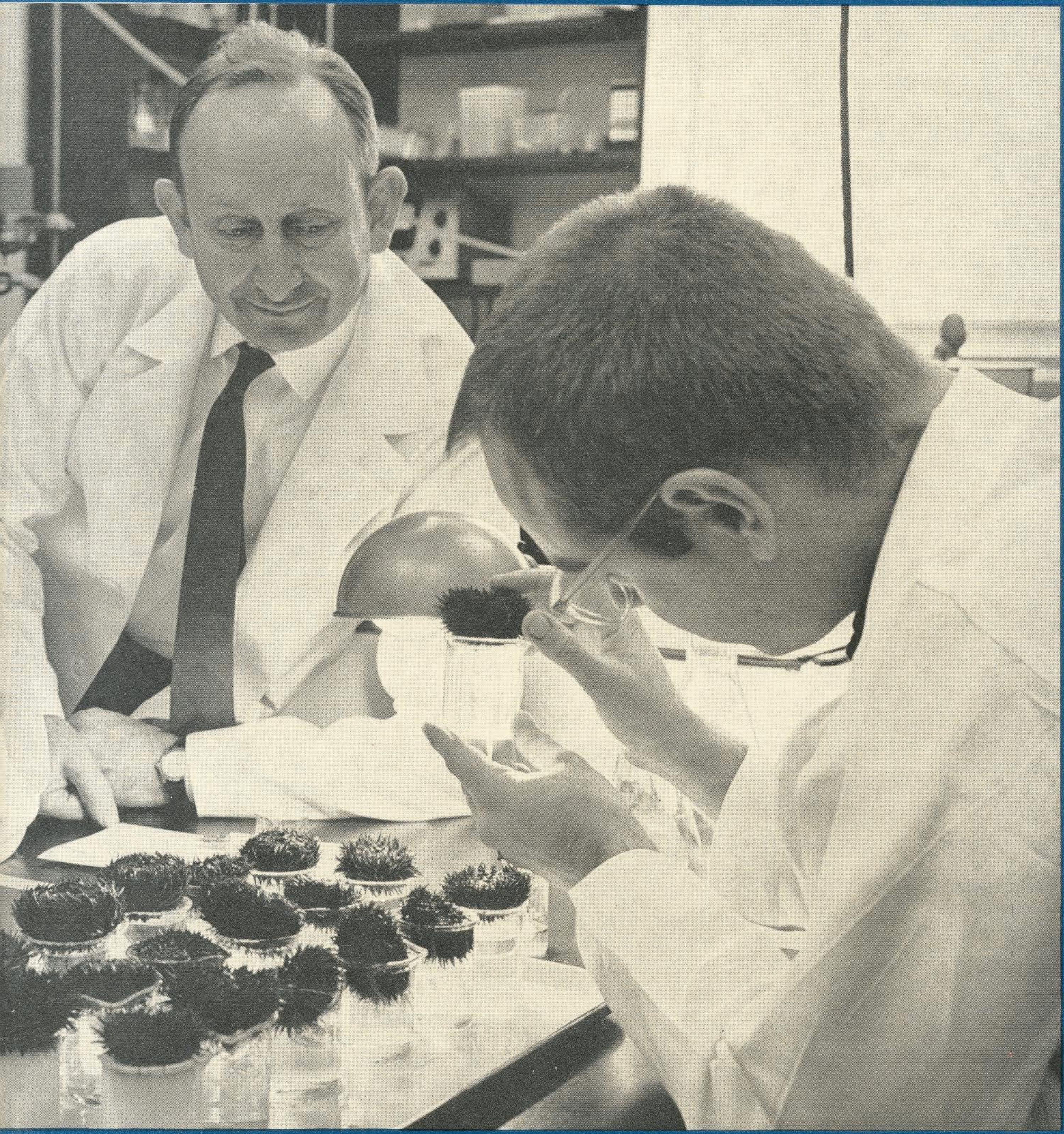
ENGINEERING | AND | SCIENCE

January 1964



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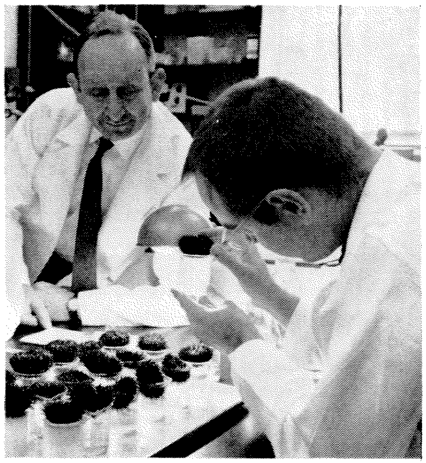

On Our Cover

Dr. Albert Tyler, professor of biology, and research fellow Richard Huemer, M.D., are collecting eggs and sperm from sea urchins for the studies on fertilization and development that are described in the article on page 17 of this issue.

On pages 18 and 19 are some really remarkable photographs taken, as part of these same studies, with the electron microscope at Caltech. These pictures show the very first steps in the fertilization of an animal egg.

Albert Tyler, who directs this research at Caltech, was graduated from Columbia University in 1927 and received his MS there in 1928. When the great geneticist Thomas Hunt Morgan came from Columbia to organize a biology department at Caltech, Tyler came along to continue his graduate studies here. He received his PhD in 1929 and has been on the Caltech staff ever since.

Dr. Tyler is a leader in the attempts to use the concepts of immunochemistry on biological problems not usually associated with this field. He has done outstanding work on the energetics of differentiation and on the mechanism of the fertilization reaction.

Private Higher Education

The subject of federal support of higher education is highly controversial. Caltech's President DuBridge tackles this subject, as well as other financial problems of the private segment of higher education, on page 11.

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For example, the story of Oliver W. Johnson, the young engineer pictured here, demonstrates how an individual can apply his full range of talents and interests at IBM to further his professional career. Since he first joined IBM, he has been assigned to several different project areas, including: special

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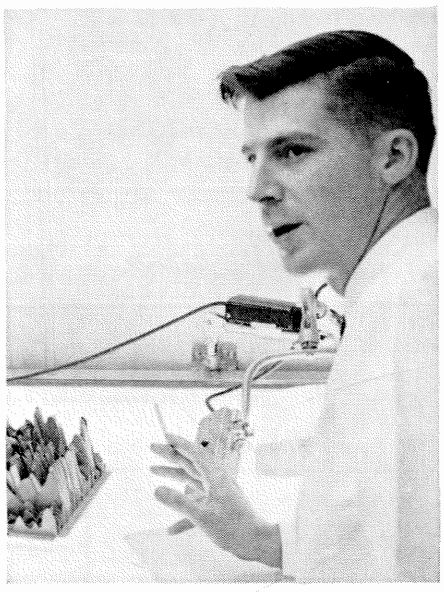

transistor circuits, cryogenic development, experimental studies on voice output from computers. He is now being recognized for his success in developing a new method of compressing speech by which time might be saved in voice transmission of data.

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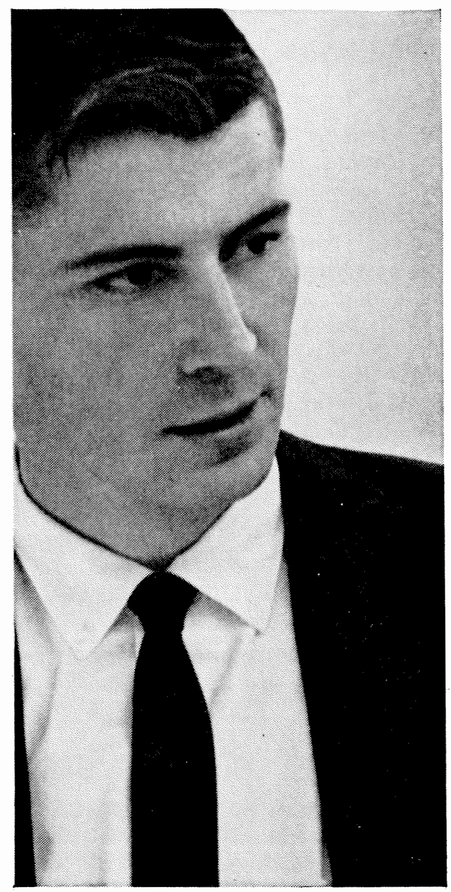

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Books

THE GENERAL PHYSIOLOGY OF CELL SPECIALIZATION

McGraw-Hill $13.50

Proceedings of a symposium of the Society of General Physiologists held at Oregon State University in 1962 concerned with the structural and functional specialization of cells. Edited by Daniel Mazia, professor of zoology at the University of California at Berkeley; and Albert Tyler, Caltech professor of biology.

MEN OF SPACE, Vols. 1-5

Chilton .... $4.95 *each*

A continuing series of profiles of leading figures in the fields of space research, development, and exploration. Shirley Thomas, the author, brings out a new volume about every six months, usually manages to include one or more Caltech men in the eight to ten biographies she runs in each book.

Of the five volumes of *Men of Space* that are now in print:

Volume One includes Theodore von Kármán. In Volume Two are Thomas F. Dixon, MS '45, chief designer of engines for the Atlas, Thor, Jupiter, Redstone, and Saturn rockets; William H. Pickering, '32, MS '33, PhD '36, director of Caltech's Jet Propulsion Laboratory; and Simon Ramo, PhD '36, leader of the scientific advisory team for Atlas, Thor, Titan, and Minuteman. Louis G. Dunn, '36, MS '37, PhD '40, who directed the scientific research and development of these missiles, is featured in Volume Three.

Volume Four includes John R. Pierce, '33, MS '34, PhD '36, executive director of Research-Communications Principles for the Bell Telephone Laboratories, and the man most responsible for Project Echo; and William Shockley, '32, who shared the Nobel Prize in physics in 1956 for his invention of the transistor.

In Volume Five are Albert R. Hibbs, '45, PhD '55, chief of the Arms Control Study Group at JPL; and Charles H. Townes, PhD '39, who conceived the idea of the maser.

METHODS IN IMMUNOLOGY

W. A. Benjamin, Inc........................... $8.75

A laboratory text for instruction and research in general immunology by Dan H. Campbell, professor of immunochemistry; Justine S. Garvey, senior research fellow in chemistry; and Natalie E. Cremer and Dieter H. Sussdorf, former fellows of the National Institutes of Health at Caltech.

MINING FRONTIERS OF THE FAR WEST, 1848-1880

Holt, Rinehart and Winston $6

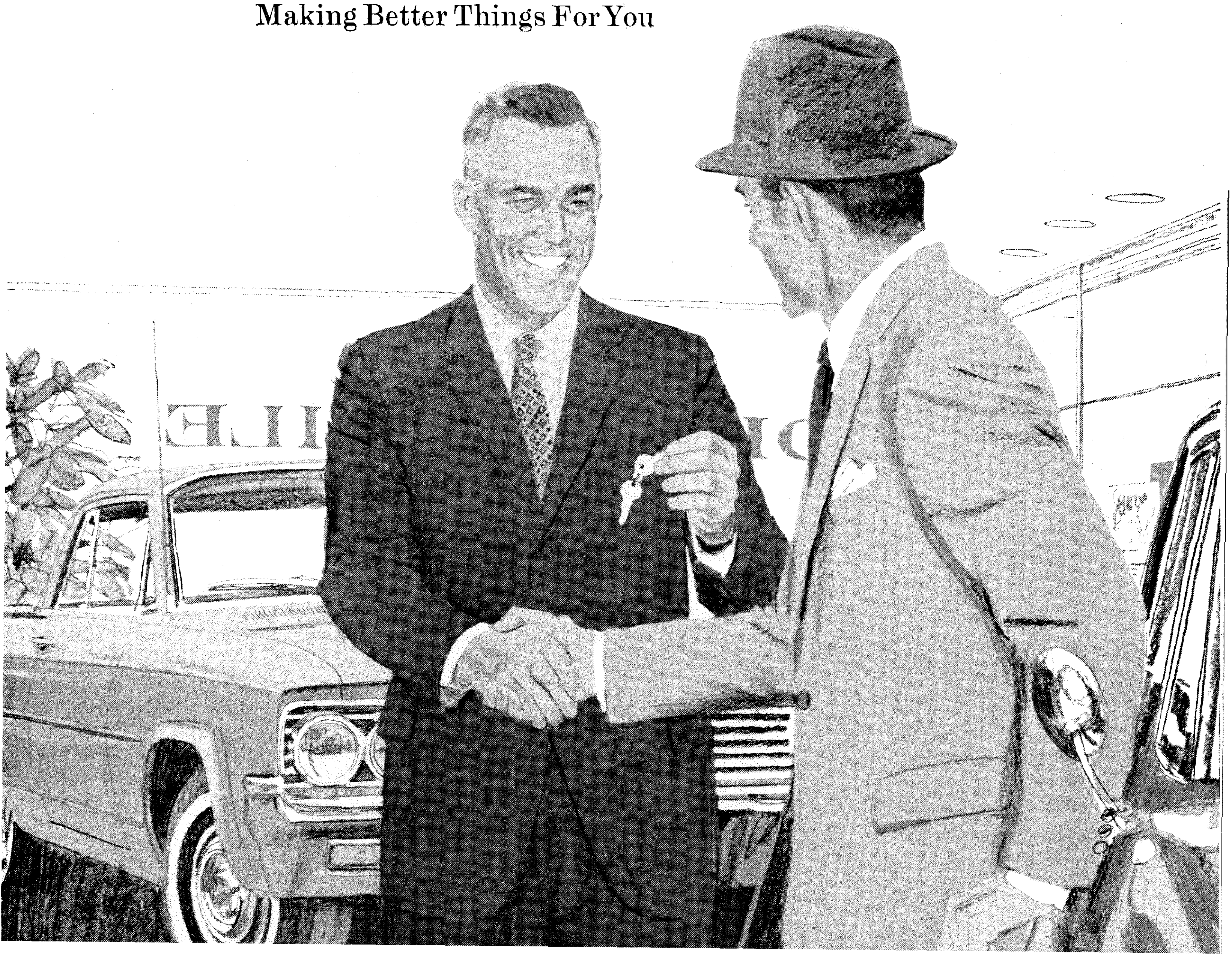
Rodman W. Paul, professor of history, is the author of this first volume in a new series on the history of the American Frontier. The book tells the story of Western mining and its "importance as a molding force in the evolution of the American social order," with special emphasis on the technical problems and engineering techniques of Western mining.

HIMALAYAN BATTLEGROUND

Sino-Indian Rivalry in Ladakh

Frederick A. Praeger $6

Robert A. Huttenback, assistant professor of history at Caltech, is co-author—with Margaret W. Fisher and Leo E. Rose of the University of California—of this study of the Ladakh area that is of such vital importance in the conflict between China and India.



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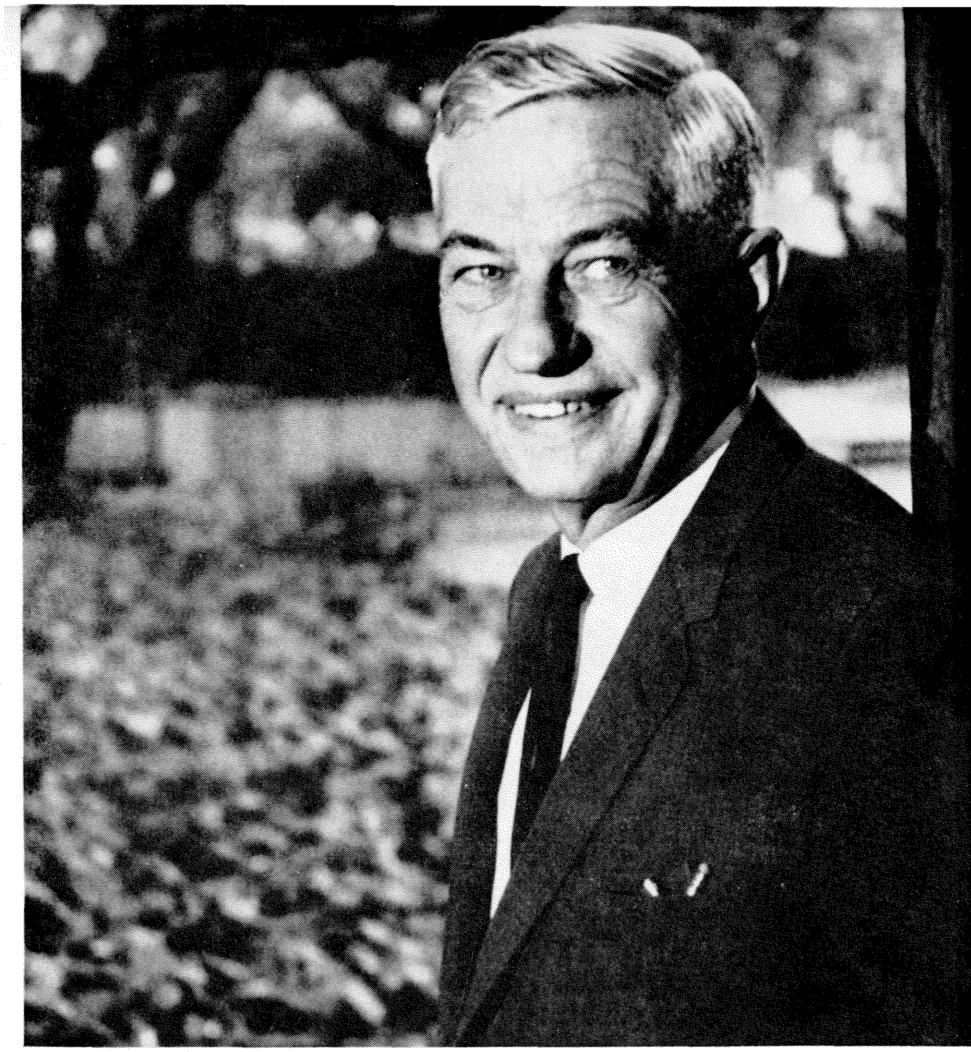


Private Higher Education

by Lee A. DuBridge

Higher education in the United States began as a private enterprise. Between the founding of Harvard in 1636 and the American Revolution in 1776, scores of private colleges were established in the American colonies to provide educational opportunity for the youth of the new nation. Most of these colleges still exist, and many of them are now among the leading colleges and universities in the world.

The first state institution, the University of North Carolina, was established in 1789, and a great period of development of state institutions began with the passage of the Morrill Act in 1862. Even so, all through the 19th century there was a spectacular growth also in the number of private colleges and universities, and even frontier communities in the Middle Western and Western states founded their colleges almost before the communities were well established.

In recent years state colleges and universities have grown so rapidly that today, in the nation as a whole, some 62 percent of the college and university students are enrolled in institutions under public control. In the state of California this figure is about 80 percent.

As the number of college students increases, not only in California but throughout the country, it is likely that publicly controlled institutions will grow in size and numbers more rapidly than the privately controlled ones – and this possibly has led many to conclude that the days of the privately controlled institution may be numbered.

Those connected with private educational institutions, however, vigorously reject this idea. While no one questions the magnificent achievements of the American system of public higher education, it is still true that our privately controlled colleges and universities form the backbone of higher education in this country. The leadership which has been shown by such world-famous institutions as Harvard, Yale, Princeton, MIT, Chicago, Johns Hopkins, Stanford, and (if you will pardon me) Caltech – to say nothing of the hundreds of liberal arts colleges – has established a pattern and a pace for higher education which has been profoundly significant throughout the history of this country, and will remain essential for the generations to come. The relative importance and influence of private institutions is not to be measured solely in terms of student enrollment.

The essential feature of any private institution is, of course, that it is wholly independent of any

The problem which faces not only the private institutions themselves but the entire national community which they serve is how such institutions can remain both independent and strong.

governmental agency — local, state, or federal. Though normally chartered by the state and subject to such public laws as are applicable, a private institution selects its own board of trustees and its own officers, and these are not responsible to any government bureau.

This means that each institution can evolve its own educational policies, adapted to fit its own objectives and ideals; it can change these policies from time to time as is deemed appropriate; and it can select both students and faculty in such numbers and to meet such qualitative standards as the institution itself may determine.

As a result of this freedom and independence, great and forward-looking advances in higher education in this country have stemmed from the independent institutions. They have pioneered and set the pace for all higher education.

How an institution can remain independent

It goes without saying that the reason an independent institution can remain independent is that its endowments, its physical plant, and its operating funds are provided largely or wholly from nongovernment sources. Private sources, even though they often give funds for designated purposes, do not normally seek to control the policies of the recipient institutions, nor impinge upon their independence. Also, the fact that such private funds usually come from many different sources (individuals, foundations, corporations) insures that no single individual or agency external to the university shall become controlling in the determination of the educational program.

A state university, by its very nature, is responsible to the state government — and, through executive, legislative, and budgetary controls, it has the power to determine institutional programs. Although most states have wisely kept their colleges and universities free from direct political influences, the institutions nevertheless are a part of the state governmental system and they cannot, and should not, forget their responsibilities to the voters and taxpayers. Our country would be much poorer if we did not have institutions with such responsibilities.

In short, both the private and public educational institutions of the country form essential parts of an integrated whole, and both components of our system of higher education deserve the continued and active support of the entire nation. These things being true, the problem which faces not only the private institutions themselves but the entire national community which they serve is how such institutions can remain both independent and strong. And this question revolves about the question of how such institutions can continue to maintain and expand their private financial support.

There have been many gloomy predictions based on the fact that, since federal tax policies now serve as barriers to building up large personal fortunes, the sources of support of private institutions will surely decline. Such predictions are not borne out by the facts.

Support of private institutions

In the first place, in spite of government tax policies, private fortunes are still being built — though not, of course, in such numbers or to such great extent as if the high-income tax rates were reduced. In any case, private gifts and bequests to private institutions have not declined but have indeed continually increased.

At least 43 private colleges and universities have in the past nine years reported campaigns to secure private funds, ranging in amounts up to over 100 million dollars and aggregating at least 1.7

billion dollars. The success of these campaigns surely indicates that the support of private institutions, far from withering away, is becoming stronger. The problem evidently is not that wealth does not exist, but that it is so difficult to persuade many owners to make substantial gifts for educational purposes. Colleges and universities have never been able to sit back and expect that voluntary gifts would roll in. They are secured only through energetic, continuous, and persuasive appeals.

On the other hand, the fact that such appeals have yielded large returns to many private institutions should not cause one to take too optimistic a view. While the number of dollars flowing into private institutions is greater today than ever before, these must be measured in terms of the needs and opportunities of such institutions. Measured in such terms, the funds being secured are still woefully inadequate.

The rising costs of running an institution

The costs of academic buildings have risen sharply in the last 25 years, as have also the costs for teaching and research equipment, for salaries and wages, and for all the other items that enter into the costs of running an educational institution. Many institutions are forced to restrict their enrollments because of inadequate finances. Others fail to attract their full quota of students because they have been unable to improve their facilities and staff for lack of adequate resources. Others that have adopted restricted enrollment policies for academic reasons still suffer from lack of space, equipment, and staff to continue and to improve their programs.

In spite of public impressions to the contrary, there are really no "wealthy" colleges or universities in America. Some institutions have been able to support more extensive and more expensive programs than others, but no institution has adequate funds fully to meet its goals or to fulfill its opportunities.

The problem of fund raising will thus be an ever-present and ever-urgent one as long as private institutions exist.

Fortunately, the potential bases of support for private education have expanded. Though very large gifts by individuals (e.g., one million dollars or more) are still relatively rare, there are many more individuals in the country who are making smaller gifts, and often making them on a regular basis. There are more individuals able and willing to give more than ever before and the full potential of individual giving has not yet been fully tapped.

The large private foundations have always been an important source of support for higher education. The most famous ones (such as Ford, Carnegie, Rockefeller) continue as essential elements in educational support. However, their combined resources and income, even though large in dollars, are small in proportion to the total need. Fortunately, hundreds of smaller private foundations have been created, and many of these are devoting funds to higher education. In 1962 private foundations gave educational grants of over 300 million dollars.

A new source of private support

Finally, a new source of private support has arisen and has become rapidly more important in recent years – namely, the business or industrial corporation. It was only 25 years ago that corporate grants to colleges and universities were almost unknown and were considered by many to be an improper use of stockholders' money. As it has become more and more evident that business and industrial corporations in America could not survive and prosper without the contribution of the nation's colleges and universities in providing educated men and women and in contributing to the advance of knowledge, corporations and their stockholders have acquired the conviction that the support of higher education is essential to their own welfare. Court decisions have supported this point of view. In the year 1962 corporate contributions to higher education amounted to $200,000,000, of which approximately 75 percent, or $150,000,000, was contributed to private institutions. (Caltech alone received over one million dollars in corporate gifts for operating funds in 1962-63.) This annual giving has risen rapidly in recent years and will surely rise still higher in the years ahead.

In short, sources of private funds for the support of higher education are by no means drying up, but are indeed expanding. It is not yet clear whether they will expand rapidly enough to meet the growing needs and increasing costs, and it is certain that many, if not most, private institutions will have to exert strenuous efforts in order to secure the funds they require. Not all will succeed; not all will even survive. This is a characteristic of the private enterprise system.

We come now to a new feature of the support of private higher education which we have so far ignored – namely, the contributions made by the

Federal Government. This is an enormously complex subject, and the radically conflicting views which have been expressed have surely surrounded the subject with a substantial degree of confusion. There are those who have said that the activities of the Federal Government are on the verge of stamping out the independence of the private college or university. At the other extreme, there are those who assert that such institutions will be saved and their independence preserved *only* through the provision of federal funds. It has been both asserted and denied that there is gross waste, extravagance, and mismanagement of taxpayers' money. Some assert that federal funds have degraded the quality of higher education and others, equally vociferously, assert that quality has been vastly improved.

In evaluating the conflicting statements made on the subject, it should be recalled that it is a general rule that sweeping generalizations about any aspect of American education are never universally true in all cases and for all institutions. The American educational system is too complex and varied to be susceptible to all-inclusive assertions. Conversely, almost any statement made about education, good or bad, is probably true of some institutions or in some circumstances. One should also remember that in the field of government spending, whenever large sums are involved, there will always be charges of waste and extravagance. Whether there is proof of substantial waste or not, there will be some who will assert that in any big program waste *must* exist.

Putting aside sweeping and unprovable generalizations, let us look at the facts.

The facts about government support

Since 1946 there has undeniably been a rapidly rising participation on the part of the Federal Government in certain activities carried on by colleges and universities, both public and private. The great contributions made by university-operated research and development centers during World War II proved to the Government and to the people that the universities had much to contribute to national welfare and security. The Federal Government has, therefore, in effect decided through a variety of both executive and legislative decisions that the Government itself shall use the colleges and universities as instruments for the advancement of the public welfare and security by supporting in such institutions *those particular activities* which pertain to recognized areas of federal responsibility.

This policy of selective support of those activities related to federal responsibilities contains the key to the present situation. The Federal Government does not support higher education *per se*. It does not give across-the-board subsidies to colleges and universities to carry on their normal operations. In fact, there are large segments of higher education which the Federal Government specifically excludes from its support program on the ground that they are not at the present time areas of recognized federal responsibility.

Government responsibility

What, then, *are* the areas of recognized federal responsibility? Some of them are obvious: agriculture, public health, national defense, atomic energy, space exploration, technical assistance to underdeveloped countries. Because all of these areas depend critically upon the advance of scientific knowledge and its application, the Government's activities in the support of higher education have been almost wholly devoted to the support of the basic sciences and of medicine, agriculture, and engineering. No government funds are available for university work in the fields of the humanities (other than foreign languages). An extremely limited amount of support is available in any of the social sciences, and almost no federal support is given to the regular tasks of undergraduate education other than certain limited funds available for the purchase of scientific laboratory equipment. Graduate education and research in pure and applied science is the major area of federal participation in university activities.

Whether one likes this policy of the Federal Government or not, one must agree that it is at least a consistent policy. When the Federal Government's own activities stimulate a need for basic knowledge in scientific areas, the Government supports those activities in universities which aim to advance these fields of knowledge. When the Government's activities produce a large increase in the need for highly educated professional personnel (such as scientists, engineers, physicians) the Government, through assistance to universities and to individual students, has sought to expand the numbers being educated.

It will no doubt be true in the future, as it has been in the past, that the areas of federal responsibilities may broaden into new fields. And, when this happens, the Government's interest in university activities may be expected correspondingly to broaden.

Nevertheless, the basic fact must be kept in mind that the Government is not in the business of supporting higher education, but is only in the business of supporting those activities of colleges and universities which enable the Government itself to carry out more effectively its assigned functions.

Now graduate education and research in pure and applied science constitutes an important segment of higher education. This segment has in recent years been provided with substantial federal financial support, and the level of this support has continued to rise. It is currently (in fiscal 1964) running at the rate of somewhat over one billion dollars per year.

Clearly, this money is not spread equally among all of the institutions of higher education in the country. Among the nearly 2,000 such institutions in the United States, only about 200 carry on any programs of graduate education at all, and less than 100 are in a position to carry on major research programs. Needless to say, the Government, in following its specific policy of supporting those activities in which it has a direct interest, must select those institutions where such activities can be competently and effectively carried out. Therefore, the concentration of funds in a rather small number of institutions, about which many Congressmen and others have recently complained, is a direct result of the organization of our higher educational system itself. In our system a large number of colleges carry on undergraduate work and only a relatively small number of universities have elected to enter the field of graduate education and research. It is to these institutions that the Government has turned, for they are the only institutions available to serve the Government's needs.

Federal funds to scientific institutions

Because education and research in the sciences are expensive, the result has been that those institutions able to carry on large research programs must receive relatively large sums of money. In a number of leading scientific institutions the federal funds supplied in support of education and research in scientific and engineering fields is nearly equal to the funds from all other sources expended on other university activities. For example, approximately 47 percent of the annual budget of the California Institute of Technology is supplied through federal contracts and grants for research and graduate educational programs.

This is not an unusual situation, though obviously this percentage is more likely to be high for an institute of technology than for a university with extensive activities in nonscience fields. In the academic year ending June 1961 (the latest year for which we can get comparable figures) when 47 percent of Caltech's budget came from federal funds, Stanford's corresponding figure was 46 percent, MIT's was 51 percent, Princeton's was 59 percent and Harvard's was 28 percent.

In recent years the various agencies of the Government and the Congress have recognized that the extension and improvement of graduate education and research cannot be fully achieved without the improvement and expansion also of undergraduate education — and even the improvement of elementary and secondary school education in mathematics and the sciences. Thus, the National Science Foundation has, for example, supported a large number of relatively small research projects being carried on by faculty members of undergraduate colleges, has assisted such colleges in improving their undergraduate instructional equipment, and has financed a large program for the improvement of course content and instructional materials for elementary and secondary schools and the concomitant retraining of schoolteachers. The new (1963) higher education act provided funds to expand undergraduate teaching facilities in mathematics and the sciences.

Reaction to federal support

How have the universities themselves reacted to these programs of federal support? Again one must avoid generalizations. Some institutions with large numbers of competent scientists and engineers on their faculties have found these individuals commanding very substantial support of their proposals for scientific research. Thus, the science departments have expanded rapidly — often embarrassing the institution, which finds it difficult to provide adequate space and other facilities and services, and giving rise to unhappiness in nonscience departments since their activities seem to be receiving rather niggardly support.

Other universities, on the other hand, have found federal funds of enormous value in expanding and improving their scientific and engineering departments, and enabling them more completely to fulfill their objectives of carrying on high-quality research and education. In many cases, too, the nonscience departments are actually better off than before, since the institutions' nonfederal funds, which would otherwise be required for science and engineering, are available for other areas.

Needless to say, government support has given rise to many problems and headaches. There have been difficulties in arriving at proper formulas for calculating the "overhead" charges which should be paid by government research contracts and grants. There have been problems of revising institutional business and auditing procedures to meet government requirements for accountability of tax funds. Then, too, some universities with large and competent staffs equipped to carry on large enterprises have been enabled to build large and expensive research equipment, such as nuclear accelerators. While these universities have faced their own problems in accommodating such large enterprises, other institutions, unable to accommodate such big projects, have found faculty members unhappy and inclined to drift to institutions where "big things" are going on. Concurrently, a few faculty members find their preferences away from "big research" and are drifting to the smaller institutions.

Undeniably, the increase in research funds has created increased demand for research scientists and engineers and the competition among colleges and universities for first-class faculty members has become very severe.

On the whole, however, the fact is that American university research in science and engineering now occupies a position of outstanding leadership in the world, a very much larger number of graduate students are being given high-quality training, and the frontiers of knowledge have been greatly extended – all by virtue of federal support. No institution engaged in major federally supported activities would wish to return to the "old days." These institutions believe – with good reason – that the headaches can be cured, that readjustments can be made, and they hope also that nonfederal funds can be found to support those educational and research areas for which federal funds are not yet available.

The situation at Caltech

In conclusion, it may be well to ask what the situation is at Caltech.

On the whole, there is much to be said on the bright side. Our endowment funds, all from private sources, now stand at about $63,000,000. We have expended something like $29,000,000 in new buildings and equipment in the past ten years. Our total expenses for campus operations were $17,905,000 in 1962-63, of which 47 percent was for research supported by federal funds.

The Caltech situation is rather unusual because of our management contract for the operation of the Jet Propulsion Laboratory for the National Aeronautics and Space Administration. In terms of annual budget (not included in the above figures), this laboratory is the largest university-operated government facility in the country. It is carrying on an extensive program of managing NASA's deep-space unmanned flight projects and supervises extensive contracts for development work in many industrial companies. The funds expended in JPL operations, for which the Institute is reimbursed, loom large on a budget sheet but of course contribute very little directly to the financing of the campus program.

The campus program supported by the Federal Government, on the other hand, is entirely devoted to basic research in pure and applied science. All projects are originated and the funds requested by individual members of the faculty. No proposed program is approved for submission to a government agency until it is reviewed by a faculty committee, as well as by the administration, to make sure that it is an appropriate program for the campus and that the necessary space and facilities for it can be made available. In a very real sense, therefore, it can be said that the Federal Government is contributing funds for our research program which private funds alone could not support. We do not – nor does the Government expect us to – carry on military or other development programs on the campus.

The problems ahead

As we look to the future, serious problems face us. Federal funds are not available or are not adequate to carry on all the activities which we should like to pursue. Private funds must still be found to improve our general programs of undergraduate and graduate education, to support all of our work in the humanities and social sciences, and to provide most of the funds which we will require for additional urgently needed campus buildings. To meet our needs and opportunities, and their increasing costs, our endowment should be substantially expanded, our annual income from private sources must continue to grow rapidly, and millions of dollars of private funds for additional buildings must be secured.

Caltech occupies an outstanding position in the field of higher education in the United States. It can continue to maintain its relative position only as it moves forward in the future, as it has in the past, continually aiming to develop and improve its programs of education and research.

Studies on Fertilization and Early Development

Caltech biologists, working on the general problem of fertilization, have obtained new information on how the development of a new living creature is initiated.

Dr. Albert Tyler, professor of biology, and some members of his team – Drs. Lajos Piko and Hector Timourian, research fellows; and Paul C. Denny and Joram Piatigorsky, graduate students – are currently trying to discover what turns on protein synthesis at the start of development. Their research, done mostly with sea-urchins and other marine animals which produce large numbers of eggs, is supported by the Public Health Service and the National Science Foundation.

Synthetic activity is very low in the unfertilized egg, although it has all the machinery for the accelerated manufacture of the proteins that are the building blocks of life. Until recently, it was thought that the sperm, in fertilizing the egg, triggered the DNA's in the egg's nucleus to produce messenger RNA's – the DNA's serving as templates for the production of the RNA's, and the RNA's in turn serving as the templates on which the proteins are made. Messenger RNA's play key roles in cell differentiation; they determine which protein – hair, heart muscle, fingernail, or whatever – a cell will manufacture.

Dr. Tyler's group has now shown that messenger RNA's for proteins that are formed during early development already exist in the unfertilized cell.

In one experiment, the Caltech biologists spun unfertilized sea-urchin eggs in a centrifuge until most of the cells were pulled into two sections. One section included the nucleus, containing the DNA; the other section had no nucleus. The cell sections with no nucleus were then treated briefly with a solution of butyric acid. This chemical is one of many that can cause an entire egg to start developing and synthesizing protein as though it were a fertilized egg. In this experiment, the cell section with no nucleus shows this same activity, synthesizing protein for several hours until, apparently, its messenger RNA's wear out.

The results are the same whether the measurements are made on the intact egg, segments of the egg, or a cytoplasmic homogenate (cell-free system).

Cell-free systems that synthesize proteins are prepared by disrupting the cells and removing most of the "debris." The active system then consists of small particles of about 250 Angstroms called ribosomes, amino-acid-activating enzymes, "transfer" RNA, and extra energy sources.

Such systems manufacture the type of protein specified by the messenger RNA's that would ordinarily be present in the cells. After the endogenous messenger RNA's have "worn out" in the homogenates, the system will respond to new messenger RNA's – including even synthetic ones such as polyuridylic acid – and will manufacture the corresponding protein. For example, polyuridylic acid specifies formation of polyphenylalanine.

Cell-free systems from unfertilized eggs have very low activity. However, when polyuridylic acid is given to them, they respond quite as actively as do those developing from eggs. This shows that excess protein-synthesizing machinery is present in the unfertilized egg and ready to go to work. Messenger RNA's for the manufacture of proteins of the early embryo are present too, but are masked. Fertilization (or artificial activation of the egg) unmasks the natural messenger RNA's. Certain ions, particularly magnesium and potassium, may be part of the controlling mechanism.

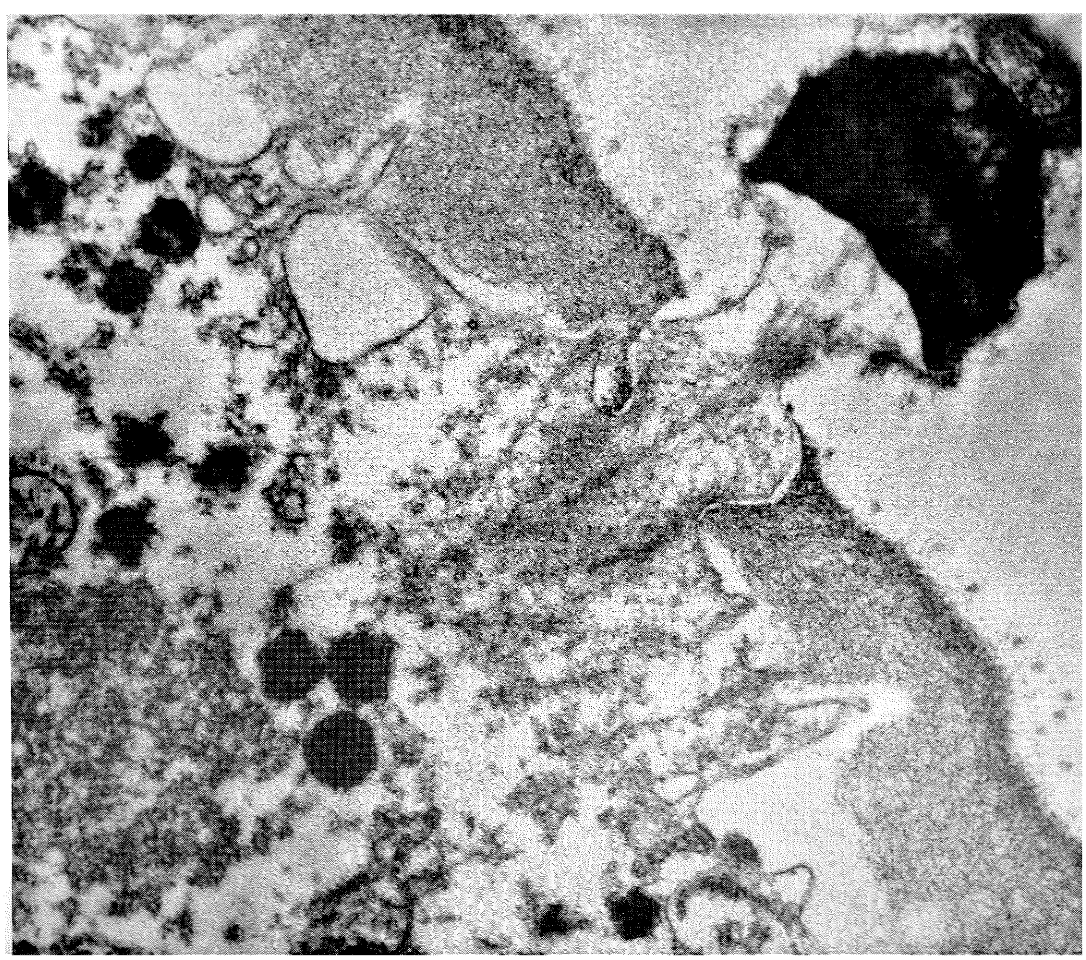
A former Caltech research fellow, Professor A. Rich of MIT, using different systems, has shown that the actual protein-synthesizing site is a cluster of ribosomes (polysomes) tied by a strand of messenger RNA. The Caltech group has demonstrated that, upon fertilization, polysomes form concomitantly with the increase in protein synthesis. The polysomes can be separated and the messenger RNA liberated by lowering magnesium-ion concentration. Experiments along this line, now in progress, open new possibilities for the analysis of cell differentiation.

The Caltech researchers have also found that polyuridylic acid can activate the *intact,* unfertilized egg so that it incorporates various amino acids into protein. This has abnormal effects on development. However, one can envisage the possibility that, by manipulations with messenger RNA's, development may someday be controlled in beneficial ways.

ONE MINUTE AFTER INSEMINATION

The sperm's surface membrane unites with the egg's plasma membrane, which protrudes in the form of finger-like processes (microvilli) through an overlying coat (vitelline) membrane. Magnified 27,000 times.

THE ENTRANCE OF A SPERM INTO AN ANIMAL EGG



THREE MINUTES AFTER INSEMINATION

As they join, the two membranes break down so that the sperm nucleus becomes exposed to the egg-cytoplasm that flows toward it. Magnified 27,000 times.

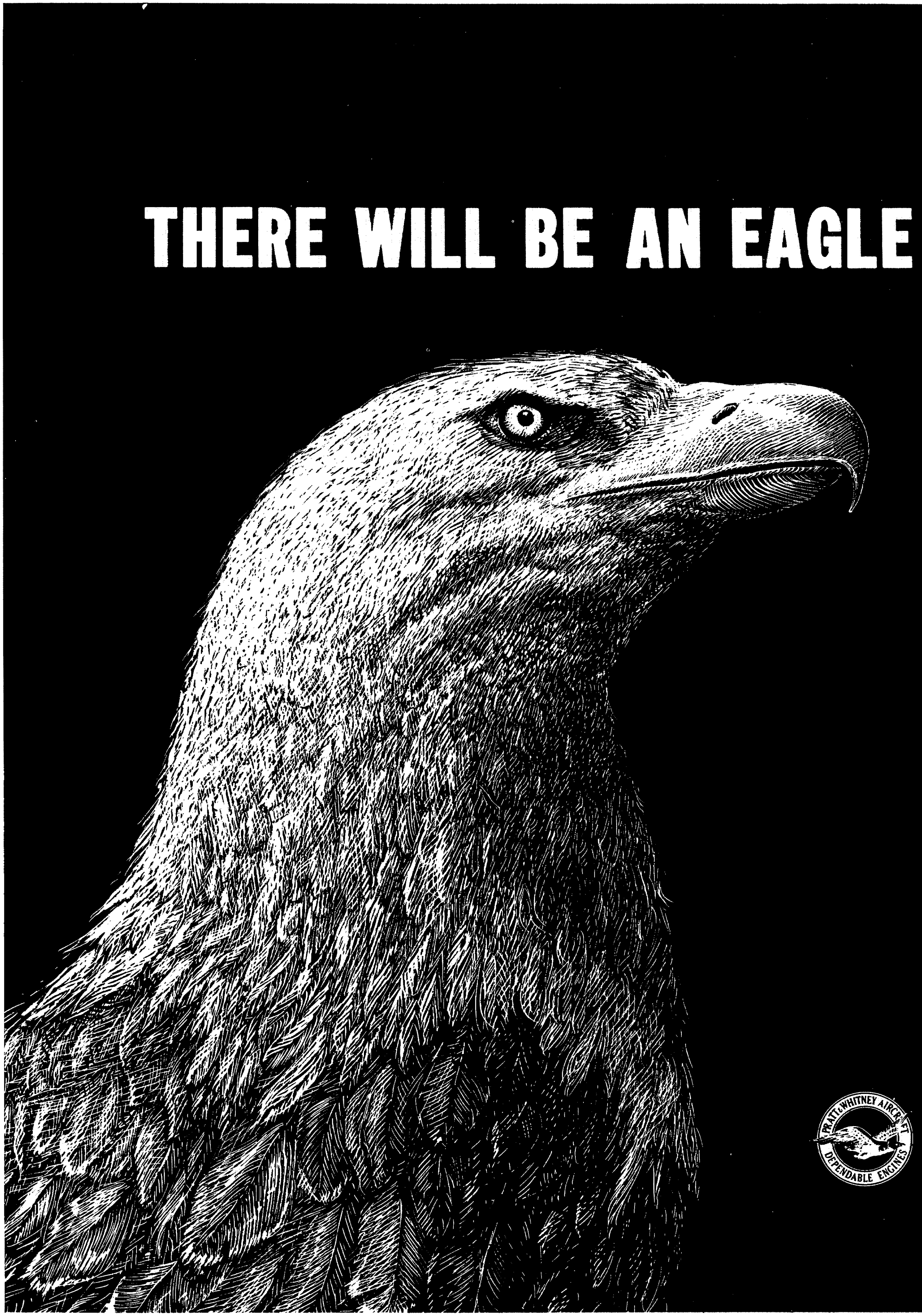
FIVE MINUTES AFTER INSEMINATION

The nucleus of the sperm is squeezed through the opening in the vitelline membrane but gets through the egg surface, or plasma membrane, without there being any openings to admit it or any holes left after its entry. Magnified 13,000 times.

THESE remarkable pictures, taken at Caltech with the electron microscope, are thin sections of the sperm and egg of a sea worm known as *Urechis caupo*. The sections are about 500 Angstroms thick. The diameter of the sperm head is 1.8 microns. The egg, only partly shown, has a diameter of 100 microns.

SEVEN MINUTES AFTER INSEMINATION

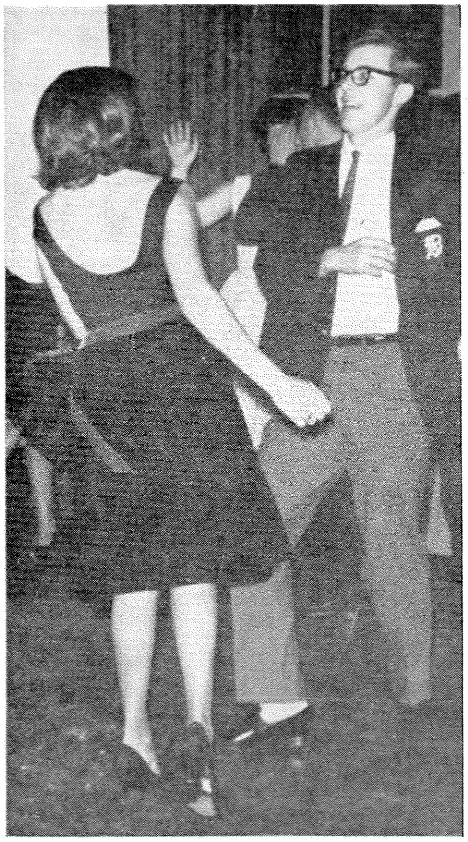
The nucleus of the sperm is drawn further into the egg, which has formed an entrance cone with structural elements that are probably concerned with the further progress of the sperm towards the place where it meets the egg nucleus. Magnified 13,000 times.


THERE WILL BE AN EAGLE
PRATT & WHITNEY AIRCRAFT
DEPENDABLE ENGINES

No

Matter

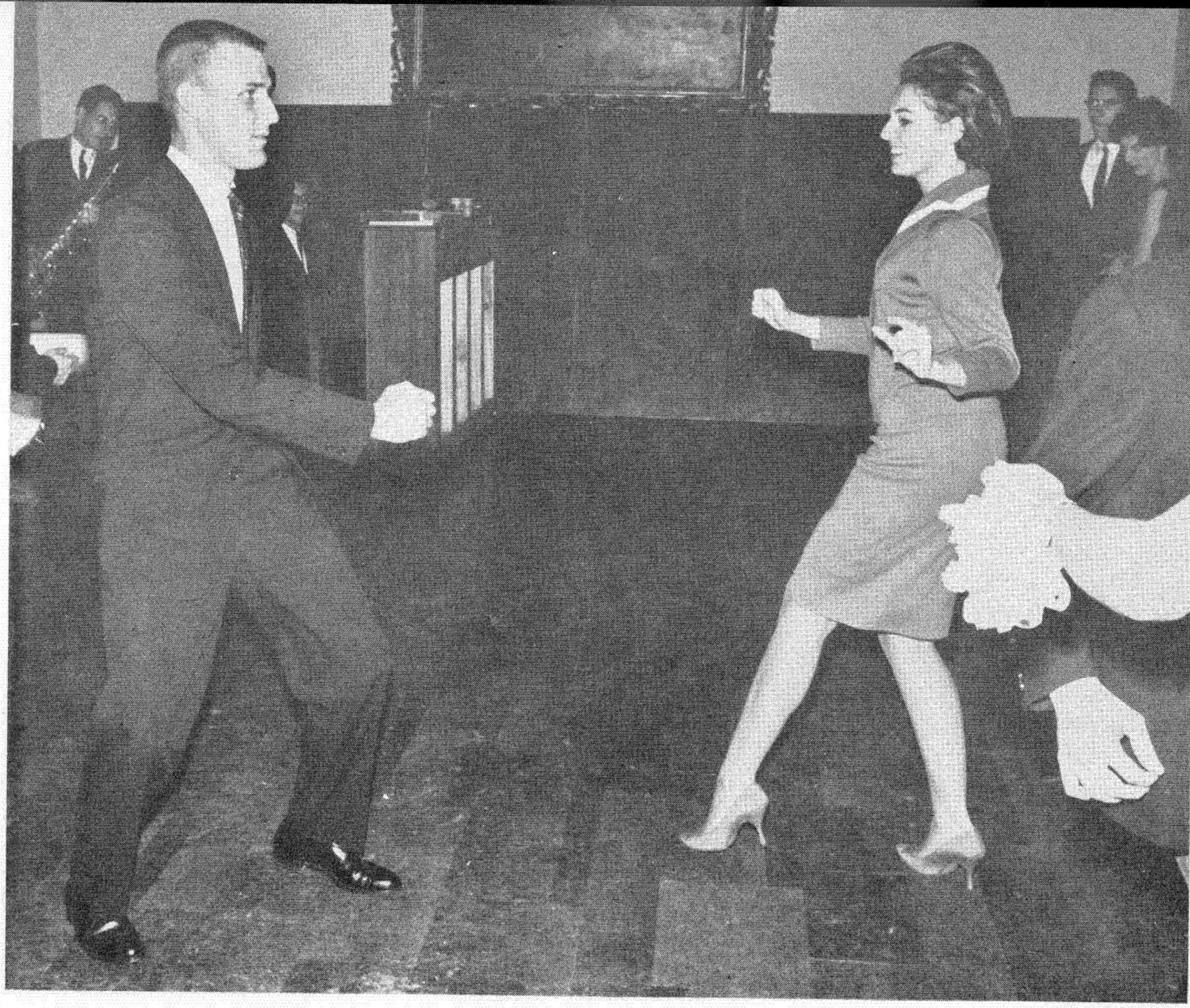
What



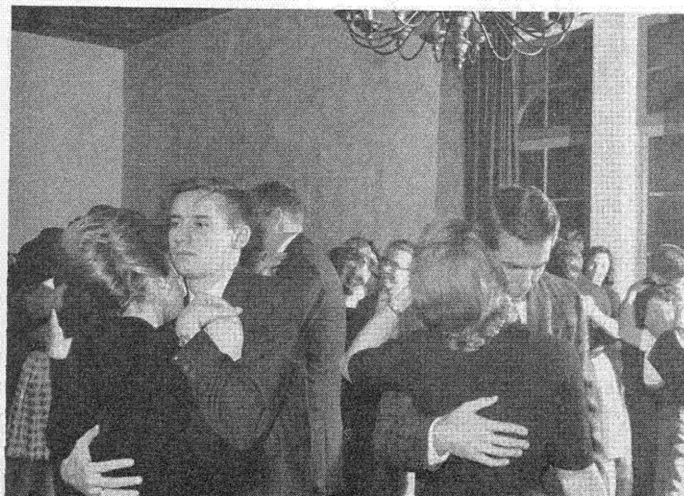
You

Think

It Is —

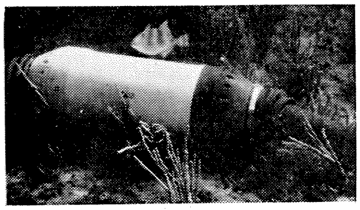


They Still Call It Dancing

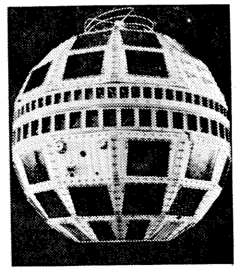


Photographs taken at the Caltech Interhouse Dance, 1963

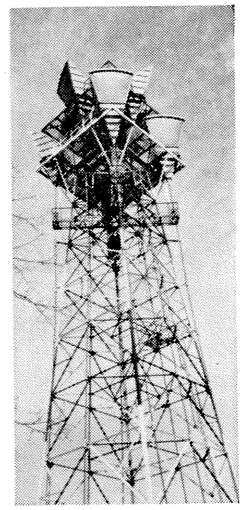
Progress in the Bell System...



SWIMS...



ORBITS...

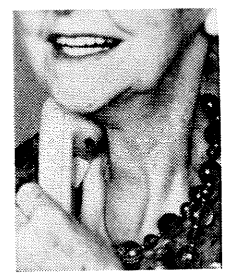


BEAMS...

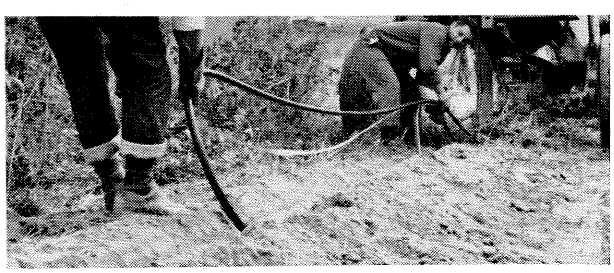
FLASHES...

PUSHES...

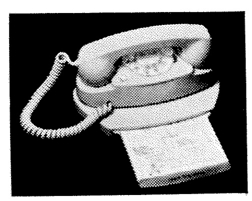
PULSES...



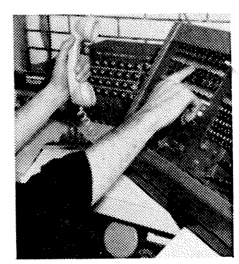
TALKS...



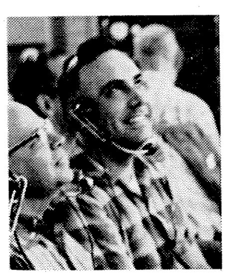
BURROWS...

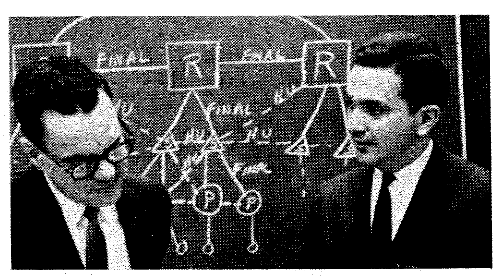


WINKS...



BLINKS...





AND LIVES AND BREATHES...

Progress takes many shapes in the Bell System. And among the shapers are young men, not unlike yourself, impatient to make things happen for their companies and themselves. There are few places where such restlessness is more welcomed or rewarded than in the fast-growing phone business.

Bell Telephone Companies

The Month at Caltech

Chairman of the Board

Arnold O. Beckman, president and founder of Beckman Instruments, Inc., and a Caltech trustee since 1953, has been elected chairman of the board of trustees of the Institute. He succeeds the late Robert L. Minckler, chairman since 1961, who died on August 6, 1963.

A native of Cullom, Illinois, Dr. Beckman received his BS and MS degrees from the University of Illinois, and his PhD in photo-chemistry from Caltech in 1928. He taught chemistry at Caltech for 14 years, until 1940, when he left to go into the business of making scientific instruments. His firm now makes a broad range of precision instruments, systems, and components used in science, industry, medicine, space-defense, education, and agriculture.

Dr. Beckman has been a member of the California Institute Associates since 1948 and in 1953 he became the first alumnus to serve on the Caltech board of trustees. He headed the Institute's development program, launched in 1958, which raised $19.5 million dollars for new buildings and faculty salaries. The Institute's new Beckman Auditorium, built with funds contributed by Dr. and Mrs. Beckman, is to be dedicated next month.

Dr. Beckman is a regional trustee of Mills College in Oakland, California, and a member of the lay advisory board of Orange State College. He is chairman of the technical committee of the Southern California Air Pollution Coordinating Council, and adviser to the Orange County Board of Supervisors. He served as president of the Los Angeles Chamber of Commerce in 1956, and serves as a director and chairman of many southern California corporations.

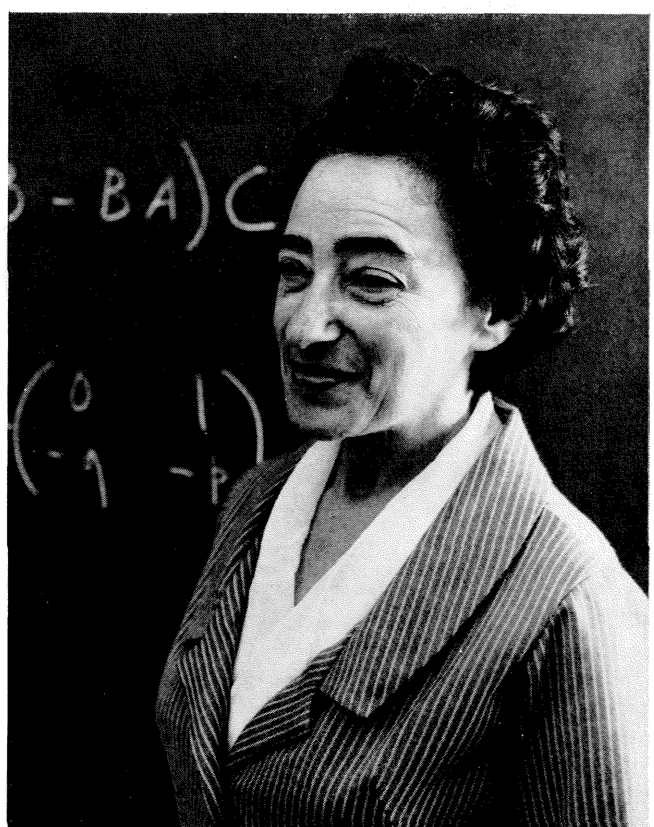
Hans A. Bethe, Visiting Professor

Hans A. Bethe, professor of physics at the Laboratory of Nuclear Studies at Cornell University since 1937, came to Caltech this month to give a series of lectures on "The Theory of Nuclear Matter" and to conduct research in elementary particle physics and nuclear physics. Dr. Bethe is the originator of the theory which accounts for the sun's heat by conversion of hydrogen into helium and contributed greatly to the research done on the development of the atomic bomb and the H-bomb.

Woman of the Year

Olga Taussky Todd, research associate in mathematics at Caltech, has been named one of the 1963 Women of the Year by the Los Angeles *Times*. Dr. Todd is one of the world's most outstanding women mathematicians. She and her husband, John Todd, who is professor of mathematics at Caltech, came to the Institute in 1957 after ten years with the National Bureau of Standards in Washington, D.C.

A native of Czechoslovakia, Dr. Todd received her PhD from the University of Vienna in 1930, and her MA from the University of Cambridge in



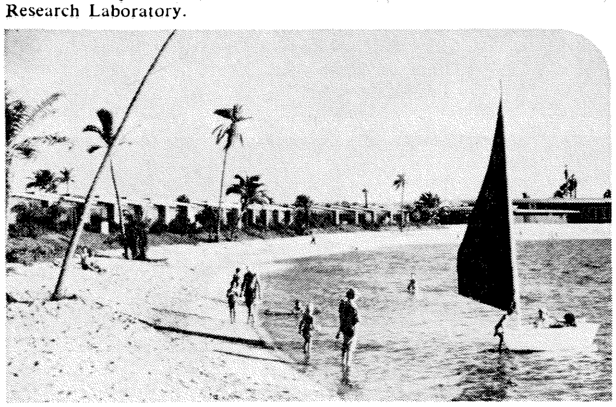
Olga Taussky Todd, Woman of the Year

GRADUATING ENGINEERS & SCIENTISTS:

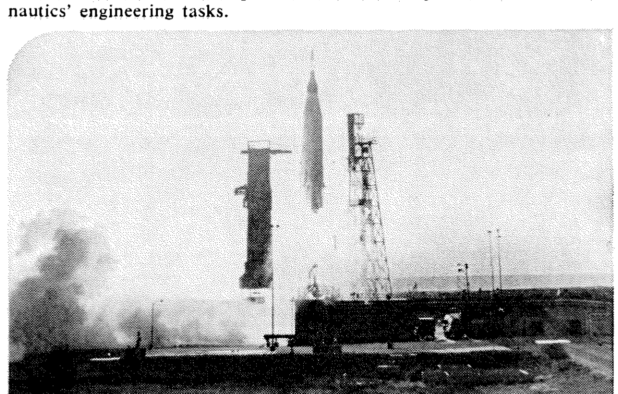
Some sound reasons why you should consider General Dynamics | Astronautics for a challenging and rewarding aerospace career are pictured below.
We urge you to learn still more about Astronautics—the important completely space-oriented division of General Dynamics Corporation—by listening to the 33⅓ rpm recording offered below and by following news of Astronautics' activities and accomplishments in your newspaper, trade magazines and technical journals.
For more information and a personal interview, visit the Astronautics representative who will be on your campus soon.

Advanced Programs An array of active projects and widely varied studies at Astronautics range from Atlas SLV-3, Centaur and Glotrac to Manned Space Stations, Lunar Base Support Systems and Orbiting Research Laboratory.

Modern Facilities More than $50 million have been invested in Astronautics' plant and equipment. Complete laboratory, test and computer facilities are established in-plant to enhance the performance of Astronautics' engineering tasks.

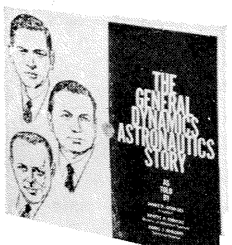


Ideal Location San Diego, California is the capital of moderate climate in the nation. Outdoor sports and recreation are year-round activities for enjoyment of your leisure hours. There is an abundance of academic and cultural opportunity in this city of more than 600,000 — a vigorous and growing community.



Inspiring Achievements The reliable Atlas, first ICBM in the free world, has also established a remarkable record as a launch vehicle — boosting more pounds of payload from the earth than any other vehicle in the free world to date. The impressive list of Atlas achievements includes a perfect performance in the Atlas-Mercury series—four for four!

WE WILL VISIT YOUR CAMPUS FEBRUARY 11



HEAR "THE GENERAL DYNAMICS | ASTRONAUTICS STORY" as told by the men who have had major responsibilities in the direction of such dramatic technological advancements as the Atlas-Mercury manned orbital flights and Centaur, the free world's first liquid hydrogen-fueled space vehicle. See your placement office for your personal copy of this 33⅓ rpm recording, or write to Mr. R. E. Sutherland, Chief of Professional Placement and Personnel, Dept. 130-90, General Dynamics | Astronautics, 5882 Kearny Villa Road, San Diego, California 92112.

GENERAL DYNAMICS | ASTRONAUTICS

An Equal Opportunity Employer

1937. She has won world-wide recognition for her work in matrix theory and class field theory, and her interests range from the most abstract mathematics to specific problems such as the flutter theory in aeronautics. At Caltech she has greatly supplemented and strengthened the work in algebra and number theory. She is the Institute's only voting woman faculty member.

Christian M. Clausen

Christian M. Clausen, head of the public information and education department of Caltech's Jet Propulsion Laboratory, died of a heart attack on December 10 at his home. He was 49.

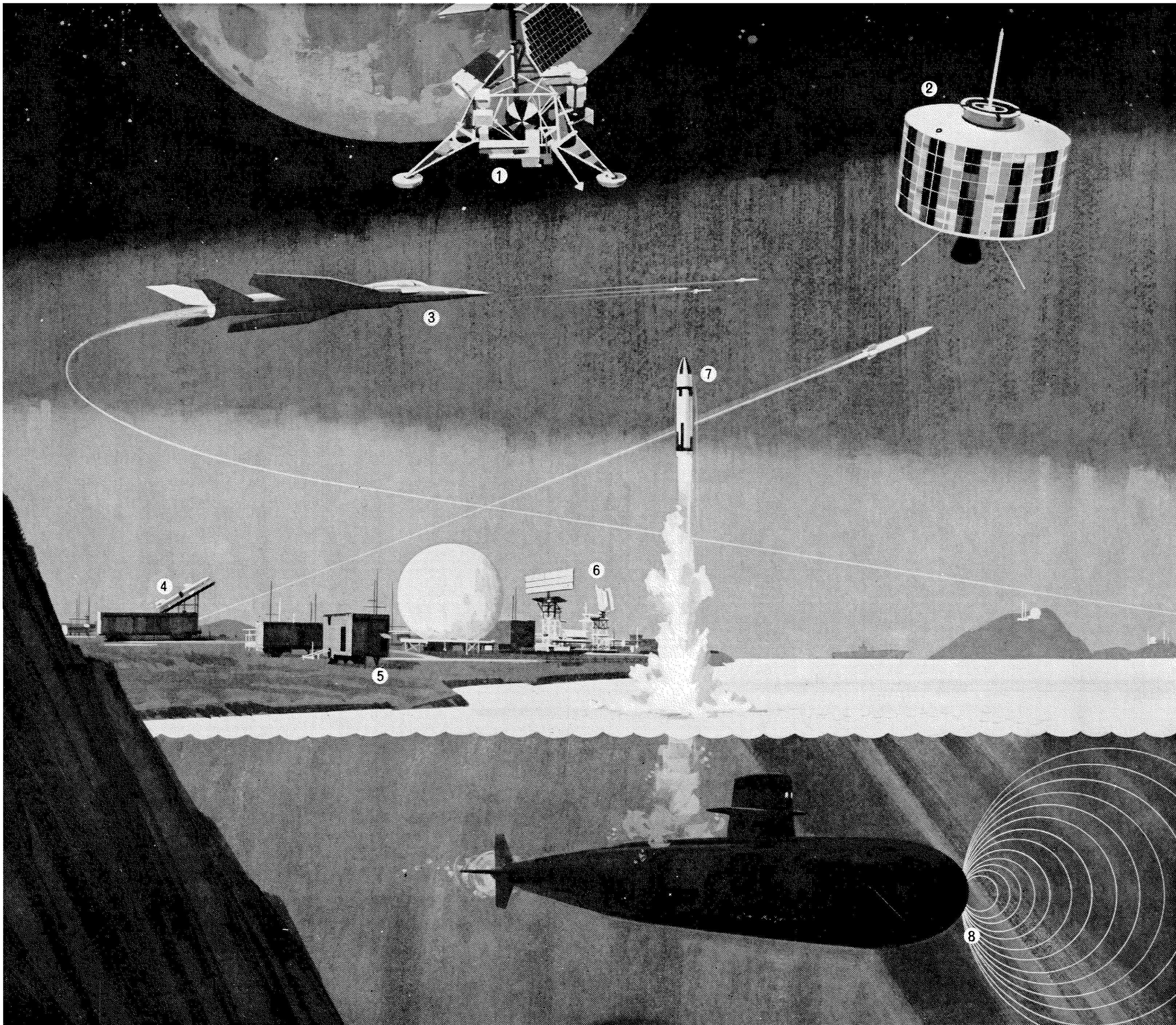
Clausen had been at JPL since 1957. He was the originator of the Lab's public information department and also served as a staff assistant to Dr. William Pickering, director of the Laboratory. Prior to joining JPL Chris Clausen was a science writer for the Los Angeles *Daily News,* and had served for eight years as medical editor for the Los Angeles *Examiner.*

AUFS Checks In

On January 7, the first of four representatives of the American Universities Field Staff came to Caltech to report on political, social, and economic conditions in foreign areas. Willard Hanna will be on campus from January 7-16 to give a series of lectures and informal talks to the faculty and students on Malaysia. John Hanessian will report on Antarctica, from January 21-30; Victor Du Bois, French West Africa, arrives on February 4 and will be on campus until February 13, and Louis Dupree will discuss conditions in Pakistan, from February 18-27.

P.S.

A faculty member who went to this year's Rose Bowl game reports that the University of Washington card-section, in the middle of their halftime demonstration, flashed the crowd a quick "CALTECH," hastily withdrew it, came up with an "OOPS," then produced "U of W."



Opportunities at Hughes for EE's—Physicists—Scientists:

from the ocean floor to the moon...and beyond

Hughes sphere of activity extends from the far reaches of outer space to the bottom of the sea... includes advanced studies, research, design, development and production on projects such as: ① **SURVEYOR**—unmanned, soft-landing lunar spacecraft for chemical and visual analysis of the moon's surface; ② **SYNCOM** (Synchronous-orbit Communications Satellite)—provides world-wide communications with only three satellites; ③ **F-111B PHOENIX** Missile System—an advanced weapon system designed to radically extend the defensive strike capability of supersonic aircraft; ④ **Anti-ICBM Defense Systems**—designed to locate, intercept and destroy attacking enemy ballistic missiles in flight; ⑤ **Air Defense Control Systems**— border-to-border control of air defenses from a single command center—combines 3D radar, real-time computer technology and display systems within a flexible communications network; ⑥ **3D Radar**—ground and ship-based systems give simultaneous height, range and bearing data—now in service on the nuclear-powered U.S.S. Enterprise; ⑦ **POLARIS** Guidance System—guidance components for the long-range POLARIS missile; ⑧ **Hydrospace**—advanced sonar and other anti-submarine warfare systems.

Other responsible assignments include: *TOW* wire-guided anti-tank missile, *VATE* automatic check-out equipment, Hard Point defense systems.... R & D work on *ion* engines, advanced *infrared* systems, associative computers, *lasers, plasma* physics, *nuclear* electronics, *communications* systems, microwave tubes, parametric *amplifiers, solid state* materials and devices... *and many others.*

B.S., M.S. and Ph.D. Candidates
Members of our staff will conduct

CAMPUS INTERVIEWS

February 20 & 21, 1964

Learn more about opportunities at Hughes, our educational programs, and the extra benefits Southern California living offers. **For interview appointment and literature, consult your College Placement Director.** ***Or write: College Placement Office, Hughes Aircraft Company, P. O. Box 90515, Los Angeles 9, California.***

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Alumni Speak Out . . . III

In the more than 5,000 Alumni Survey questionnaires that have been returned to the Institute to date, responses to the back-page invitation for "comments" have been gratifyingly numerous. Although there is no such thing as a typical comment, these are some representative ones.

The Caltech Honor System was a good thing while a student but left me unprepared for the dishonesty rampant in industry. In the Caltech atmosphere, I got the idea that all scientists and technical people were honest and straightforward. In industry, after some bad experiences, I have learned that they are just ordinary people, though more clever in their dishonesty.

I have been most thankful I had the privilege of graduation from CIT. Not only a marvelous education but much personal contact with faculty men such as Sorensen, MacArthur, Hinrichs, Kramer, MacMinn, Judy, Watson, etc. A wonderful group of men. Furthermore, it is a tremendous advantage in post-college life to reply when asked where graduated—"Caltech." One is immediately considered to have had a top-notch education and to be highly qualified.

I would like to recommend that new students be screened for psychological maturity. In my own case, my lack of maturity contributed significantly to the waste of a good part of my education.

I am of the sincere belief that the engineering graduate curriculum offered by Caltech at the time I attended (1956-1957) was much too theoretical. A more generalized approach for the average student would be much more beneficial. As an engineering manager for the past 3 years, I find my year of graduate work of relative little value to me.

Why not give a course in business ethics in the senior year in which to make it realistic — such ethics would replace the usual Tech honor system; i.e. cheating, collusion, etc., would not only be allowed but encouraged. In this way the cut-throats in the crowd would be identified among their classmates for future reference, and the honest student — the future victim — would get a "vaccination" against the reality of the world he is about to enter.

There is a feeling at Caltech that I. Q. is the only significant factor in scientific work. I now think interest and personal drive are more important, or at least as important. It is not easy to have a proper combination of relaxed scholarly effort and stimulation to excellence in the same institution. It is not known what constitutes a good education or what is the proper training for a scientist, although there are many workable programs in existence. In striving to have every graduate as nearly "perfect" as possible, an institution like Caltech can reject and fail many who do not fit the mold. Caltech is too introspective, too ready to condemn to failure those who do not exceed them.

Approximately 1/3 of my freshman class left before graduation, which is a great waste and failure on the Institute's part.

The Institute selects on native intelligence, examines on native intelligence and bases the whole education on native intelligence. Unfortunately the type of native intelligence is not the only factor in successful work but is the easiest to measure. I believe that Caltech could benefit by not attacking the students so violently with the curriculum, but rather by relaxing the standards if necessary and let the students come to you.

There would be much to gain if the undergraduates could have their education as less of a grueling, bitter ordeal.

I feel that the students should be encouraged to attend the church of their choice in a similar way that they are encouraged to join a prof. society or take an interest in politics.

When I first graduated, I felt deficient in the so-called "practical" engineering-type course. After a few years in industry, this was no longer a problem. CIT should continue to emphasize basic theory and leave to industry the job of teaching the young engineer the practical and economic aspects of engineering.

Questionnaire gives me a pain.

NO CASH DISCOUNT

This is the third article in a series about the 1963-64 Alumni Fund.

If you have never read of the very early days of Throop Polytechnic Institute you have missed something. No important event went unchronicled. "Received from the sale of oranges, $464.88; wood, $12.50; rent of ground for hay, $50.00." This was from the Annual Report of 1908. An entry from a trustee meeting September 2, 1907, suggests that the Institute ". . . buy two cows for boarding halls if deemed advisable." A local bank remitted interest charges for three months on a note for $6000 with future interest to be reduced from eight to seven percent. Tuition in '95 was increased to $105 annually with no discount for cash. Dr. Hiram Reid donated the wagon used to haul the Harvard telescope to Mt. Wilson. The Executive Committee was considering life insurance as a means of raising money.

Trustee meetings took place in private homes and were generally concerned with fund raising. For, even before the turn of the century, TPI was spending far more on its students than was received from tuition. Dr. Norman Bridge made the following statement to the Board of Trustees at the annual meeting, June 13, 1899:

> "No one of us will pretend for an instant that any school doing the high order of work this one does can be supported and fulfill its mission from tuition, together with the income that can be gotten out of . . . property which the Institute owns."

There are those who dismiss these years as only a preamble to the changes which occurred with the installation of Dr. Millikan as Chairman of the Executive Council. But, as early as 1914 Throop College of Technology led the six top-ranked California schools in at least four important aspects. An early survey by a Santa Paula businessman interested in finding the best college for his son showed that Throop spent three times as much on its students as any of the other six schools; that the average instructor's salary was the highest; that more money was invested per student in plant and equipment; and, finally, that the instructor-to-student ratio was the best at one-to-three.

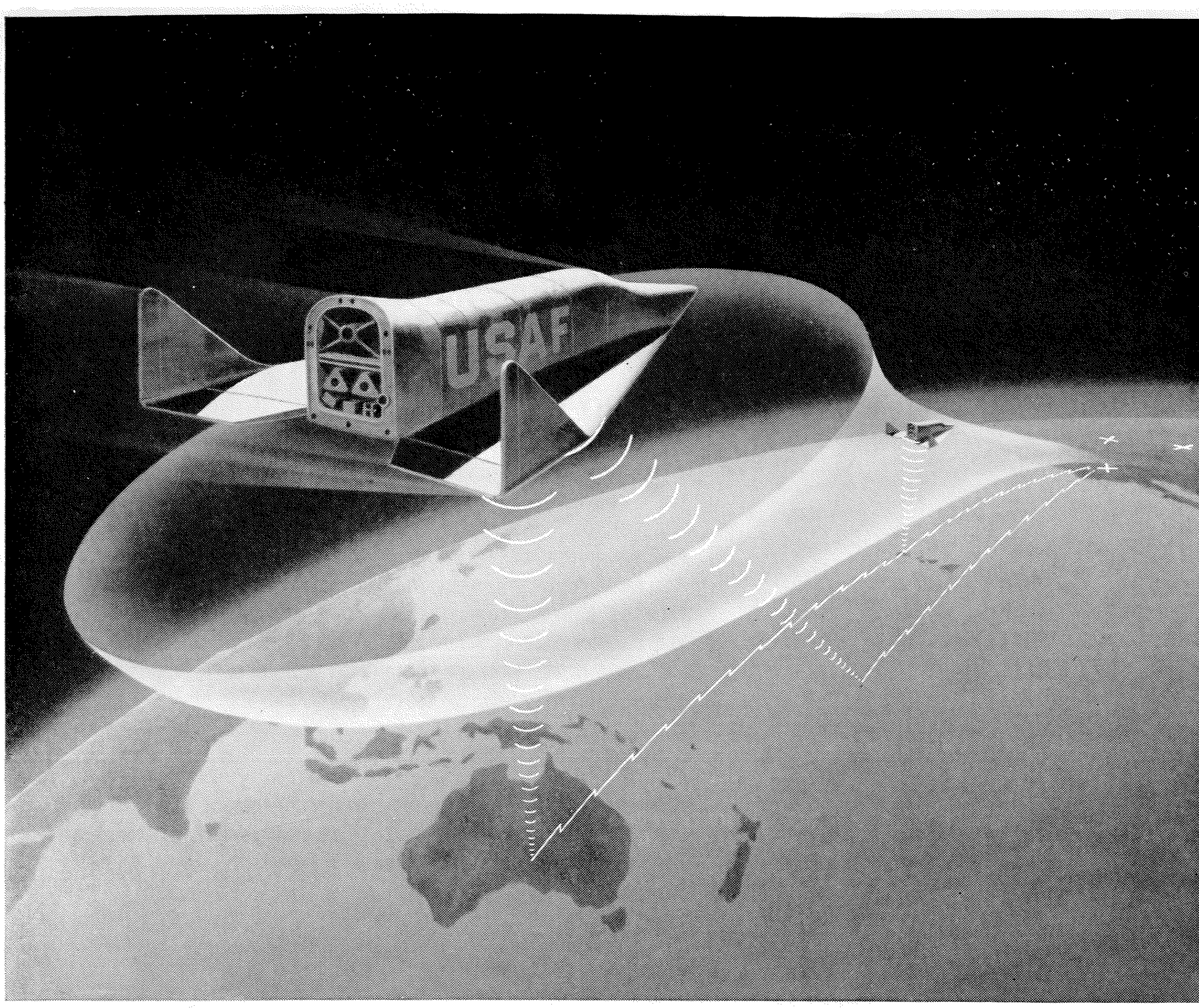
No one could fail to be impressed by the dedication of the men who were entrusted with the tremendous task of building the college envisioned by Amos G. Throop. They gave of their time and of their ingenuity and of their money. But most important was their foresight and common sense.

Today we have the California Institute of Technology. Its eminence is world renowned. We pursue disciplines unimaginable to Throop's founders, but our trustees, our president, and our faculty are united in the same basic effort; to provide the younger generations with the finest engineering and scientific education available anywhere.

The problem of financing such quality education is still with us, but fortunately we can call on a larger and larger base for help. Alumni make up the vast majority of this base and we ask you for annual financial support in whatever amount you can afford. Unrestricted funds, of course, are generally the most useful, but a gift to any area of your choice will be warmly welcomed.

The Institute is a great deal larger, and perhaps more sophisticated, than it was in Father Throop's time. But let us not admit that its friends are any less dedicated to its principles.

— *G. Russell Nance '36 and David L. Hanna '52*
Directors of the Caltech Alumni Fund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EXCITING THINGS HAPPEN AT FORD MOTOR COMPANY!

THE 100,000-MILE ENGINEERING TEST THAT SET OVER 100 NEW WORLD RECORDS

It began September 21 in Florida, when a team of four 1964 Comets, specially equipped and prepared for high-speed driving, set out to do the equivalent of four earth orbits at Daytona International Speedway—100,000 miles at speeds well over 100 miles an hour, round the clock for 40 days, through weather fair and foul.

They did it, all four of them, and they made history! They did it in the full glare of publicity. In semi-tropical heat. In the teeth of torrential squalls that fringed two hurricanes. Including time out for refueling and maintenance, the lead car averaged over 108 miles an hour, toppling over 100 national and world records!*

For all practical purposes this was an engineering trial—the most grueling test of staying power and durability ever demanded of a new car. Only near perfection could stand the punishment dished out to parts and components hour after hour, mile after mile. Brakes, engines, transmissions, ignition systems—every single part a pawn in a grim game of truth or consequence, with *total* product quality the stake. And they all came through hands down!

Now that it's over and in the record books, what does it mean? New proof of Ford-built stamina and durability! New evidence that Ford-built means better built! Yes—and more, it is a direct reflection of the confidence and creative know-how, the spirit and spunk of Ford Motor Company's engineering, styling and manufacturing team—men who find rewarding adventure in technical breakthroughs.

More proof of the exciting things that happen at Ford Motor Company to bring brighter ideas and better-built cars to the American Road.

*World Unlimited and Class C records, subject to FIA approval

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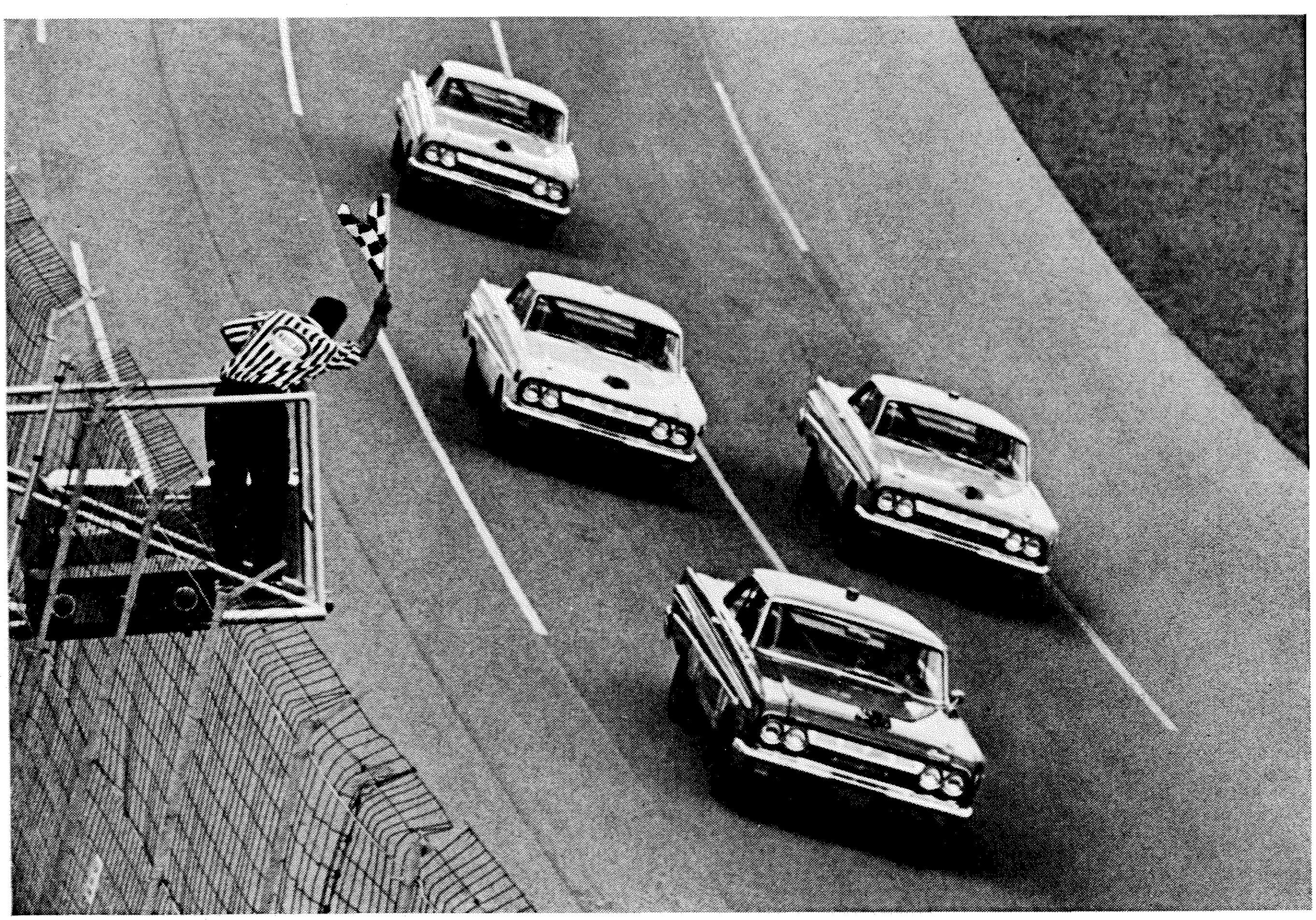
WHERE ENGINEERING LEADERSHIP BRINGS YOU BETTER-BUILT CARS



Personals

1927

ALLAN C. G. MITCHELL, PhD, head of the Indiana University physics department since 1938, died of a heart attack on November 7. A native of Houston, Texas, he was a graduate of the University of Virginia. He worked on atomic development at the University of Chicago during the war and also did research for the Navy at the Johns Hopkins Applied Physics Laboratory. Before going to Indiana, he was head of the physics department at New York University.

1936

LOUIS G. DUNN, MS(ME) '37, MS (AE) '38, PhD '40, is now vice president and general manager of the Aerojet-General Corporation's Sacramento plants. In 1940 he joined the Caltech faculty, worked on the rocket project during World War II, and in 1947 became director of Caltech's Jet Propulsion Laboratory. In 1954 he became head of research and development, and director, of the Guided Missile Research Division of the Ramo-Wooldridge Corporation, and was instrumental in reorganizing the division into the Space Technology Laboratories.

1944

CLIFFORD I. CUMMINGS is now manager of advanced system development operations at Electro-Optical Systems, Inc., in Pasadena. He had been on the staff of Caltech's Jet Propulsion Laboratory for the past 17 years, serving at one time as director of the entire lunar program, and later as special assistant to William H. Pickering, director of JPL.

1950

ROBERT T. STEVENS writes that "after several years developing and selling tools and machines for the manufacturing industry, I have recently specialized in the relatively new field of pressure welding of metals, acting as consultant in product design and application for this process and also acting as West Coast representative.

"This method produces true intermolecular bonds in non-ferrous metals with absolutely no heat requirements, and no fluxes or electrical connections, so that the bond is pure metal without cast structure or normal alloying. For instance, when a copper tube is butt-welded to an aluminum tube, a hermetic interface results without the usual CU-AL alloy, and with a joint strength greater than either of the tubes. At the pressures used (about 200,000 PSI) the metals fuse at room temperatures or below.

"Present applications are mainly electrical connections, heat-transfer devices, and hermetically sealed metal enclosures for such things as transistors, radio crystals, diodes, SCR, power rectifiers, explosive actuators, gas generators, radio isotopes and medicines."

1957

MICHAEL B. DUKE, MS '61, PhD '63, scientist in the U.S. Geological Survey's astrogeology branch, is co-winner of the Nininger Meteorite Award for 1963. Dr. Duke receives $500 as his share of the prize. The Dukes live in Hyattsville, Md., with their two children.

1958

JOHN L. HOKANSON, MS, has received an International Nickel Company Fellowship to continue graduate study at Purdue University in Lafayette, Ind. His doctoral work is in the field of physical metallurgy, specifically in the study of dislocation arrangements in twisted single crystals.

CIRCLE THIS DATE ON YOUR CALENDAR

Saturday—February 15, 1964

ANNUAL ALUMNI DINNER DANCE

at

The University Club of Los Angeles
614 South Hope Street
Los Angeles

Cocktails at 6:30—Dinner at 8:00—Dancing at 9

Personals — Class of '38

A fulsome and fact-filled report on the 25th reunion of the Class of '38 by Secretary Charles W. Clarke reveals that:

The reunion of the Class of '38 was a great success and fun for those who were able to attend. For those who could not attend, I will do my best to tell you a little about what happened.

As planned, we started our festivities at *Bill Nash's* home. *Carl Friend* and I were the first to arrive. Carl, who has been with Ryan Aircraft in San Diego for the last several years, has recently taken a new job in Research & Development at Lockheed—Burbank.

Paul Dennis and *Paul Siechert* showed up slightly later. Paul Dennis is consulting, and Paul Siechert is still busy making castings as president of Alhambra Foundry.

Lupton Wilkinson surprised us all by appearing on the scene after writing a long letter explaining he would not be able to attend. At the last minute, he talked the boss into a business trip to Los Angeles. Wilkie is Manufacturing Controls boss at McDonnell Aircraft in St. Louis. Having had some experience in this area myself, I was surprised to find Wilkie still sound of mind and body. We had lunch together the next day and toured some of the Garrett Corporation's facilities.

Harper North had no trouble getting the afternoon off because as vice president of Research & Development at Thompson-Ramo, he is boss. Harper has made quite a name for himself by starting Pacific Semi-Conductor and guiding it through its rapid growth.

Harry Boller is still doing very well as president of his company Boller & Chivens Inc., and *Roland Stone* continues to pay high taxes from the profits of his Superior Honey Company. It's amazing what happened from an interest in the birds and bees.

Gardner Wilson, manager of Brush Instruments, arrived with an unusual smile and announced his recent marriage. We are all interested in meeting the new bride. Rumor has it that she is from Paris—France. Not bad for a kid from Fresno.

Most everyone arrived at Bill's home by car; but *Homer Wood,* as we all might expect, arrived via motorcycle—clad in space helmet and all related gear. Homer is doing exceptionally well with his consulting business, H. J. Wood & Associates.

Fred Llewelyn's busy schedule allowed him to get to Bill's home but not to the banquet. Fred is still running Forest Lawn.

Later in the afternoon, *Phil Shepherd,* vice president of James, Pond, & Clark Inc.; *Tom Davis,* staff representative for The Boeing Company; *Cliff Downing,* production engineer for General Electric—Ontario, arrived. They were so busy catching up on the drinks, the writer had very little chance to talk to them. At that time *Bruce Elliot* arrived. Bruce has recently taken a new job at Ford Aeronutronic.

Bob Barry, of course, made a grand entrance late in the afternoon. Bob is still doing well with his consulting business, Barry & Associates. He was late because that was his day to count the cash.

Clay Smith was, undoubtedly, the man in the best physical condition. He is chairman of the Department of Geology at New Mexico Institute of Mining and Technology.

Stan Wolfberg arrived with a truckload of suits but couldn't find a buyer. Maybe that's why he is in the consulting business with Cresap, McCormick & Paget.

Free drinks went to the classmate who came the greatest distance. This was our great Class Vice President *Evan Johnson.* Evan had that winning smile and was a great asset to our gathering. He lives in New York as president of the American Messer Company.

At the banquet at Rodger Young Auditorium, more members of the class were evident, including *Sidney Bertram, Don Davidson, Arthur Downing, Art Ellings, Nick Ivanoff, Sam Keller, John McGraw, Kneeland Nunan, Ed Shanahan, Joe Westheimer,* and *Bill Althouse.*

For the Class of '38, the main event at the banquet was the presentation of a Life Membership in the Class of 1938 to *Dr. Donald Clark.* This was in the form of a scroll prepared by the diligent efforts of *Bob Barry.* Bob also made the presentation. Doc was speechless for two reasons: he was pleasantly surprised and he had lost his voice as a result of a cold. However, Doc smiled—and his smile is worth a thousand words.

Of course, after the banquet, the bar was full of '38 class members. Besides some of those previously mentioned, *Peter Goff* was there with his unchanged Australian accent. *Bob Metzner* told us about plans for a business trip to Tokyo in July. This is old stuff for Bob, who is president of Roberts Engineering. Bob makes some parts for his tape recorders in Japan and, therefore, makes several business trips to the Orient every year.

Also seen at the bar were two of our civil engineering types — *Bill Milburne* and *John Minasian.* Bill is still with Los Angeles City Engineers and has become quite famous through radio and TV news broadcasts. Every time we have a landslide, Bill either gets the credit for what he did or did not do to prevent it. John has been doing some terrific structural engineering jobs, like the Space Needle at the Seattle Fair.

Armand Du Fresne, who always attends Caltech events, is still with Consolidated Electrodynamics. He is now chief product engineer. *Jose Velasquez,* whom we had not seen for some time, is now with Hughes Aircraft as engineering project manager.

We always miss those who could not attend and appreciate the notes from them. *Frank Jewitt,* our class president, sent a telegram expressing his best wishes. Frank lives in New York City as president of the Vitro Corporation.

Jack Johannessen wrote a letter explaining a business trip to Florida would prevent his presence. Jack has recently retired from North American Aviation to devote his full time to property investments.

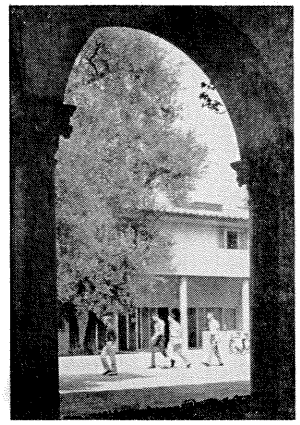
Boyne Grainger phoned in from Bakersfield to express his best wishes and explain that business prevented his attendance. *August Segelhorst* also sent a note. As chief engineer for Jabsco Pump in Costa Mesa, he is doing well but complains he hasn't made enough to retire. Welcome to the club!

We really hit the jackpot on letters from the *Jack Baker* family. Jack wrote a letter from an offshore drilling platform in the Gulf of Mexico at the Isthmus of Tehuantepec. Jack's wife Dood also wrote a letter from the home base. Jack moved his family to Mexico some time ago so he could take a position as manager and vice president of Baker-Herramientas Petroleras, S.A. This is an affiliate of Baker Oil Tools where Jack has worked since graduation.

Ralph Jones, who played a helpful part in organizing the class reunion, was not able to attend for pleasure reasons. The conflict was a European trip for him and his wife. Unfortunately, he returned the day after the reunion to resume his duties as vice president of Booz, Allen, & Hamilton.

We can all relax now and look forward to the next reunion in 1968. In the meantime, however, your Class Secretary would be happy to hear from you at any time.

CALTECH CALENDAR



ALUMNI EVENTS

February 15 Alumni Dinner Dance
May 2 Alumni Seminar
June 10 Annual Alumni Meeting

ATHLETIC SCHEDULE

Basketball

January 17
Claremont-H. Mudd at Caltech
January 18
Upland at Upland
January 24
Biola at Caltech
January 25
LaVerne at Caltech
January 28
Occidental at Occidental
February 1
Whittier at Caltech

FRIDAY EVENING DEMONSTRATION LECTURES

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

January 17
The Unexpectedness of History
—Peter W. Fay

January 24
The Death of a Star
—Jesse L. Greenstein

January 31
Three Exciting Underwater Environments: Coral Reefs, Submarine Canyons, and Kelp Beds.
—Wheeler J. North

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

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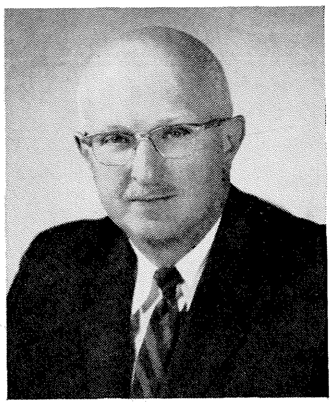
Visiting alumni cordially invited—no reservation.

An interview with G.E.'s Dr. George L. Haller Vice President— Advanced Technology



As Vice President—Advanced Technology Services, Dr. Haller is charged with coupling scientific knowledge to the practical operating problems of a Company that designs and builds a great variety of technical products. He has been a radio engineer, both in industry and the armed services (Legion of Merit for development of radar counter-measures); physics professor at Penn State and dean of its College of Chemistry and Physics; and a consulting engineer. With G.E. since 1954, he has been manager of its *Electronics Laboratory*, and general manager of the Defense Electronics Division. He was elected a vice president in 1958.

For complete information on opportunities for engineers at General Electric, write: Personalized Career Planning, General Electric Company, Section 699-09, Schenectady, N. Y. 12305

GROWTH THROUGH TECHNOLOGICAL CHANGE

The Role of R&D in Industry

Q. Dr. Haller, how does General Electric define that overworked term, Research and Development?

A. At General Electric we consider "R&D" to cover a whole spectrum of activities, ranging from basic scientific investigation for its own sake to the constant efforts of engineers in our manufacturing departments to improve their products—even in small ways. Somewhere in the middle of this range is an area we call simply "technology", the practical know-how that couples scientific knowledge with the engineering of products and services to meet customer needs.

Q. How is General Electric organized to do research and development?

A. Our Company has four broad product groups—Aerospace and Defense, Consumer, Electric Utility, and Industrial. Each group is divided into divisions, and each division into departments. The departments are like separate businesses, responsible for engineering their products and serving their markets. So one end of the R&D spectrum is clearly a department function—engineering and product design. At the other end is the Research Laboratory which performs both basic and applied research for the whole Company, and the Advanced Technology Laboratories which also works for the whole Company in the vital linking function of putting new knowledge to practical use.

Having centralized services of Research and Advanced Technology does not mean that divisions or departments cannot set up their own R&D operations, more or less specialized to their technical or market interests. There are many such laboratories; e.g., in electronics, nuclear power, space technology, polymer chemistry, jet engine technology, and so on.

Q. Doesn't such a variety of *kinds* of R&D hamper the Company's potential contribution? Don't you find yourselves stepping on each other's toes?

A. On the contrary! With a great many engineers and scientists working intensively on the problems they understand better than anyone else, we go ahead simultaneously on many fronts. Our total effort is broadened. Our central, Company-wide services in Research and Advanced Technology are enhanced by this variety of effort by individual departments.

Q. How is Advanced Technology Services organized?

A. There are three Advanced Technology Laboratories: Chemical and Materials Engineering, Electrical and Information Engineering, and Mechanical Engineering; and the Nuclear Materials and Propulsion Operation. The Laboratories do advanced technology work on their own, with Company funds, and on contract to product departments or outside customers and government agencies. NMPO works for the AEC and the military to develop materials and systems for high-temperature, high-power, low-weight nuclear reactors. ATS is the Company's communication and information center for disseminating new technologies. It also plans and develops potential new business areas for General Electric.

Q. So R&D at General Electric is the work of a great many men in a great many areas?

A. Of course. The world is going through a vast technological revolution—in the ways men can handle energy, materials, and information. Our knowledge is increasing exponentially. In the last five years we have spent more than half the money ever spent for research and development. To keep competitive, and to grow, industry must master that mountain of new knowledge and find ways to put it to practical use for mankind. Only by knowing his field well and keeping up with the rush of new developments, can the young engineer contribute to the growth of his industry—and society as a whole.

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