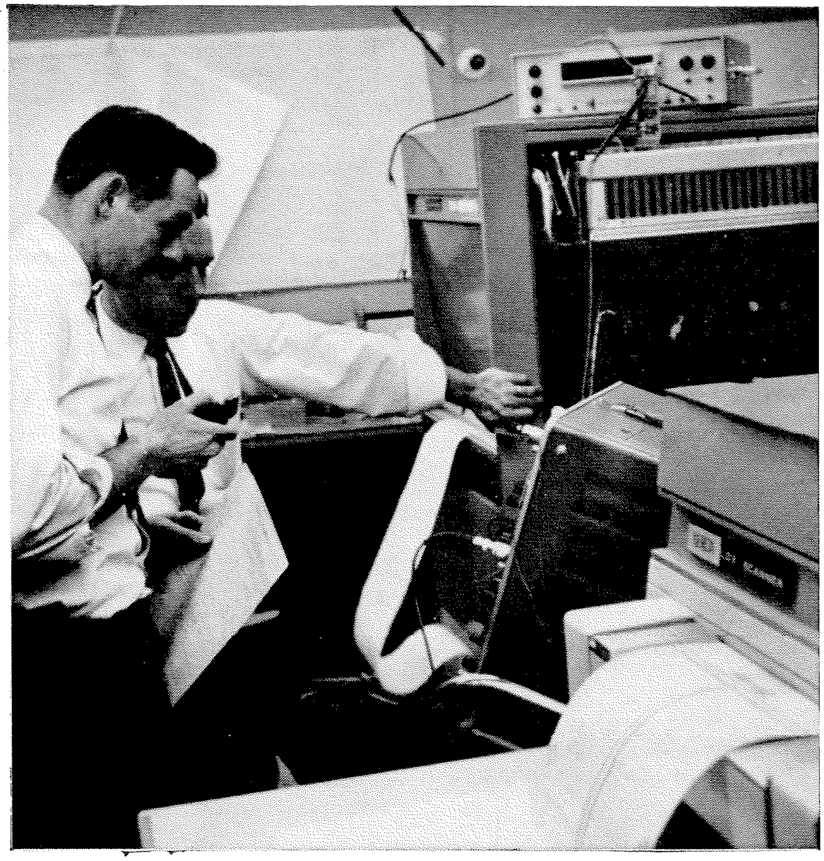
In "The Steady State Cosmology" Hoyle discusses the role of wrong facts in scientific theory-making. He carefully measures "the relative emotional strengths" of two contentions, and states: "I personally spend no time investigating theories that require special initial conditions."

"A Radical Departure" discusses the C-field, the oscillatory universe, and related mysteries.

"An Outline of the History of Matter" contains a lot of intricate nuclear physics and this comment on NASA: ". . . it is well to understand that NASA exists in order to put a man on the moon. . . . I do not believe that anything really worthwhile will come out of the exploration of the slag heap that constitutes the surface of the moon . . . Nobody should imagine that the enormous financial budget of NASA implies that astronomy is now well supported."

In this reviewer's opinion, *Galaxies, Nuclei, and Quasars* is an equally good book for the idly curious and for the deadly earnest. From it a journalist could learn roughly what is going on in astronomy today, or a graduate student could learn detail and theory. One may regret Professor Hoyle's acid throwing at NASA. The eminent, articulate, and persistent Hoyle detracts more from the space program than a platoon of the rest of us can add to it. Conversely, if there were any way to induce Hoyle to help formulate the objectives of the space program, our "tens of billions of dollars" would perhaps be better spent.

Continued on page 40



Does this look like an answer to global problems of ignorance, disease and physical deprivation?

Not yet. But we're getting closer.

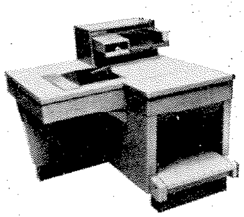
Behind this movement is a simple statistic with startling implications for all of us — *If you count all the scientists and engineers since the beginning of recorded history, ninety percent are alive today!*

We are now in the midst of the result — an incredible explosion of information from every corner of the globe. And somewhere within this explosion will be the ultimate answers to mankind's oldest, and newest problems.

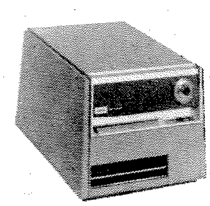
The challenges are many. First, to understand the nature of this giant intellectual force. Then, to find the best way to collect it, classify it, store it... and distribute it appropriately and instantly to the people who need it.

In this light, you might consider today's Xerox products early and primitive steps along a difficult but fascinating path. You'd be right. Yet, has anyone taken these steps before us?

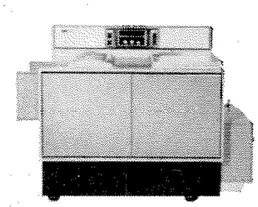
Your degree in Engineering, Science, Business Administration or Liberal Arts can qualify you for some intriguing openings at Xerox, in fundamental and applied research, engineering, manufacturing, marketing/sales, finance and administration. See your Placement Director or write directly to Mr. Stephen G. Crawford, Xerox Corporation, P.O. Box 1540, Rochester, New York 14603. An Equal Opportunity Employer.



The Xerox 914 Copier revolutionized the office copying industry when it was introduced in 1959... and really started us on our way.



Less than 3 years later, the 813 further extended low-cost, quality office copying. One-seventh the volume of the 914, it does just about everything the 914 does except copy solid, 3-dimensional objects.



Another revolution. An electro-mechanical-chemical-optical device called the 2400 because it produces 2,400 copies per hour *directly* from an original document. No stencil or "master" of any kind. You press a button.

XEROX

TOP PHOTO: LDX (Long Distance Xerography) scans, transmits and reproduces images over distances limited only by the transmission medium. Something like it may print the morning paper at your breakfast table some day, or help you manage a global business.

ENGINEERING
AND SCIENCE
November 1965, Vol. XXIX, No. 2

Richard P. Feynman

Nobel Prizewinner

October 21, 1965, 3:45 a.m.

"Hello? Dr. Richard Feynman? This is the American Broadcasting Company calling. May I congratulate you on your Nobel Prize?"

"Look. This is a heck of an hour—"

"But aren't you pleased to hear that you've won the prize?"

"I could have found out later this morning."

"Well, how do you feel, now that you've won it?"

"Please – some other time . . ."

And so Richard P. Feynman, Richard Chace Tolman Professor of Theoretical Physics at Caltech, sleepily learned that he was winner of the 1965 Nobel Prize in physics.

9 a.m.

Stockholm, Sweden

Royal Academs of Sciences today awarded you and Tomonaga and Schwinger jointly the 1965 Nobel Prize for Physics for your fundamental work in quantum electrodynamics with deep ploughing consequences for the physics of elementary particles. Prize money each one-third. Our warm congratulations. Letter will follow.

Erik Rudberg
The Permanent Secretary

It was official. Richard Feynman shared the $55,000 prize with Shinichero Tomonaga of Tokyo and Julian Schwinger of Harvard for their independent work in quantum electrodynamics done in the years 1947-49.

10:30 a.m.

Accompanied by his wife, Gweneth, and three-year-old son, Carl, Feynman meets the press – radio, television, newspaper, and magazine – in the Athenaeum on the Caltech campus.

Reporter: "Is there any way your work can be explained in laymen's terms?"

Feynman: "There certainly must be. But I don't know what it is."

Reporter: 'Well, then, what was your reaction when you first heard that you had won the Nobel Prize?"

Feynman: "I thought it was some student calling as a prank. I wasn't too polite. But after the third call I was convinced. I hope the guys who called will accept my apologies."

11:45 a.m.

Some reporters who couldn't get to the morning press conference show up in Feynman's office for a repeat performance.

Television newsman: "I'll tell you what I'm going to ask you, so you'll be ready when the cameras start. One of the questions is: What applications does this paper have in the computer industry?"

Feynman: "The answer to that will be — none."

"Well, then, does it have application?"

"It hasn't got any."

"Oh, you're kidding, sir!"

"No."

"Well, I'm going to ask you also to comment on the statement that your work was to convert *experimental data* on strange particles into *hard mathematical fact.*"

"No, I'm not going to comment on *that.*"

"All right — What time did you hear about the award?"

"OK — now turn on the cameras!"

4:15 p.m.

Feynman is the center of attention at a packed physics department research conference tea in East Bridge, as he describes his busy day.

"This man from the *Times* came to photograph me. He was taking a lot of pictures, and he was talking all the time and he said, 'This morning — what did they ask you?' I said, 'Well, the hardest one they asked me was to explain in a few words — you know — what the damn thing is about.' So he says to me, still taking pictures, 'Hell! If you could explain in a few words what it was all about, it wouldn't be worth no Nobel Prize!'"

Someone asks Feynman when he is supposed to be in Stockholm for the award ceremony.

Feynman: "The tenth of December . . . I'll have to get a borrowed tux somewhere."

"Tails," says Carl Anderson, chairman of the physics department and winner of the Nobel Prize in physics in 1936.

Feynman: "Tails —"

Feynman shares the limelight with his wife, Gweneth, and son, Carl, at a press conference in the Athenaeum.

Anderson: "Tails. And you have to have a tall silk hat. Get the collapsible kind, that you can sit on. You can get them in Stockholm. You can rent them all there."

Feynman: "Y'know, I'll put it on and think to myself — here, but a few years ago, stood Anderson."

Anderson: "Many years, many years."

Feynman: "In this *very suit!*"

Late evening

At his home, in a private interview with student editors of the *California Tech,* Feynman tells of phoning Tomonaga earlier in the afternoon (when it was nearly midnight in Japan).

"Congratulations."

"What did we do to win the award?"

"We invented a scheme for pushing a great problem under the rug."

"Maybe it will stay under the rug — but maybe it won't."

"Same to you."

"How does it feel to be a Nobel Prizewinner?"

"I guess you know."

"Can you explain to me in laymen's terms exactly what it was you did to win the prize?"

"Please — I'm very sleepy!"

Some other achievements

Richard P. Feynman already has an impressive list of honors and achievements to his credit. He is a fellow of the Royal Society of London and a member of the National Academy of Sciences. In 1954 he won the Albert Einstein Award for scientific achievement, and, in 1962, the Ernest Orlando Lawrence Memorial Award given by the Atomic Energy Commission for significant contributions to nuclear science.

Just as famous a teacher as he is a theoretical physicist, Feynman has completely revised Caltech's courses in introductory physics. In 1964 he served as a member of the California State Curriculum Commission to select textbooks for elementary grade arithmetic courses.

Born in New York City in 1918, Feynman received his BS degree from MIT in 1939, and his PhD from Princeton in 1942. After wartime work at the Los Alamos Scientific Laboratory, he became professor of theoretical physics at Cornell University in 1945. In 1950 he came to Caltech with the same title. He has been Richard Chace Tolman Professor of Theoretical Physics since 1959.

Feynman's interests range well beyond the field of theoretical physics. He likes to go camping with his family, play the bongo drums, and draw. (He is currently trading drawing lessons for physics lessons with an artist friend.)

Feynman, who is also an enthusiastic traveler, believes in speaking to his hosts in their own language. Recently, in the hope of taking a trip to South America, he worked hard learning Spanish. Finally he got an invitation to speak in Brazil — where the native language is Portuguese. Undaunted, he found a tutor and took six weeks to prepare for delivering a series of lectures on quantum theory in Portuguese — or in what he calls "Feynman's Portuguese" ("I could understand what I was saying, but I couldn't understand real Portuguese").

At last report he was starting to learn Swedish.

The work that won the prize

Quantum electrodynamics, the field in which Feynman's work was done, was born in the late 20s when Dirac, Fermi, Heisenberg, and Pauli applied the new quantum mechanics to the old equations of Maxwell's classical electrodynamics. The new theory, by quantizing the fields and physical quantities involved, was able to describe the standard

Feynman celebrates with students, friends, and colleagues Carl Anderson and Robert F. Bacher.

Caltech undergraduates publicly — not to say perilously — congratulate Feynman from the tower of Throop Hall.

radiation processes occurring in atomic physics.

However, the new theory was unable to provide precise answers. Thus, when an electron moved into a lower-energy orbit and emitted a photon, the theory could predict only a first approximation of the wavelength of the photon. Correction terms in the equations, which should have yielded more precise answers, diverged and gave infinite values, which were physically meaningless. The general feeling was that these difficulties reflected some basic errors in the formulation of the theory, and from 1935 to 1945 there were numerous attempts to determine what revisions were necessary to make it work.

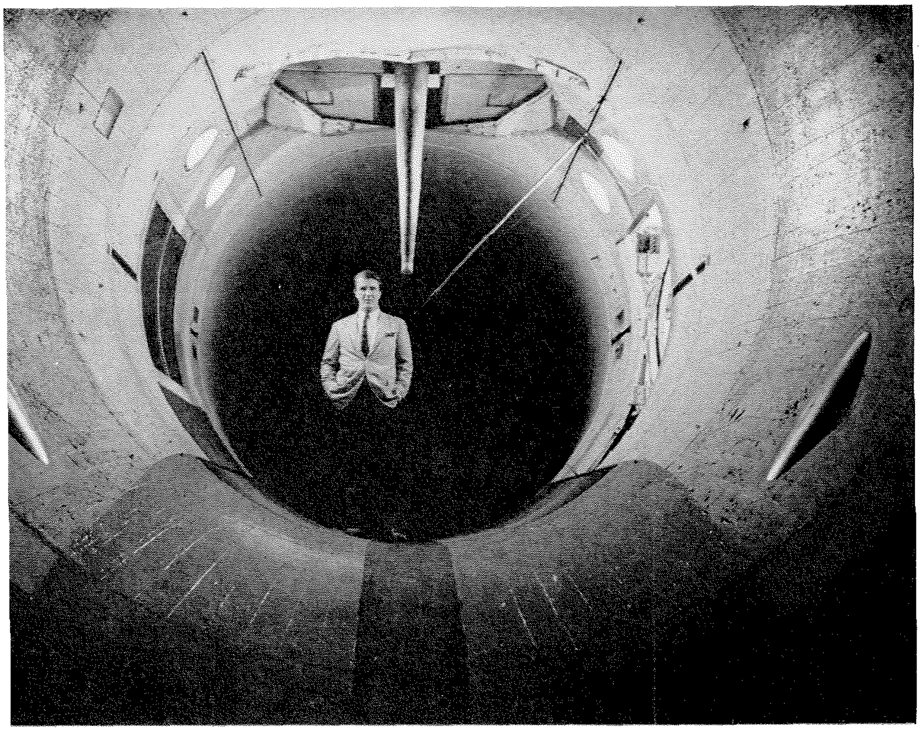
But no radical flaw could be found. Moreover, by 1946 experiments were being conducted with much-improved accuracy, made possible by the development of microwave techniques, and the weaknesses of the theory were being re-exposed. Feynman and Schwinger, independently, took up the problem again, while Tomonaga continued work already in progress.

The fact that the three worked independently using three different methods gave great breadth and richness to the theory that finally emerged. Tomonaga proceeded with basic physical principles, Schwinger with massive mathematical formulation, and Feynman with a reconstruction of almost the whole of quantum mechanics and electrodynamics from his own point of view. Tomonaga and Schwinger worked within the framework of field theory, and Feynman took a radical approach that treated all events in terms of particles.

The nature of Feynman's approach made it difficult for him to find acceptance for his results at first. After he had some spectacular successes in solving problems, he and Schwinger decided in 1948 to present their theories at a conference. The audience was not too receptive to either, but seemed particularly hostile to Feynman's unorthodox, particle approach. So, even though not all the divergence difficulties had been overcome, he decided to publish his results, at about the same time as did Tomonaga and Schwinger. Seventeen years later, while those few problems still remain, modern quantum electrodynamics has brought order to that vast part of physics lying between gravity and nuclear forces. Moreover, Feynman's simplified rules of calculation are now standard tools of theoretical analysis in both quantum electrodynamics and high-energy physics, and the Feynman diagrams (pictures of interaction trajectories) vastly simplify quantum electrodynamics interaction calculations.

Feynman himself believes that the discrepancies of the few remaining divergences in his theory have not been resolved; they still present a serious problem.

—Tim Hendrickson '67, Stuart Galley '66, Fred Lamb '67.



Peter Lissaman, assistant professor of aeronautics, in the GALCIT 10-foot wind tunnel.

The Winds of Change in Aeronautics

by Peter Lissaman

Throughout the centuries man has been obsessed with the thought of being able to travel in the Earth's atmosphere and beyond. From the legend of Icarus to the fantasies of Jules Verne, the mind is constantly stimulated with the prospect of being able to break the bonds tying man to the surface of our own sphere. A multitude of sages has made fantastic and sanguine prophecies of future air and space travel, and yet most of these visions have foundered on the hard facts of physics. The chains of gravity proved hard to break; and it is only in the last half-century that we have been able to sever our links with the nap of the Earth to make possible those ancient visions. The history of man's fight to fly has been described as a "long story, of legends and dreams, theories and fancies, all suddenly transformed into facts; a tale of the hopes of madmen suddenly recognized as reasonable ambitions."

Momentum and the Red Queen

Aerial transport has always lagged behind the predictions made for it because, of all forms of earth-bound locomotion, the aircraft is incomparably the most complicated. This is really because it is an interface vehicle, one which travels free from the Earth, but depends upon Earth and its surrounding atmosphere to maintain a precarious equilibrium. The land- or water-based vehicle accepts and concedes to the Earth's gravitational field, and the space vehicle escapes gravity — but the airplane continually defies gravity .

The air vehicle sustains itself by continually pushing air downwards. While it is obvious that a propeller obtains its thrust by pushing air backwards, it is not quite so evident that the wing of an airplane is operating in exactly the same way. It deflects downward the air through which the vehicle is moving to provide a vertical momentum, thus giving the upward force necessary to maintain equilibrium. We may therefore regard the aerial vehicle as a *momentum generator:* a device that operates upon a certain amount of air — the amount depending on its speed and its capture area — and deflects it downwards. The lift it derives from this process depends on the two capture factors, speed and size, as well as the actual density of the air.

Now air is light, and man is heavy, so, because of what Shakespeare called "this insubstantial air," in order to lift our own "too, too solid flesh" we have to handle a great deal of air. This can be done either by using a very large capture area (long wings or rotors), or by traveling at high speeds. The energy or power required to impart the necessary downward momentum depends in a simple way upon the mass of the air. The more air captured, the less downward velocity it need be given, and the less power is required to produce a given lift. Thus, in general, as we reduce our capture mass by making smaller and slower devices, we increase the power required for sustentation.

So, unlike the ship, or hard-surface vehicle, the aerial device must constantly expend power merely to stay aloft. It must then use additional power to move from one point to another against air resistance. Ironically, the power required increases as the vehicle tries to fly very slowly or to hover because the mass of air encountered is reduced so that full engine capacity is usually required for slow flight. The aircraft, in fact, exists in a type of Wonderland where, as the Red Queen said to Alice, "it takes all the running one can do to stay in the same place."

What price speed?

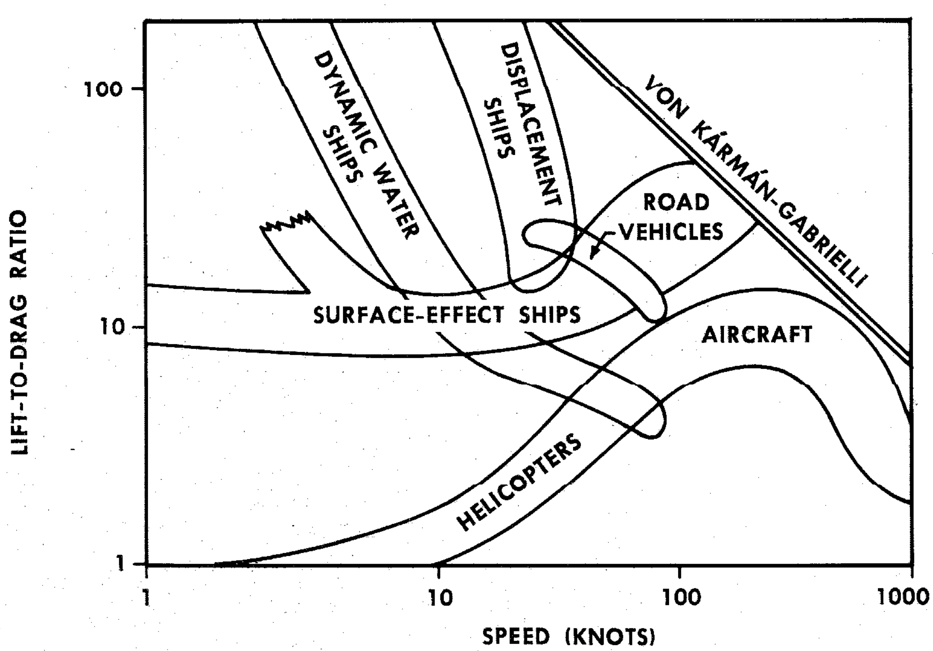
Some years ago, Theodore von Kármán and Giuseppe Gabrielli took to thinking about the myriad means man uses to move himself over the globe, and to analyzing these in terms of transport effectiveness. They produced the graph shown below which compares the speed and lifting translational efficiency (lift-to-drag ratio) of different vehicles.

As can be seen, displacement ships have an exceptionally high translational efficiency right up to 100 and above; it takes a very small amount of power to push a large load at moderate speeds through the ocean. However, to make a ship go fast requires large power expenditures. Beyond about 40 knots, the well-known wave barrier for ships, the power required increases rapidly, and the voyage becomes very bumpy and rough.

Another class of ocean vehicle, the so-called dynamic water ship, is able to break through the 40-knot wave barrier and to approach the 100-knot region, where it starts to get into severe problems of buffet and high drag. These ships rise partially out of the water in cruise and derive a large part of their lift from their forward velocity. One type is the planing boat, of which the best known is the PT boat of the second world war; another is the hydrofoil boat, which is supported by small subsurface hydrodynamic wings, and, as it were, flies through the water. Both consume power simply to stay up, regardless of their motion, so they are intrinsically less efficient than regular ships.

Road vehicles, which include automobiles, buses, and trains, are also less efficient than regular ships because they operate against the friction of the ground; on the other hand, having nothing corresponding to a wave barrier, they can travel faster, their speeds being limited mainly by very physical barriers like people, corners, and other vehicles!

Aircraft always require more power than any other type of vehicle; in particular, aircraft that are designed to travel very slowly, like helicopters, have



Lift-to-drag ratio is a measure of the effectiveness of different vehicles. For a given speed, the vehicle highest on the chart will have the best transportation effectiveness.

(After Von Kármán and Gabrielli.)

a very low translational efficiency. However, as the speed of an aircraft increases, so does its translational efficiency, up to about 600 knots, when the airplane starts to meet its own wave barrier, the speed of sound. At that point the drag increases severely, and the efficiency falls off.

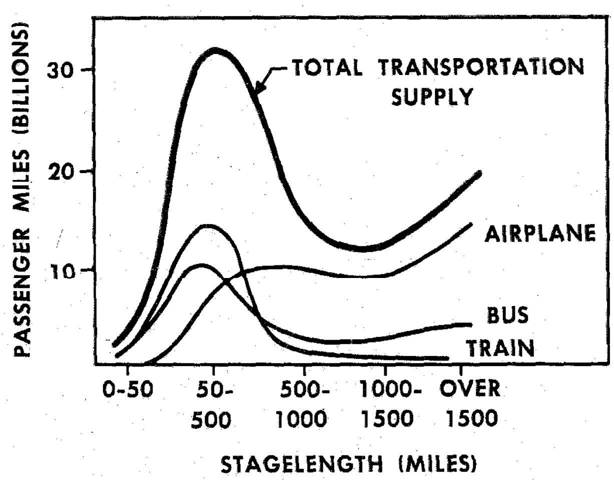
Von Kármán and Gabrielli proposed, on a purely statistical basis, a line which they suggested was the absolute limit for transport effectiveness. And, interestingly enough, very few vehicles have succeeded in crossing that line. However, a curious class of vessels, called surface-effect ships, falls in a region not covered by either airplanes or ships, and holds great promise.

The important thing about transport is that one always pays a price for speed. However, in some areas one gets a better bargain for one's money, especially when one operates close to the limiting line. Therefore, for about the 150- to 600-knot range, aircraft are the best mode of travel; for about the 40- to 150-knot range, surface-effect ships; and below 40 knots, displacement ships.

A statistical picture of people's demands and habits of perambulation shows two very significant factors: (1) the enormous demand in the 500-mile range, and (2) the fact that the airplane does not have its share of this traffic.

These curves have been drawn for the highly mobile and technological society of the United States. Similar data from the underdeveloped countries or from the intensely populated regions of Western Europe would show an even more striking illustration of the great gap that can be filled only by air transportation.

Consider those great land masses of India, Africa, and South America: continents that awoke after the Industrial Revolution, that do not have the inland waterways suitable for hydro transportation, and that struggle with overcrowded rail and road systems to move their teeming peoples. It is too late in history to build railroads, to cut so painfully slowly across the Earth's face. But the Huntingtons, the Stanfords, of a new age are already living, and to them the Amazonian jungle and escarpments of the Drakensberg are Sierras of the mind; from 15,000 feet they are merely marks on a map. Above those virgin lands lie the vast and limitless highways of the skies. The benefits to the underdeveloped countries of a comprehensive and efficient air transport system stagger the imagination; because of the topographic barriers to surface travel, they have no way to go but *up* in the literal sense of the word.



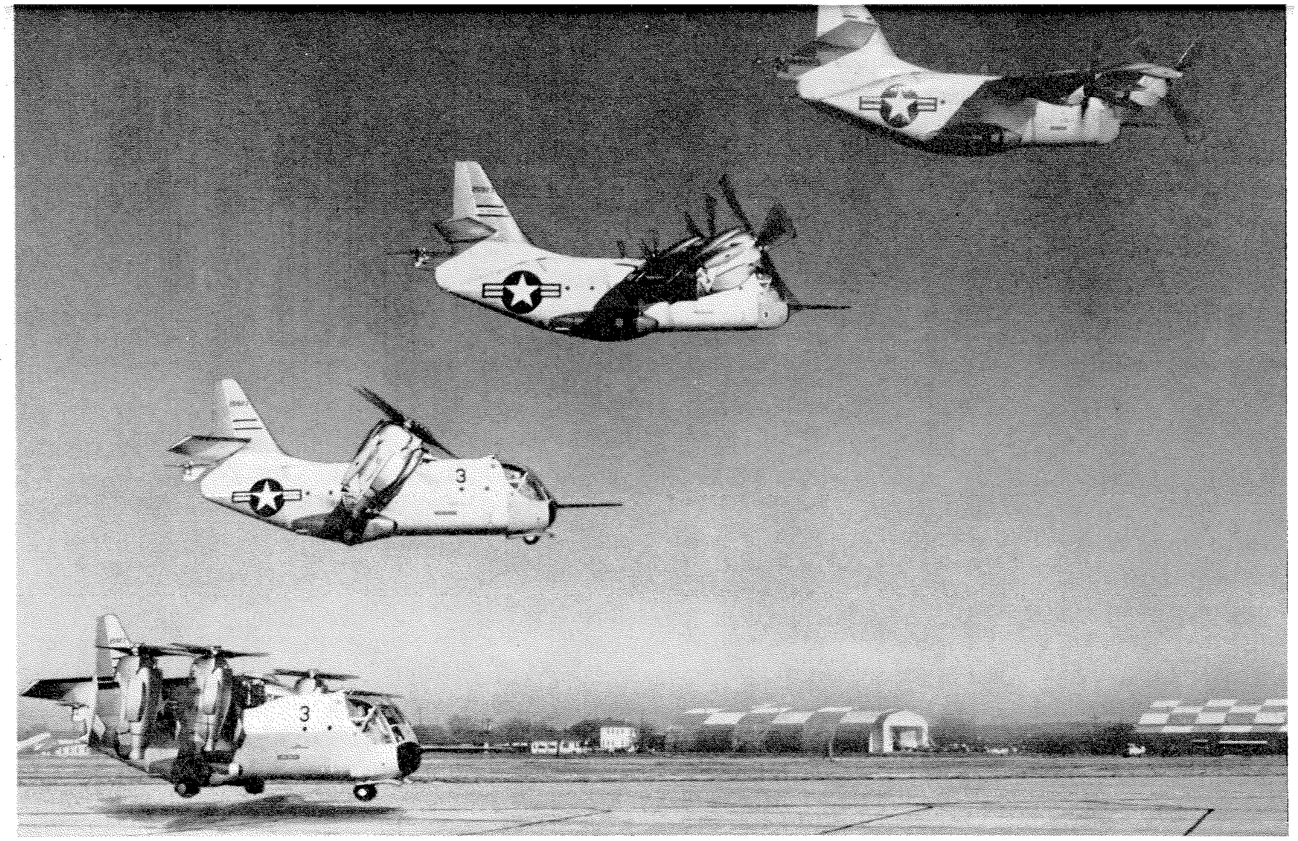
Transportation spectrum, showing how demands for various-length journeys are met in the United States.

Consider for a moment what can be done using conventional aircraft. The great C5-A transport airplane, commissioned this October by the U.S. Government, will carry a quarter of a million pounds over stagelengths of thousands of miles at speeds in excess of 500 knots. One of these airplanes can do the same transportation job as a 50-car freight train. To be sure, it will still cost less to transport certain goods — timber, steel, sides of bacon — by surface vehicle; flying is expensive for pigs. But if one demands more salubrious accommodations than would a side of bacon, the cost comparison is remarkable. Projected C5-A passenger versions give transcontinental airfares at levels comparable to bus rates and make the $100 Atlantic crossing look quite feasible.

This is a look at the future for high-density, long-range routes with advanced terminal facilities at either end. However, present demand for the intercontinental stagelength journey is still fairly low, particularly on a world-wide basis. In the 50- to 500-mile range a new type of aerial conveyance is needed. It will look quite different from the conventional bird-like airplane, since it must possess performance characteristics that in the past we have been unable to achieve.

Low, slow, and safely

The reason that aeronautics has not, up to now, provided the vehicles for mass transportation lies in the serious terminal problems of modern high-speed aircraft. The jet airplane is a marvelous device for traveling comfortably and speedily from A to B. There is no more effective way to pass from Tehachapi to Leadville — provided you don't want to get on or off at either of these spots. The modern subsonic jet has its major failing in its landing and take-off requirements — which are immense and rapidly



A composite photograph of the XC-142, a highly promising V/STOL aircraft, showing the stages of transition flight.

becoming more severe. These involve large, costly airports which are noisy and far from cities, and high landing and take-off speeds which greatly increase the danger, especially in conditions of marginal visibility.

For decades we have realized that the answer to this was a vehicle that could alight vertically or at a very low forward speed (the vertical/short take-off and land aircraft – V/STOL); but to design such a machine is an extremely difficult technological task because of both the high power requirements and the stability problems. Our current answer is the helicopter, which today has been carried to the limit of its development in its present form, as has the fixed-wing airplane.

The helicopter, which performs admirably as a VTOL, is seriously limited in maximum speeds. At higher speeds those great flapping blades, so essential to enable it to capture the air mass required for hovering flight, become a high drag encumbrance. It appears as though 200 knots may be about the limiting speed of the craft in its conventional form; but even this is remarkable when one considers that half the rotor blades are still going backwards when most of the machine is lumbering haphazardly forward. To see a helicopter in high-speed forward flight reminds one irresistibly of the romantic character who "flung himself upon his horse and rode madly off in all directions." The problems of the fixed-wing airplane at low speeds are well known; a very high proportion of aircraft accidents are caused by low-speed stall.

Airplanes and helicopters are at the threshold of a new wave of development in aeronautics, which consists, in essence, of controlling the external airflow, not only by geometrical techniques (with rigid flying surfaces), but also by the addition and subtraction of tailored high-energy air. Today circumstances are ripe for a new revolution in aeronautics which could finally bring cheap travel within the reach of Everyman. The three new ingredients of this mix are:

(1) The need exists and is recognized.

(2) The means of producing auxiliary airflow is available in the gas turbine.

(3) The technological ability to handle the complex theoretical problems involved is within our grasp.

One proposed solution to the problem of V/STOL is the Ling-Temco-Vought XC-142, a vehicle that very obviously combines the characteristics of the helicopter and the airplane. It is undoubtedly a complicated machine, expensive to build and operate, and difficult to fly. But it represents a firm step in the direction of V/STOL transport.

The tiltwing vehicle, of which the XC-142 is an outstandingly successful example, is a very direct approach to the problem of forcing air downwards by means of rotating machinery, having given up hope of doing it with a fixed wing or vane. However, extensive work is in progress in attempts to get the air to adhere to a surface even while turning through very large angles (in other words, to prevent stalling). This involves flow control, in the form of *boundary layer control* and the *jet flap*.

Flow control

It has long been known that when a surface moved through a fluid it was surrounded by a layer of slow-moving air which, in effect, stuck to the wing. This sheet of low-energy air, of the order of ¼-inch thick on a conventional wing, is known as the boundary layer, and is the root of all the problems associated with stall.

As the angle of attack of the wing is increased, the boundary layer air on the upper surface becomes progressively more sluggish until it is unable to make the passage to the back or trailing edge of the wing, and separates from the surface to mix with the main airstream. When this happens, the air on the upper surface no longer flows down along the wing itself, but streams straight backwards with the main airflow. Thus, the lift of the upper surface is lost, usually quite abruptly and with catastrophic consequences, and the wing is said to be stalled.

The most fundamental way to eliminate this problem is to get rid of the low-energy air in the boundary layer. This can be done by perforating the wing surface with a multitude of tiny holes or slots. Now, curiously, the desired result can be achieved either by blowing or sucking through these orifices. In the first case, a high-energy flow is blown out from the wing interior, which rejuvenates the sluggish boundary layer; in the latter, the low-energy air layer is sucked away into the interior of the wing, thus foiling its reactionary tendencies. The second method consumes appreciably less power. However, the main operational applications of boundary layer control have been in the use of the blowing philosophy, where a high-energy jet is blown over portions of the wing upper surface. This technique is used successfully in some naval aircraft, with their notoriously severe carrier landing problems. While it is true that blowing requires considerably more power input, it is easier and it works.

A more elegant and sophisticated approach to the high-lift problem is to blow a very high energy sheet of air backwards and downwards from the entire trailing edge of the wing. This both ameliorates the stall problem and creates an effective artificial wing many times larger than the actual rigid wing surface. This device is known as the jet flap. Extensive theoretical and experimental work is being done in this field in Europe, and the problem is also being studied at Caltech. Because of some peculiar advantages, it could be the next step in STOL aircraft.

The most striking thing about the jet flap is the phenomenon called the *thrust paradox*. It is so named because it seems like one of those rare but delightful occasions when one gets something for nothing. The jet sheet leaving the wing is directed downwards, and thus contributes appreciably to the lift; however, as it progresses downstream it is gradually turned by the oncoming air until it is finally going almost horizontally, so that the momentum is now directed backwards and provides the thrust necessary to propel the aircraft. Thus we first obtain lift from the air jet and then, most obligingly, it turns to provide thrust. The extra lift of a possible jet-flap aircraft may be five or six times that of a plain wing, and is obtained at little extra power cost. The significance of this development can be realized when one notes that up to now all airplanes have been, essentially, powered gliders. In other words, they consist of a lifting system (the wing) to which is bolted, with more or less elegance, a thrust system (the engines). In the jet flap we have a fully integrated flight system, one in which lift and thrust are developed simultaneously — a principle our feathered friends have used for centuries.

A further promising application of the jet-flap principle is to the helicopter. Here we envisage a wide rotor blade emitting the jet curtain all along its trailing edge — the jet thrust provides the torque necessary to turn the rotors, while the highly efficient lifting characteristics eliminate or avoid blade stall, one of the major factors militating against high-speed helicopter operations. Very recent theoretical work in this field has suggested that a helicopter with jet-driven and -controlled rotors could achieve speeds of the order of 300 knots. Alternatively, in the design of a device for operation at lower speeds, it seems that the jet-flap rotor might have other very desirable characteristics: reduction of mechanical complexity, increased engine-out safety, and lower noise levels.

It has been known for many years that when a wing flew close to the ground its lift was increased by a small amount, because of a cushion of air built up underneath the lifting surface. This effect is much more pronounced in the case of the jet-flapped wing, which makes the device even more effective close to the ground when, of course, the high-lift properties are most desirable.

It seems endemic to human nature that when one is on to a good thing one cannot resist carrying it to

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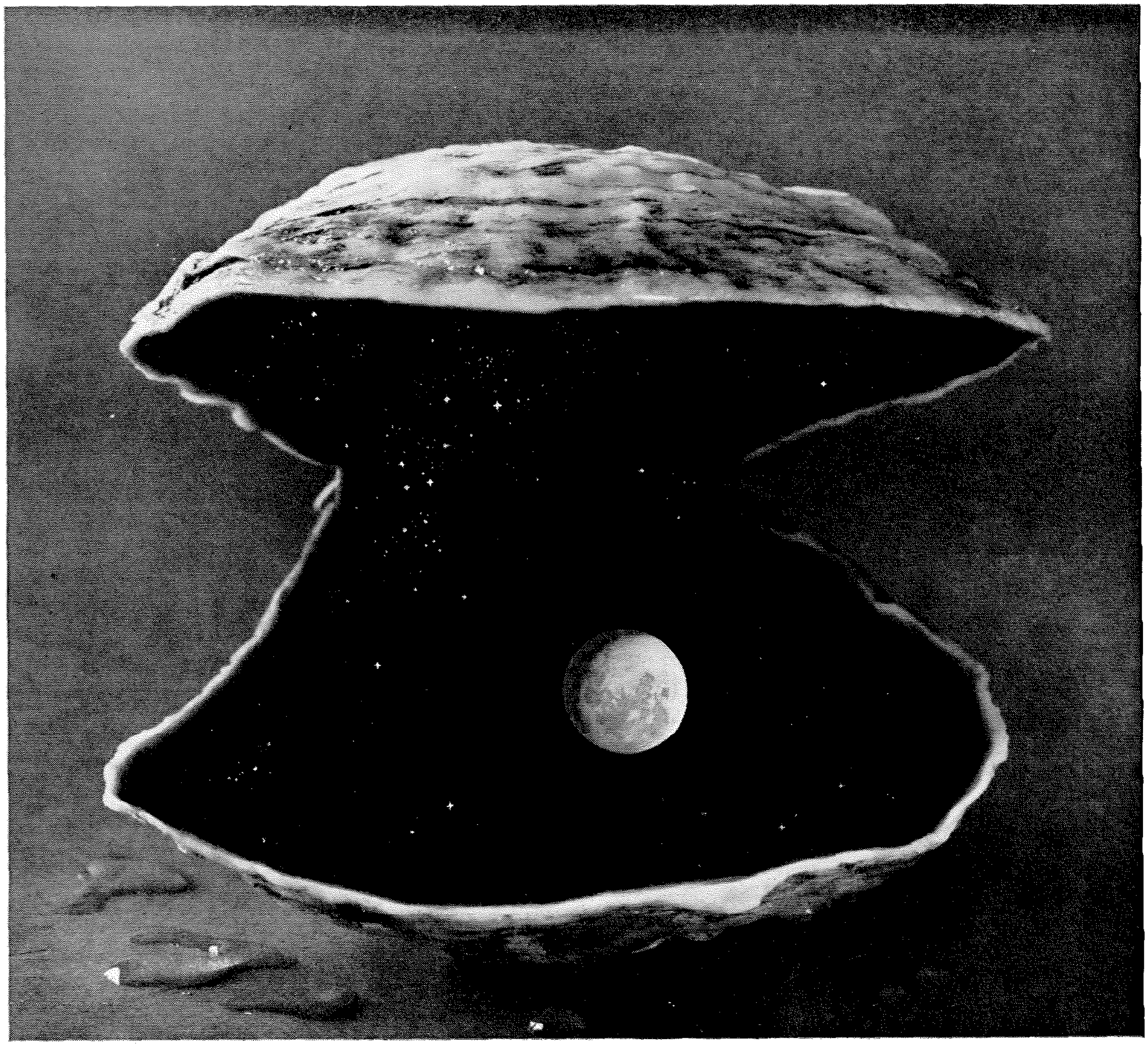

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A foretaste of things to come—a Hovercraft ground-effect machine, now in commercial use on San Francisco Bay.

ridiculous extremes. Therefore, it was only natural for someone to think of operating a jet-flapped wing in very close proximity to the ground – and thus was born one of the few radically different lifting vehicles of this decade, the ground-effect machine (GEM) or Hovercraft which is generically known as a surface-effect ship.

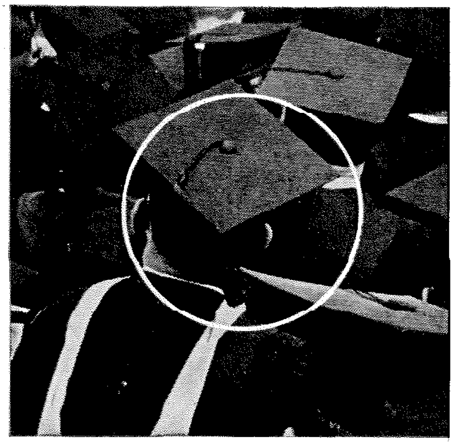
Surface-effect ships

Throughout the centuries man has waged an unremitting, and to a large extent successful, battle against friction. One major step was when he decided to roll rather than slide and invented the wheel; the next great step was when he lifted himself from the ground and was able to escape even rolling resistance. In aerial navigation he was retarded only by the insubstantial air and was able to achieve undreamed-of speeds, but always at the cost of the power required to stay aloft.

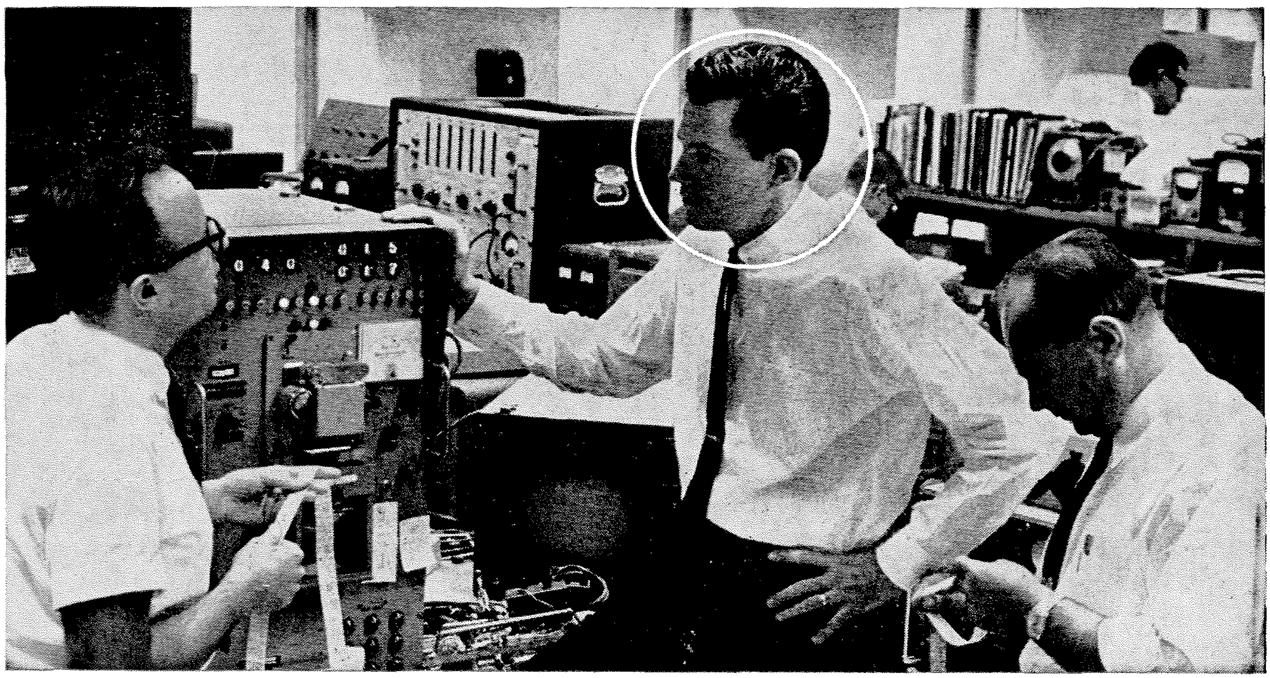
By operating very close to the ground we can greatly reduce this power and still move almost without resistance on a cushion of air. GEMs blow out a high-energy curtain of air around their periphery, thus trapping a high-pressure air bubble beneath them and the ground upon which they float. Of course, they cannot rise very high off the ground; current heights are scarcely more than a foot or two, but this lift is obtained at very low power cost. These vehicles can operate at high speeds, of the order of 100 knots, very cheaply, and provide a most attractive means of high-speed surface travel in a region that lies essentially between land vehicles and airplanes, and thus fill an important gap in the transportation spectrum. Moreover, because the vehicles travel equally well over land or water, they can deposit passengers right at city centers.

Fresh winds in aeronautics

The developments discussed here involve some of the more important movements in modern subsonic aeronautics. We have come to the end of a phase – one that started with man's first fragile flutterings and ends with his thrusting of white-hot supersonic vehicles through the audibly protesting air. It seems now that the time of brute force is over; we are realizing that air must be coaxed and induced, rather than forced to serve our ends, and that this can be done most elegantly by molding the airflow with auxiliary airstreams. We now have the ability to change completely the face of the world transportation spectrum by intelligent use of new techniques of lift and propulsion. This will be a change that will place travel and mobility within the reach of the common man – that will bring us commercial, educational, and human gains of enormous significance, and may finally realize the Wright Brothers' old and noble dream of "aeronautics as a benefit to the peoples of the world."



John Lauritzen wanted further knowledge



He's finding it at Western Electric

When the University of Nevada awarded John Lauritzen his B.S.E.E. in 1961, it was only the first big step in the learning program he envisions for himself. This led him to Western Electric. For WE agrees that ever-increasing knowledge is essential to the development of its engineers—and is helping John in furthering his education.

John attended one of Western Electric's three Graduate Engineering Training Centers and graduated with honors. Now, through the Company-paid Tuition Refund Plan, John is working toward his Master's in Industrial Management at Brooklyn Polytechnic Institute. He is currently a planning engineer developing test equipment for the Bell System's revolutionary electronic telephone switching system.

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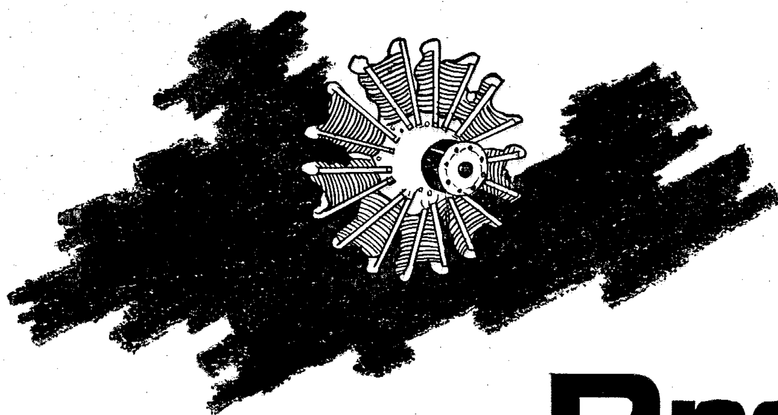
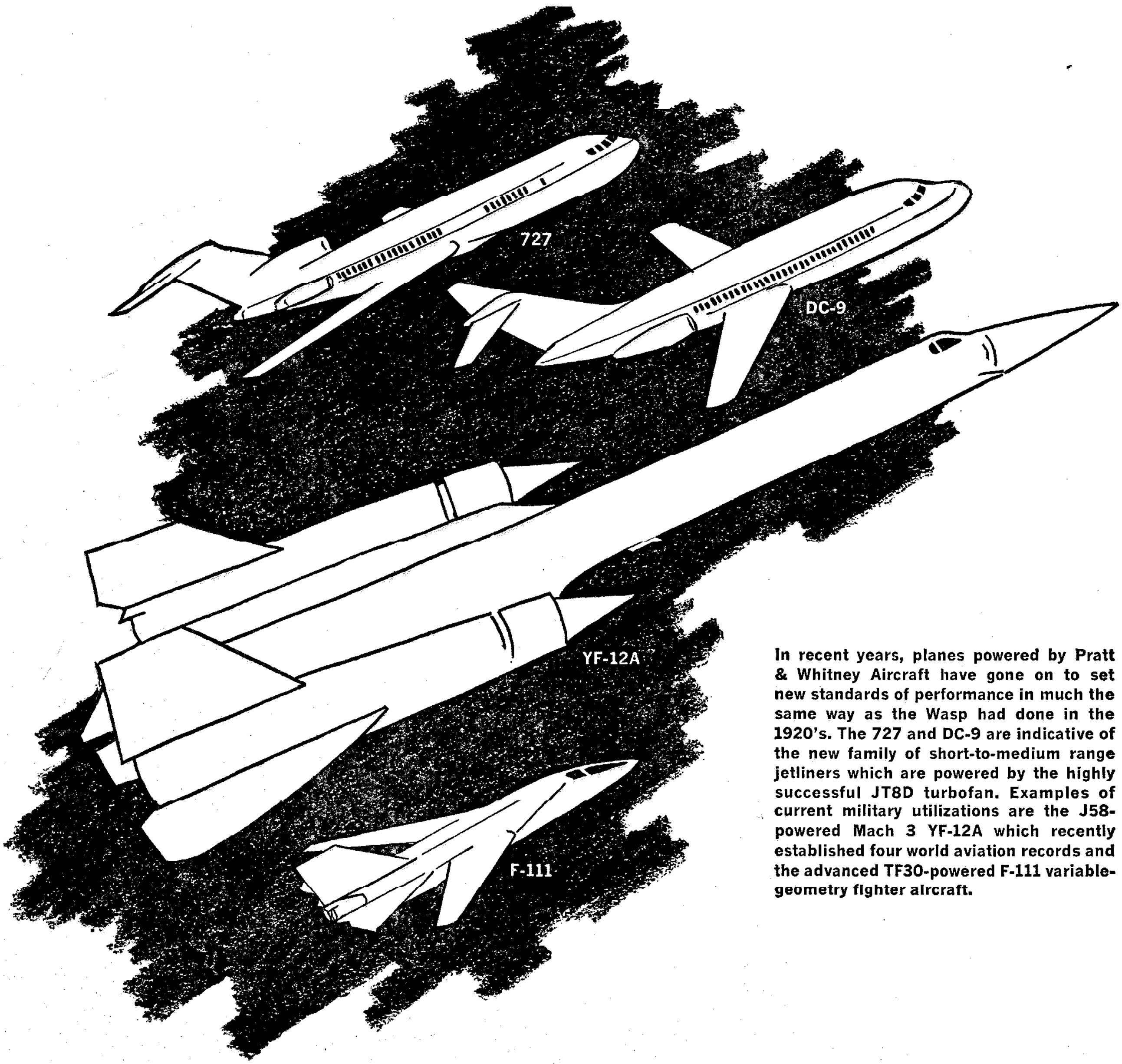
Past



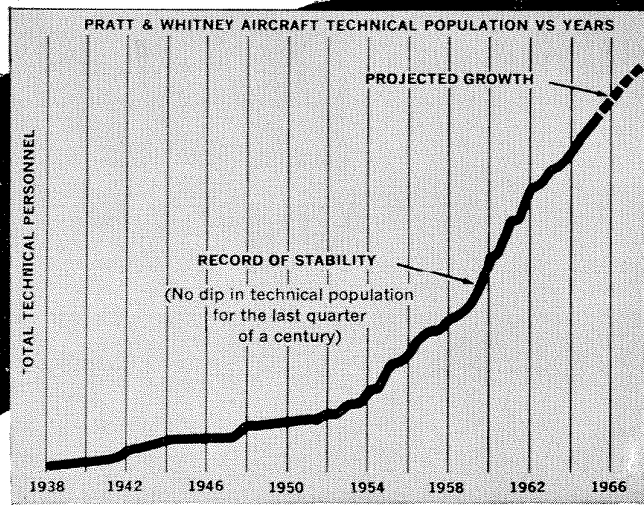
The Company's first engine, the Wasp, took to the air on May 5, 1926. Within a year the Wasp set its first world record and went on to smash existing records and set standards for both land and seaplanes for years to come, carrying airframes and pilots higher, farther, and faster than they had ever gone before.

Present



In recent years, planes powered by Pratt & Whitney Aircraft have gone on to set new standards of performance in much the same way as the Wasp had done in the 1920's. The 727 and DC-9 are indicative of the new family of short-to-medium range jetliners which are powered by the highly successful JT8D turbofan. Examples of current military utilizations are the J58-powered Mach 3 YF-12A which recently established four world aviation records and the advanced TF30-powered F-111 variable-geometry fighter aircraft.

Your
and ~~the~~ Future



Take a look at the above chart; then a good long look at Pratt & Whitney Aircraft—where technical careers offer exciting growth, continuing challenge, and lasting stability—where engineers and scientists are recognized as the major reason for the Company's continued success.

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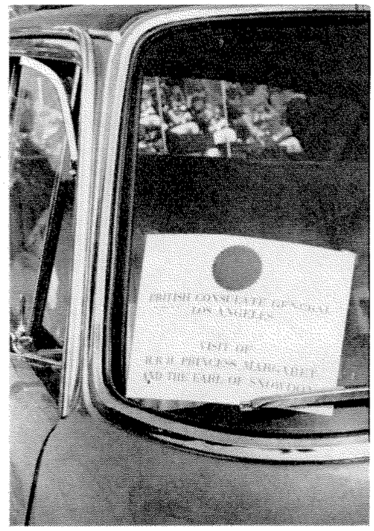
Princess Margaret and President DuBridge tour the campus on November 9.

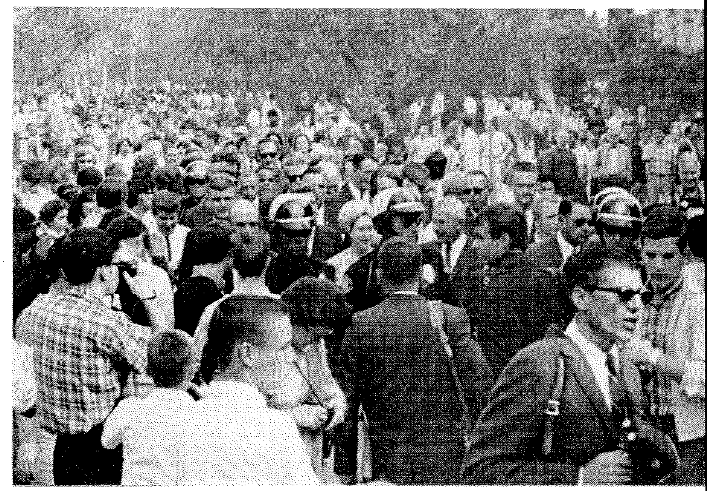


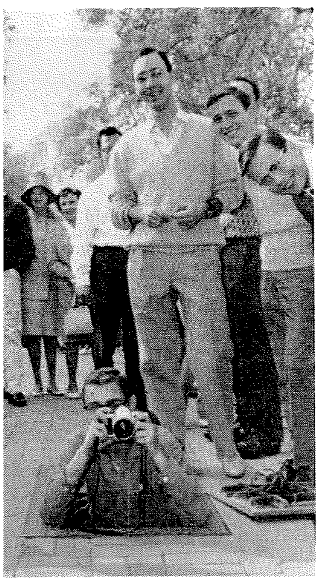
PRINCESS MARGARET AT CALTECH

Princess Margaret and Lord Snowdon, on the stage of Beckman Auditorium, with their hosts — President and Mrs. DuBridge; Arnold Beckman, chairman of the board of trustees, and Mrs. Beckman.

The royal party, well attended by security police, arrives at Beckman Auditorium.

After luncheon at the Athenaeum, a stroll down the Olive Walk.



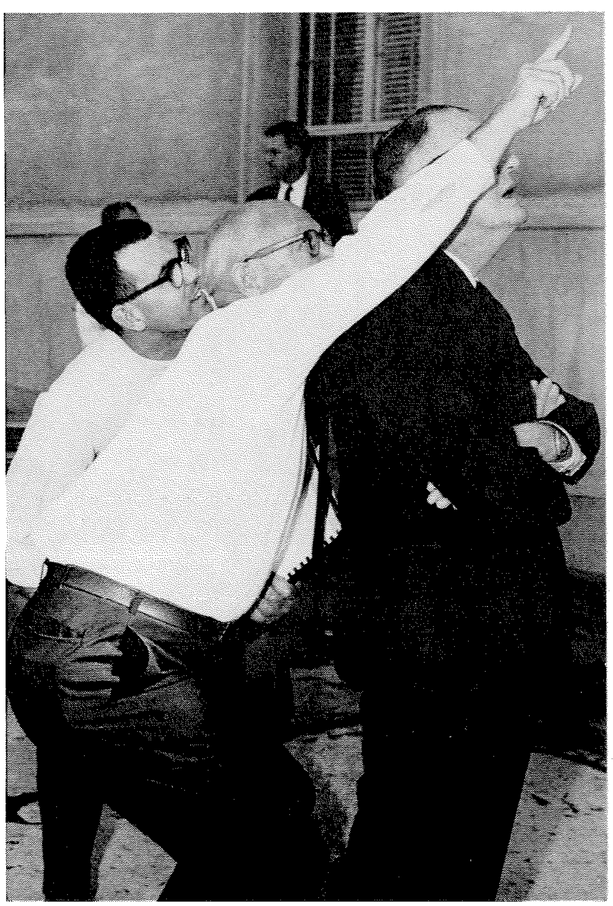


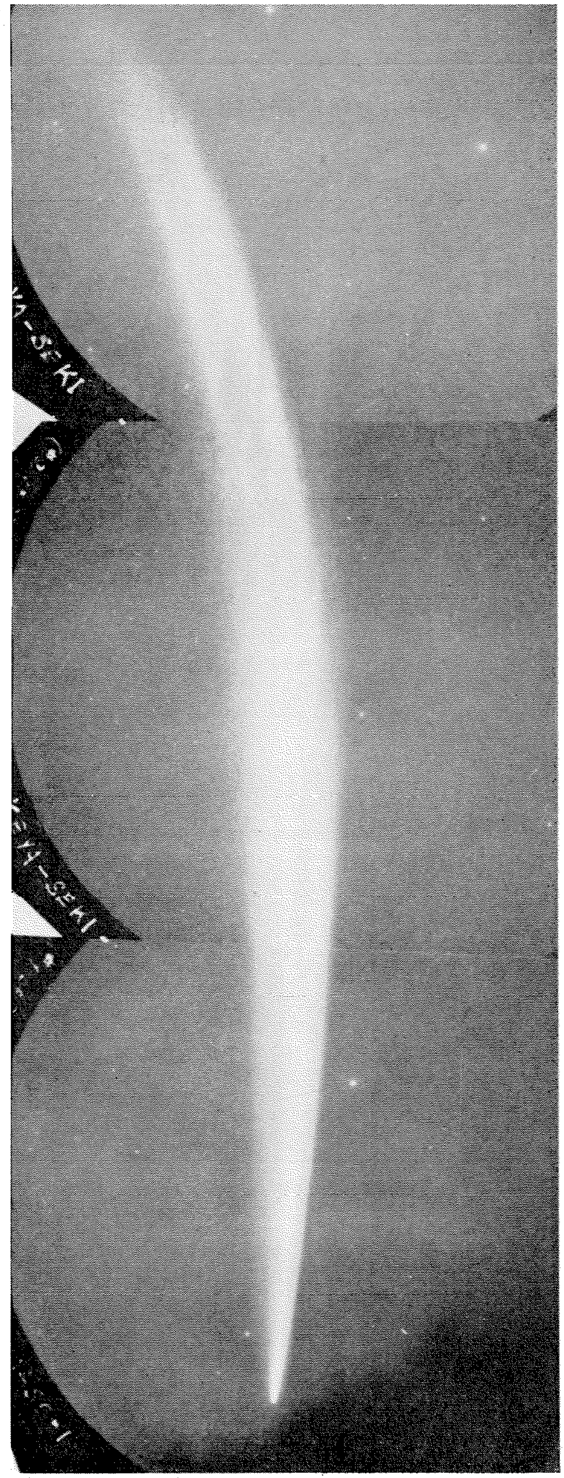
Freshman Kenneth Kamm gets set for an exclusive shot of the royal visitors.

Though he was snatched up by security guards as soon as he popped out of the manhole, Kamm still managed to get this unique photograph.

RARE VISITOR

Comet Ikeya-Seki, flying in from the edge of the solar system, made a sharp swing around the sun, reached its closest point to the sun on October 20, and headed again for outer space. The path of its orbit took it within 800,000 miles of the sun and afforded astronomers a rare chance to observe its flight through the solar corona at speeds approaching a million miles an hour. When the last comet of this kind appeared in 1887, scientists did not have the delicate instruments which were used this time to obtain valuable new information on the makeup of comets.





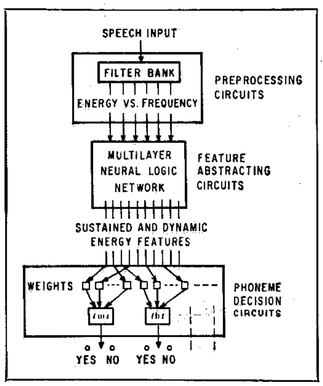
Ikeya-Seki, tail first, precedes the sun above the horizon at 4:30 a.m. on October 29, and is caught on film by the 18-inch Schmidt telescope at Palomar Observatory. The length of the tail at this time was 20 degrees.

Caltech students and faculty line up, on October 20, to watch Ikeya-Seki head into its solar "fly-by," from a prime observation spot on campus, in the shadow of Von Karman Laboratory.

Engineering and Science at RCA

Neural Networks

For a long time machines that recognize speech have stimulated the imagination of scientists, from the engineer to the linguist, both because of their potential usefulness to communication technology and for the formidable technical challenge they represent. Several years of research at RCA have resulted in notable successes in this field by using networks of electronic neurons (simulated nerve cells) to identify phonemes—the smallest practical units into which speech sounds can be divided without losing their identity. These neural networks operate on the several outputs of a spectrum-analyzing filter, dynamically examining the spectrum and making decisions as to phoneme identity.



During recent investigations, 18 consonant sounds (for example, /m/ as in "mad" and /h/ as in "hid") and 10 vowel sounds were identified with 86% to 99% reliability when uttered by any of 6 speakers. Machine recognition of consonants is, in general, much more elusive than that of vowels, since the identity of consonants is hidden in the transient behavior of the spectrum to a much greater extent than in its steady-state nature, as is the case with vowels. Vowel characteristics, however, usually are more speaker dependent. The recognition performance obtained represents, by a considerable margin, the best results achieved to date by any investigator.

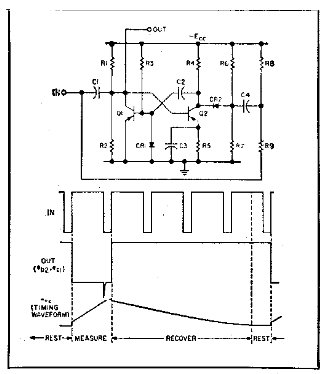
A "neuron," as used in these networks, is a simple computing element exhibiting the characteristics of fan-in and fan-out, an input threshold, and a specified analog relation between output and input when the input exceeds threshold. An array of several hundred neurons used in speech analysis is structured in layers; the first layer receives 20 parallel inputs from the spectrum filter, and by interconnections among its member neurons makes elementary decisions about the shape of the spectrum. The many outputs of the first layer pass, in turn, to a second and then to successive layers, which make ever more sophisticated judgments both of the instantaneous characteristics of the spectrum and of the nature of its changes with time. Finally, binary logic networks make decisions as to the most likely identity of the phoneme.

In speech processing, neural networks perform with great simplicity, limited-accuracy operations on a large number of simultaneous inputs, and maintain continuously analog measures of the reliability of each decision by virtue of the analog properties of the computing elements. These properties, so well suited for speech analysis, are just those required for solving pattern recognition problems in general. It is not surprising then, that neural networks also show exciting promise in the fields of visual and other kinds of pattern recognition, as well as speech.

Reference—A. L. Nelson, M. B. Herscher, T. B. Martin, H. J. Zadell, J. W. Falter, "Acoustic Recognition by Analog Feature-Abstraction Techniques," Proc. of Symposium on Models of Perception of Speech and Visual Form, 14 Nov., 1964, Boston, Mass.

A Novel Frequency Divider for TV Sync Generators

An economical, efficient and high-performance frequency divider circuit for use in new RCA color TV broadcast equipment has been developed. The circuit is a monostable multivibrator with a unique ability to adjust its timing period to be proportional to the period of the input trigger pulses. The circuit uses only two transistors, and it has the ability to divide an input frequency by a constant for a wide range of input frequencies. It is also quite immune to power supply variations and requires no precision capacitors. The circuit requires no externally-applied AFC voltage for regulating the timing period, such as would be required in this application with an ordinary monostable divider.



The two periods of a cycle of operation, as shown in the waveforms, are first, "measure," and then a "recover." When the circuit is in the rest or "stable" state, Q1 is saturated and Q2 is turned off. Once triggered by an input pulse, Q2 is placed in a constant current conducting mode which causes C2 to discharge at an essentially constant rate. This action is terminated by the next succeeding pulse which leaves the voltage across C2 at a value directly related to the time period between the pulses. The capacitor voltage is thus a measure of the pulse repetition interval. The second pulse, which terminates the measure period, also causes regenerative circuit action which turns Q2 off. Succeeding input pulses cause no further circuit action until C2 charges (through R4) to the point where diode CR2 can again conduct. The first trigger pulse following the "recover" period causes the cycle to reoccur.

A constant frequency division ratio is maintained over a wider input frequency range than was previously possible as a result of the self-adjusting timing feature. A new color sync generator, which uses this type of circuit in the frequency divider that relates the horizontal and vertical scanning frequencies, is proving to be highly successful. A 525:1 divider chain is used which requires only 8 transistors. If a chain of binary stages were used, 22 transistors would be required. Also, a modified form of this circuit is used to relate the horizontal scanning frequency to the color TV subcarrier frequency.

Reference—A. J. Banks and F. I. Johnson, "Novel Frequency Dividers for TV Sync Generators," 1965 IEEE International Convention Record, Part 2.

Transistorized Portable "Victrolas"

Although transistors have previously enjoyed widespread use in portable receivers and military communication equipment, only recently have solid-state devices made any significant penetration into line operated home instrument equipment. Advancing device technology has made transistor circuitry cost competitive with equivalent tube circuitry, while providing improved reliability, instant warm-up, lighter weight and cooler operation.

In low-cost phonographs using single stage tube amplifiers, high-output pickups are required. Such pickups are quite stiff mechanically, require a high stylus force, and thus track marginally. These low-cost amplifiers ordinarily use "transformerless" power supplies with the attendant design problems of minimizing hum and shock hazards.

RCA Victor's new transistorized portable phonographs use multistage DC-coupled circuits providing ample power gain for use with pickups of higher compliance and smoother frequency response. Record wear and tracking are thereby improved. The higher efficiency of the output stage and the elimination of the heater-power requirement result in a cooler amplifier—and make possible the use of a secondary winding on the phonograph motor for the power supply. The resulting isolation eliminates the shock hazard and makes possible the application of conventional grounding techniques.

To minimize costs and improve reliability, this amplifier has been designed to be built on a printed circuit board. The need for a separate supporting chassis has been eliminated by mounting the printed board under the turntable on the record changer motorboard, allowing the output chokes and filter capacitor to extend through the motorboard. The motorboard serves both as a heat sink and mounting for the output transistors. Volume and tone controls are mounted on the motorboard, and all inter-connecting cables and wiring are integral with the record changer assembly.

Reference—J.A. Tourtellot, RCA technical report.

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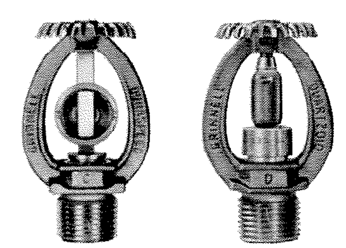

Grinnell Automatic Sprinklers include the Duraspeed® type (left) that incorporates a fusible-solder joint and the Quartzoid® Bulb type (right) filled with heat-expandable liquid.

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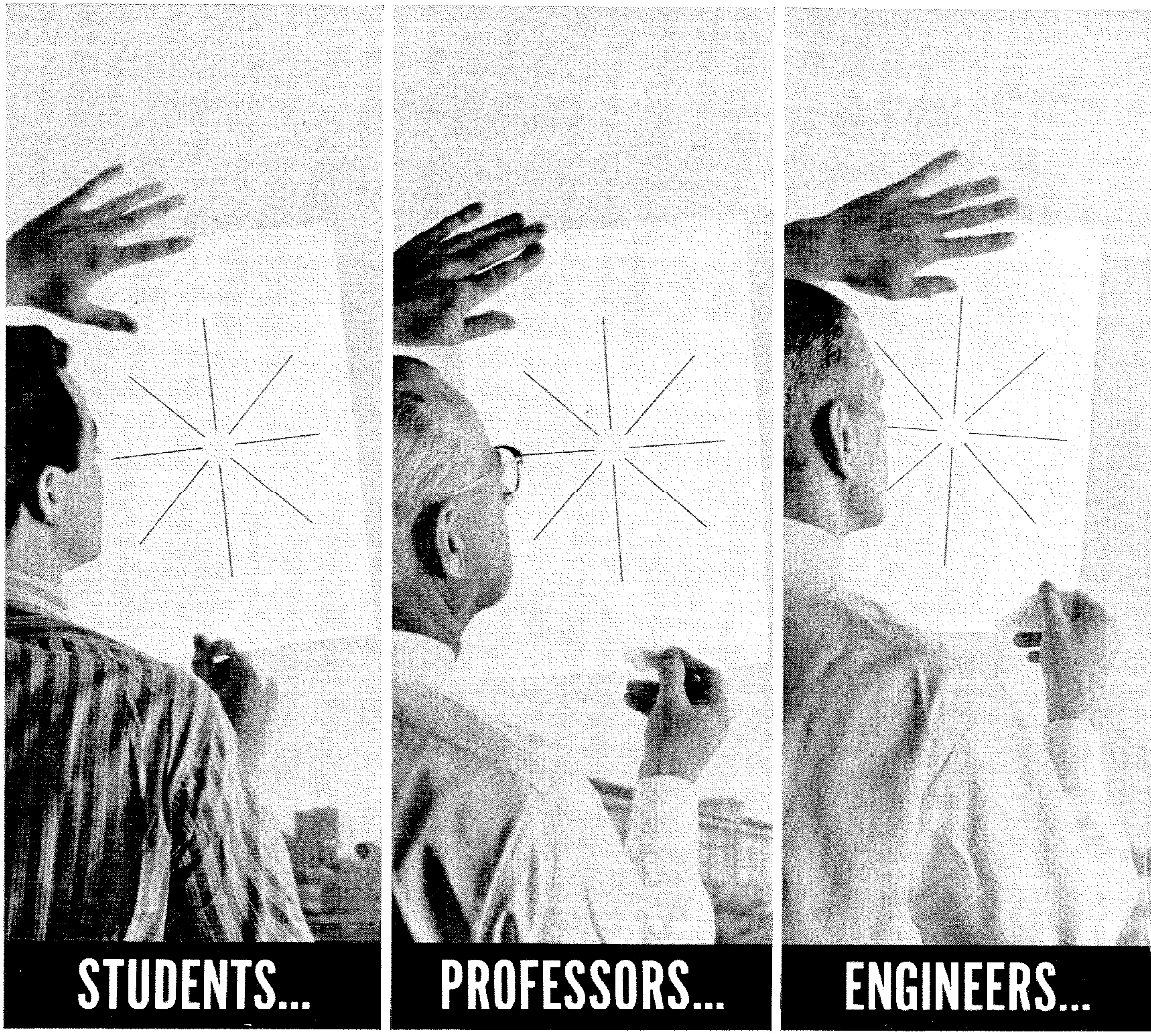
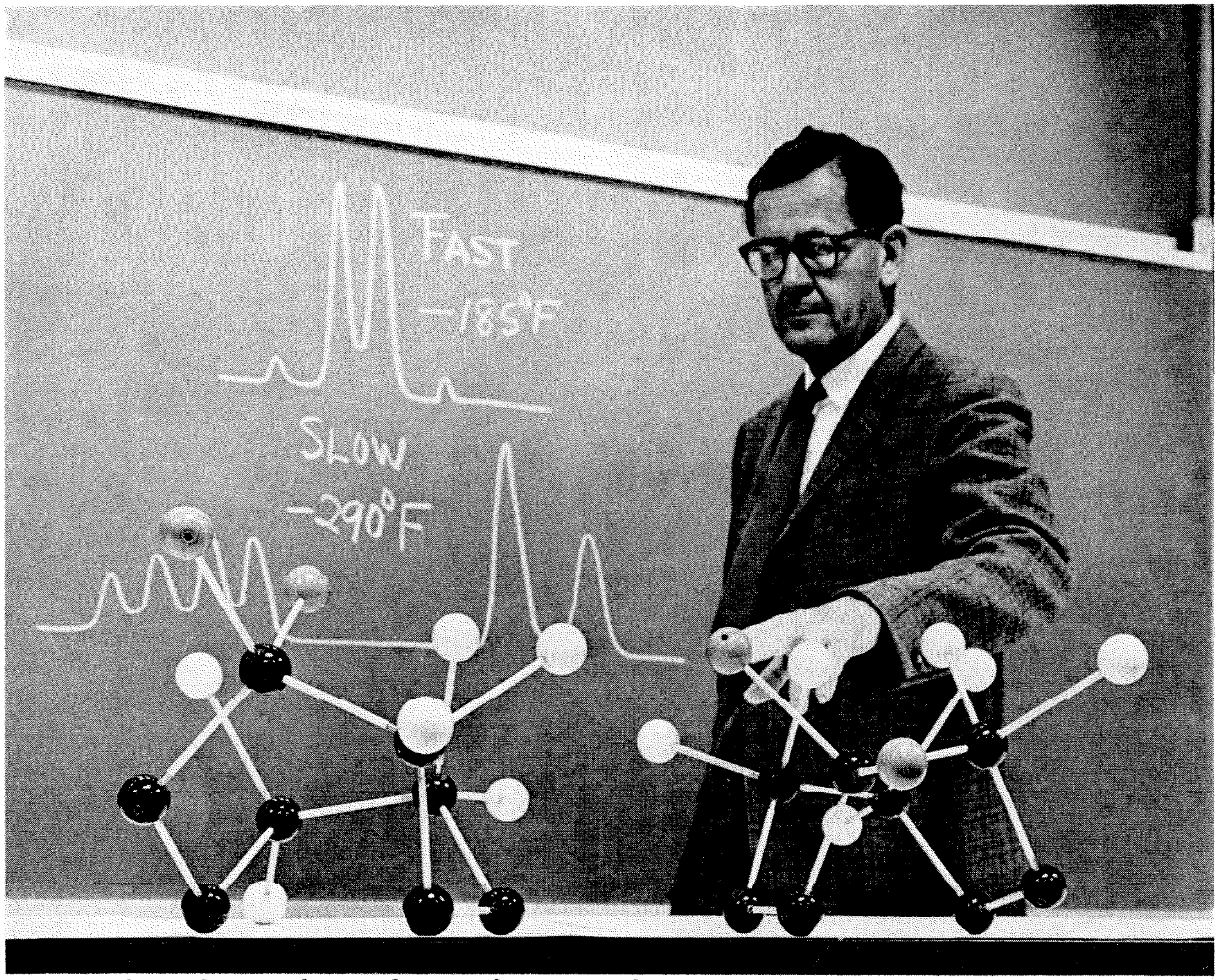

STUDENTS...
PROFESSORS...
ENGINEERS...



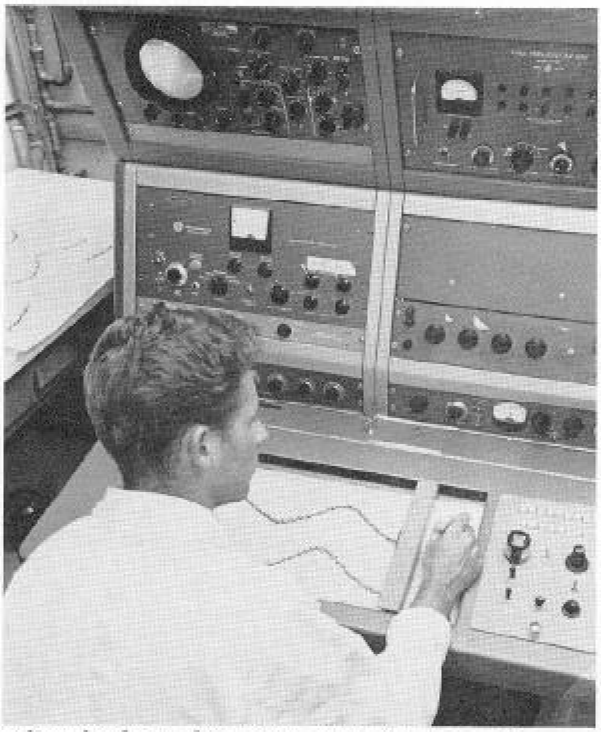
John D. Roberts, chemistry division chairman, demonstrates the effects of temperature on conformations of a molecule.

CONFORMATIONAL CHANGES

Caltech scientists study molecules that twist and flip-flop, often at very high speeds

Caltech chemists, under the direction of Professor John D. Roberts, are investigating conformational changes in certain types of hydrocarbon-ring molecules, some of which occur in pharmaceutical and industrial products. Conformational changes are changes in the spatial arrangements of the atoms within a molecule and may play a major role in influencing chemical and physical properties. (The coiling and uncoiling of DNA molecules is an example of a conformational change.) Knowledge of conformations of molecules and how they change is important in understanding drug action and the ways in which molecules are broken apart by enzymes, as in digestive processes.

For many molecules, conformational changes are amazingly rapid, often occurring as fast as billions of times per second. However, for other molecules, even of closely related structures, conformational changes may be extremely slow, so that some take place only once in 10,000 years.

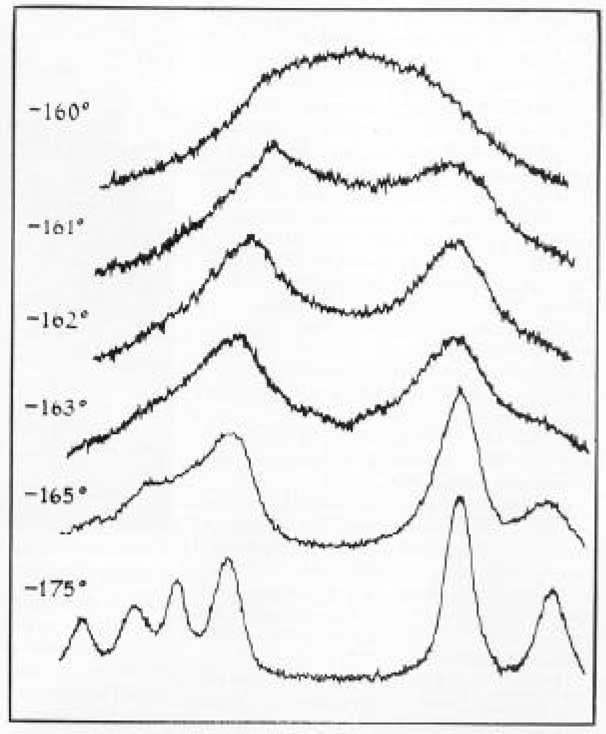


Edward Glazer determines a nuclear magnetic spectrum. The sample is in an adjoining 12-inch electromagnet. The spectrum recorded at the console will later be compared with other spectra of the same material taken at different temperatures.

The stable conformation of a molecule is one in which the atoms interfere with each other as little as possible within the constraints put on them by the chemical bonds between atoms. However, intermolecular collisions can deform them, "knocking" them into other conformations. Professor Roberts, Edward S. Glazer, and Drs. Gerhard Binsch, J. Thomas C. Gerig, and Dean L. Griffith have been studying conformations of rings of hydrocarbon molecules (cycloalkanes) to determine the favored conformations (if any) of those with six to ten carbons in the rings. Changes in the shapes of the rings as the carbon atoms flip from one position to another are basically mechanical processes that can be demonstrated and, to a degree, predicted with ball-and-stick models of molecules. These models show graphically that, in general, the larger the ring, the easier it is for the ring to twist and flip-flop without the carbon atoms having to break the chemical bonds with neighbor atoms.

Experimental technique

The technique used to analyze the conformations of these molecules is nuclear magnetic resonance (NMR), an extremely precise and comparatively rapid method that is also widely used in industry for chemical analysis of liquids and, sometimes, gases. In the apparatus used at Caltech, NMR measurements are made on samples in a strong magnetic field (14,000 gauss), which partially aligns the nuclei of the hydrogen or fluorine atoms in the field direction. The aligned nuclei can absorb energy in the radio frequency region, the specific frequencies being determined by the kind and chemical environment of the nuclei. The record of absorbed frequencies, which results in a series of peaks on a graph, permits determination of the type and number of atoms in the molecule. Rate processes such as conformational changes may show up as a blurring or averaging of the NMR spectrum. The changes, because they are caused by intermolecular collisions, are temperature-dependent. For that reason, molecules having a high rate of change are studied at low temperatures. Cyclooctane, an eight-membered ring for which a hitherto unsuspected form (the "twist boat") was found to be most stable, had to be cooled to —300° F for determination of its structure, because at room temperatures the ring changes between conformations more than a billion times per second. This research in conformational changes has been supported by the National Science Foundation and the Office of Naval Research.



Between -160° and -175°C the spectrum of 1,1-difluorocyclooctane changes drastically. At -160°C the rate of conformational change becomes slow enough that the fluorine atoms can begin to be detected in the extreme positions; at -175°C the molecule is essentially frozen, and the different locations of the fluorines are clearly distinguished.

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IN-HOUSE TRAINING. The new NSA employee first attends a six-week general orientation program, followed by a period of specialized classroom study designed to broaden familiarity with an area or areas of heavy NSA concern (e.g., communications theory, cryptanalysis, computer logic and analysis, solid state physics). Formal study is complemented by on-the-job training, as you work and learn under the guidance and direction of highly experienced associates.

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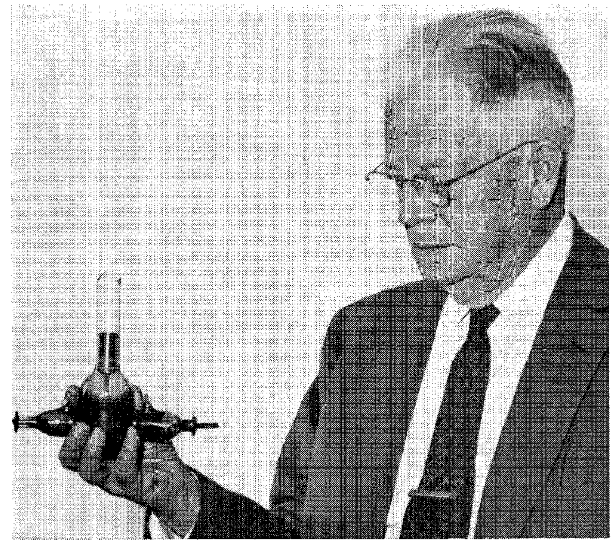
ROYAL W. SORENSEN

(1882-1965)

This tribute to Royal Sorensen was delivered by Frederick C. Lindvall, Caltech professor of electrical and mechanical engineering, and chairman of the division of engineering and applied science, at a memorial service held on October 29 at the First Baptist Church in Pasadena. Dr. Sorensen died at his home in Pasadena, on October 27, after a long illness.



Royal Sorensen with the 1923 model of his vacuum switch, now on display at the Smithsonian Institute.

Royal Wasson Sorensen was a distinguished engineer and educator who also lived as a man with a deep feeling of professional responsibility to his community and his fellow man. Born in a log cabin in Wabaunsee County, Kansas, on April 25, 1882, he spent his childhood and college years in Colorado. His engineering career began with graduation from the University of Colorado in 1905. He then became a transformer design engineer with the General Electric Company in Pittsfield, Massachusetts. In 1910, Royal Sorensen left industry to teach electrical engineering in a new, virtually unknown institution in California – the Throop College of Technology – because he was impressed with the educational objectives of its founders and the opportunities presented for improved engineering education.

Professor Sorensen grew with Throop and also as an engineer, participating in California's pioneer work in high-voltage long-distance transmission of electrical power. Indeed, in these early days he foresaw more clearly than most of his contemporaries the great need for the large-scale electrical power transmission grid which has since come into being.

In 1921, Throop College became the California Institute of Technology, which marked the start of its great growth in the basic sciences and mathematics. Professor Sorensen was quick to recognize the merit of a stronger scientific base for his engineering students and to endorse the then novel idea of an unusually large amount of undergraduate education in the humanities for engineering students. He also foresaw that the best future professional practice would require education beyond the traditional baccalaureate degree and conceived a plan for graduate study in electrical engineering at Caltech which consisted in large measure of advanced work in basic science and mathematics, rather than of advanced topics solely in specialized engineering areas. From the master's and doctoral programs in electrical engineering, begun in the early 20s, have come a large group of alumni whose achievements attest to the merits of Professor Sorensen's concept.

At this same time, a High Voltage Laboratory was erected on the Caltech campus as a cooperative development with the Southern California Edison Company to solve some of the emerging problems in power transmission. Professor Sorensen personally designed the transformers and conceived the chain or cascade connection through which the four transformers operated as the first million-volt power testing facility in the United States.

Keenly aware of the serious problems of control and protection of high-voltage power systems, Professor Sorensen in 1923 began experiments with power current interruption in vacuum and by 1925 had demonstrated the feasibility of the concept. However, commercial application would be forced to wait until 1960 when new vacuum technology and metallurgy had made possible a vacuum switch of acceptable commercial reliability. A measure of the significance of the vacuum switch invention is the fact that the original 1923 model was accepted in 1962 for permanent display in the Smithsonian Institute in Washington.

His professional work was internationally known, and his honors and awards were numerous and distinguished. Among these: His alma mater, University of Colorado, conferred on him the degree of D. Sc. He served his professional society, the Amer-

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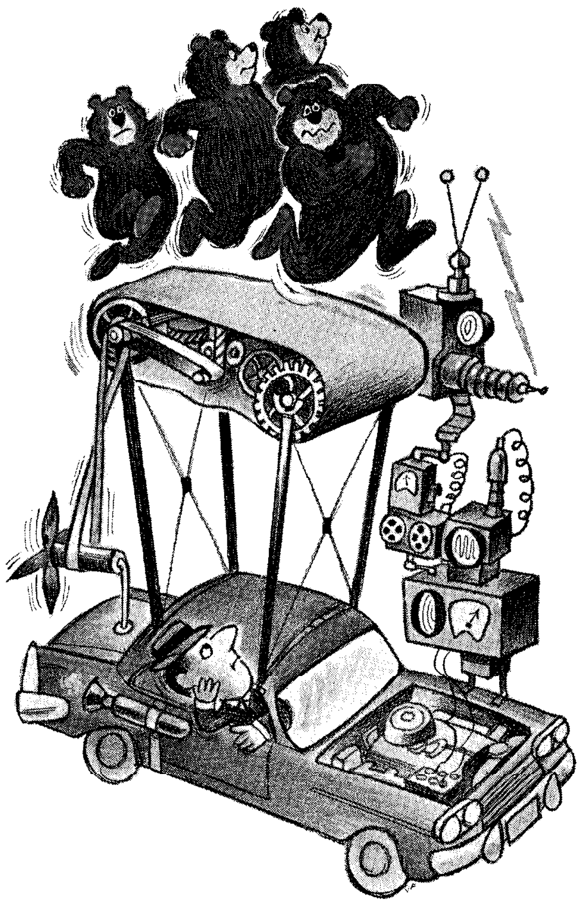
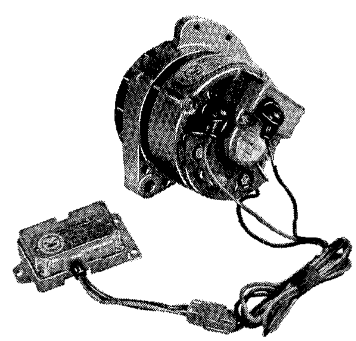


Hitch it to a herd of grizzlies . . .



. . . or feed it a Motorola alternator system*

THE PROBLEM: HOW DO YOU GIVE YOUR CAR BATTERY THE ENERGY OF A GRIZZLY BEAR — UPHILL, DOWNHILL, OR JUST TO GET GOING?

There was a time when engineering an alternator system was an impracticality. Most everyone in the business tried it—no one could successfully mass produce the automotive diode—the key to the system. Finally, Motorola engineers made the breakthrough— alternator systems are committing hapless generators to the museum showcase.

Today, alternator systems are designed for automotive, industrial, and marine use.

This sort of engineering sophistication is producing automotive electronic equipment to do things for the car that are impractical to accomplish mechanically.

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*An electronic system that maintains a consistent, reliable energy supply for the car's electrical equipment.

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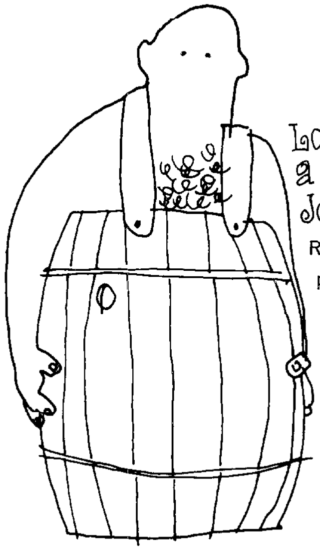

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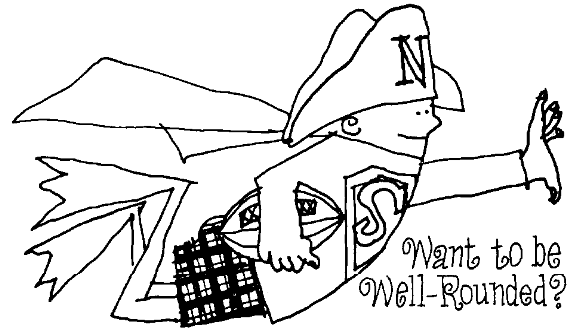

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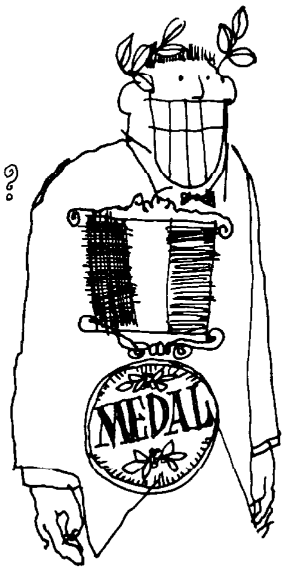

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ican Institute of Electrical Engineers, as national president in 1940-41 and in later years was designated as Honorary Member, a distinction few engineers achieve. For his professional work and for his contributions to engineering education in Japan, the Japanese Institute of Electrical Engineers designated Professor Sorensen as an Honorary Member. His pleasure in this recognition was in a sense a measure of his broad interest in people everywhere. Another and more personal honor was the establishment by a group of senior engineers in the Los Angeles area, all Fellows of the Institute of Electrical and Electronic Engineers, of an informal organization known as the Royal W. Sorensen Fellows. The group appreciated this additional opportunity of association with Royal, and its name will now sustain his memory in local engineering circles. In furtherance of professional ideals, Professor Sorensen served for several years on the California State Board of Registration of Professional Engineers. In the community he was well known for his long and devoted service to his church, to the Pasadena YMCA, and the Tuberculosis Association.

In all, Professor Sorensen was officially a part of Caltech for 42 years and Caltech was a part of him. He contributed more than his inventions, his educational innovations, and his professional activities. He served the Institute and the students for many years in the additional capacity of Director of Athletics. He was concerned both for the student's education and for his physical well-being. His influence on students thus extended far beyond the bounds of his electrical engineering classroom. His extensive knowledge of students was matched only by his amazing memory for their names and careers. In 1948 the Caltech Alumni Association made him an honorary member — a distinction held by only seven men — and at the time of his retirement from the Institute an alumni group established a fund for a Royal W. Sorensen Fellowship.

In 1952, Royal Sorensen became Professor Emeritus, which for him meant "retired" in name only. Continuous productive professional and community service followed until his health no longer permitted. He came often to his campus office, to faculty meetings, and to student affairs, particularly those of the Caltech YMCA. He was instrumental in establishing the Caltech YMCA in 1916 and served continuously on its Board of Directors for almost 50 years.

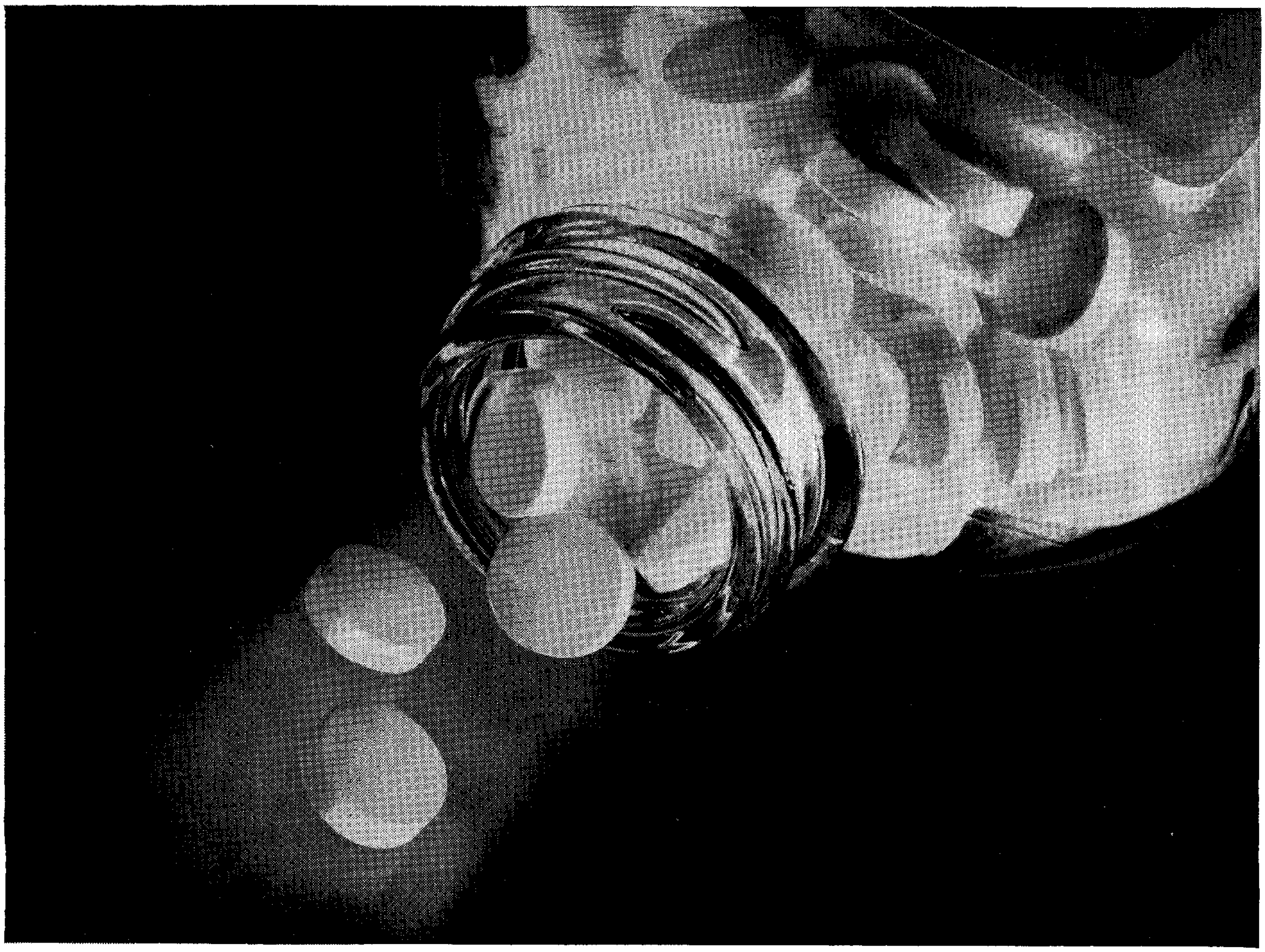
As a friend, a colleague, and a wise counselor he will be sorely missed, but we will cherish his memory and be ever grateful for all of his kindly help and wise guidance along the road. These words must surely be inadequate. Yet who can know the measure of a man?

CALTECH ALUMNI ATHENAEUM MEMBERSHIP

The Board of Governors of the Athenaeum has extended the privilege of membership in the Athenaeum to members of the Caltech Alumni Association. Those alumni who are members of the Association in good standing may avail themselves of this privilege of becoming an Athenaeum member. All the facilities of the Athenaeum will be available to these members with the exception of extending overnight guest privileges to others.

Any alumnus interested in this membership should procure an application card from the Alumni Association.

Donald S. Clark, Secretary
Alumni Association



Alumni News

Richard W. Shoemaker (1881-1965)

Richard W. Shoemaker '03, died on October 19, in Grass Valley, California, where he had been retired since 1953. One of the oldest living Caltech alumni, he made significant contributions to the field of engineering during his lifetime. His family has established an R. W. Shoemaker Memorial Fund to be given to the California Institute of Technology.

When Richard Shoemaker was still a student at Caltech – then called Throop College – he sent the first wireless message to Catalina Island. Carrier pigeons flew messages the 28 miles from the mainland for the island's newspapers at that time. After graduation Shoemaker went with the Federal Lead Mines in Missouri, where he installed an electrical method of hauling out ore, this time replacing donkeys being used for the job.

Back in California, in 1914, with the Bowie Switch Company, he put in the country's first trackless trolley in Laurel Canyon near Hollywood. In 1917 he enlisted in the U.S. Navy and became the officer in charge of the building of the first battleship, *Guinn*, in Seattle. After the war he went to Shanghai and Hong Kong to study electrical opportunities there, and to Manchuria to negotiate for the electrical railways in Harbin.

On his return to California, Shoemaker entered the hydroelectric field and was consulted regarding the power potential of Hoover Dam. He designed the drop for the All-American Canal in Imperial Valley and the power house at the Don Pedro Dam on the Tuolumne River near Turlock. He had more than 20 patents in his name. The most widely used is his bus bar, found in the Hoover and Grand Coulee dams.

In 1928 Shoemaker went to Brazil to centralize the electric companies in the state of Sao Paulo. Upon his return in 1934, he was engaged as a consulting engineer for the Chase Brass & Copper Company and the Kennecott Wire and Cable Company in Connecticut, and became an authority on radiant heating. His book on the subject was printed in French and Spanish.

Returning to California in 1946, Shoemaker was appointed consulting engineer for the Oakdale Irrigation District's Tri-Dam Project on the San Joaquin River and, in 1950, for the Nevada Irrigation District.

He was a fellow of the Institute of Electronics and Electrical Engineers and a member of the American Society of Mechanical Engineers and the American Society of Heating and Ventilating Engineers. In 1962 he was chosen by the Engineering Council of Sacramento Valley as the engineer who had contributed most to the growth and development of the electrical power industry and the engineering profession.

Shoemaker was a member of the Caltech Alumni Association and, in 1953, was honored by the Institute on the golden anniversary of his graduation from Throop College.

He is survived by his wife and a son, Richard, of Washington, D.C.

Freshman Event

A "Gentlemen's Tea" for freshmen entering Caltech this fall from the New York City area was held by the Caltech Alumni Association's New York chapter in September. Nineteen guests, including Caltech sophomores, juniors, and seniors from the Metropolitan area, were entertained at New York's Columbia University Club. Victor Wouk, MS '40, PhD '42, was unofficial host, and Bruno Pilorz '44, president of the alumni chapter, presided at a question-and-answer session. Harry J. Moore, Jr., '48, was in charge of arrangements.

The New York Chapter hopes the tea will become an annual event.

–Victor Wouk

Books . . . *continued*

Foundations of Solid Mechanics

by Y. C. Fung, MS '43, PhD '48

Prentice-Hall Inc. $13.50

Y. C. Fung, professor of aeronautics at Caltech, intends this book to bridge the gap between elementary textbooks and more advanced literature; it is the only one available covering the entire field of solid mechanics. The book belongs in the Prentice-Hall International Series in Dynamics, of which Dr. Fung is also editor.

Ideas in Modern Biology

edited by John A. Moore

The Natural History Press $8.00

Based on papers delivered at the XVI International Congress of Zoology, this book examines most of the major ideas in modern animal biology. Contributions include "The Duplication and Recombination of Genes," by Matthew S. Meselson, PhD '57, associate professor of biology at Harvard University.

The Architecture of Molecules

by Linus Pauling and Roger Hayward

W. H. Freeman and Co. $10.00

This elegant book has a text by Dr. Pauling and 57 plates in full color by Roger Hayward, the scientific illustrator who also illustrated Pauling's widely used *General Chemistry* and *College Chemistry*. It is planned especially for young people who are just beginning to develop an interest in science. The discussions treat the subject of how atoms are arranged and interconnected in molecules and crystals, and the way in which the geometry of this organization accounts for some of the properties of substances.

Space Propulsion

by Donald L. Turcotte, '54, PhD '58

Blaisdell Publishing Co. $2.50

Donald Turcotte, associate professor of aerospace engineering at Cornell University, wrote this for an introductory course in astronautics. It is not intended to show how to design a particular space vehicle or propulsion system, but to show how the fundamental physical and chemical laws place limitations on vehicle performance and influence the selection of propulsion systems for specific mission requirements. Topics include: requirements for a space propulsion system, chemical propulsion systems, nuclear propulsion systems, electrical propulsion devices combined with a nuclear reactor, and photon propulsion and solar sailing.

Personals

1921

CLIFFORD C. POTTS died on September 23 in Los Angeles, after a long illness. He had been with the Westinghouse Electric Corp. since 1923 and, at the time of his retirement in 1962, was a special representative for their electric utility department. He is survived by his wife, Betty, his daughter, Mrs. Thomas McMahon, and two granddaughters.

1925

KENNETH W. RANNEY died on July 4 in Garden Grove, Calif., where he made his home. Retired chief executive of Cal-Compack Foods, Inc., of Santa Ana, Ranney was a pioneer in the Orange County food processing industry. He is survived by his wife, Marjorie; two sons, Gilbert and David; a daughter, Sylvia, and one granddaughter.

1931

GEORGE LANGSNER, California deputy state highway engineer, has been reelected secretary-treasurer of the Western Association of State Highway Officials.

1933

ROBERT C. HOGAN is the new Western regional manager of the Englander Company, Inc., in charge of sales offices in San Francisco, Seattle, and Los Angeles, with headquarters in L.A.

1935

DAVID J. LEHMICKE has been named research associate for fundamental problems in textiles and fibers research at the Firestone Tire & Rubber Company's central research laboratories in Akron, Ohio. Lehmicke, who has been with Firestone since 1955, was serving as group leader in the textiles and adhesives division of the laboratories.

1938

DAVID K. BEAVON has joined the Ralph M. Parsons Co. in Los Angeles, as director of process operations, petroleum-chemical engineering.

1940

LEO BREWER, professor of chemistry at the University of California at Berkeley, is director of the new Inorganic Materials Research Laboratory of the Lawrence Radiation Laboratory at the University of California at Berkeley, which was dedicated in July.

ROSS D. F. THOMPSON has been promoted to professor of physics at California State College at Los Angeles. He has been on the Cal State faculty since 1959 and, before that, spent nine years in the physics department at USC.

1942

HENRY W. MENARD, JR., MS '47, writes that he is on a year's leave of absence from the University of California at San Diego and is a technical assistant with the Executive Office of the President, Office of Science and Technology, in Washington, D.C.

1943

WILLIAM HOVANITZ, PhD, professor of zoology at California State College at Los Angeles, is on sabbatical leave doing research under the sponsorship of the Lepidoptera Research Foundation and the National Science Foundation.

1944

WILLIAM E. LOCKWOOD, JR., has been appointed manager of manufacturing for the eastern metal division of the Continental Can Company in New York City.

1945

OTIS E. LANCASTER, AE, has been elected vice president and member of the board of directors of the American Society of Engineering Education. He is George Westinghouse Professor of Engineering Education, at Pennsylvania State University.

HARRIS M. SCHURMEIER, MS '48, AE '49, former Ranger Project manager at Caltech's Jet Propulsion Laboratory, has been appointed Voyager deputy project manager and Voyager capsule system manager. The spacecraft is scheduled for operational launch to Mars in 1971.

1946

MIKE W. FOSSIER, MS, AE '47, has been elected vice president and division assistant general manager-technical of the Raytheon Company in Lexington, Mass. Fossier, who has been with Raytheon since 1950, was chief engineer for the missile systems division.

1947

PAUL G. ATKINSON, JR., MS, colonel in the U.S. Air Force, is deputy commander of the Aerospace Research Labortories at Wright-Patterson Air Force Base in Ohio. Atkinson, a recipient of the Distinguished Service Cross and the Legion of Merit, recently received the Air Force Commendation Medal for outstanding achievement during his assignment as propulsion division chief for research and development at USAF headquarters in Washington, D.C.

1948

GLENN A. CHAFFEE has resigned as pastor of the First Church of the Nazarene in San Francisco to study for his PhD at Michigan State University.

CHARLES I. BROWNE, JR., MS, has been named an assistant test division leader at the Los Alamos Scientific Laboratory in New Mexico. Browne has been with the Laboratory since 1955.

1949

CLEMENT J. SAVANT, JR., MS '50, PhD '53, will serve as director of Whittaker Corp.'s new advanced development department in the controls and guidance division in North Hollywood.

1950

WILLIAM F. SAMPSON has been appointed assistant general manager of a newly established Manned Orbiting Laboratory systems engineering office for the Aerospace Corporation in El Segundo. He was previously group director of several military space programs in the satellite systems division.

1951

JOHN R. JANNARONE, MS, was promoted to the rank of brigadier general and appointed dean of the United States Military Academy at West Point on June 1. General Jannarone has been professor in the physics and chemistry departments at West Point since 1957 and was head of both departments last year.

EDWIN E. PYATT is at the University of Florida in Gainesville as professor of sanitary engineering. He was formerly a senior research engineer at the Travelers Research Center in Hartford, Conn.

1952

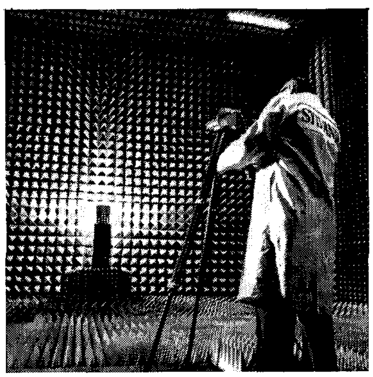
MELVIN A PEDERSEN, MS, physicist with the U.S. Navy Electronics Laboratory in San Diego, was awarded $1200 by the Bureau of Ships for research that led to the adaptation of computer techniques to underwater sound propagation. The new method, it is estimated, will save the Navy $450,000 a year.

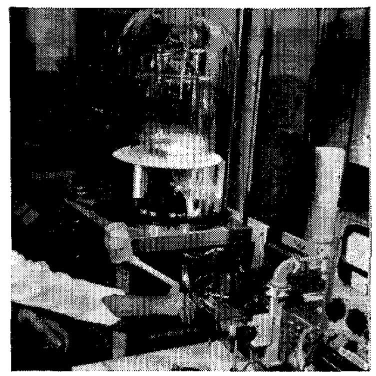
1954

SIDNEY B. BELLINGER, JR., MD., writes that he has completed a four-year residency in general surgery at the U.S. Naval Hospital in Oakland, Calif., and is enroute to the U.S. Naval Hospital in Guam with his wife, Edie, and children, Mark (4), and Kristen, (2).

1956

WILLIAM K. PURVES, JR., associate professor of botany at the University of California at Santa Barbara, has received the Plous Memorial Award for substantial contributions to the intellectual life of the college community. Purves has been at Santa Barbara for four years and holds a





National Science Foundation grant to conduct research on a plant growth hormone.

1957

REUBEN B. MOULTON, Jr., and his wife, Beverly, send news of the birth of their first child, Victoria Lynne, on August 19. Rube is division commercial supervisor for Pacific Telephone in Alhambra.

T. NEIL DAVIS, MS, has been appointed assistant director of the Geophysical Institute at the University of Alaska. He will continue his investigations of the upper atmosphere, using sounding rockets, which he began while working for NASA.

1958

ROBERT E. TOKHEIM, MS '59, has joined the electron devices division of Watkins-Johnson Company in Palo Alto. Before joining W-J he was a research assistant at the Stanford University Microwave Laboratory.

GORDON D. LANGE received his PhD from The Rockefeller University in June.

1961

JOEL A. MICHAEL has received a research fellowship from the Carnegie Institution and will spend a year at the National Physical Laboratory, Teddington, England. He will investigate the processes in the brain involved in vision. Michael has been working on his PhD at MIT.

1962

RAYMOND P. LUTZ, PhD, was recently appointed assistant professor of chemistry at the University of Illinois. He went to Urbana from Harvard University, where he had been on the faculty since 1961.

1963

DAVID WARREN HALL, PhD, has been named advanced research chemist at the Marathon Oil Company's Denver Research Center. Hall, who joined Marathon in 1962, is the inventor of a new method for production of a raw material for synthetic rubber.

1965

ROGER L. PETERSON, PhD, has joined International Minerals & Chemical Corporation as a research chemist at the company's research and development center near Skokie, Illinois.

GLENN GARY CLINARD has received the 1965 Honeywell award for significant work in undergraduate engineering and science. He is doing graduate work at Caltech in mechanical engineering.

ALUMNI EVENTS

November 20	Interhouse Dinner-Dance
May 7	Annual Alumni Seminar
June 8	Annual Meeting

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Contact Mr. Farrar, EX 9-5277, on Thursday morning for reservations.

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Visiting alumni cordially invited—no reservation.