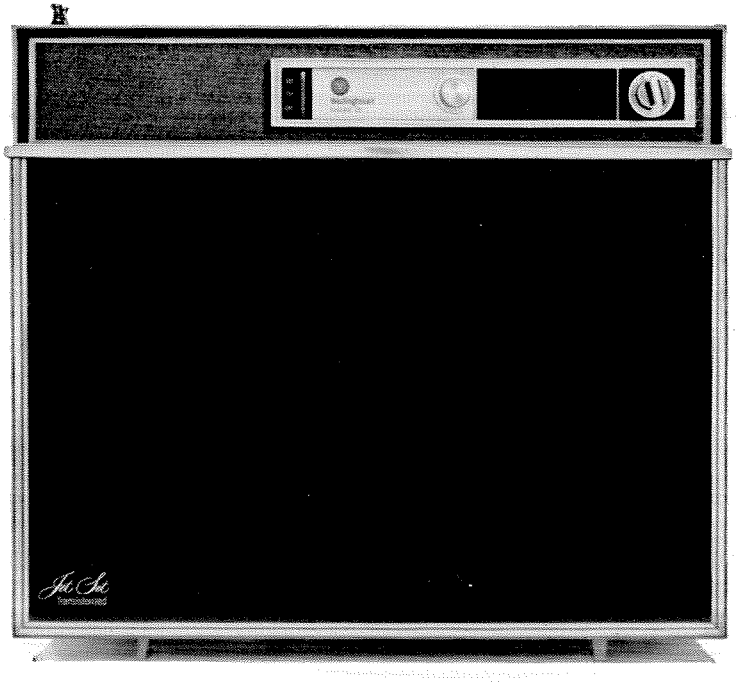
MARCH 1966

ENGINEERING AND SCIENCE

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

New Westinghouse Jet Set gives you a beautiful picture...



even when it's off

The picture tube doesn't stare back at you. And there's no wait for warm-up because it's Instant-On™ television.

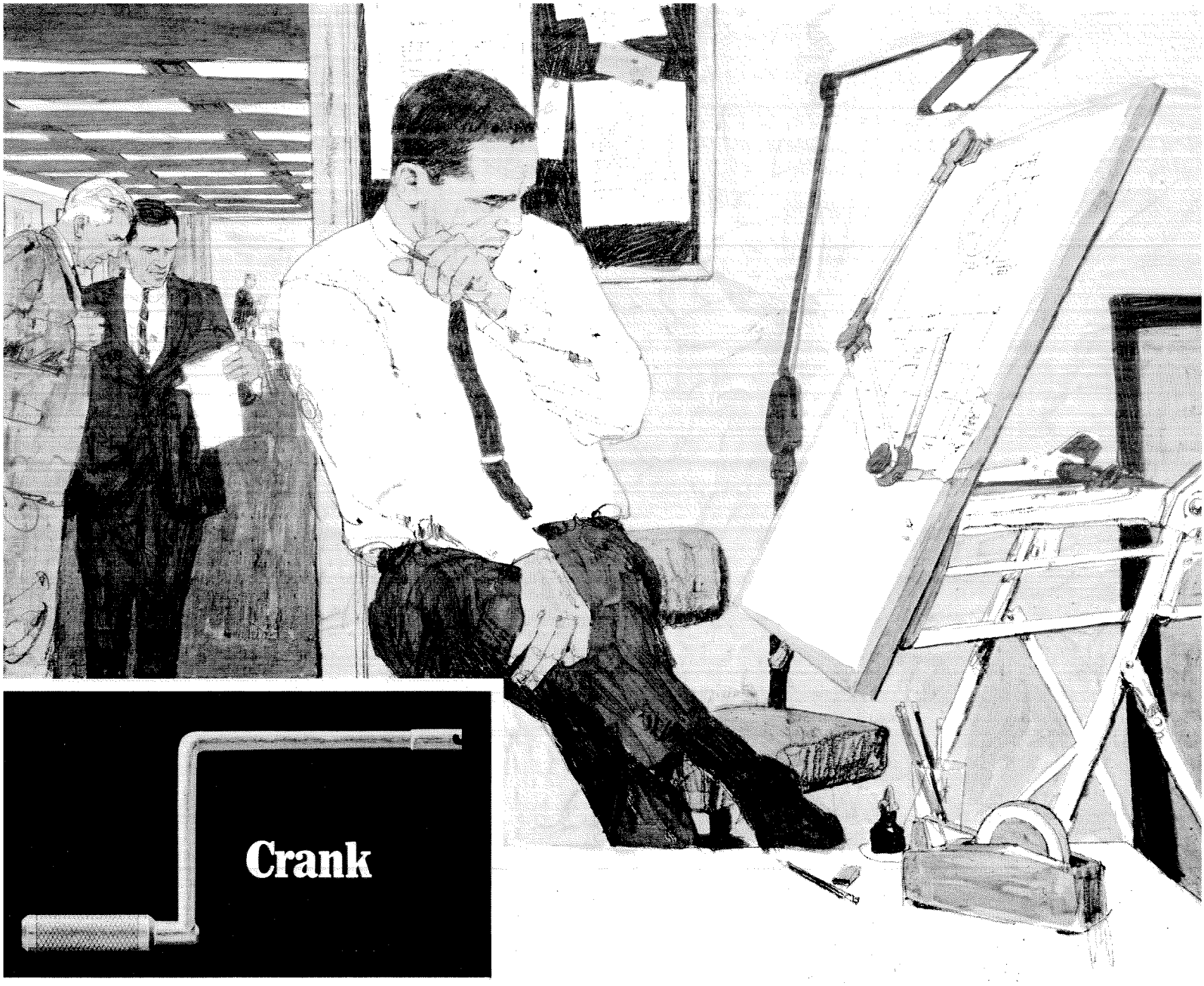
Turned on, Jet Set delivers a soft, clear, easy-on-the-eyes picture. New Memory Fine Tuning lets you pre-tune each channel for best picture and sound. Set it once—and forget it.

Turned off, Jet Set doesn't even look like a TV set. But off or on, it's beautiful.

Westinghouse makes a product so you'll enjoy it—any way you look at it.

You can be sure if it's Westinghouse

For information on a career at Westinghouse, an equal opportunity employer, write L. H. Noggle, Westinghouse Educational Center, Pittsburgh, Pa. 15221.



Self-Starter

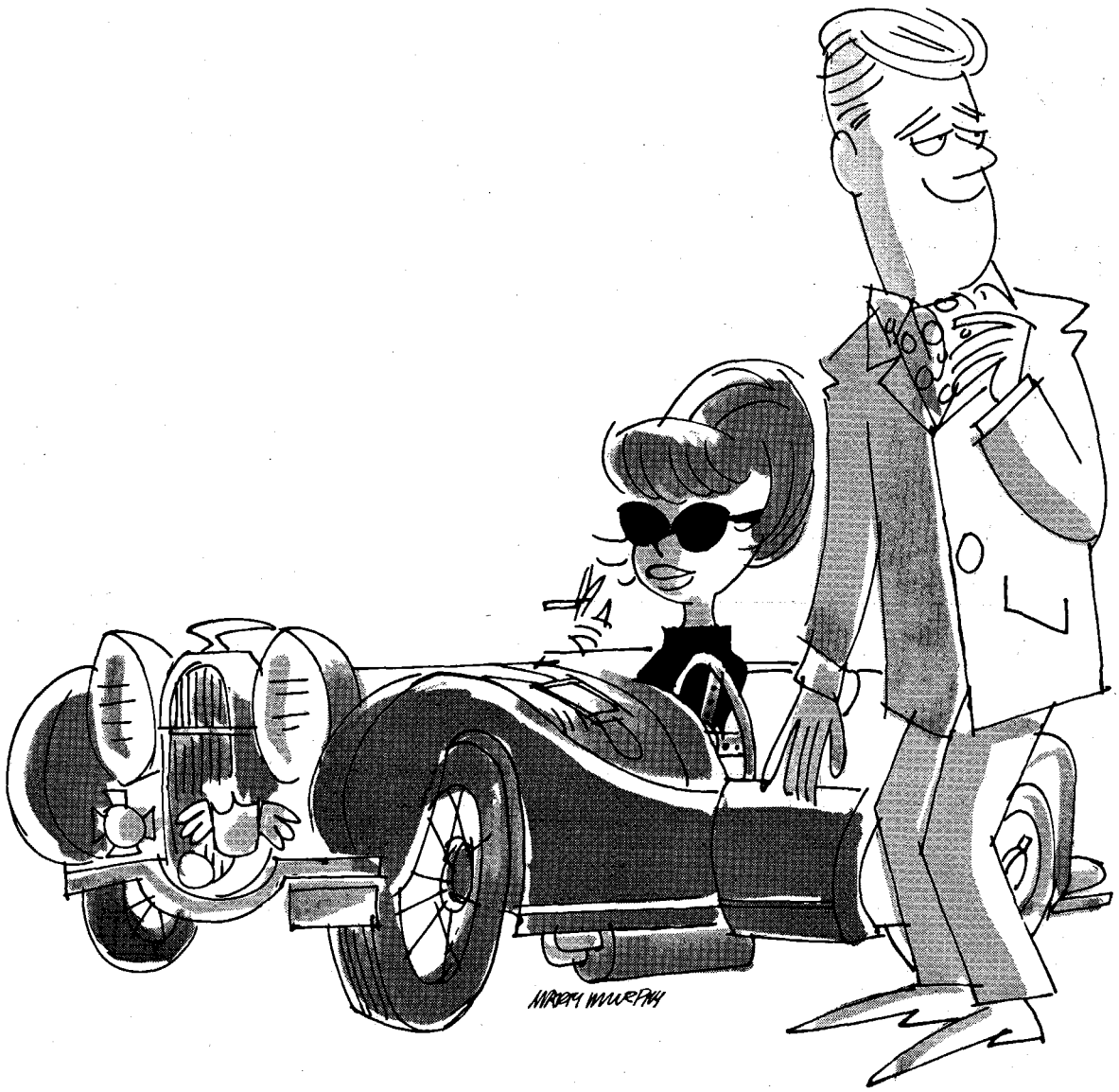
It took a human self-starter to eliminate the crank. General Motors engineers have been inspired by that example ever since. They have kept to the trail laid down by a genius named Charles F. Kettering.

Back in 1910, the experts told Mr. Kettering that a practical electric starter for automobile engines was an impossibility. It took him six months to develop one. His self-starter eventually eliminated the dangerous hand-crank, revolutionizing motoring and putting women in the driver's seat. His record of scientific achievement in the decades that followed is without parallel.

And like this remarkable man's most famous invention, today's GM engineer is a self-starter—one who doesn't wait to be asked, who seeks out the tough problems and sets out to solve them.

They're a vital group, these men of science who follow the Kettering flame—restless, curious and devoted to the idea that nothing is so good it can't be improved. Their collective contribution to GM's progress over the years is beyond measure.

General Motors Is People... making better things for you



Stimulated by independent research and development?

At Douglas, we have many independent research and development programs underway right now. (They're just part of the activity at our extensive and exceptional Southern California facilities.) Many of our people publish, too. Or pursue advanced degrees at the many nearby Southland colleges and universities. There's an exciting atmosphere at Douglas for any young engineer or scientist on his way up. Interested? Contact your placement office or send your resume to L. P. Kilgore, Box 702-C, Corporate Offices, Douglas Aircraft Co., Inc., Santa Monica, California.

DOUGLAS

An equal opportunity employer

ENGINEERING AND SCIENCE

March 1966 / Volume XXIX / Number 6

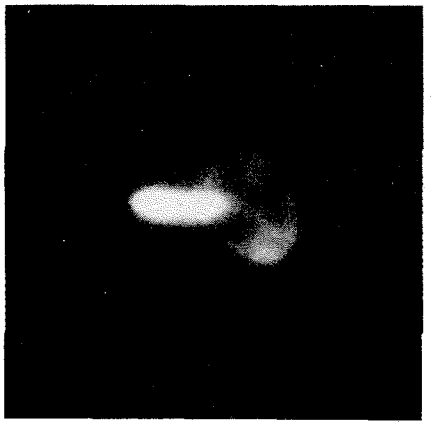
Picture Credits

Cover, 11 — Mt. Wilson and Palomar Observatories
6 — Nordisk Pressefoto
12, 13, 18 — James McClanahan
15 — Carl T. Eastvedt
20 — Thayer Scudder

Staff

Publisher . . . . . Richard C. Armstrong '28
Editor and Business Manager . Edward Hutchings, Jr.
Associate Editor . . . . . Bruce R. Abell '62
Assistant to the Editor . . . . . Phyllis Brewster
Photographer . . . . . James McClanahan

Published monthly, October through June, at the California Institute of Technology, 1201 East California Blvd., Pasadena, Calif. 91109. Annual subscription $4.50 domestic, $5.50 foreign, single copies 50 cents. Second class postage paid at Pasadena, California, under the Act of August 24, 1912.



On Our Cover

is number 148 in an *Atlas of Peculiar Galaxies* just published by Halton Arp, staff member of the Mount Wilson and Palomar Observatories. This galaxy appears to have three radio sources near it—two of which are quasars. If this is actually the case, then it may be that quasars are not the very distant objects they have been thought to be. Dr. Arp speculates on the implications of his findings, which are counter to most current theories, in "Peculiar Galaxies—New Light on Quasars," on page 11.

Norman H. Brooks.

professor of civil engineering, has been instrumental in developing techniques for the control of ocean pollution. His research at Caltech, coupled with consultation on most of the major projects for sewage disposal in the ocean off southern California, has been significant in helping Los Angeles to have coastal water as clean as that of any major metropolitan area in the United States. Dr. Brooks explains how this cleanup has been brought about in the last 15 years in "Controlling Ocean Pollution" on page 13.

Why become an engineer at Garrett-AiResearch? You'll have to work harder and use more of your knowledge than engineers at most other companies.

If you're our kind of engineer, you have some very definite ideas about your career.

For example:

You've worked hard to get a good education. Now you want to put it to work in the best way possible.

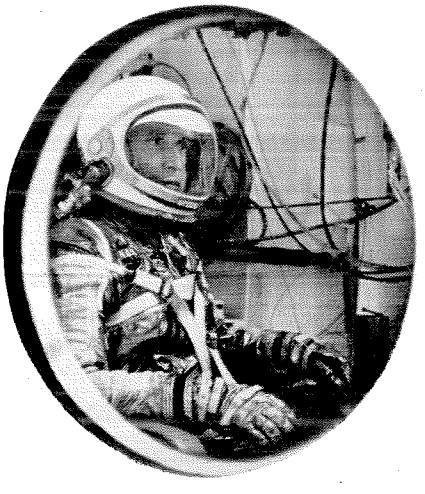
You will never be satisfied with run-of-the-mill assignments. You demand exciting, challenging projects.

You not only accept individual responsibility – you insist upon it.

Does that sound like you? Then AiResearch is your cup of tea.

Our business is mainly in sophisticated aerospace systems and subsystems.

Here, research, design, and development lead to production of actual hardware. That means you have the opportunity to start with a customer's problem and see it through to a system that will get the job done.



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.

If the AiResearch story sounds like opportunity speaking to you – don't fail to contact AiResearch, Los Angeles, or Phoenix, or see our representative when he comes to your campus.

An equal opportunity employer

AiResearch *is* challenge

GARRETT

Los Angeles • Phoenix

Find your "occupatibility" at Du Pont

It won't take much looking.

What's "occupatibility"?

It's a term we've invented to express the opportunity Du Pont offers you as a technical man* to find the job that best matches your interests and abilities. You may find it could be in research, or scientific marketing, product development, or plant operations.

At the moment, you may not be sure exactly what it is that you want to do. We'll help you find out, by giving you actual experience on different jobs.

You'll find, too, that we have plenty of room for you to move around. Many Du Pont technical men have changed jobs, even switched from one discipline to another right within the company.

We realize, you see, that with this year's graduating technical men, "occupatibility" is a pretty important thing.

Learn more about Du Pont. Send this coupon for a subscription to the Du Pont magazine.

E. I. du Pont de Nemours & Co. (Inc.)
3658 Nemours Building
Wilmington, Delaware 19898
Please send me the Du Pont magazine.

Name_____

Class_____ Major_____ Degree expected_____

College_____

My address_____

City_____ State_____ Zip Code_____

*This year, our recruiters will be at your school looking mainly for: Ch.E., M.E., I.E., E.E., C.E., chemistry, physics and mathematics graduates. Du Pont is an equal opportunity employer.

DU PONT
REG. U.S. PAT. OFF.

Better Things for Better Living . . . *through Chemistry*

Letters

New York, New York

EDITOR:

The article in the February issue of *E&S* paying tribute to the late Professor Paul Epstein could not cover some of the more humanistic aspects of this great man, in particular his relationship to his students and his sense of humor. I believe the following deserves to be mentioned to honor his wit.

Frankly I must admit that this story is secondhand, but it was circulated among the EE PhD candidates, prior to their orals, in the early '40's. The candidates were warned that one of Professor Epstein's favorite questions was the following:

> "You are at a dinner party, and your dinner partner at the left is a good-looking blonde. You are engaged in fascinating conversation with her, it is your turn to talk and, therefore, you cannot watch too closely the coffee that has just been poured. A small portion of cream was served with the coffee.
>
> "Assuming you want the coffee to be as cool as possible when you drink it, and you know that it will be several minutes before the conversation takes such a turn that the blonde will begin to talk and you will have a chance to drink the coffee, when should you pour the cream into the coffee? When you start to talk, or when the blonde starts to talk? Support your opinion quantitatively."

Note the catholicity of the question. It covers Social Relations, the War Between the Sexes, and Thermodynamics.

Since some people may disagree with Mr. Boris N. Sammer '26, whose letter appears on page 6 of the same issue, and may want to project the image of Caltech as a "fun college," I believe I should not give the answer to the problem. The first undergraduate who supplies the correct answer should be given a reward, such as a date with the best-looking blonde at PCC, etc. I leave the details with the good offices of Dr. Clark.

VICTOR WOUK, MS '40, PHD '42

Pasadena, California

EDITOR:

Though I have many pleasant memories of Professor Paul Epstein, those most vivid to me will always remain those of his lectures. In my most impressionable years he set an example of good organization, orderly presentation, and careful scientific procedure which ever since has determined my own personal standards—even though I have seldom measured up to them.

I first saw him near the beginning of the academic year 1923-1924. Dr. R. A. Millikan was giving a series of lectures on the newer developments in physics; they were open to visitors, and I came from Los Angeles regularly to attend. I found that Epstein was lecturing on atomic theory just before the Millikan lectures, and I began to come an hour earlier. Unfortunately for me, at that time Dr. Epstein spoke English with some inaccuracies and with a heavy accent. Since I was also insufficiently prepared for his mathematical treatment, I soon gave up.

At the beginning of the academic year 1924-1925, I registered as a graduate student in physics and, as a matter of course, attended lectures by Epstein. His English delivery had improved enormously, and I had no difficulty understanding him. He had worked hard on his English lecturing. It was later rumored that he even took to crossword puzzles extensively with the idea of broadening his vocabulary, but eventually he discovered that this added vocabulary had certain peculiarities, and he abandoned the project.

His lectures were perfectly organized; any set of them could have been issued in book form. This was later done with his course in thermodynamics. His delivery was careful and deliberate so that it was possible to take very complete notes. My first notebooks were carefully edited. They are still useful for reference and are a pleasure to read. In some later years I amused myself by recording the lectures precisely as they were given, with all the minor slips, mannerisms, and residual oddities in English. This, perhaps, was hardly fair, but other students to whom I lent my notes read them with affectionate enjoyment. To us who knew him it was like the tuning up of an orchestra to have him enter and begin with his usual, "Gentlemen, we have seen in the last hour . . ."

These first lectures were in a room on the third floor of Bridge, used for classes but designed for future use as a laboratory. A conduit beneath the floor was protected by a metal cover. Epstein was a pacing lecturer. On his round he almost invariably came down with one foot on the metal so that his lecturing was regularly punctuated by crashes.

Most students were too much affected by awe and respect to disturb Epstein's lectures with questions or comments. I recall one exception—a gifted and eager student. One day when Epstein was writing an expression which stretched the whole length of the blackboard, there was one of the now usual interruptions:

"Professor Epstein, there is a factor left off at the beginning."

"Ah!" replied Epstein, "but I can put it on the end."

And he did so, with all the triumphant and crushing dignity of an elephant sitting down.

I had the great privilege of writing my doctoral thesis under Epstein's supervision. He was very kind and treated me with great understanding and patience—more, indeed, than I deserved.

Many years later I took an opportunity again to attend his course in quantum mechanics and bring myself a little better up to date. I found him, as always, a perfect lecturer. His personality will live forever in the work of his students and their students' students.

CHARLES F. RICHTER, PhD '28

Palo Alto, California

EDITOR:

In response to the letter of B.N. Sammer in the February issue of *E&S*, might I suggest that he consider IBM rather than CIT for the development of a product which is not concerned with social skills or emotional maturity?

STUART LINN '62

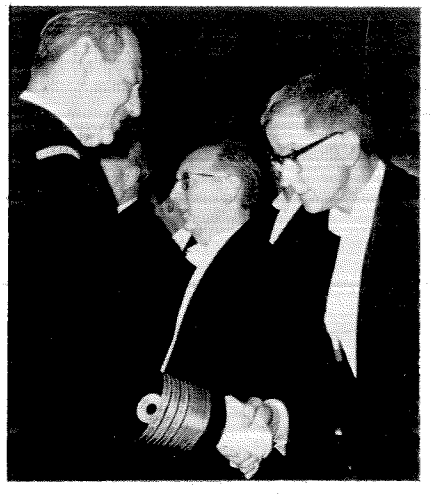
Pasadena, California

EDITOR:

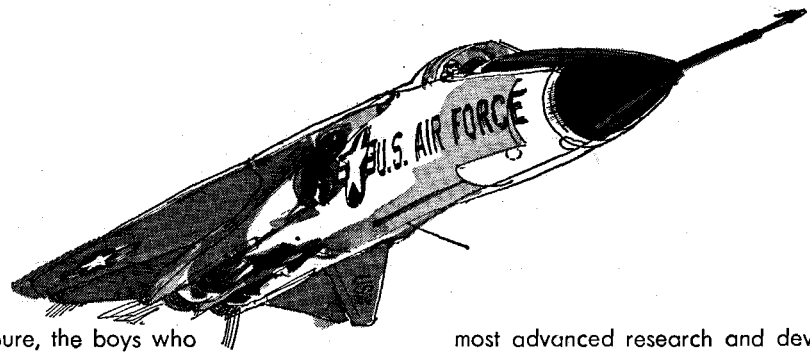
You can't be serious! Or can you? Please confirm or deny and end my uncertainty. Did Max Delbrück of Caltech *really* refuse to shake hands with King Frederik of Denmark? (E&S, January 1966, p. 27.) Or was Mogens Westergaard's account a joke?

JOE HELLER '62

Dr. Westergaard is a joker. But, to set the record straight, he has submitted new pictorial evidence (below) of Dr. Delbrück's pro-royalist sentiments.



Have astronauts made pilots old hat?



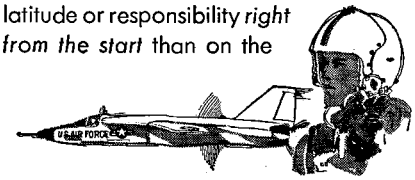
Sure, the boys who go off the "pads" get the big, bold headlines. But if you want to fly, the big opportunities are still with the aircraft that take off and land on several thousand feet of runway.

Who needs pilots? TAC does. And MAC. And SAC.

There's a real future in Air Force flying. In years to come aircraft may fly higher, faster, and farther than we dare dream today. But they'll be flying, with men who've had Air Force flight training at the controls.

Of course the Air Force also has plenty of jobs for those who won't be flying. As one of the world's largest and most advanced research and development organizations, we have a continuing need for scientists and engineers, as well as administrators.

Young college graduates (both men and women) in these fields will find that they'll have the opportunity to do work that is both interesting and important. The fact is, nowhere will you have greater latitude or responsibility *right from the start* than on the



Aerospace Team—the U.S. Air Force.

Interested? The place to find out more is at the office of the Professor of Aerospace Studies, if there is an Air Force ROTC unit on your campus. If not, contact the nearest Air Force recruiter for information on all Air Force officer opportunities. Or mail the coupon below.

Officer Career Information
Box A, Randolph Air Force Base, Texas 78148

Name_____

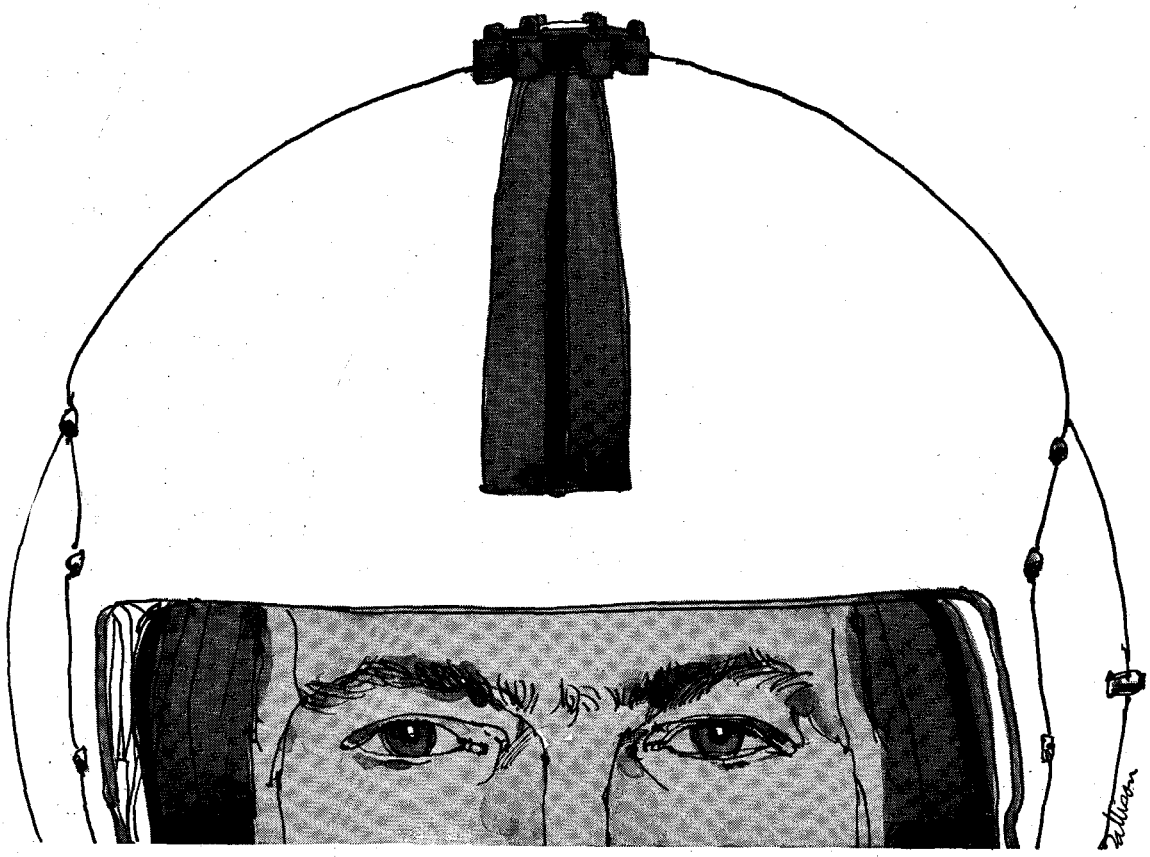
College_____

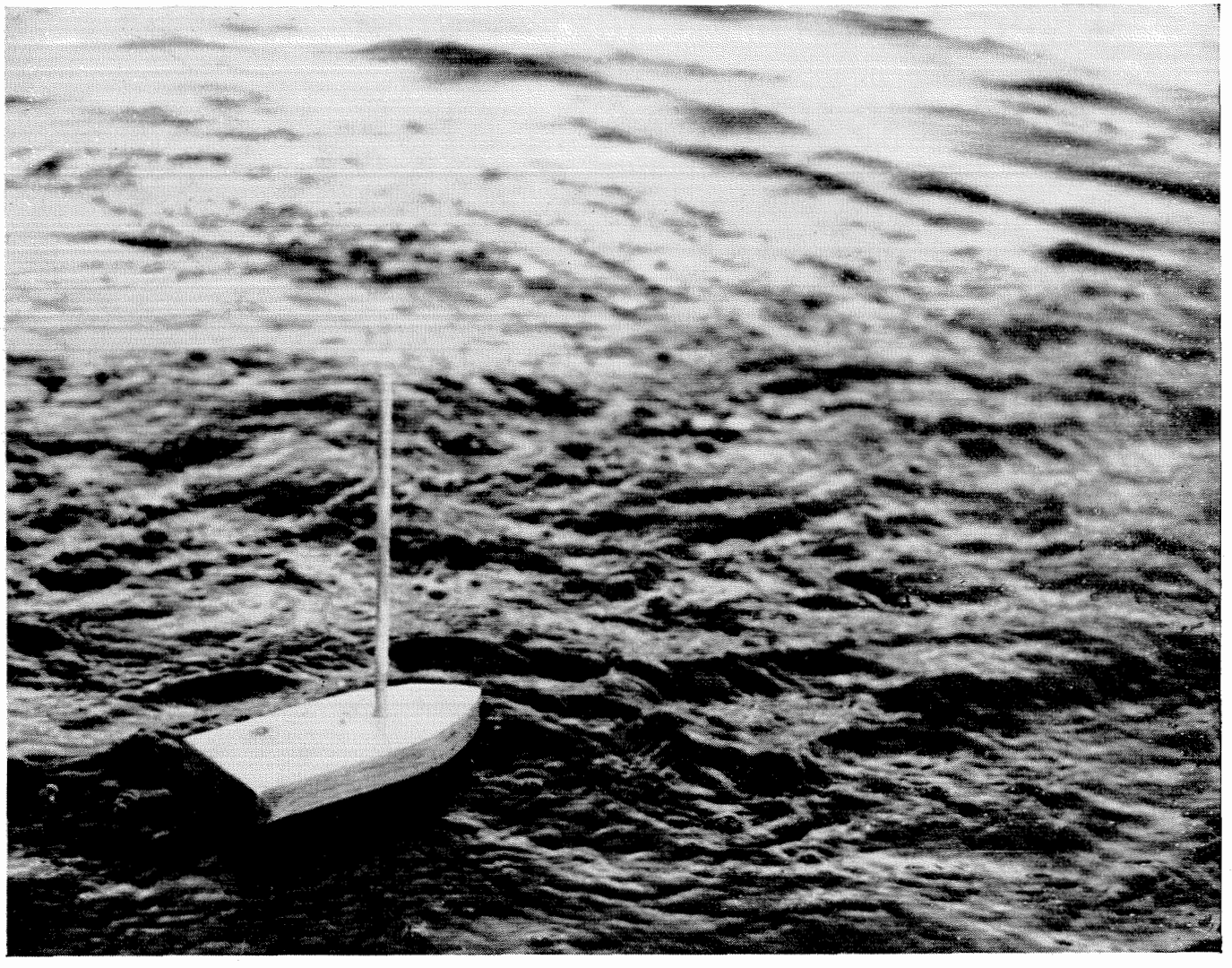
Class of 19_____

Address_____

City_____ State_____ Zip_____

UNITED STATES AIR FORCE





"Drift-along" careers? We don't have them.

You won't find the environment at Sikorsky Aircraft conducive to inertia. We earned our reputation as a pioneer and leader in our dynamic, young industry by applying a lot of mental muscle to a bewildering array of problems. And being willing to buck the current in order to go places is an essential engineering attitude with us today.

Are you this kind of young engineer? Willing to wrestle with new ideas, hard work? Then you should certainly talk to us about the opportunities for personal progress and rewarding professional satisfaction offered in our world of advanced VTOL systems.

The Sikorsky vehicle of today reflects a startling new technology . . . the merging of sophisticated electronic systems with the VTOL airframe to provide new dimensions in airborne capabilities. These advanced VTOL systems are fulfilling the broadest demands on their versatility . . . from space capsule recovery to wide-ranging military and commercial application. As for the future—it's bounded only by the span of engineering imagination.

THE RIGHT SPOT FOR YOU? We'll have it. You'll be given tough, responsible assignments within one of our small, interdependent groups—working on demanding problems in such areas as **aerodynamics • human factors engineering • automatic controls • structures engineering • weight prediction • systems analysis • operations research • reliability/maintainability engineering • autonavigation systems • computer technology . . . among others.**

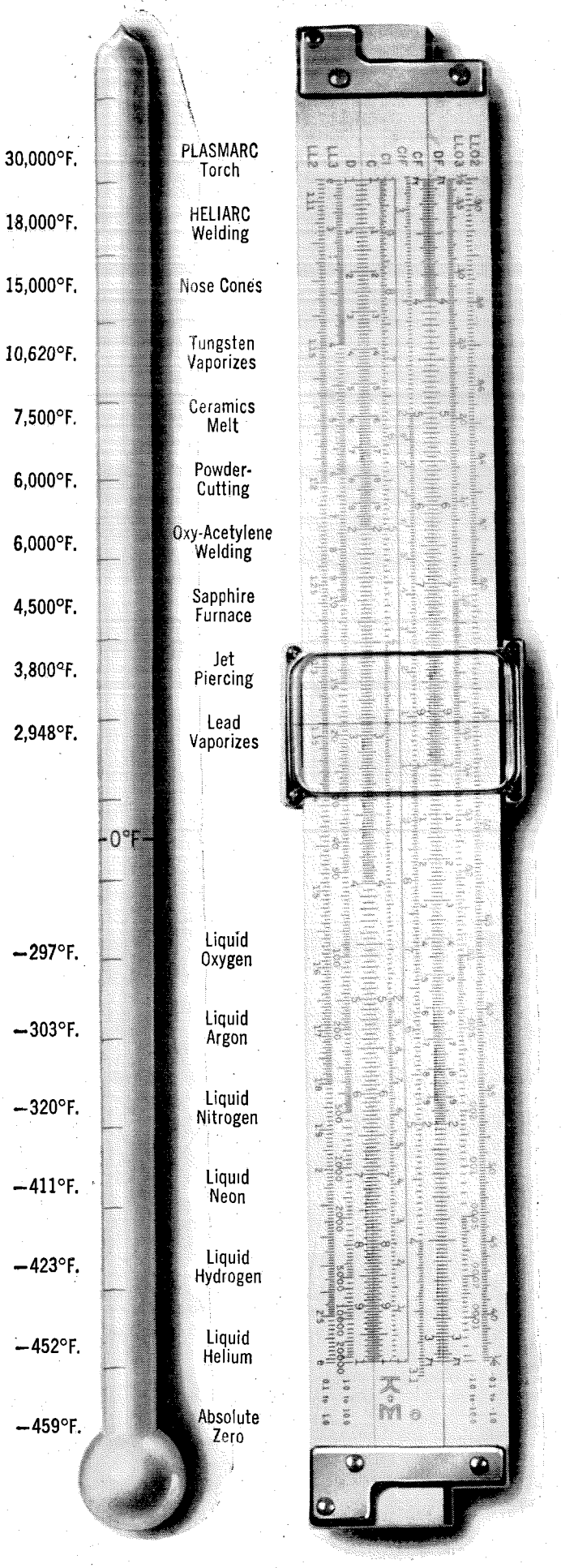
And your career potential can be increased materially by our corporation-financed Graduate Education Program . . . available in many outstanding colleges within the area.

Please consult your College Placement Office for campus interview dates—or—for further information, write to Mr. Leo J. Shalvoy, Engineering Personnel.

Sikorsky Aircraft DIVISION OF UNITED AIRCRAFT CORPORATION

STRATFORD, CONNECTICUT

An Equal Opportunity Employer (M & F)



A career at LINDE is a matter of degrees

Degrees—temperature as well as engineering—really matter at Union Carbide's Linde Division.

LINDE, a leading commercial producer of industrial gases for over 50 years, is now engaged in many diverse industrial activities. Heat, cold, pressure, vacuum, and engineering talent are the basic creative tools used in continuing efforts to develop new products and advanced technological capabilities. Temperatures utilized may run as hot as 30,000°F., to as cold as −452°F. This work particularly requires the skills of Mechanical, Chemical, Metallurgical, Electrical, and Civil engineers.

There are excellent opportunities in programs in Cryogenics, Plasmas, Flame-Plating, Industrial Gases, Electronics, Molecular Sieves, Bio-Chemistry, Crystallography, and other technical areas.

You can look forward to a rewarding career in Research, Development, Engineering, Production, Sales Engineering.

LINDE is a nationwide organization with offices, plants, factories and laboratories throughout the country. Where you work will largely depend upon the work you do.

Research and Development: LINDE has four technical centers at Buffalo, N.Y., Newark, N. J., Indianapolis, Ind., and Cleveland, Ohio.

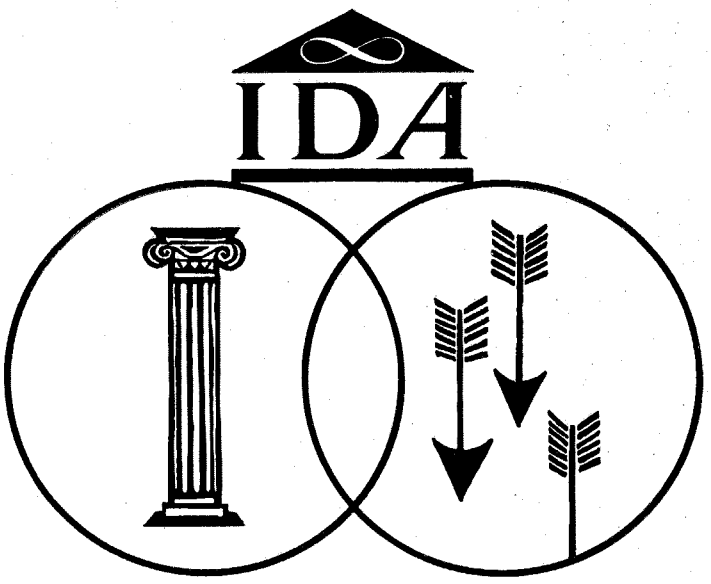
Production Facilities: LINDE operates production facilities in nearly every state of the Union.

General Offices and Sales Offices: LINDE's general offices are located in New York City; region sales offices are located in major cities throughout the country.

LINDE offers a progressive employment benefit program: relocation; Educational Refund Plan for advanced study in your field of interest. Promotion from within is a basic company policy. If you'd like to know more about your opportunities with us, contact your College Placement Office. A campus interview can be arranged with one of our representatives. Or write to: Union Carbide Corporation, Linde Division, Recruiting Department, 270 Park Avenue New York, N. Y. 10017.

UNION CARBIDE **LINDE DIVISION**

AN EQUAL-OPPORTUNITY EMPLOYER



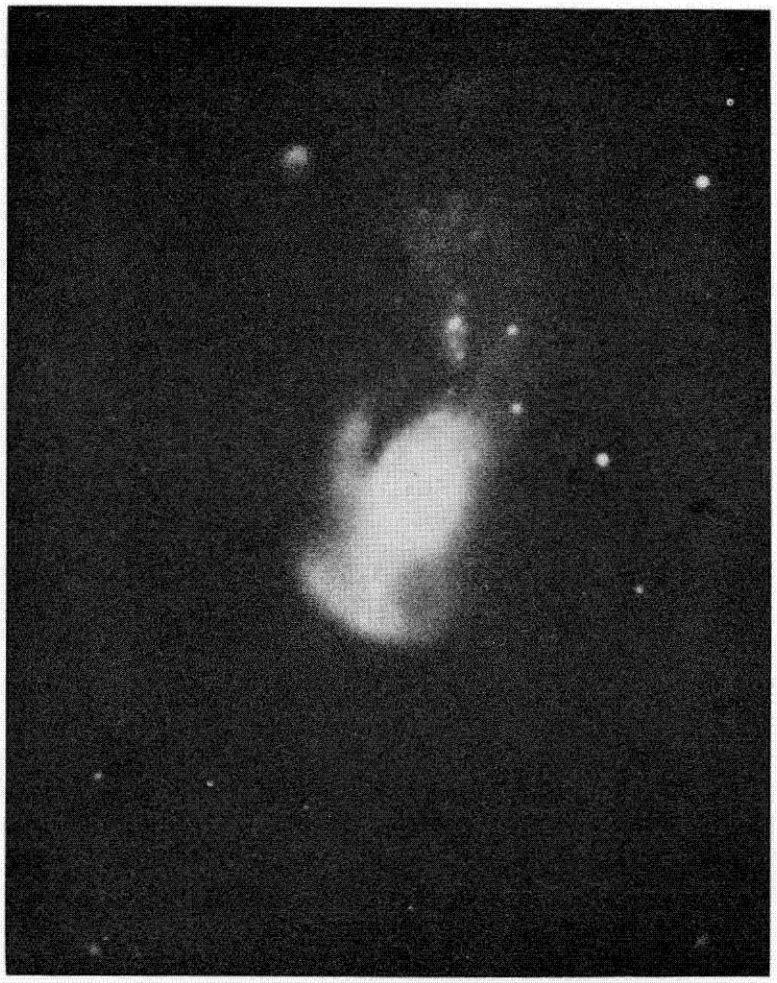
Where Two Worlds Meet. The nature of the problems assigned to the Institute for Defense Analyses provides our staff members with the best of two worlds—one of intellectual challenge, the other of national purpose.

In one world, the analysis of military systems and processes plunges us deep into development of new and penetrating methodological techniques, an exciting and fulfilling activity.

At the same time, our staff is squarely in the world of national defense. Offices from which many of the nation's basic decisions must come—the Joint Chiefs of Staff, the Director of Defense Research and Engineering, and others—look to IDA for advice and research on which to base these decisions.

We presently need scientifically trained people with grounding in operations research and systems analysis. If you require both challenge and purposefulness, write to T. J. Shirhall, ***Institute for Defense Analyses,*** 400 Army-Navy Drive, Arlington, Virginia 22202 (near the Pentagon). An equal opportunity employer sponsored by twelve of the nation's leading universities.

ENGINEERING
AND SCIENCE
March 1966, Vol. XXIX, No. 6



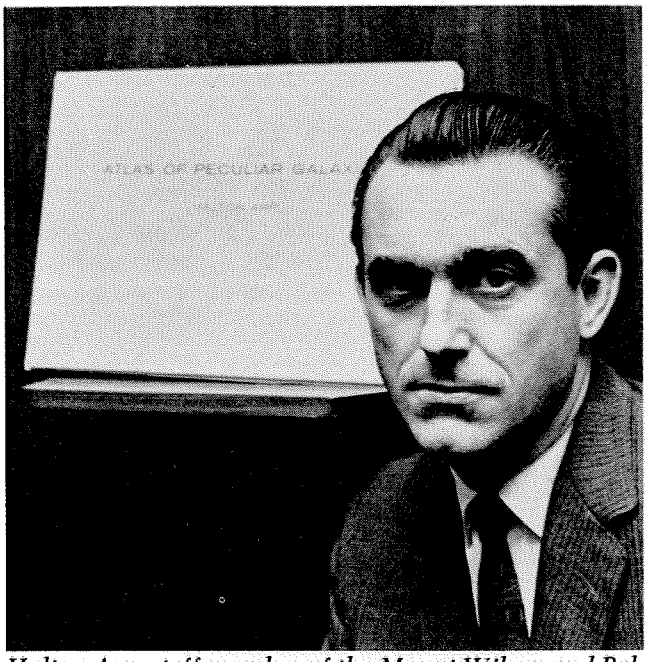
Galaxy Number 160 in Halton Arp's Atlas of Peculiar Galaxies *has three radio sources close to it.*

Peculiar Galaxies — New Light on Quasars

by Graham Berry

Quasars may not be the most distant objects in the universe ("Extending the Frontiers of Space" —*E&S, May 1965*) but instead may be small, compact galaxies at intermediate distances. Halton C. Arp, staff member of the Mount Wilson and Palomar Observatories, said he has found evidence that some quasars (quasi-stellar radio sources) have been exploded out of peculiarly shaped galaxies that are only 30 million to 300 million light years distant. Among these quasars are 3C-273, which was the first one identified, and possibly 3C-9, supposedly one of the most distant known objects.

The evidence is contained in a study Dr. Arp has made of what he calls "peculiar galaxies." These objects do not resemble "normal" spiral and elliptical galaxies, but appear to be distorted and deformed as though they had undergone titanic explosions. A total of 338 of these abnormal objects is contained in a recently published *Atlas of Peculiar Galaxies* which he has compiled over the past four years. The objects were photographed through the 200-inch Hale telescope at Palomar Observatory.



Halton Arp, staff member of the Mount Wilson and Palomar Observatories, and his Atlas of Peculiar Galaxies.

Dr. Arp lists eight quasars that he says probably are near seven of the peculiar galaxies, and three more that may be near three other similar galaxies. He has found a consistent pattern in which peculiar galaxies are bracketed by radio objects. Some of these radio objects are quasars, and some are radio galaxies. Both quasars and radio galaxies radiate energy as light and as radio waves. He lists 19 such probable systems and 10 possible ones.

In general there is a tendency for filaments and axes of the peculiar galaxies to point toward the radio sources. Some peculiar galaxies have four neighboring radio sources, tending to be paired oppositely. And one of them in the southern sky is surrounded by five sources.

Dr. Arp believes that the peculiar galaxies originally were large galaxies that became unstable for some undetermined reason and ejected luminous material and plasma into space. With nothing to stop it, the material may have continued traveling out in two opposite directions and become radio galaxies and quasars.

The quasar 3C-273 is located on one side of a peculiar galaxy—No. 134 in his atlas—and the radio galaxy Virgo A (a very strong radio source) is located about the same distance away on the other side of the peculiar galaxy. Jets of material appear to be emerging both from 3C-273 and Virgo A. Moreover, Virgo A's jet points toward yet another radio galaxy. There are several other systems with the same pattern—a central peculiar galaxy flanked by radio sources on each side of it, and the radio sources emitting jets.

Quasars have been thought to be much farther away than virtually all other known objects because of their very large red shifts. The red shifts for what were thought to be the three most distant quasars indicate they are receding at more than 149,000 miles a second. However, they are comparatively bright and emit strong radio signals. If they were as far away as their red shifts indicate, they would be the most energetic objects yet found and many times brighter than galaxies.

Astronomers have considered the possibility that quasars are not at cosmological distances. One possibility is that the red shifts of quasars are not indicative of velocities and distances. Perhaps the quasar's red shift is determined by its gravitational field. If a quasar is a very compact, heavy body, it may have a strong enough gravitational field to lengthen the wavelengths of the light radiating from it, producing a red shift. A second possibility considered by Dr. Arp is that the red shift also may reflect a "high collapse velocity." If material in a quasar is collapsing at high speed, this velocity could show up as a red shift. Of course, there is the possibility, too, that the red shift may reflect some other, unknown phenomenon.

It may be that when matter is exploded out of a galaxy it spreads out, as radio observations indicate it does, leaving the parent galaxy peculiarly shaped. Later, under its own gravitational attraction, the spread-out matter may begin to condense. The last stages of this condensation could be a quasar. If, indeed, quasars are nearby, they are less bright than the average galaxy.

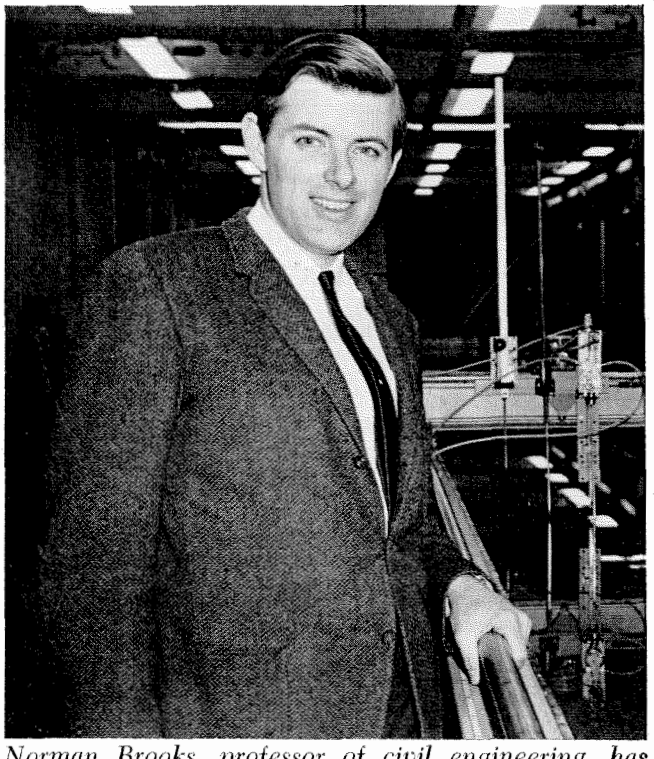
Dr. Arp estimates that the explosive events that created the systems occurred 10 million to a billion years ago. He calculates that the quasars and radio galaxies are traveling 200,000 to 200 million miles an hour and have reached distances of 3 million to 30 million light years from their parent peculiar galaxies.

Dr. Arp says that the results open many possibilities. If the red shifts for quasars are not indicative of distances, then the red-shift yardstick for galaxies should be regarded with slightly more caution. If enough material to form a galaxy can be ejected from a large galaxy, then certain kinds of galaxies, especially spirals, may be much younger than other kinds of galaxies.

Further, it may now be possible to show that the very small, compact, dwarf galaxies discovered a few months ago were ejected from nearby parent galaxies. The mechanism by which material is ejected from galaxies is very puzzling, but if understood, it could provide new insight into the formation of galaxies.

CONTROLLING OCEAN POLLUTION

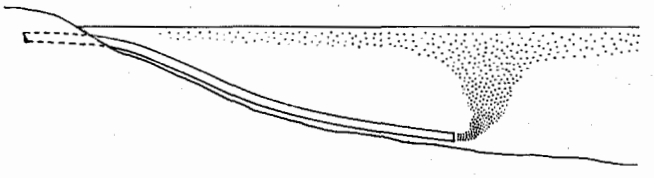
by Norman H. Brooks



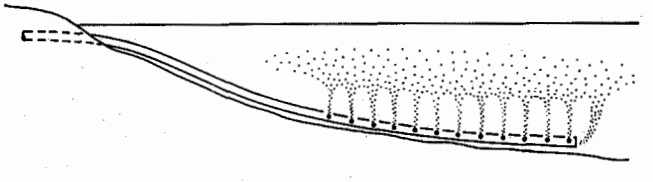
Norman Brooks, professor of civil engineering, has been a technical consultant for more than 10 years on problems of sewage disposal in the ocean.

Sewage disposal into the ocean has come a long way from the time when there was indiscriminate dumping of wastes. The alarming ocean pollution that resulted from such practice has, in most places, been virtually eliminated in recent years. Today disposal is a carefully controlled operation based on extensive engineering research and design.

However, up until 10 years ago it was the usual practice to discharge sewage effluent from the end of a pipe or submarine outfall in a single large stream. The buoyancy of such a flow was so strong in relation to its mixing rate that the effluent plume would invariably rise to the surface and spread as a surface current. Pollution of the shoreline was likely when onshore currents occurred.



However, in the last decade there have been two significant advances in techniques of sewage disposal into the ocean. First, the natural density stratification of the ocean has been used to great benefit in keeping waste discharges submerged in the lower layers of the ocean. Second, very large multiple-jet diffusers have been successfully designed and operated without clogging or maldistribution of flow. Diffusers greatly increase the dilution of sewage effluent with seawater, and dilutions of 200 parts of seawater to one part of sewage effluent are now commonly achieved. It is only by this new technique of using a large number of small, widely-spaced jets that full advantage can be taken of the slight but definite density stratification patterns in the ocean.



A very large outfall and diffuser was put into operation by the County Sanitation Districts of Los Angeles in December 1965 at Whites Point on the Palos Verdes Peninsula, a few miles west of San Pedro. It is a submerged concrete pipeline 11,880 feet long, with 742 circular holes, or diffuser ports,

arranged in pairs, spaced every 12 feet in the last 4,440 feet (the diffuser section). This is probably the largest number of ports ever used in an outfall diffuser. The depth at the diffuser ports ranges from 165 feet to 190 feet at the far end. The diameter of the ports varies from 2.55 to 3.60 inches, except for a few experimental ports of 2.00 inches at the shallower end. A complicated hydraulic analysis had to be made to determine the various port diameters required to ensure satisfactory hydraulic performance over the full range of flow. The pipeline diameter also changes size in the diffuser section, starting at 120 inches, then reducing to 102, and finally to 72 inches at the far end.

Although there are three other, older outfalls at Whites Point (60, 72, and 90 inches in diameter), the new pipe is large enough to carry the entire present-day sewage flow of 308 million gallons per day for the outfall system of the County Sanitation Districts. The older outfalls will be used as required to handle the increasing flows in the future. The system serves a population of 3,700,000 people living in an area of 608 square miles in the southern and eastern parts of the Los Angeles metropolitan area. The other major system in the Los Angeles area is operated by the City of Los Angeles; it discharges 304 million gallons per day through a five-mile-long outfall in Santa Monica Bay and serves 3,000,000 people. It is 12 feet in diameter and has two diffuser pipes, each 3,984 feet long, with 84 ports, at an average depth of 185 feet.

Sewage disposal systems

Generally, sewage disposal systems involve *collection, treatment,* and *dispersion.* All water used in man's activities ultimately must be returned to the water environment, unless evaporated. In large metropolitan areas domestic sewage and industrial wastes are collected by a system of sewers to central locations where the treatment and ultimate disposal can be closely controlled by engineers. It is interesting to note that one of the difficult problems of air pollution is that it is impractical to collect "used" air on a community-wide basis for treatment and disposal; instead we must impose directly on the consumer (such as the owner of an automobile) some responsibility for control of air pollution.

Strict rules prohibit industries from dumping into the sewers any highly obnoxious wastes which would have an adverse effect on either the ocean or the treatment plant operation. Furthermore, storm water must be excluded because it would grossly overtax the sanitary sewer system. For example, the daily mean flow of 308 million gallons collected by the County Sanitation Districts is equivalent to only 0.03 inch in water depth per day distributed over the drainage area. When it rains several inches in one day, the storm runoff may be tens of times larger than the flow which can be taken in the sanitary sewers. It is unforunate that many Eastern cities have sewers that allow the sanitary sewage to become mixed with the storm runoff, and to overflow into the natural watercourses whenever sewage treatment plants cannot handle the huge flows.

Ocean disposal

To plan a new system for ocean sewage disposal the engineer must start by considering the water quality standards to be met in the ocean environment—including maximum allowable bacteria concentrations, maximum increase in turbidity, limitations on any grease, absence of odors, minimum dissolved oxygen, absence of floating or suspended solids of recognizable sewage origin, or any other aesthetically unacceptable condition. The State of California, for example, has many detailed and strict requirements related to all of the foregoing characteristics; nonetheless, huge quantities of sewage effluent may be dispersed from properly controlled outfall systems without pollution.

Usually only *primary* treatment of sewage and industrial wastes is required, as in the case of the two large Los Angeles systems and the new San Diego sewerage system. Such treatment includes screening; sedimentation for removal of settleable solids, floatable solids, and grease; and chlorination if required for control of bacteria and viruses. The City of Los Angeles and the City of San Diego do not have to chlorinate at all to meet the rigid bacterial requirements of the state, while the County Sanitation Districts chlorinates its effluent only for a few days in the winter when the stratification in the ocean disappears. In all cases the dilution of the effluents with seawater is so great that all the other standards are very easily met after just the primary treatment.

The solids or sludge collected in the treatment plant are subjected to anaerobic decomposition in large digestion tanks, where sludge is reduced to a relatively stable humus-like liquid material of very fine particles in suspension. There is insufficient demand for all the digested sludge as fertilizer, so it is often pumped to the ocean also, either through a separate small outfall (as for the City of Los Angeles) or mixed with the sewage effluent (as by the County Sanitation Districts). In neither instance has the buildup of deposits on the bottom been progressive, because organisms and currents cause a

gradual disappearance or assimilation into the natural bottom sediments.

If the outfalls in the Los Angeles area were not equipped with large diffusers, very expensive secondary treatment would be necessary to provide the necessary biodegradation of the sewage effluent to prevent pollution. In effect, the ocean provides the secondary treatment. The ocean already does this with organic wastes from natural ocean life. Thus, the main problem is to provide wide enough dispersal of man's effluents so as not to overtax the ocean and create aesthetic nuisances.

The design of ocean outfalls requires detailed oceanographic surveys to determine salinity, temperature, and density stratification; current speeds, directions, and frequencies; and submarine topography and geology. For future evaluation of the effects of the discharge, the characteristics of the marine biology and the turbidity and dissolved oxygen levels should also be measured before waste discharge is started.

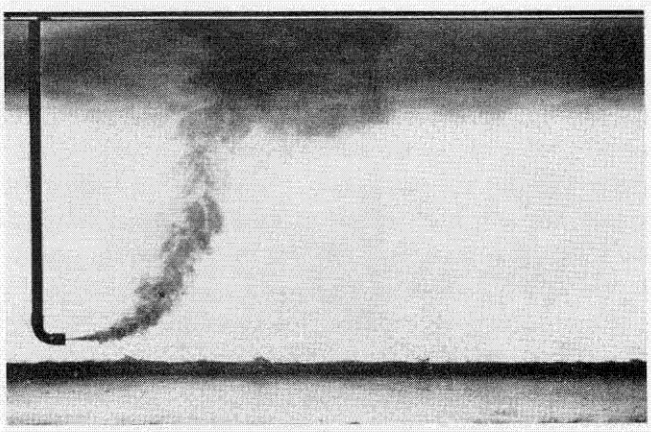
The turbulent diffusion of the sewage effluent occurs in two stages. First there is the jet or plume mixing near the diffuser pipes, which is controlled by the nature of the manmade diffuser. Second is the movement of the diluted sewage "cloud" by the ocean currents and further dilution by the natural ocean turbulence. For the greatest security it is good practice to achieve as much manmade mixing as feasible right at the diffuser and to avoid depending too heavily on the natural dispersive mechanisms of the ocean, which are more difficult to predict analytically and statistically. Diffuser pipes are oriented, within allowable limits of the bottom topography, in directions to intercept as much of the ocean current as possible for critical shoreward current directions. The number and spacing of ports is based on considerations of the behavior of the buoyant jets discharged from the ports. The port diameters are selected to make the "inside" hydraulics of the diffuser correct for a good manifold.

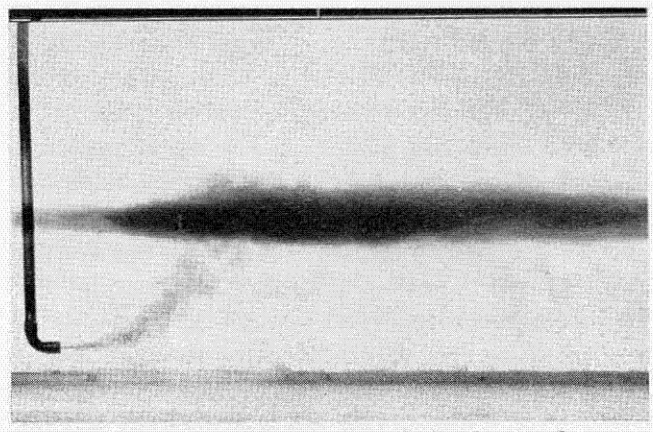
Buoyant plumes

The behavior of buoyant jets and plumes is one of several density-stratified flow problems which have been studied in recent years in Caltech's W.M. Keck Laboratory of Hydraulics and Water Resources under sponsorship of the U.S. Public Health Service. Density-stratified flows are those in which small variations in the weight of the fluid have a marked effect on the over-all flow pattern. For example, if fresh water is jetted into a homogeneous tankful of salt water, the slight buoyancy of the fresh-water stream will cause a horizontal jet to deflect upward. The fresh water begins as a submerged jet which is a flow dominated by the initial momentum. It then changes to a buoyant plume, a rising current strongly dominated by buoyancy and not influenced much by its initial momentum. The fresh water is, of course, mixed with the salt water as the surrounding fluid is mixed into the jet by the strong turbulence, and the density difference between the discharge and the ambient fluid decreases. But the plume will always remain slightly lighter than its surroundings because of its original fresh-water component, and it will rise until it reaches the water surface and spreads out laterally.

Effect of density stratification

A remarkable change in the flow pattern occurs when there is a slight gradation of density in the ambient fluid, caused by temperature and salinity changes with depth. In the ocean the stratification is almost always hydrodynamically stable, with warmer (or less saline) layers at the top. In the laboratory, the ambient salt water is stratified by





These two laboratory tank experiments illustrate the effect of density stratification in the water. Above, the water is of uniform density, and the buoyant plume rises to the surface. However, a slight density layering in the water stops the rising plume and keeps the cloud completely submerged.

filling the tank very slowly with thin layers of progressively decreasing salt content at the same temperature; the "staircase" variation of density is soon smoothed into a uniform gradient by molecular diffusion.

In the stratified environment the buoyant plume may no longer rise to the surface because the plume loses its buoyancy before it gets there. In the experiment illustrated on the previous page, the specific gravity in the tank at the bottom was 1.026, decreasing uniformly to 1.022 at the surface; the fresh-water jet was at 1.001. Denser water entrained into the plume near the bottom produced a mixture slightly heavier than the ambient fluid at a higher level. If each part of the fresh-water discharge of specific gravity 1.001 is mixed with 30 parts of bottom salt water at 1.026, the resulting mixture has a density of 1.0251, which is considerably heavier than the salt water at the surface (1.022).

Actually, the density of the entrained fluid decreases as the plume rises; nonetheless, a point of neutral buoyancy will be reached at which the fresh-water component is just counter-balanced with denser water entrained from the lower levels of the tank.

Theoretical investigations

The behavior of buoyant plumes in a stratified environment has been investigated theoretically by Robert C. Y. Koh, a recent Caltech research fellow, Loh-nien Fan, a present PhD candidate, and the writer. Numerical solutions for the trajectories and dilutions were obtained, using the Caltech IBM 7094 computer, for various initial conditions and density gradients of the environment. The theoretical solutions have been found to agree well with laboratory experiments and observed sewage plumes in the ocean.

One of the most interesting applications of the theory is the prediction of the maximum height of rise of a plume in a stratified environment. This is of special interest in the ocean, where submergence of the cloud of mixed sewage and seawater is beneficial in controlling pollution. The equations show that the maximum height of rise may be made less than the total depth by making the discharge (per port) sufficiently small in relation to the density gradient and the other quantities in the equations. To produce a submerged sewage cloud one must first measure the natural density stratification in the ocean and then design a diffuser to produce small enough jets so that the stratification may act as the brake on the buoyant rise.

Off the southern California coast there is strong thermal stratification in the summer. For example, the surface water may typically be at 65° to 70°F while the water at 200 feet is only 50°. At about 50 feet there is a relatively steep temperature gradient in a zone called the thermocline; above and below the thermocline there is a gradual decrease in temperature with depth. In the fall and early winter the thermocline sinks lower, and the stratification becomes weaker. In the spring the thermocline condition is established again by the increased solar heating of the upper layers. With rare exception the stratification is always stable (i.e., the density increases with depth below the surface).

The density stratification for coastal waters varies with the time of year. For example, in January off Point Loma near San Diego there is a difference in specific gravity from bottom (200 feet) to top of only 0.00022, which corresponds to a temperature differential of 2°F; in July it is 0.00220, for a temperature difference of 18° F.

Predicting submergence

The rate of change of density with depth is never exactly constant, but for a first approximation it may be assumed to be so. The new San Diego ocean outfall at Point Loma (put in service in 1963) discharges at a depth of about 200 feet through 58 horizontal ports more than two miles from shore.

For 1965 the mean flow per port was 1.5 cubic feet per second. According to our theory, to achieve submergence of the diluted cloud the density differential for the 200-foot depth must be greater than 0.00018, which is the case throughout the year now. The operation of the outfall has indeed confirmed this theoretical prediction; the sewage effluent cloud has never been observed at the surface. Ultimately the peak flow will increase to more than 6 cubic feet per second per port, and the required differential for submergence will increase to 0.00048. Submergence will still occur for approximately 11 months each year, with surfacing predicted only in January. Even then the treated sewage effluent will be diluted with approximately 170 times as much ocean water by the time it reaches the surface. Thus, even without submergence, the pollution is largely controlled by high dilution and by rapid natural die-off of bacteria and viruses in the hostile ocean environment.

For the five-mile outfall of the City of Los Angeles, at present flows the theory predicts that the sewage field will be submerged when the temperature differential between the 185-foot depth and the surface is 3.7°F. In fact, several years of observation have indicated that complete submergence

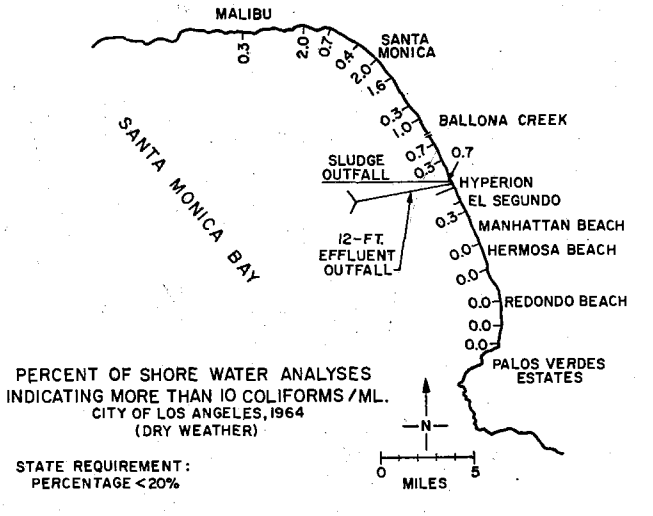
occurs when the temperature differential is more than 2°F. With all the possible sources of discrepancy—such as non-linearity of the density gradient and effect of the currents—the basic consistency of the results is again good and demonstrates that the theory is reasonably reliable for design purposes.

Results in Santa Monica Bay

The successful operation of an ocean sewage disposal system certainly involves more than the behavior of the jets and plumes near the outfall diffuser pipes. After the sewage effluent cloud is formed, whether submerged or not, it is carried away by the ocean current, and further turbulent diffusion takes place. The organisms in the cloud rapidly die off in the hostile ocean environment. For example, the coliform bacteria may be expected to die off at the rate of 90 percent every 4 to 5 hours, or faster. The final result may best be judged by the quality of the water along the shorelines, the most important area to protect for the health and enjoyment of the public.

For an example, consider the 20 miles of beaches along Santa Monica Bay. Even as recently as the 1940s about 10 miles of beach were heavily polluted with sewage discharge by the City of Los Angeles. Since then there has been a vast improvement because of the extensive new sewage treatment plant at Hyperion and the five-mile-long ocean outfall with a very large diffuser.

In 1964 no sampling station along the Los Angeles beaches had more than 2 percent of its samples exceeding a coliform bacteria count of 10 per milliliter (considered to be the threshold indicator for a detectable effect of water of sewage origin). The State



Los Angeles beaches, badly polluted 20 years ago, are extremely clean today as a result of the use of diffusers that keep the effluent well submerged.

of California requires that no more than 20 percent of the samples exceed that count. In other words, even at the worst station the occurrence of counts of 10 or more was less than one-tenth as frequent as is allowed by the state. For the over-all monitoring program on the shore only 31 samples out of 5,219 exceeded the standard in dry weather. (Samples during periods of storm are excluded because some low-level pollution is caused by the outflow from storm drains, which obscures the effect of the sewage outfall.)

The sewage effluent itself has a coliform bacteria concentration of between 500,000 and 1,000,000 per milliliter as it leaves the diffuser pipe. Therefore, the combined action of dilution and die-off must bring about an over-all reduction by a factor of 100,000 in the ocean. Typically, the dilution might account for a factor of 500, with the remaining factor of 200 or more being due to die-off.

Future of ocean disposal

Ocean outfalls will not become obsolete even when much of the wastewater is eventually reclaimed for re-use. With growing demands for water there will undoubtedly be extensive wastewater reclamation in the Los Angeles area, because such water is much cheaper than de-salted seawater. Wastewater is already being reclaimed on a small scale, but there will always be substantial outflows to the ocean because only part of the sewage flows can be reclaimed and reused. Some types of industrial wastes are unsuitable for reclamation but may be discharged to the ocean. Furthermore, the waste products from the wastewater reclamation plants must go somewhere, and the ocean is the most feasible place.

New diffusion structures have virtually eliminated many pollution problems. There is no danger of ocean transmission of communicable diseases in areas such as Los Angeles and San Diego, nor are there any aesthetically objectionable conditions whatever in the ocean. In fact, the layman would have the greatest difficulty finding any evidence at all of waste disposal. However, there are some subtle ecological changes taking place in the ocean environment due to the waste discharges. These changes are being identified and evaluated through biological research, such as the kelp and sea urchin studies by Wheeler North, associate professor of environmental health engineering at Caltech. Man has never succeeded in completely avoiding ecological changes, but by using fluid mechanics to obtain high dispersion we are trying to minimize these long-range effects.

MANMADE LAKES AND SOCIAL CHANGE

by Thayer Scudder

Thayer Scudder is assistant professor of anthropology at Caltech. At the invitation of the Rhodes-Livingstone Institute (now the Institute for Social Research of the University of Zambia) he spent the year 1956-57 in the Middle Zambezi Valley studying the African population soon to be resettled because of construction of the Kariba Dam. Their relocation was completed in 1959, and Dr. Scudder returned to Zambia in 1962 for a follow-up study, the first of a series he expects to make at several-year intervals.

In Egypt during 1961-62 Dr. Scudder was involved in the base-line studies of the project to relocate the Nubians because of the construction of the Aswan High Dam. This study was initiated by the Social Research Center of the American University in Cairo. More recently he has been involved in the planning of similar research in connection with Nigeria's Kainji Dam, on which construction started in 1964.

Dr. Scudder originally undertook this work because of the opportunity to study human behavior under conditions of accelerated social and economic change. He is now also interested in the use of such research in the planning and implementation of development at the time of resettlement and during and after the period of reservoir formation.

An anthropologist uses population relocation to study cultural evolution on a speeded-up scale

In recent years the formation of large manmade lakes has begun to transform the landscape of Africa. Rhodesia and Zambia's Kariba Lake, which has a surface area of nearly 2,000 square miles, is responsible for the relocation of 50,000 people. Currently the world's largest impoundment, its storage capacity is approximately 130 million acre-feet, which is more than four times that of Lake Mead. The lake now filling behind Ghana's Volta Dam will eventually inundate more than 3,000 square miles, or approximately four percent of the surface area of Ghana. Lake Nasser (to be formed behind Egypt's High Dam) in time will cover a similar area. Once filled, it will inundate the villages and towns of 120,000 Nubians, while the Volta Dam has already been responsible for the relocation of more than 70,000 people, or approximately one percent of the Ghanaian population.

These three projects represent only the beginning of a trend that will affect most of Africa. On the Niger, construction is proceeding on Nigeria's Kainji Dam. Three river basin surveys involving seven countries and financed by the United Nations Special Fund are currently under way along the Senegal, Mono, and Kafue Rivers. In South Africa, planning continues in connection with the Orange River Development Project. Eventually all the great rivers of Africa and many of the smaller ones will be af-

fected by similar development programs.

Such projects present an exceptional opportunity for an integrated river and lake basin development program. This will involve not only power generation, flood control, and improved transport, but also fisheries and agriculture, market and small industrial centers, conservation areas and parks, and recreational, residential, and tourist facilities. Population relocation on such a scale can be used to provide a more meaningful life for the African population. With proper timing and planning, new environments with improved social services can be created in carefully selected relocation areas. Through experimentation before and after resettlement, new production techniques can be developed to increase per capita income without depleting soil fertility and other local resources.

Lack of perspective

In spite of the opportunity, the development potential of African manmade lakes is not being realized. There are a number of reasons for this, and the most important one relates to a lack of perspective on the part of regional, national, and international development agencies. Instead of thinking in terms of the whole range of human and natural resources, planners tend to overemphasize such tangible benefits as increases in electrical power and gross national product. Development is seen primarily in terms of spiraling per capita income, as opposed to the emergence of relatively creative, relatively productive, and relatively integrated human populations. Manmade lakes, at worst, are viewed merely as dam by-products, while the people requiring relocation are seen as an expensive nuisance.

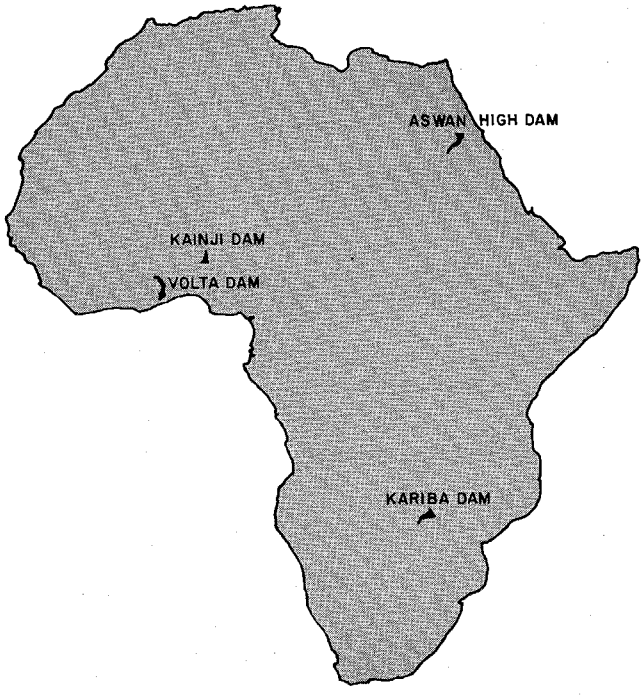
A good example of this lack of perspective is seen in fisheries development in connection with Nigeria's multi-purpose Kainji Dam Project. Once the reservoir is full, it is possible that up to 10,000 tons of fish might be caught each year. This catch could support up to 2,500 fishermen and their dependents. This exceeds the number of laborers who will eventually be employed, for example, by Ghana's aluminum smelter at Tema—which, as the main consumer of Volta power, may well employ a larger labor force than any of the industrial plants associated with Nigeria's Kainji Project. Furthermore, the expected income accruing to individual fishermen (over £130 per capita) should enable them to realize a standard of living little different from that of industrial workers.

The realization of this potential requires certain preparatory measures, of which the most important is selective bush clearing in the lake basin area. Though costly (at least £10 per acre), bush clearing is an important precautionary measure against the possible rapid buildup of aquatic weeds. Not only would the weeds reduce the recreational and tourist potential of the lake, but they could also hamper lake transport. The actual expense of clearing would be about equal to the retail value of two years' catches of fish.

In spite of the benefits to be gained, the amount of money allocated to bush clearing and other preparatory measures (including those whose purpose is to help the present fishing population convert to commercial fishing methods) is totally inadequate. In large part I believe this is because international consultants involved in pre-investment studies have seriously underestimated the attitudes of the local population toward fishing. In fact, policy-influencing statements have even been made to the effect that the people have no special interest in fishing.

More recent surveys have shown that this is definitely not the case. Not only is fishing now a respected part-time activity, with a wide range of techniques used to procure fish, but some fishermen are active throughout much of the year on a full-time basis.

Developments elsewhere in Africa (which have involved less-skilled fishermen and a less-diversified fish population) lead one to expect commercial fisheries to develop within a few years after lake formation, as opposed to the often-stated ten-year minimum. Ten years is a long time. Because it exceeds the duration of the present Nigerian development plan, it is not unreasonable to expect that such



The Tonga living along the Zambezi River used a variety of fishing methods before Kariba Dam was built, but none produced more than a meager catch. Here, women fashion a crude basket that is dragged through shallow water in an attempt to catch small fish.

a negative appraisal has influenced the allocation of funds. Of course, if selective bush-clearing is not carried out prior to dam completion in 1968, commercial fisheries may never develop—which would support the uninformed projections of the original planners! The main losers, of course, will be the local population and, in the long run, Nigeria.

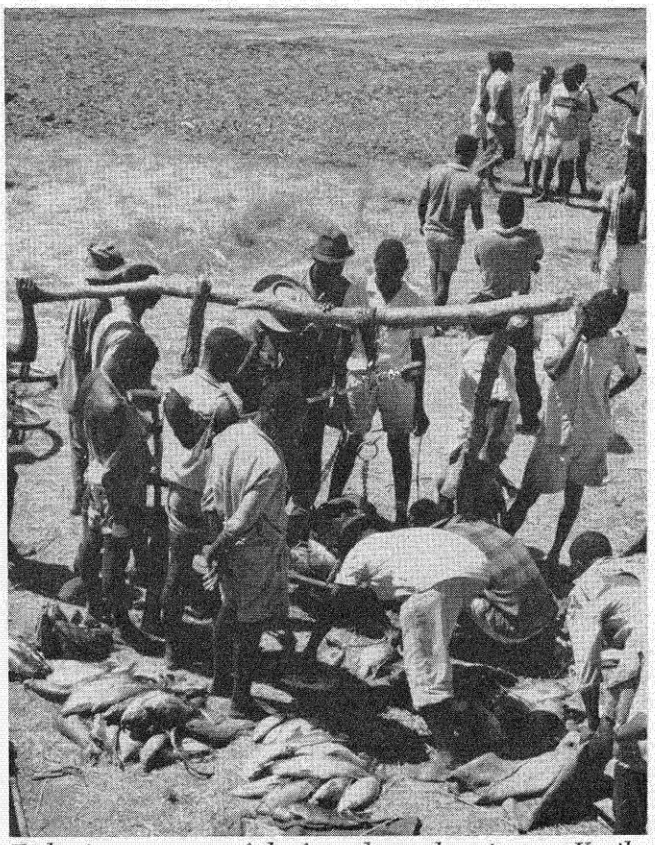
A second factor impeding the realization of the development potential of manmade lakes in Africa relates to inadequate coordination between and within local, regional, national, and international agencies, including the relevant River Authority. Lack of coordination at Kainji already has led to a series of unfortunate events. For example, though the East Bank Soil Survey was completed in 1963, resettlement officers searching for new village sites had not received copies of the maps by mid-1965. Moreover, the Soil Survey of the major township (New Bussa) was carried out too late to influence site selection and town planning. Though the survey results suggest that there is not enough land to support expected population densities under existing techniques of agriculture, insufficient capital and personnel have been set aside for the intensification of agriculture. The problem is aggravated by the location of an airstrip which has so bisected one area as to reduce the suitability of the adjacent pieces of land.

To limit the occurrence of such situations, a high-level coordinating council is necessary. Its membership should include representatives from government, the scientific community, the National Development Bank or its equivalent, and the local population. Along with the River Authority, it should be set up before the first feasibility surveys are made. Since these are often in the hands of international firms of consulting engineers as well as the World Bank, the Special Fund, and the Food and Agriculture Organization, close liaison with such agencies is essential to ensure that continuity between basin surveys and subsequent development is maintained.

In the Kariba Dam scheme, there was neither a Zambezi River Authority nor a lake basin coordinating body. Though the Kariba Lake Coordinating Committee was formed to deal with the lake, its jurisdiction did not extend to the lakeshore hinterland. Furthermore, it was not established until two years after the decision to proceed with the dam. As for the Federal Power Board, it became interested in the lake only when events there threatened operations at the dam itself.

Inadequate research is a third factor preventing realization of the full potential of manmade lakes. Ideally, research should have both immediate and long-range effects. The first type of research relates to surveys and base-line studies which have a direct relationship to local development. The second relates to studies which can be expected to increase

continued on page 22



Fisheries were one of the few planned projects at Kariba Lake. The impressive results show how much human potential exists. These Tonga now enjoy a much higher standard of living, and they have become valuable members of the national economy.

man's control and intelligent manipulation of his physical, biotic, and cultural surroundings.

To the scientist, the formation of large manmade lakes presents a unique opportunity to carry out fundamental research involving a wide range of disciplines. Rates of change are accelerated through such massive human interference, and studies that are carried out before, during, and after inundation can be expected not only to increase knowledge but also to contribute directly to planned developments.

Unique chance for research

In other words, the dichotomy between pure and applied research simply does not apply to such manmade situations. This is true whether the investigator is a geophysicist studying possible crustal movements arising from the added weight of millions of acre-feet of water, or a behavioral scientist interested in the effects of relocation on human populations. We really know very little about how people will behave under different types of resettlement, but population relocation presents us with an important opportunity to widen our knowledge of human behavior under conditions of increased stress. Such knowledge will also increase our ability to induce the type of social change that is meaningful in terms of both individuals and the societies to which they belong.

In spite of the excellent opportunities presented by manmade lakes, research—whether involving meteorologists, hydrologists, biological ecologists, or behavioral and social scientists—*has been totally inadequate*. Furthermore, much of that undertaken has been completed too late to be useful in terms of lake basin development. In part, this is because development planners have not been sufficiently aware of the need for ecologically oriented research. In part, it is because universities and research institutions have not taken advantage of the opportunities offered.

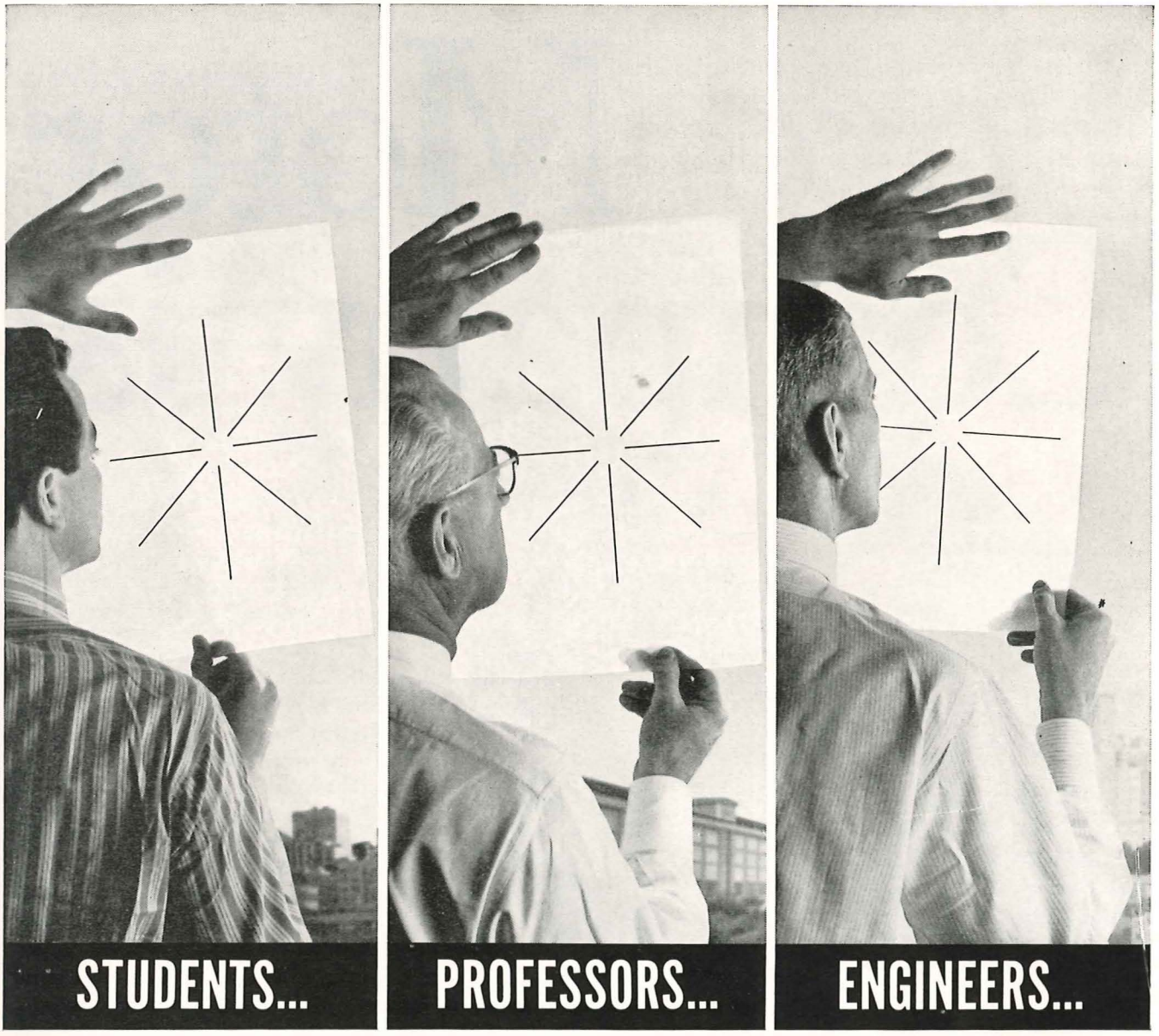
The words *too late* bring up a fourth bottleneck, which relates to poor scheduling of relevant activities. The record of resettlement is particularly revealing in this regard. Resettlement is a complicated process. Costs—in terms of capital, personnel, and equipment—are continually underestimated. Effective timing requires careful planning based on hydrological, ecological, medical, social, and other surveys.

Regardless of government attitudes toward lake basin development, little serious attention has been paid to the resettlement process in the major African schemes until after the commencement of dam-site preparations. This leaves insufficient time to undertake the necessary research and to relate it to effective resettlement and development. Rather, resettlement becomes a crash program to get the people physically moved before the dam is closed and the waters rise. One result is relocation prior to the ability of resettlement areas to support the population.

At Kariba it took the evacuees approximately two years to prepare enough farm land to meet their subsistence needs. Inadequate harvests prior to that time forced them to rely on government-organized famine relief. Though government policy in connection with the Volta and Aswan High Dam projects was to prepare (at government expense) more productive environments, again relocation occurred before these could support the people. Hence, a year after some communities were moved, the Ghanaian government's ambitious agricultural program was well under way in only one of 52 planned communities. In Egypt, less than 10 percent of the acreage set aside for the people had been reclaimed at the time of resettlement. In both cases the opportunity to fit people into a more productive environment from the start has been lost. During the demoralizing transition period that must elapse before development requires the people's full participation, there is a definite risk that the more progressive individuals will seek work elsewhere. As for the less highly motivated, they may become accustomed to living off relief supplied by the government on the one hand, and wage-earning kin on the other.

Future projects

The logical corrective here is to broaden the feasibility studies, which are apt to stretch out over a number of years prior to site selection. To date, the scope of these has been much too narrow, which brings us back to the problem of inadequate perspective. Though expansion of the usual geological, economic, and engineering surveys will increase costs, these are slight in terms of the cost in both human and financial terms of a prolonged period of famine relief. They are even smaller when measured against the benefits that could accrue from a well-planned, well-timed, and well-implemented program of river and lake basin development whose ultimate purpose is to make regions more habitable for people.



CLEARPRINT IS THEIR COMMON DENOMINATOR

The reason for that is quality. To do the best work you have to start with the best materials. For over 30 years Clearprint Technical Papers have served students, educators, and professionals with distinction. ■ Clearprint's unchanging character includes 100% rag uniformity, permanent transparency, outstanding erasing and handling qualities. You get all this in addition to Clearprint's ideal ink and pencil surface.

■ Everyone who uses technical papers should try this comparative test: Draw, erase, and hold the sheet to the light. Not a chance of a ghost! ■ Repeat and repeat this test. The results will amaze you. You will agree — Clearprint is America's finest technical paper. Introduce your students to it today. ■ Write now for Clearprint samples, sizes, and prices.

CLEARPRINT®

"FADE-OUT" PAPER
T. M.
TECHNICAL PAPER
FORMS • CHARTS • GRAPHS
"PRE-PRINT" PAPER
T. M.
THERE IS NO SUBSTITUTE
Clearprint is Watermarked For Your Protection

22

CLEARPRINT PAPER CO. CEM-22

1482-67th Street, Emeryville, California

☐ Send me Clearprint samples, with prices, for the following uses:

_____

Name _____

School _____

Address _____

City _____ State _____ Zip _____

Ford Motor Company is:

diversity

Larry Moore
B.M.E., Univ. of Kansas

The college graduate's initial exposure to the world of business is often less than exhilarating. The reason? A great many companies require the recent graduate to serve a long-term apprenticeship in a role that offers little or no opportunity to demonstrate personal capabilities. That is not the way at Ford Motor Company. Our College Graduate Program brings you into contact with many phases of business, encourages self-expression and helps you—and us—determine where your greatest potential lies. An important benefit of the Program is getting to know and work with some of the most capable people in industry. One of many young men who believes he has gained tremendously from this exposure and experience is Larry Moore, a Product Design engineer.

After receiving his B.M.E. in February, 1964, Larry joined our College Graduate Program and began work in brake design. Stimulating assignments followed in product evaluation and disc brake development. Later, he learned production techniques while supervising one phase of the Mustang assembly line operations. An assignment in our Truck Sales Promotion and Training Department added still another dimension to his experience. The "big picture" of product development was brought into focus for Larry when he became associated with Thunderbird Product Planning. From there he moved to the Special Vehicles Section . . . into the exciting world of high-performance cars!

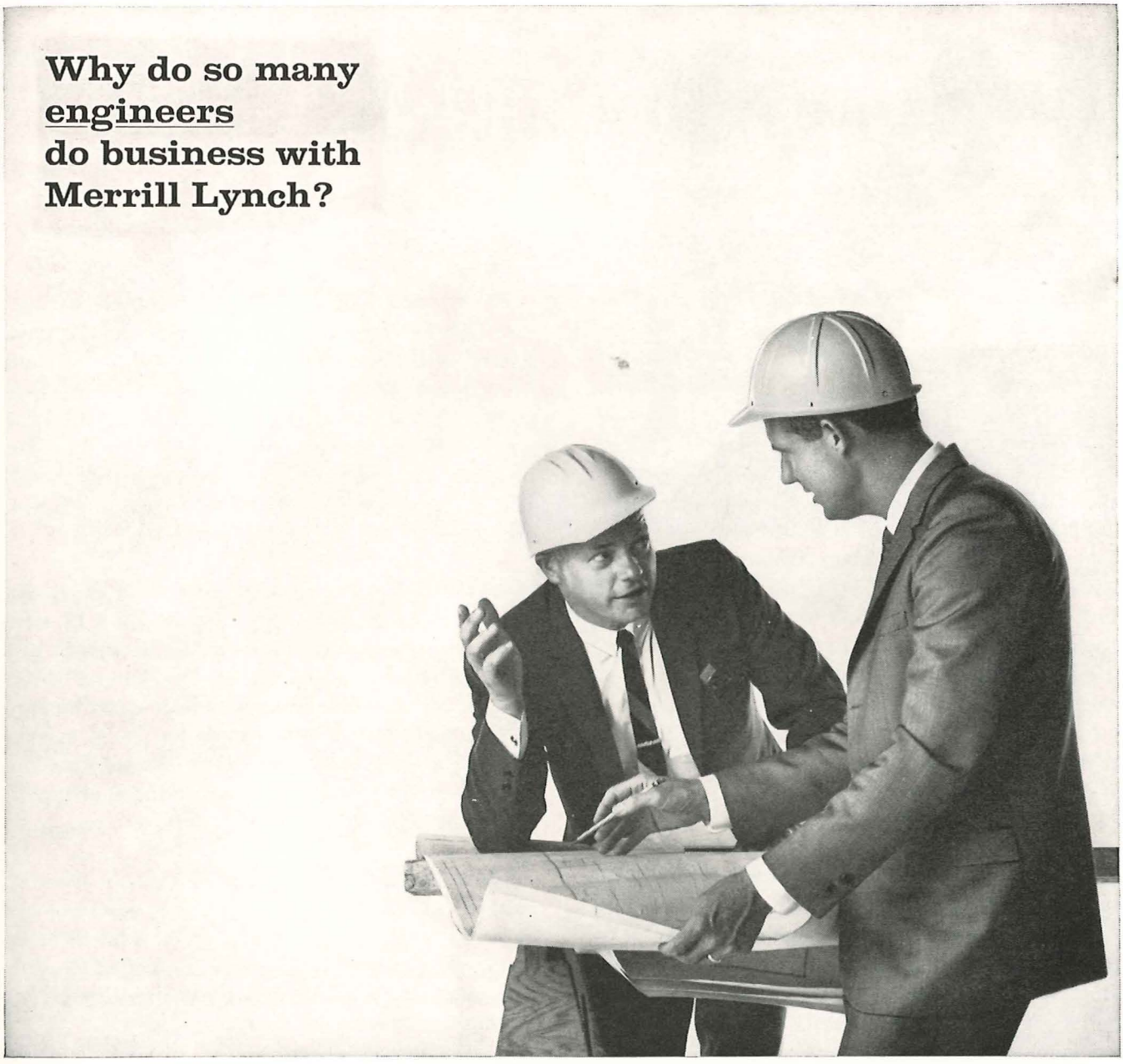
Currently, Larry Moore is on leave of absence, studying to acquire his M.B.A. degree at Michigan State. He feels—and rightly so—that we're 100 percent behind his desire to improve his educational background. Young men with talent, initiative and ambition can go far with Ford Motor Company. Think about it—and talk to our representative when he next visits your campus.

Ford

The American Road, Dearborn, Michigan

An equal opportunity employer

Why do so many engineers do business with Merrill Lynch?



We can't blueprint the answer.

But we do know that most engineers —all kinds of them, including those who direct our own computer operations—have a certain affection for the orderly and the organized.

That's why we think that most engineers would have a particularly high regard for the work of our Research Division—its reports on hundreds of individual companies, its industry studies, its quarterly review of business conditions and the market outlook, and especially its premier product—the individual portfolio review.

Last year, some 60,000 people asked for and got (at no cost to them) just that kind of personalized investment help—a detailed analysis of all their holdings in the light of their own investment objective, specific suggestions for the purchase or sale of individual securities, proposals for the investment of additional funds. Some of those reviews were only a few pages long; some ran to dozens of pages. But whether long or short, every review ended up with a recapitulation sheet showing the investor just what his holdings were worth and what yield he was realizing from them, and everyone of them was accompanied by such Merrill Lynch reports as were pertinent to his portfolio.

Suggestion?

Whether you're an engineer or not, write to us about your own situation. Your own ideas of the risks you can afford. The rewards you seek.

You'll get the very best answer we can come up with—for you—without charge or obligation of any kind.

Simply address your letter to the attention of Clarke Berdan, Manager, Department TC-4.

MERRILL LYNCH, PIERCE, FENNER & SMITH INC

MEMBERS OF THE NEW YORK STOCK EXCHANGE AND OTHER PRINCIPAL STOCK AND COMMODITY EXCHANGES

575 EAST GREEN STREET, PASADENA, CALIF. 91101

MAIN OFFICE: 70 PINE STREET, NEW YORK, N.Y. 10005

The Month at Caltech

Caltech in Kanpur

Three members of the Caltech faculty and administration will be in Kanpur, India, in the next few months to take part in the Kanpur Indo-American Program in support of the five-year-old Indian Institute of Technology there. Taras Kiceniuk, Caltech lecturer in engineering design, left with his family last month for a year of teaching at the IIT; Fred Lindvall, chairman of the division of engineering and applied science, will visit Kanpur for ten days this month as a member of an eight-man committee sent to evaluate the progress of the Institute; and Ernest Hugg, assistant director of Caltech's physical plant, will leave in June for an 18-month stay at the Institute as an advisor on the operation and maintenance of the physical plant.

Caltech is one of nine U.S. institutions involved in the program, supported by the U.S. Department of State's Agency for International Development (AID), to aid in the development of the Indian Institute of Technology. Six Caltech men have taken part in the school's operation in Kanpur since it opened in 1960, and two Caltech faculty members have served on the steering committee of the nine-school consortium. Marc Nicolet, associate professor of electrical engineering, is currently on the committee, replacing Donald E. Hudson, professor of mechanical engineering and applied mechanics, who served from 1961 to 1965.

Speaking of Microcirculation

J. Harold Wayland, Caltech professor of engineering science, is taking a four-month leave of absence to lecture at medical schools, laboratories, and at conferences on a schedule that will take him around the world. Dr. Wayland leaves April 8 for Japan, Thailand, Iran, and Greece, where he will speak on his bioengineering research in relation to microcirculation. In June he will conduct a symposium on methods of research in the microcirculation, to be held in Cambridge, England, four days before the Fourth European Conference on Microcirculation. His last speaking engagement will be in Reykjavik, Iceland, at the First International Congress on Hemorheology on July 10-16.

Honors and Awards

Pol Duwez, Caltech professor of materials science, has been elected a fellow of the Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers, one of five U.S. engineers and scientists to be given the honor this year. Dr. Duwez's citation is in recognition of "his imaginative contributions to the science of metals and to the development of new types and new structures of material for the space age."

Robert B. Leighton, Caltech professor of physics and principal investigator for the Mariner IV television experiment, is one of seven American scientists to be named by NASA to a special U.S.–U.S.S.R. data coordination board on space biology and medicine. The joint group has been formed under an agreement made with the Soviet Academy of Sciences for mutual assistance in medical knowledge relative to long space flights.

Hans W. Liepmann, Caltech professor of aeronautics, has been elected to the National Academy of Engineering for his fundamental contributions to the field of fluid mechanics. He is the fifth Caltech man to be honored by membership in the Academy.

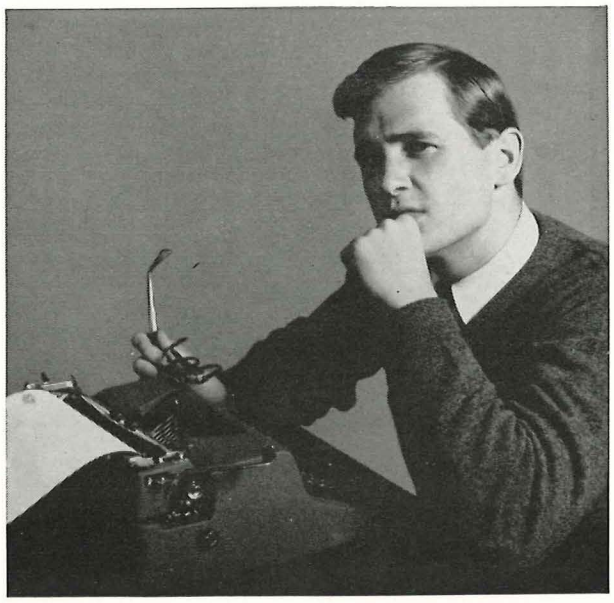
An authority on shock waves, plasmas, and the flow of rarefied gases, Dr. Leipmann is also chairman of NASA's research advisory committee for fluid mechanics. In NAE membership he joins Caltech's Simon Ramo, research associate in electrical engineering and a member of the Institute's board of trustees; George W. Housner, professor of civil engineering and applied mechanics; and the late Clark Millikan, professor of aeronautics and director of the Graduate Aeronautical Laboratories.

Sloan Foundation Grants

Five Caltech men are among the 90 scientists in the United States and Canada selected to receive basic research grants from the Alfred P. Sloan Foundation: Don L. Anderson, associate professor of geophysics; Everett C. Dade, associate pro-

continued on page 30

Engineers & Scientists



With all the companies making the same promises, how do you tell the difference?

It is difficult! Perhaps the best and only way is to study the company carefully—to see if its structure, range and operational modes permit it to make good its promises. If you scrutinize Sylvania Electronic Systems, you'll discover a number of salient facts that may help clarify the matter for you.

Note first that Sylvania employs the small group form of organization—within its nationwide complex of research and development groups, manufacturing plants and world-wide field engineering operation. This makes swift individual progress and development possible within a wide choice of current in-house projects.

Note particularly the diversity and breadth of SES projects. You may advance in a technical or administrative capacity in any of these areas: ground electronics equipment for Minuteman missile sites...research and development in electronic warfare field...electronic security systems... ASW systems...special purpose airborne computers for incorporation into U.S. Air Force large scale electronic systems...laser systems...design of spaceborne electronic and optical systems...plus world-wide engineering support systems.

Note that SES has worked out three distinct routes for advancement, all with equal rewards—technical specialist, technical manager, program/project manager.

Finally, note how SES encourages ambitious individuals to accelerate their development through participation in Division-wide conferences, in-plant courses and seminars and post-graduate study plans conducted on an unusually generous scale.

The success of the SES mission—to manage government systems programs for General Telephone & Electronics, the parent corporation—depends on the professional and intellectual growth of its personnel. In every respect, SES has created an environment to foster that growth. Be sure that any prospective employer you consider has established a growth climate of like specifications.

Making promises is one thing. Making progress is another.

GT&E

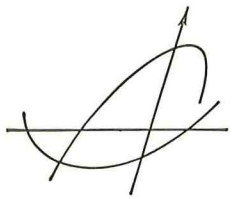
GENERAL TELEPHONE & ELECTRONICS

Total Communications from a single source through

SYLVANIA ELECTRONIC SYSTEMS

SES LABORATORIES ARE LOCATED SUBURBAN TO SAN FRANCISCO, BUFFALO AND BOSTON

For further information about any of these locations, see your college placement officer or write to:
Manager of College Relations, 40 Sylvan Road, Waltham, Massachusetts 02154. An Equal Opportunity Employer.



SOPHISTICATION IN APPROACH, DIVERSITY IN PROGRAMS

Creative scientists and engineers with advanced degrees are invited to investigate career opportunities with one of the nation's foremost research and technical service organizations

Booz, Allen Applied Research has enjoyed conspicuous success in solving complex, non-routine problems and developing new products and processes for industry, government and the armed forces. So much success, in fact, that we are in need of new talent to meet new and still greater challenges in:

APPLIED RESEARCH AND ANALYSIS
Operations Research — Operations Analysis — Systems Analysis — Applied Mathematics — Mathematical Analysis — Statistical Analysis — Environmental Analysis — Communication Studies — Technical Program Planning — Reliability — Computer Applications.

PRODUCT DESIGN AND DEVELOPMENT
Electronic and Mechanical Product Development — Industrial Design — Commercial Service Products and Equipment.

CHEMICAL TESTING AND DEVELOPMENT
Problem Solving in Chemistry—Bacteriology — Toxicology — Pilot Plant Design and Development—Chemical Marketing Research — Synthetic Resins — Protective Coatings — Detergents — Organic Synthesis — Physical Testing — Chemical Analysis—Food Technology—Cosmetics—New Product Development.

We seek creative scientists and engineers with advanced degrees—individuals with a bent for **both** the practical and the theoretical, who can come to grips with projects which freely cross disciplinary boundaries.

What do we offer in return? A constant flow of diversified, intellectually stimulating assignments, which you may pursue individually and/or as a member of interdependent teams. Attractive remuneration and broad career benefits including encouragement of advanced study. A wholly professional working environment combining the best elements of the industrial and the academic. Most important, a future limited only by the bounds of your own capabilities. For further information, please send your resume to Mr. Robert Flint, Director of Professional Appointments.

BOOZ • ALLEN APPLIED RESEARCH Inc.
135 South LaSalle Street, Chicago, Illinois 60603
New York • Washington • Cleveland • Chicago • Kansas City • Los Angeles
An equal opportunity employer (M&F)

738

Our newest baby

This one is called SGLS. It is a standardized, S-band, TT&C system, the most versatile of all Space Ground Link Systems for manned and unmanned vehicles. The modular Digital Telemetry Unit is shown above. It's work like this that creates technical and administrative openings in Inertial Guidance and Control Systems; Communications; Spacecraft Heat Transfer; Electric Space Power; Digital Systems; Human Factors; Electro-optical Systems; Scientific Programming; Applied Mathematics; Aerodynamics; and Management Systems Development; Financial Analysis; Contract Administration; Writing of Technical Proposals. Why not write us. TRW Professional Placement, One Space Park, Dept. K–3, Redondo Beach, California. TRW Systems is an operating group of TRW Inc., a company diversified in the fields of aerospace, automotive and electronics. TRW is an equal opportunity employer, male and female.

TRW SYSTEMS

fessor of mathematics; Roger F. Dashen, assistant professor of theoretical physics; Kip S. Thorne, research fellow in physics; and George Zweig, assistant professor of physics.

Report to the President

Arie J. Haagen-Smit, Caltech professor of bioorganic chemistry, now in charge of the Earhart-Campbell Plant Research Laboratories, recently completed a 15-month study of pollution as a member of a special panel of the President's Science Advisory Committee on Pollution Problems. The published report, "Restoring the Quality of Our Environment," contains more than 100 recommendations for managing pollution of air, water, and soil, and is currently being studied by government agencies and departments for possible implementation in an anticipated, all-out, government drive against pollution.

Dr. Haagen-Smit, who says he is "taking a vacation from smog," to concentrate on administration of the plant laboratories and on other research projects, spent alternate weekends for more than a year in Washington, D.C., along with the 14 other educators, scientists, industrialists, and government officials on the panel.

The Y's Fiftieth

"The YMCA is Caltech's antidote to random trolls and talented nuts. Against academic pressures that would make a sow's ear out of a silk purse, the YMCA has battled nobly to make rounders out of squares, lounge lizards out of snakes, and politicians out of hermits . . . it is to apathy and withdrawal what the committee report is to insomnia . . ."

This breezy tribute to the Y's half-century of contribution to Caltech life was delivered to some 800 students, faculty, and friends gathered in Beckman Auditorium on February 25 to celebrate the Caltech Y's 50th birthday.

Eleven students came to the first meeting of the Caltech Y in 1916, and each of them paid 50 cents in dues to cover expenses for the rest of the year. Although the Y has come a long way to its $55,000 budget for 1966, the goals established 50 years ago still apply—to help students gain an understanding of themselves and their society, and to give moral direction to their lives.

In its infancy the Caltech Y was strong on the traditional evangelical approach. However, in addition to Bible study classes and a program to encourage students to attend church, it offered a success course, athletic activities at the Pasadena YMCA, a room-and-board service, and sex lectures.

In the thirties the rallying point of the Y shifted to humanitarian concern, and student interests broadened to include such social action as peace movements, labor unions, and socialism.

World War II, with accelerated student schedules, involvement of faculty in military-oriented research, and the suspension of many Institute traditions, altered most regular activities and limited the Y's program to something of a "holding operation."

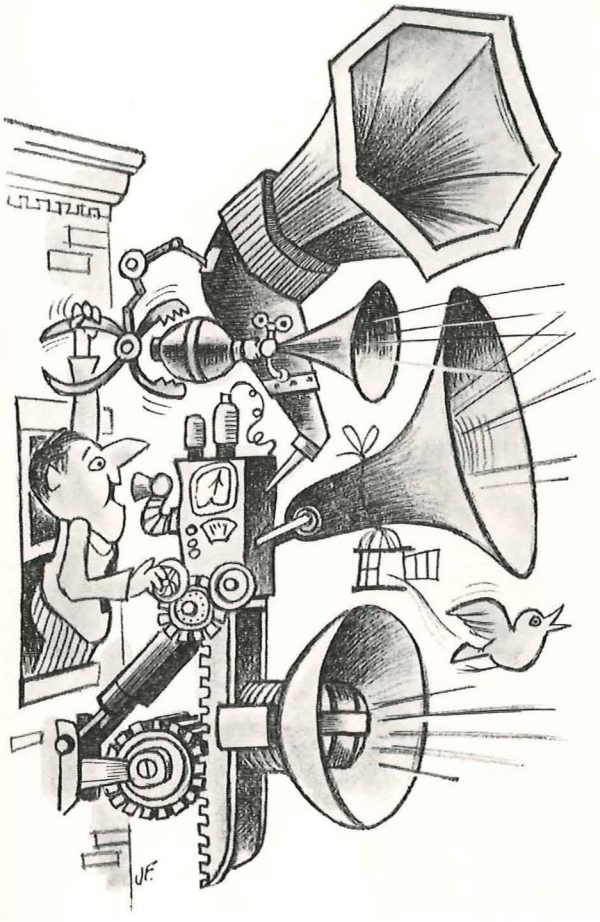
When peace came, so did a new executive secretary, Wesley L. Hershey—now celebrating his 20th anniversary at Caltech. The presence of veterans on campus seasoned the Y's concerns and activities, and continued the broadening of its religious outlook. Many new programs were initiated at this time—programs that have today become the weekly frosh dinner forum; the weekly Athenaeum luncheon-with-guest-speaker; the weekly informal graduate sack lunch; the Leaders of America program, bringing to campus such distinguished men as Paul Hoffman, Ralph Bunche, Martin Luther King, Archibald MacLeish, and Ted Sorensen; weekend conferences and retreats, including the annual Caltech-Scripps Conference; personal counseling for students; and work and service projects such as the tutoring of needy high school students.

"If a college education means the whole of the experience a student has in college," said President Lee A. DuBridge, saluting the Y on its 50th birthday, "then the Caltech Y is a major educational organization . . . May it live and prosper forever!"

Caltech Bookstore

Esther Green, who has managed the Caltech bookstore since 1929, will retire next month. In her 38 years at the Institute she has played an important part in developing the store from a mere cubbyhole in Throop (where space and business were so limited that she also operated the switchboard and kept books for the accounting office) to the model university bookstore it is today.

Vernon Rohe, manager of the Earlham College Store in Richmond, Indiana, for the past eight years, will take charge of the Caltech bookstore on April 1. Before going to Earlham he was head of the campus bookstore at his alma mater, Heidelberg College in Tiffin, Ohio, for 10 years.



Yell it out the window!

. . . or whisper it over his MOTRAN Radio*

THE PROBLEM: HOW CAN YOU BE SURE YOUR MAN IN THE TRUCK MAKES THE SECOND STOP FIRST?

You might try the megaphone if you're not too concerned about the message. But if it's one that *has* to get through . . . better you flip a switch and tell it to him over his Motorola MOTRAN 2-way radio.

As a matter of fact, for any 2-way communications problem, Motorola engineers more than likely have the solution . . . or they'll find it. They've been in the business since it began, and just about every significant development in 2-way radio since 1940 has been by Motorola.

It was no small task to design a pocket-sized radio pager that could reach a doctor 20 miles away on a golf course.

Motorola did *that* too!

*MOTRAN — Motorola Mobile 2-way Transistor Radio

TRUST THIS EMSIGNIA WHEREVER YOU FIND IT

MOTOROLA

Alumni News

Board Nominations

The Board of Directors of the Alumni Association met as a Nominating Committee on February 22, 1966, in accordance with Section 5.01 of the By-Laws. Eight vacancies will occur on the Board at the end of the fiscal year, June 1966. Four of these vacancies will be filled by the Immediate Past President, President, Secretary, and Treasurer, ex officio, and four will be filled by direct election. The present members of the Board, with the years their terms expire are:

James L. Adams '55	1966	Robert W. Lynam '54	1967
Donald S. Clark '29	1966	John L. Mason '47	1966
Theodore C. Combs '27	1967	John T. McGraw '38	1966
Patrick J. Fazio '53	1966	Paul D. Saltman '49	1967
John R. Fee '51	1966	Richard P. Schuster, Jr. '46	1967

The following nominations have been made:

President—Sidney K. Gally '41	(1 year)
Vice President—Frederic T. Selleck '49	(1 year)
Secretary—Donald S. Clark '29	(1 year)
Treasurer—John R. Fee '51	(1 year)
Director—Donald D. Davidson '38	(2 years)
Director—Manfred Eimer '47	(2 years)
Director—Craig T. Elliott '58	(2 years)
Director—Frank W. Lehan '44	(2 years)

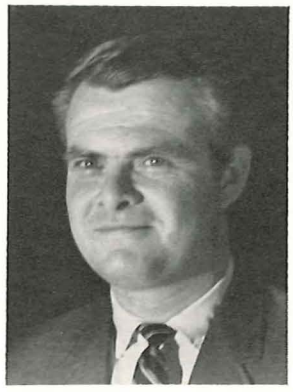
Section 5.01 of the By-Laws provides that the membership may make additional nominations for the four (4) Directors by petition signed by at least twenty-five (25) members in good standing, provided the petition is received by the Secretary not later than April 15. In accordance with Section 5.02 of the By-Laws, if further nominations are not received by April 15, the Secretary casts a unanimous ballot for the members nominated by the Board. Otherwise a letter ballot is required.

Statements about the nominees are presented below.

—Donald S. Clark, Secretary

DONALD B. DAVIDSON received his BS in chemistry in 1938. He spent the next 14 years with the Shell Companies: from 1938-40 as a junior research engineer with Shell Development in southern California; from 1940-42 as assistant head of the chemical division of Shell Oil and Shell Chemical in Houston; and from 1942-52 as research supervisor for Shell Development in California. In 1952 he joined the Golden Bear Oil Company of Los Angeles where he is currently vice president of manufacturing and engineering. He served as a member of the program committee for the Alumni seminar in 1954.

MANFRED EIMER received his BS in mechanical engineering in 1947, and his MS and PhD degrees in aeronautics, in 1948 and in 1953. For the next ten years he was with Caltech's Jet Propulsion Laboratory and in 1962 was assigned by JPL to NASA's Office of Manned Space Flight in Washington, D.C., as a part of the Apollo program. In 1963 he joined the Space-General Corp. of El Monte and was recently appointed vice president, engineering, of the firm. He has twice served on the program committee of the Alumni Seminar—as a member in 1954 and as chairman in 1957.



CRAIG T. ELLIOTT received his BS in mechanical engineering in 1958 and was ASCIT president in his junior year. In 1956 he joined Wiancko Engineering of Pasadena (now the technical products division of Whittaker Corp. in Los Angeles) as an engineer trainee. He has subsequently served as project engineer, manager of production engineering, and manager of transducer engineering. He is now director of transducer engineering. In 1965 he was chairman of the program committee of the Alumni Seminar, and this year he is assistant general chairman of the Seminar.

FRANK LEHAN received his BS in electrical engineering in 1944, and for the next ten years was at Caltech's Jet Propulsion Laboratory working in the fields of telemetry, telecommunications, and electronics research. The following four years he was with Space Technology Laboratories in Redondo Beach (now TRW Systems), where he was associate director for the electronics laboratories on the ballistic missile programs. In 1958 he was co-founder of the Space-General Corp. of El Monte, a subsidiary of Aerojet General Corporation, and became its president in 1962.

Twenty-five hundred dollars in cash awards to engineering and metallurgy students.

The Forging Industry Educational and Research Foundation announces a $2,500 award competition for the best paper on the subject "The Principal Technical Development Needed by the Forging Industry in the Next Decade." First prize, $1,000, plus eight other awards totaling $1,500.

Competition is open to senior and graduate engineering and metallurgy students. Length of the paper, 3,000 to 3,500 words. Deadline for completed paper: June 1, 1966.

Winner and his faculty advisor will also receive an all-expense-paid trip to Colorado Springs, Colorado, where the award presentation will be made at the 1966 meeting of the Foundation.

For full details fill in and mail the coupon or write:

The President

Forging Industry Educational and Research Foundation

55 Public Square • Cleveland, Ohio

Name_____

Address_____

_____

School_____

_____

Faculty Advisor_____

For your immediate information, a new 16-millimeter sound and color film, *TO BE FORGED,* describes the forging process, design considerations and production methods . . . the applications and advantages of forged parts. Length 18 minutes. Made available by Forging Industry Association, this film is on loan free from Modern Talking Picture Service, Inc. Check your telephone directory for the office nearest you.

Dear Alumnus:

The Co-Directors of the Alumni Fund wish to thank ~~you~~ the 1700 generous donors to the 1965-66 Fund appeal. Thank you.

We wish to ~~tell~~ suggest to ~~the rest of you guys~~ those of you who have not yet ~~come across~~ given that ~~it's high time we~~ I/you we sincerely hope you will do so, ~~now today Monday~~ soon.

Our ~~quota~~ goal is to ~~please~~ secure ~~lots of money~~ support from 30 percent of the alumni, and this means we ~~must~~ ~~cannot~~ need another 1000 donors. ~~Quick~~.

The time has come when ~~we'll take anything we can get~~ the important thing is to give — regardless of the size of the gift.

~~You'd better come through, too~~. Won't you give, now?

Sincerely,
Ted Combs '27
John Mason '47

Personals

1917

ROY T. RICHARDS died suddenly on February 22 at his home in La Jolla, Calif. He had been planning to attend the Caltech YMCA's 50th birthday celebration on February 25, and was to have been honored as the campus Y's second president in 1916-17. Richards is survived by his wife.

1921

ALFRED J. STAMM, who is Robertson Distinguished Professor of Wood Science and Technology at North Carolina State University in Raleigh, was voted the outstanding teacher in the forestry school in 1965 by his students.

1925

JAMES E. MOORE has retired as vice president—traffic of United Air Lines. He writes from Tryon, N.C., that he and his wife, Mary, are enjoying their grandchildren, poodles, music, photography, gardening, and golf.

ROBERT W. FULWIDER, partner in the patent law firm of Fulwider, Patton, Rieber, Lee & Utecht in Los Angeles, has been appointed by President Clark Kerr of the University of California to the Advisory Council under the State Technical Services Act. The council evaluates the annual programs submitted by the university departments in implementing a five-year plan being developed for placing the benefits of research more effectively in the hands of business, commerce, and industrial establishments.

1927

THOMAS S. SOUTHWICK, MS '29, in Thailand for the UN (*E&S*, October 1965), writes that he expects to "retire for the second time, and for good, I hope," at the end of this year. He and his wife plan to live in England awhile before returning to their home in Falls Church, Va.

1928

EDWARD E. TUTTLE, president of the Essick Manufacturing Company in Los Angeles, is one of eight Southern California business and industrial leaders recently elected to the board of directors of the Merchants & Manufacturers Assn.

WILLIAM M. JACOBS has been named president of the Pacific Lighting Service and Supply Company in Los Angeles. He has been vice president of the parent company, Pacific Lighting Corporation, in San Francisco.

JEAN E. JOUJON-ROCHE has retired from the Shell Oil Company after 31 years in the Pacific Coast area exploration department. Ed was seismic crew manager for the group that discovered the first oil field to be found by reflection shooting in California—near Bakersfield in 1936. He writes that he plans to play tennis, fish, and travel, but that he will be doing some ground water geology work for Hydrodevelopment, Inc. and Hydroexploration, Inc. in Bakersfield.

1930

HOWARD CARY, president of the Applied Physics Corp., recently took part in groundbreaking ceremonies for the company's new research and corporate headquarters in Monrovia. Also present was JOSEPH B. EARL '44, president of the O.K. Earl Corp., general contractors of Pasadena, for the new building.

1931

ARTHUR C. BROOKS is teacher, coach, and chaplain at the Asheville School, boys preparatory school in North Carolina. He says that he and his wife often visit their son's family (three grandchildren) in Boston, and are otherwise occupied building a house in the country where they plan to retire eventually.

1934

EDWARD B. DOLL, MS '35, PhD '38, has been named a senior vice president of TRW Systems of Redondo Beach, Calif. For ten years he has held executive positions in TRW, and most recently served as vice president of special projects.

1936

EUGENE BOLLAY, MS, has been given the Award for Outstanding Contributions to the Advance of Applied Meteorology by the American Meteorological Society in "recognition of his roles as champion of the cause of industrial meteorology and as an able architect of an image of the private meteorological practitioner." Bollay is president of E. Bollay Associates, Inc. of Boulder, Colo.

1938

ROBERT C. DAVIDSON has been appointed manager of the catalyst division of the Nalco Chemical Company in Chicago. He has been with Nalco since 1960, his latest position being the division's assistant manager.

1941

LELAND G. SWART, MS, is head of the sonar and Nike communications equipment department at the Bell Telephone

Laboratories in Greensboro, N.C. Leland sends news of his family—daughter Donna Lee is at Douglass College in New Brunswick, N.J., daughter Pamela is in high school, and son, Chip, is in fourth grade.

SAMUEL J. EASLEY, MS, meteorologist at the U.S. Weather Bureau station at Ft. Worth's Greater Southwest International Airport, has been named chief of the Dallas Love Field weather bureau station in Texas. Easley has been in weather bureau service since 1940 and has been at Ft. Worth since 1956.

1944

BERT H. GOLDING, MS '48, ChE '54, writes from Dhahran: "Marny and I have just completed 10 years in Arabia. We celebrated by getting a new four-wheel drive with air conditioning so we can bounce over the sand dunes in style." Golding is with the Arabian American Oil Company as a senior study engineer for the producing department in charge of the future oil development planning and technical programming units.

1945

WALTER F. HILTNER, PhD, died on February 14 of a heart attack suffered two days earlier. He was an aerospace scientist at the Boeing Company in Seattle, Wash., and as manager of the space science integration for Voyager, was one of the earliest exponents of space exploration. His teaching career, which began in 1937, included assignments at MIT and the University of Washington in Seattle, and he headed the fluid mechanics department at Lehigh University in Bethlehem, Pa. Hiltner was born in Shanghai, China, in 1912 and attended the University of Washington, MIT, and Caltech. He is survived by his wife, Willa Lou, and five children.

1946

JAMES F. CHALMERS, BS '47, has been named director of the newly established management systems organization in the Manned Orbiting Laboratory systems engineering office at Aerospace Corporation in El Segundo. He was formerly assistant director of operations planning for technical operations there.

1947

MANFRED EIMER, MS '48, PhD '53, has been appointed vice president—engineering of the Space-General Corp. in El Monte, Calif. Before Eimer joined Space-General in 1963, he was a senior staff scientist at Caltech's JPL.

1948

HARVEY R. FRASER, MS, has been appointed president at the South Dakota School of Mines and Technology in Rapid City, where he has been dean of engineering since July 1965. He will continue as dean and as professor of civil engineering. Before joining the school last year, Fraser was a colonel in the U.S. Army and deputy head of the department of mechanics at West Point.

1949

CHARLES H. KNIGHT JR. has been appointed western regional manager of the Portland Cement Association, with headquarters in San Francisco. Knight has been with PCA since 1956, and was district engineer for the Seattle area from 1960 until the present appointment.

1950

RICHARD B. WRIGHT is the new president of the Wright Tool & Forge Co. of Barberton, Ohio. He has been with the firm for 14 years, and most recently served as vice president.

1951

ROBERT E. COVEY, MS '52, manager of the space simulators and facilities engineering section of Caltech's JPL, has been elected the 1966 chairman of the American Institute of Aeronautics and Astronautics's working group on space simulation. This group of professional delegates from government and industry fosters the exchange of technical information on problems of space simulator design, operation, and instrumentation.

1953

CARL A. ROUSE, MS, PhD '56, writes that he is at the E. O. Hulburt Center, U.S. Naval Research Laboratory in Washington, D.C., on a one-year National Science Foundation research grant.

1956

HOWARD CURTIS BERG has been appointed assistant professor of biology and chairman of the board of tutors in the biochemical sciences at Harvard, effective July 1. He has been a junior fellow of Harvard's Society of Fellows, studying the chemical modification of the red cell membrane and will teach membrane structure and function. Berg, who received his MA and PhD degrees at Harvard, spent a year at the Carlsberg Laboratory in Denmark following two years in preclinical study at the Harvard Medical School. He held a National Institutes of Health predoctoral fellowship from 1959 to 1963.

EDWARD M. DAVIS JR., MS, assistant to the president of IBM Corporation's data processing division in White Plains, N.Y., has been named the Outstanding Young Electrical Engineer of 1965 by Eta Kappa Nu, national electrical engineering honor society. Davis has been active in the development of components, circuits and memory devices for electronic computers, and helped create the microminiature circuit technology used in IBM's most advanced data processing system.

1957

CHARLES W. STEPHENS, MS, has been named federal marketing coordinator of Electro-Optical Systems, Inc. in Washington, D.C., to coordinate the separate federal marketing activities of the subsidiary with the parent company, Xerox Corporation. Stephens was previously manager of the EOS optics division in Pasadena.

1958

DONALD B. CHESNUT, PhD, is associate professor of chemistry at Duke University in Durham, N.C. He went to Duke from the E. I. du Pont de Nemours & Co.'s central research department in Wilmington, Del., where he had worked since 1958.

1960

CAPT. LOUIS KINGSLAND JR., USAF, MS, AE '61, was recently awarded the USAF Air Medal for meritorious achievement at Hickam AFB in Hawaii for his assistance in accomplishing an important vehicle test flight. King is a navigator and a member of the Military Airlift Command which provides global airlift, air rescue, aeromedical evacuation, air weather and air photographic and geodetic services for the U.S. forces.

1962

HAL WYMAN, who is a computer programmer for UCLA's Brain Research Institute in Westwood, was married last December to Carolyn Guggenaster, in Columbus, Ohio. Wyman got his pilot's license recently and is reportedly trying to talk his friends (not always successfully) into flying with him.

RONALD F. GEBHARDT received his MS in geological engineering from Princeton in January.

LIEUT. CHARLES H. RADOY USAF is at the Air Force Institute of Technology at Wright-Patterson AFB near Dayton, Ohio, beginning a two-year course of study in electronics systems. The program is conducted as part of the Air University professional military education system and leads to a MS degree in electrical engineering.

1965

DAVID TILTON DENHARDT, PhD, has been appointed assistant professor of biology at Harvard, where he has been serving as instructor. Denhardt is married and has one child.

MAY 7
ALUMNI SEMINAR

An all-day program of lectures
Social hour and dinner at the
Huntington-Sheraton Hotel

guest speaker

JOHN McCONE

Former Under Secretary of the Air Force, Chairman of the Atomic Energy Commission, Director of the Central Intelligence Agency, and Chairman, Governor's Commission on the Los Angeles Riots.

Complete program and registration forms will be mailed in early April

PLACEMENT ASSISTANCE TO CALTECH ALUMNI

There are two ways in which the Placement Service may be of assistance to you:

(1) To help you seek new employment or a change of employment.

(2) To inform you when outstanding opportunities arise.

This service is provided to Alumni by the Institute. A fee or charge is not involved.
If you wish to avail yourself of this service, fill in and mail the following form:

To: Caltech Alumni Placement Service
California Institute of Technology
Pasadena, California 91109

Please send me:

☐ An Application for Placement Assistance

☐ A form to report my field and operation so that I may be notified of any outstanding opportunities.

Name ..... Degree (s) .....

Address ..... Year (s) .....

.....

MAY 6

Alumni, faculty, and friends
are giving a dinner in honor of

HAROLD Z. MUSSELMAN

at the

Roger Young Auditorium

Hal's friends plan to send him and his wife on a trip to Hawaii. Contributions for this gift may be sent to the Caltech Alumni Office. Alumni in the Los Angeles area will receive a mail announcement of the dinner. Others wishing to attend, write or call the Alumni Office for reservations.

ALUMNI ASSOCIATION OFFICERS AND DIRECTORS

PRESIDENT
Richard P. Schuster, Jr., '46

VICE PRESIDENT
Sidney K. Gally, '41

SECRETARY
Donald S. Clark, '29

TREASURER
John R. Fee, '51

James L. Adams, '55
Theodore C. Combs, '27
Robert W. Lynam, '54
John L. Mason, '47

John T. McGraw, '38
Paul D. Saltman, '49
Frederic T. Selleck, '49
Patrick J. Fazio, '53

ALUMNI CHAPTER OFFICERS

NEW YORK CHAPTER

President — Bruno H. Pilorz, '44, 75 Echo Lane, Larchmont, N.Y.

Vice-President — Willis A. Bussard, '44, Appleby Drive, RFD 1, Box 78B, Bedford, N.Y. 10506

Secretary-Treasurer — Harry J. Moore, Jr., '48, Old Orchard Road, Armonk, N.Y. 10504

BOSTON CHAPTER

President — Francis Morse, '40, 16 Reservoir Rd., Wayland, Mass

Vice-President — Theodore G. Johnson, '57, Blueberry Hill Rd., Sudbury, Mass.

Secretary-Treasurer — Thomas C. Stockebrand, '53, 55 Summer St , West Acton, Mass. 01780

WASHINGTON, D.C. CHAPTER

Chairman — Willard M. Hanger, '43, 4720 Sedgwick St., N.W., Washington, D.C.

CHICAGO CHAPTER

President — Laurence H. Nobles, '49, Dept. of Geology, Northwestern Univ., Evanston, Ill.

Vice-President — Philip E. Smith, '39, Eastman Kodak Co., 1712 Prairie Ave., Chicago, Ill.

SAN FRANCISCO CHAPTER

President — Edwin P. Schlinger, '52, G. E. Vallecitos Atomic Lab., Pleasanton, Calif.

Vice-President — Dallas L. Peck, '51, U.S. Geological Survey, Menlo Park, Calif.

Secretary-Treasurer — Thomas G. Taussig, '55, Lawrence Radiation Lab., Univ. of Calif., Berkeley, Calif.

Meetings: 15th Floor, Engineers' Club, 206 Sansome St., San Francisco
Informal luncheons every Thursday at 11:45 A.M.
Contact Mr. Farrar, EX 9-5277, on Thursday morning for reservations.

SACRAMENTO CHAPTER

President — Harris K. Mauzy, '30, 2551 Carson Way, Sacramento, Calif. 95821

Vice-President — Frederick J. Groat, '24, 877 - 53rd St., Sacramento, Calif. 95819

Secretary-Treasurer — William D. Pyle, '49, 3920 Dunster Way, Sacramento, Calif. 95825

Meetings: University Club, 1319 "K" St.
Luncheon first Friday of each month at noon.
Visiting alumni cordially invited—no reservations.

Kodak

wants two kinds of mechanical engineers:

1. burning with ambition to reach manager's status as soon as possible

- **College grade-point average on the high side in technical subjects**

Secretly admitted to self at certain point in undergraduate career that the scholar's way of life is for other people *but smart enough to have kept secret from the professors who are, after all, scholars.* Diploma in, secret out.

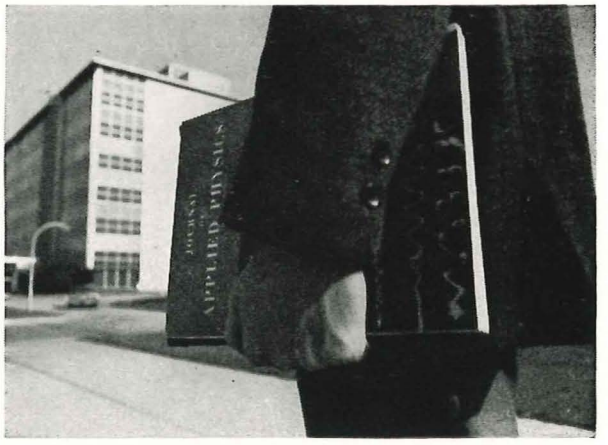
- **Seeks prosperous, highly diversified employer**

Competitive personality who wants to play on a strong, long-lasting team in the big leagues.

- **Unafraid of choices and changes**

With a mechanical engineering background, we might find him adept at keeping a troupe of welders happy on a new petrochemical project, or designing a new type of machine for the lithographic industry, or organizing a small laser-manufacturing department, or operating a large magnetic tape plant, or profitably piloting one of the world's major industrial corporations.

2. able to hold a manager's job in time but sure he wouldn't like it



- **College grade-point average on the high side in technical subjects**

Why not? The subjects were intrinsically interesting, and most of the professors proved to have a clear understanding of them.

- **Seeks prosperous, highly diversified employer**

To practice modern mechanical engineering—this is not 1936—one needs scope, contacts, and resources.

- **Unafraid of choices and changes**

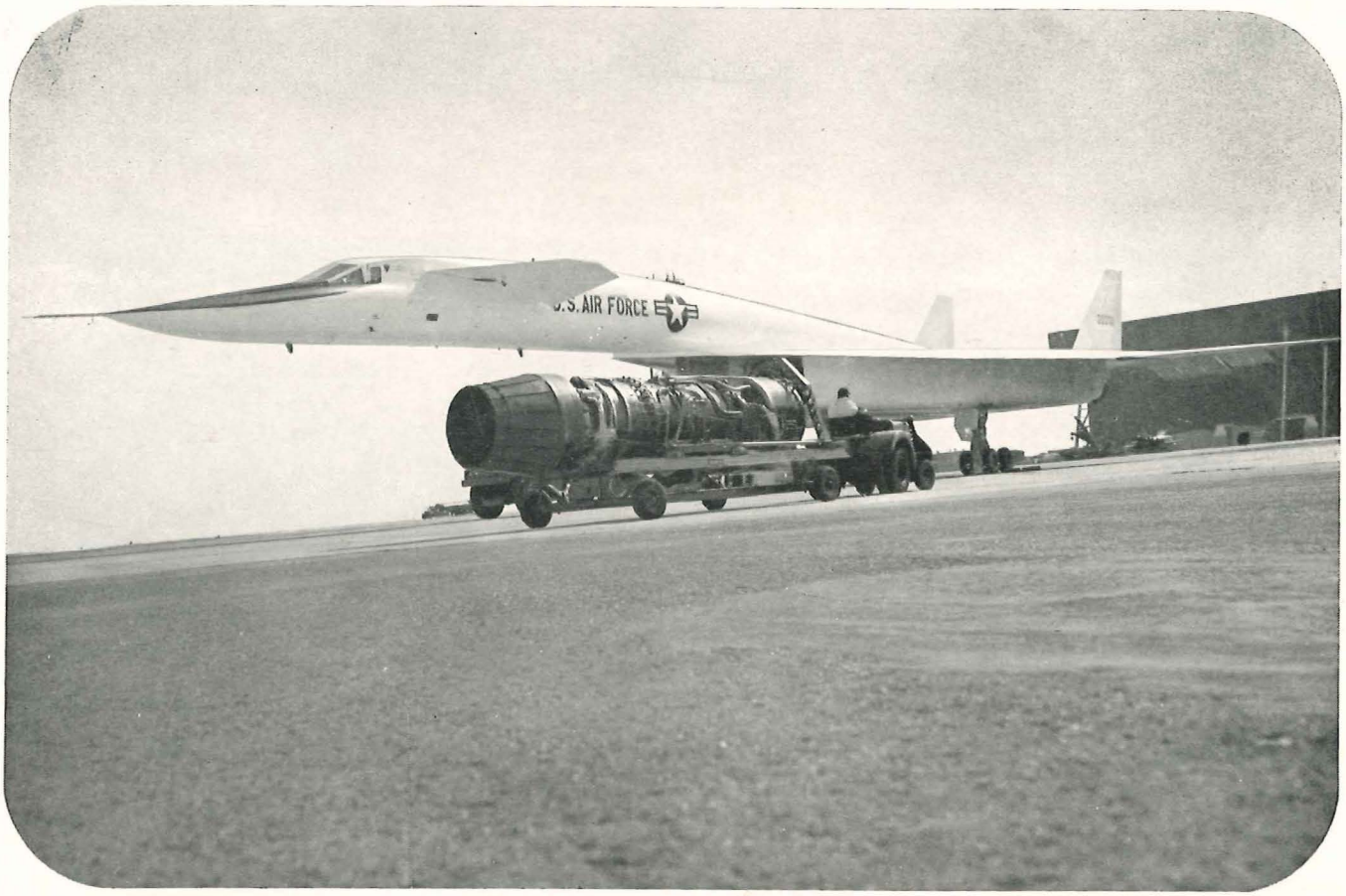
With a mechanical engineering background, he might choose to take a high leap over the interdisciplinary wall into solid state physics, pull some excessively generalized equations out of a journal that others on the circulation list quickly glance at and pass along. Six months later he may have a new composition of matter on board a ship bucking the solar wind to Mars.

What is said here about mechanical engineers is equally applicable to chemical engineers and electrical engineers. Our expansion rate now demands technical people who, at the one extreme, are still fresh from the classroom with its benefits and, at the other, have had ten years of practice in their professions and are now ready to select a lifetime employer. We offer a choice of three communities: Rochester, N. Y., Kingsport, Tenn., and Longview, Tex. We earnestly solicit serious and honest self-descriptions addressed to:

EASTMAN KODAK COMPANY

Business and Technical Personnel Department/Rochester, N. Y. 14650

An equal-opportunity employer.



SIX G-E J93 ENGINES push USAF XB-70 to MACH 3.

JACK WADDEY, Auburn U., 1965, translates customer requirements into aircraft electrical systems on a Technical Marketing Program assignment at Specialty Control Dept.

PAUL HENRY is assigned to design and analysis of compressor components for G.E.'s Large Jet Engine Dept. He holds a BSME from the University of Cincinnati, 1964.

ANDY O'KEEFE, Villanova U., BSEE, 1965, Manufacturing Training Program, works on fabrications for large jet engines at LJED, Evendale, Ohio.

A PREVIEW OF YOUR CAREER AT GENERAL ELECTRIC

Achieving Thrust for Mach 3

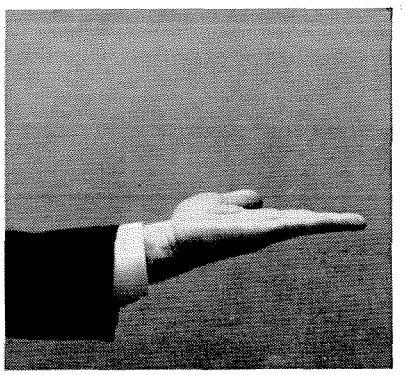
When the North American Aviation XB-70 established a milestone by achieving Mach 3 flight, it was powered by six General Electric J93 jet engines. That flight was the high point of two decades of G-E leadership in jet power that began when America's first jet plane was flown in 1942. In addition to the 30,000-pound thrust J93's, the XB-70 carries a unique, 240-kva electrical system that supplies all on-board power needs—designed by G-E engineers. The challenge of advanced flight propulsion promises even more opportunity at G.E. GETF39 engines will help the new USAF C-5A fly more payload than any other aircraft in the world; the Mach 3 in jet power since the beginning of propellerless flight has made us one of the world's leading suppliers of these prime movers. This is typical of the fast-paced technical challenge you'll find in any of G.E.'s 120 decentralized product operations. To define your career interest at General Electric, talk with your placement officer, or write us now. Section 699-16, Schenectady, N.Y. 12305. An Equal Opportunity Employer.

Progress Is Our Most Important Product

GENERAL ELECTRIC

The Rain in Maine is Plainly

$$D = \frac{SNR}{SNR_o} = \frac{t/T_{SYS}}{t_o/T_{SYS_o}} = t_x \frac{T_{SYS_o}}{T_{SYS}} = \frac{\Delta - 1}{\Delta_o - 1}^{*}$$



Attention to detail is an old Bell System habit. Or maybe you call it thoroughness. Or follow-through.

Anyway, we attended to an interesting detail recently—the effect of rain on the microwave link between a communications satellite and our pioneer ground station antenna at Andover, Maine.

If we could but measure the rain's and in this case we found ours in Cassiopeia A, a strong and stable radio star that is always visible from Andover. We measured the noise power from Cassiopeia A during dry periods, and then measured the reduction during rainy periods. The result could be expressed as a formula and employed accurately in designing future ground stations.

The initial success of our Telstar®

In space, on land or beneath the sea —wherever we operate—we go into things thoroughly.

Sometimes we know when not to come in out of the rain.

* * *

You may well find a rewarding career in the Bell System, where people find solutions to unusual problems. Bell System Companies are equal