NOVEMBER 1966

ENGINEERING AND SCIENCE

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

ENGINEERING AND SCIENCE

NOVEMBER 1966 / VOLUME XXX / NUMBER 2

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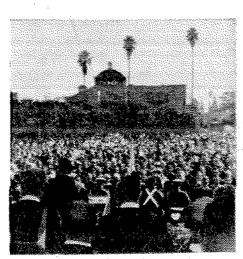
Published monthly, October through June, at the California Institute of Technology, 1201 East California Blvd., Pasadena, Calif. Annual subscription $4.50 domestic, $5.50 foreign, single copies 50 cents. Second class postage paid at Pasadena, Calif., under the Act of August 24, 1912.



COVER

"I congratulate the California Institute of Technology on completion of three-quarters of a century of service to education and to humanity. I join with you in eager anticipation of the years to come." From the President of the United States came this greeting on the occasion of Caltech's 75th Anniversary Convocation on October 24, pictured on our cover. The highlights of the event and the three-day conference which followed are on page 13.

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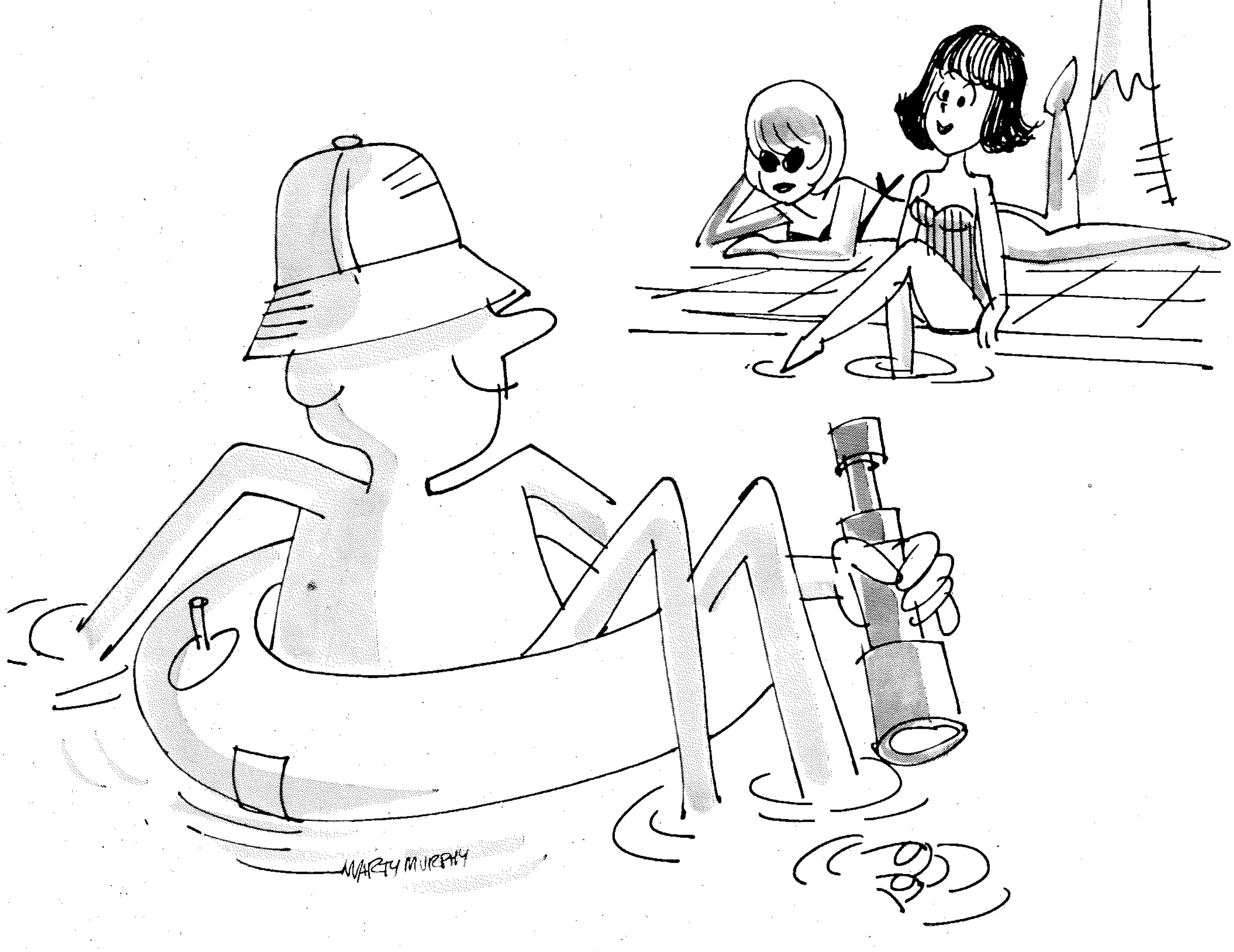


Phage and the Origins of Molecular Biology

edited by John Cairns, Gunther S. Stent, and James D. Watson

Cold Spring Harbor Laboratory of Quantitative Biology *$12.50*

Reviewed by Gerald Fling, division of biology.

A number of the men associated with the rise (and fall) of bacterial genetics have put together these accounts of their experiences. The book is dedicated to Max Delbrück, Caltech professor of biology, who, by all accounts, was the central figure in the unfolding drama and in whose laboratories at Caltech new ideas were hatched and new workers trained. Their work ultimately resulted in an explosion of knowledge and a new field.

The contributors write about how they got new ideas and tested them. They tell of the interplay between colleagues and of their own experimental losses and gains. Each man is revealed as a central figure in the chase, competing with himself and his colleagues and with nature and the unknown. Each suffers unexpected and ignominious pratfalls, occasionally overtaking the quarry and experiencing deep satisfaction, only to find that the quarry is off again in a new direction, presenting new roads and hazards to be overcome.

The personal glimpses of the scientists at work in Cold Spring Harbor and Pasadena are many. G. W. Beadle, whose recollections are limited to the rise of biochemical genetics, tells how, in 1930, he and Sterling Emerson talked about buying a balance, costing about $10, but were certain that Thomas Hunt Morgan, then chairman of the biology division, would not approve such an expenditure.

In 1954 André Lwoff found that "the California Institute of Technology, poor as many American institutions often are, could not afford to buy a microforge" and was "kindly persuaded" by Beadle, then chairman of the division of biology, that he and Renato Dulbecco should build themselves one, which they did. Lwoff goes on with a charming account of his work on the induction of bacteriophage.

Dulbecco describes the role of dichondra grass in his development of the tissue culture plaque assay for cell-killing animal viruses—and refers enviously to Jean Weigle's short-cut method for incubating cultures. Weigle had a habit of stuffing a few petri dishes inside his shirt as he set off for a desert camping trip, transferring them to his sleeping bag at night, and reading the results the next morning.

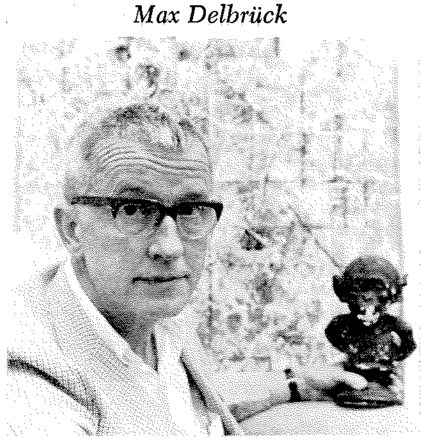
R. S. Edgar discloses that the phage mutant *amber* was named for Harris Bernstein's mother—amber being the English equivalent of the German Bernstein. Niels K. Jerne tells why he was not attracted to Pasadena, the desert, or rock climbing and recalls James Watson's "characteristic way of producing a succinct, unambiguous answer to any question: 'It stinks'." In a trip by auto across the country with Werner Reichardt, Jerne observed that the "bedbug threshold in the U.S. lay at six dollars for a double room."

For most of these men Max Delbrück was "conscience, goad and sage." As sage, Delbrück urged incorporation in experiments of what he called "the principle of limited sloppiness." As goad, he confined Seymour Benzer, Matt Meselson, and others to rooms in the Kerckhoff Marine Laboratory until they had written the papers he felt they should write. The typing was contributed by Mrs. Delbrück. He once held this reviewer incommunicado in a local printing house until the necessary editorial services were performed and the book, *Viruses 1950*, was put to bed. His critical insights are vividly expressed. After reading a draft of Benzer's paper on fine structure he said the author had "delusions of grandeur," and advised Benzer to stop writing papers, or at least to underline what was important. He called James Watson's literary style "turgid" and rewrote his paper before submitting it to the National Academy. "I don't believe a word of it," he said of George Steisinger's results concerning genetic circularity in the T4 phage.

The bacteriophage group has grown from eight in 1947 to hundreds today. Delbrück predicted to Weigle that his friends, to honor his 60th birthday, would produce a *Festschrift* of papers that had been rejected by every journal. Instead they have produced this book of very readable accounts of their historic discoveries, enlivened by a collection of stories about the founding of the phage group, its interactions, folklore, and operating methods. The accounts are expertly done, often with wry humor, which the general reader as well as the specialist in the field may find happy reading.

If Harry Rubin's speculation is correct—that most of the glories of bacterial virology lie in the past—at least we have in print a good part of the background story told by the people who did the work and achieved the glory.

Max Delbrück



Men, Machines, and Modern Times

by Elting E. Morison

The M.I.T. Press *$5.95*

Elting Morison, historian, and now Sloan Fellows Professor of Management at MIT and chairman of the Social Studies Curriculum Program of Educational Services, Inc., came to Caltech in 1950 to give a series of Athenaeum lectures. This book is the result: One of the lectures, "Gunfire at Sea: A Case Study of Innovation," not only forms the opening chapter; it sets the theme that is developed in all the chapters that follow.*

"A Case Study of Innovation" describes the disorder created in the United States Navy when an officer discovered a new way to fire a gun at sea. Morison's subject here, and throughout this book, is change—the nature of technological change, the reaction and resistance to it, and how to solve the problem of easy and rapid transition from the old to the new in a world where radical change is the steady state.

"The interesting question," according to Morison, "seems to be whether man, having succeeded after all these years in bringing so much of the natural environment under his control, can now manage the imposing system he has created for the specific purpose of enabling him to manage his natural environment."

Morison applies himself to this sober problem in a series of lively essays, replete with absorbing anecdotes and interesting historical examples.

* "A Case Study of Innovation" *(E&S*, April 1950) became the most popular article this magazine has ever run. Requests for reprints still come in today.

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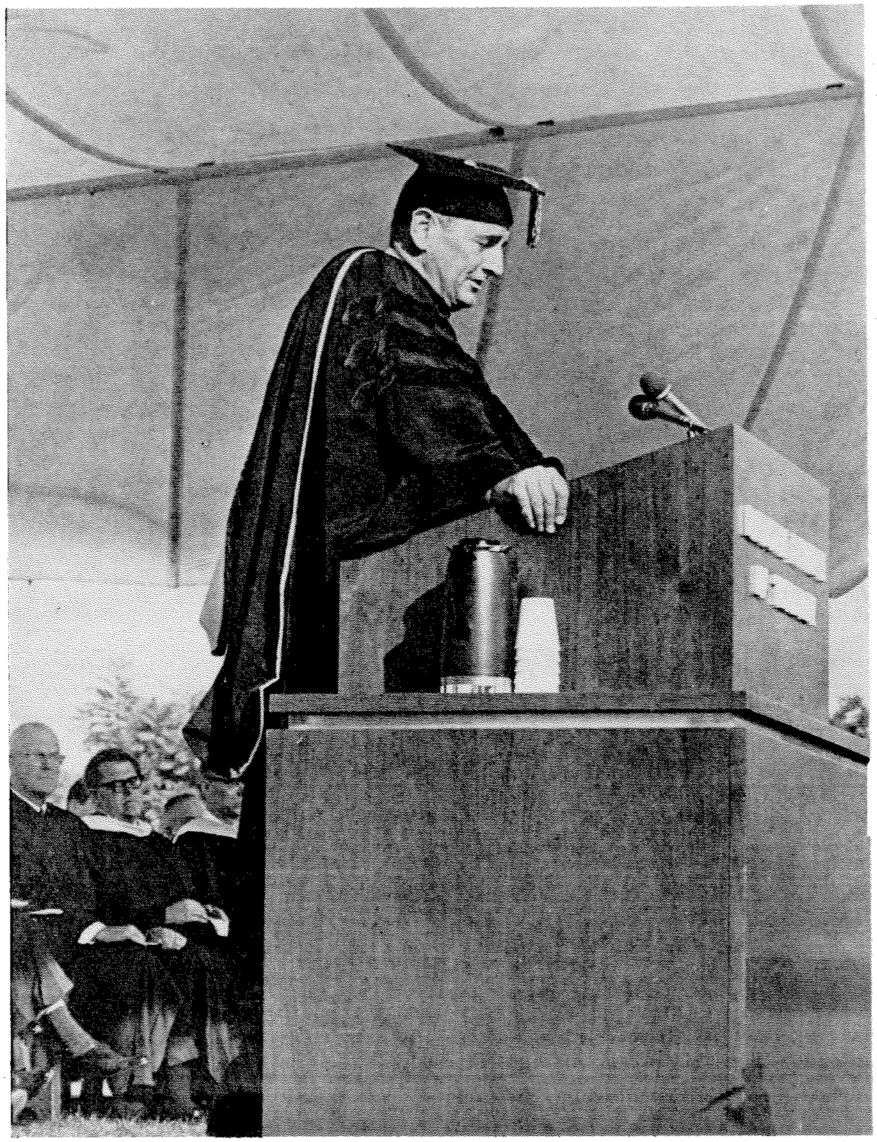
November 1966, Vol. XXX, No. 2



THE IVORY TOWER AND THE EXECUTIVE DESK

by John W. Gardner

John W. Gardner, U.S. Secretary of Health, Education and Welfare, came to Pasadena on October 24, 1966, to bring greetings from the President of the United States to the California Institute of Technology on the occasion of its 75th anniversary celebration and to deliver the convocation address. "The Ivory Tower and the Executive Desk" has been adapted from his message to the more than 2,000 educators, government, civic, and industrial leaders, and friends of the Institute gathered on Beckman Mall that day to share in the historic event.

I have the deepest respect for the California Institute of Technology. But despite the solemnity of a 75th anniversary, I have to tell you my respect is not based on its great age. When I was born a very few miles from here, Caltech was only 21 years old; so there is little time between us, and in my present job I am aging more rapidly than it is. Fortunately, we are both sufficiently young that we haven't lost our faculties. There are other similarities between us. Both of us believe in serving the nation. But Caltech, having more brains at its disposal than I, *"Every great modern university must balance its responsibilities to the worlds of reflection and action."*

figured out how to do so without moving to Washington. Caltech has done better than I have financially, but it wasn't all that affluent when it was my age, and so I have considerable hope for the future.

But let me speak more seriously about this extraordinary institution for which I really do have the deepest respect. For the past 20 years I have spent a considerable portion of my time appraising the performance and the promise of institutions—universities, schools, laboratories, government agencies, industrial firms, philanthropic organizations—and those years have taught me to give free rein to my gratitude and my awe when I have the privilege of knowing an institution in its moment of greatness. It isn't an everyday experience, believe me. I don't want to alarm you by that phrase "moment of greatness," but, in the perspective of decades and centuries, institutional greatness is a transitory thing.

The appearance of greatness is more enduring. Reputation and tradition are effective cosmetics for a fading institution. But what is all too transitory is that fine moment when an institution is responding with vigor and relevance to the needs of its day, when its morale and vitality are high, and when it is holding itself to unsparing standards of performance. And when those attributes are not present, they are not easily supplied. One cannot build a great institution as one would put together a prefabricated house, knowing the ingredients and simply arranging for their assembly at some appropriate time and place. Nor can one repair a second-rate or dispirited institution the way one might repair a leaky roof. There's a pleasantly unpredictable quality about institutional vitality. One can speak of great leadership, which Caltech has most certainly had. One can speak of the brilliant men who drew other brilliant men. One can speak of loyal and generous support, which again Caltech has certainly had. But then one has to yield again to the mystery of things and to say that the growth of a small manual arts school into a world-renowned university in a brief span of 75 years is a prodigious and awe-inspiring occurrence.

One of the most striking characteristics of a university in its time of greatness is the creative interplay between the world of thought and the world of action. This is a subject of special interest to me because my own career has spanned both worlds. When I was a young man and tended to devote my career to teaching and research, particularly research, I thought my role in society would be a detached one. I thought of myself as an observer rather than a participant. As I reflect on the fact that my own career, which has led by fits and starts from almost complete disengagement to almost total involvement in the action and effort of society, I am reminded of a barnyard fable:

A pig and a hen were walking down the street one day, and they passed a church with a sign that said *Church Bazaar, Your Contribution Needed.* The hen, in a generous, expansive mood, said, "Let's give them a ham and egg dinner." The pig said, "Oh no! For you that's a contribution, but for me it's total commitment."

I am now in a position to know how he felt.

I want to talk today about the ivory tower and the executive desk. I want to talk about the whole range of social roles from the extreme of total detachment to the other extreme of complete involvement. At one end of the spectrum sits Thoreau by his pond, the poet in his garret, the scholar in his study; and at the other extreme sits the executive at his desk, the active citizen in his committee meeting, the leader surrounded by those with whom he works.

Between the two extremes are a thousand way stations. Each individual must decide where to place himself along that range. Each has to decide how much he wants to become personally involved in the action and effort of his society, and there is no correct answer. The individual must decide in terms of his own temperament and motivation.

A society that aspires to creativity has urgent need of its detached scholars and critics, as well as of those who will become deeply involved in the world of action. And a university must play a vital role in producing both.

Until very recently almost all of the conventional pressures on young people were to get them totally involved in the action of society, so perhaps I had better begin by stressing the other side of the coin—the value of the detached observer. There is a certain perspective on any social enterprise that can be had only from the outside. That is why De Tocqueville was able to see our country as no

American of the time could see it. That is why corporation presidents seek the advice of outside management consultants. That is why anthropologists can be objective about other cultures but not necessarily about their own.

Every organization, every society is under the spell of assumptions so familiar that they are never really questioned—least of all by those most intimately involved. The man who is relatively detached can scrutinize those assumptions. Creativity requires the freedom to consider "unthinkable" alternatives, to doubt the worth of cherished practices. The closer you get to the purposeful action of this world the less likely it is that you will have such freedom. People at the heart of an enterprise are striving with all their energy to accomplish certain objectives. They haven't the time to doubt or to speculate, and even if they did, it would be a risky form of self-indulgence.

So as I cope with the incredibly heavy pressures of my job, caught up in the endless crises of the day, I'm glad that there are people, in the universities and elsewhere, who have the time and the detachment to think not of the moment, but of the past and the future; not only of how to solve the problem, but whether it's worth solving; not only of what is, but what might be.

Now, having paid my respects to the detached observer, let me pay my respects to those men and women who become involved in the central action of their society. That central action is forwarded by people who are willing and able to move into leadership roles, managerial roles, professional roles—men and women who are fitted by character and inclination to endure the dust of the market, the heat of battle, and the frustrations of purposeful action.

It goes without saying that these men and women who have committed themselves to be in the battle rather than above the battle, who have undertaken to cope with the machinery of society, who have the capacity to lead or manage or execute, will play a considerable role in shaping the world we live in. No society can survive, certainly not our own complex and swiftly changing society, if it fails to persuade a high proportion of young men and women to choose this path of complete involvement. We are in desperate need of talented and highly motivated young men and women to move into the key leadership and managerial roles in government, industry, the academic world, the professions, and elsewhere in the society.

It seems clear to me that the creative society will be one in which there is continuous and fruitful interchange and interaction between the two worlds of action and reflection. And no institution in our society can do more to keep that interaction vital and productive than the university.

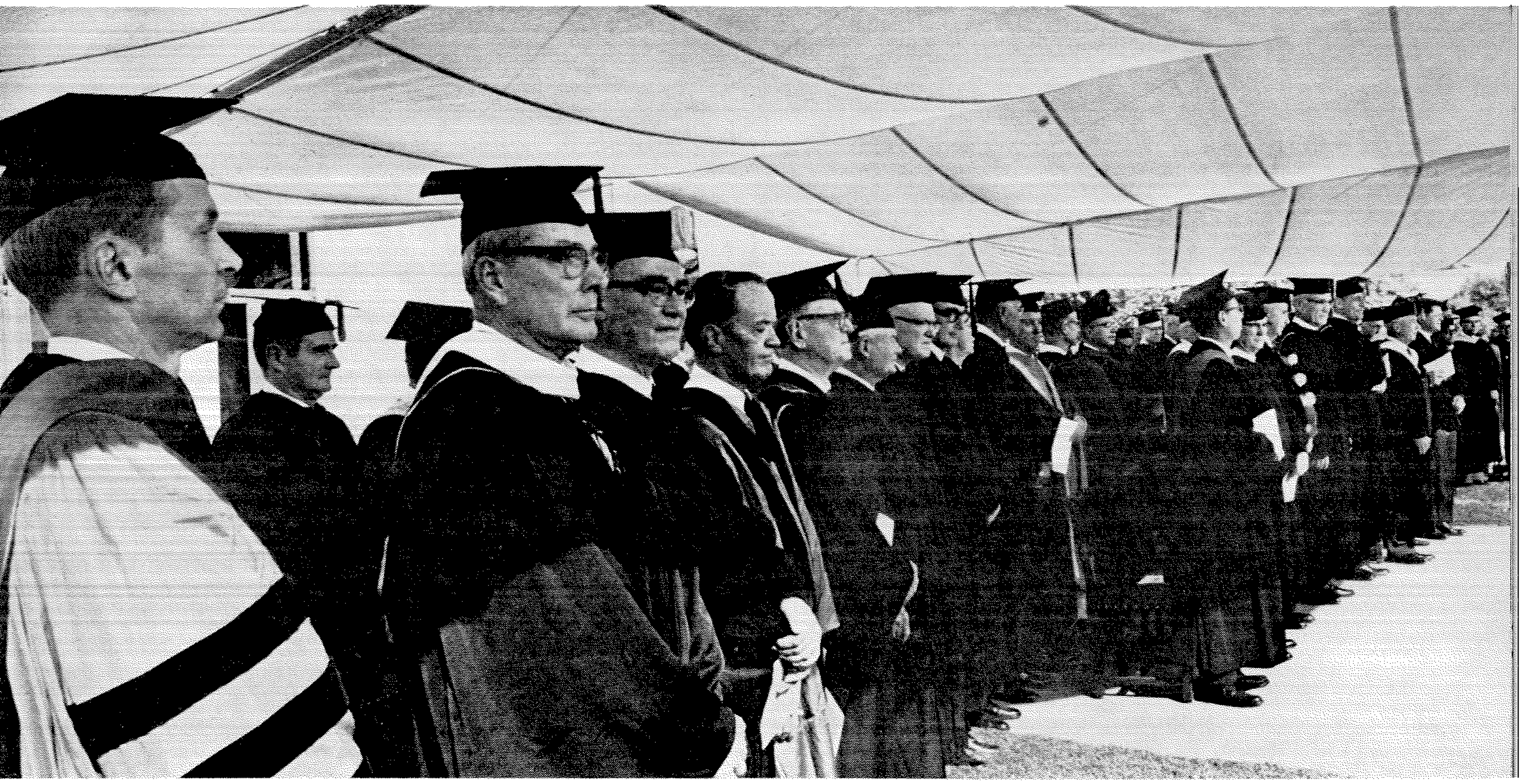
The university encompasses both worlds. It must preserve within its walls an environment in which the relatively disengaged scholar, artist, critic, writer, or scientist can live and flourish; but it must also relate itself to the organized world of action. It does this in a variety of ways, through the activities of many of its faculty members, through applied research, through its professional schools and extension activities, but most of all through educating the young men and women who will eventually act and lead. Every great modern university must balance its responsibilities to the worlds of reflection and action. It isn't easy, and forces are always at work to throw the enterprise off balance. There are those in the population, even in the alumni population and on the boards of trustees of some universities, who resent the fact that the university is a haven for dissent, for criticism, and for the free examination of assumptions and practices. They often strive to diminish this fundamental role of the university. They seem to imagine that the chief role of the university is to endorse the status quo.

On the other side, there are some within the university community who seem to want to cut all ties with the rest of the society and to persuade every last student to choose the life of detachment and dissent. They don't like the way the society is run, but they aren't inclined to prepare young people to run it better. And some of them communicate to their students a moral snobbism toward those who live with the ethical dilemmas of responsible action.

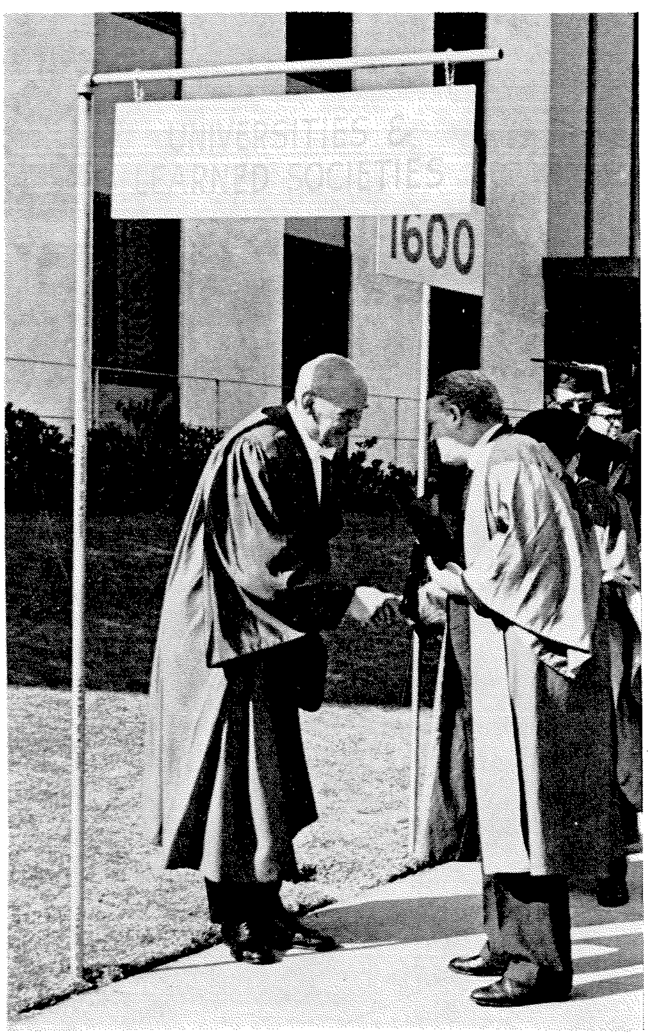
The life of reflection is not superior to the life of action nor vice versa. Both are essential to a vital society. Surely our universities should strive to be as effective as possible in preparing young people for either role. I hope that in preparing young people for lives as scholars and critics our universities will make them aware of the dangers of irresponsibility and moral snobbism. I hope that in preparing them for the world of business and government the universities will make them appreciative of the social function of the scholar, the dissenter, and the critic. Finally, I hope the universities persuade a reasonable proportion of their graduates to move back and forth between the two worlds.

In conclusion, then, our society must have the wisdom to reflect and the fortitude to act. It must provide the creative soil for new ideas and the skill, the patience, and the hardihood to put those ideas into action.

Our great universities can help us to forge that kind of society.

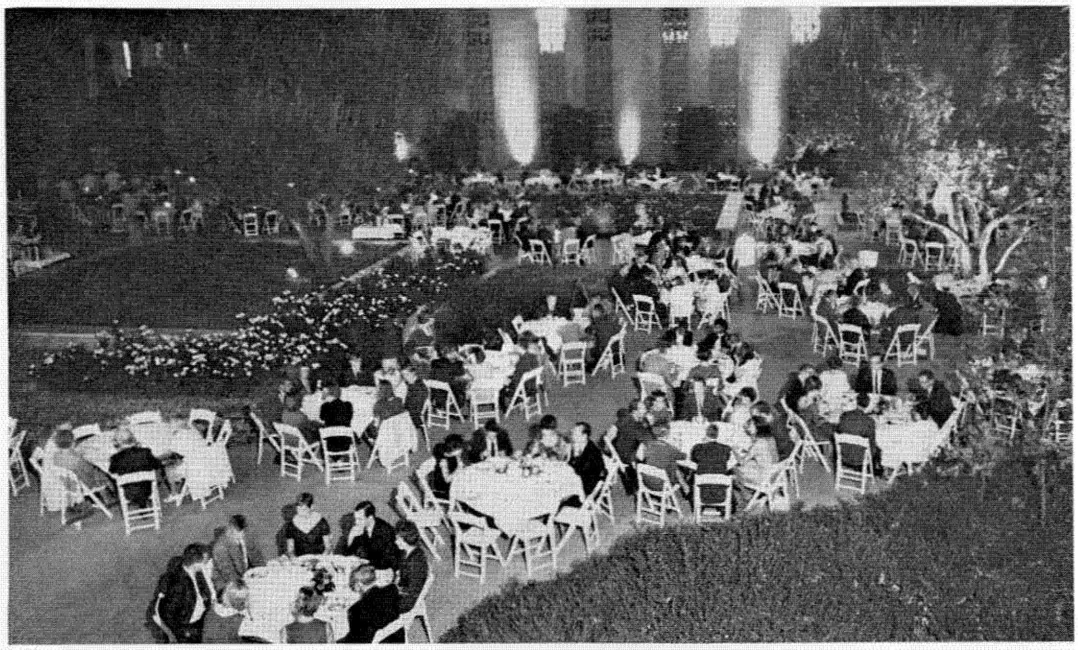


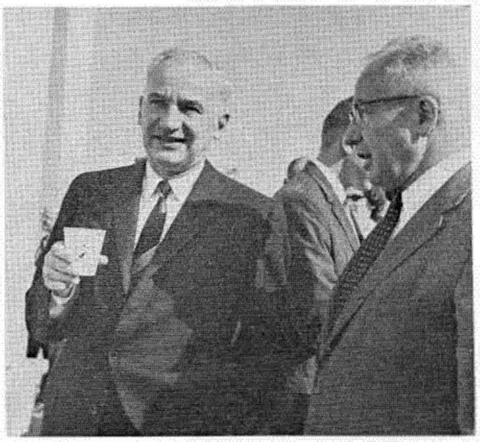
CALTECH'S 75th ANNIVERSARY



The California Institute of Technology, founded as Throop University in 1891, began its 75th anniversary celebration with a colorful convocation on October 24, in which delegates from 124 other universities and learned societies took part. This was followed by a three-day Conference on Scientific Progress and Human Values, a formal dinner at which awards were presented to 23 distinguished alumni, an outdoor dinner given by the students, and a concert conducted by Igor Stravinsky—first of many events planned for the anniversary year.

As their part of the festivities, undergraduates hosted a twilight dinner for nearly 800 people on October 26.





At the Conference on Scientific Progress and Human Values—(left) Simon Ramo, vice chairman of TRW Inc. and Caltech Provost Robert Bacher; (below) Caltech historian Rodman Paul and Asa Briggs, dean of the school of social studies at the University of Sussex, England.

Visitors had a chance to catch up on current Caltech research as Dabney Lounge was temporarily transformed into a scientific exposition.

Composer Igor Stravinsky, conducting the Caltech 75th Anniversary Orchestra, invited students to this final rehearsal before his special November 7 concert in Beckman Auditorium.

SCIENTIFIC PROGRESS AND HUMAN VALUES

A report on Caltech's 75th anniversary conference

Caltech's Conference on Scientific Progress and Human Values, the three-day meeting that was the core of the 75th anniversary celebration, brought together a group of British and American scholars who are concerned with the implications of science for our developing human society. For the most part the speeches and discussions represented an attempt to define the problems that are developing in a world which the scientist is sometimes inadvertently remaking.

The conferences began on Tuesday with a brief survey of the physical world as it appeared on October 25, 1966. Murray Gell-Mann, Caltech professor of theoretical physics, spoke of the smallest part of it, the elementary particles of matter, and of the current theories put forward to explain the complexities that new experiments keep revealing.

Jesse Greenstein, executive officer for astronomy and professor of astrophysics at Caltech, went to the other end of the scale, discussing work in astronomy that is constantly modifying our view of the universe. He ended with a pessimistic estimate of the likelihood of our knowing, even within thousands or millions of years, if man has any companions in the universe. If his estimates are correct, man will have to continue coping with his own problems without the beneficent help of some other, more advanced civilization.

Robert Sharp, chairman of Caltech's division of geological sciences, undertook to consider the vast middle ground between the atom and infinity. He pointed out that man, confined until now to the earth's thin crust, has nevertheless managed to learn a considerable amount about how his environment has been derived both from activities underneath him in the earth's interior and also from encounters with extra-terrestrial objects. We may learn, he suggested, that those hunks of wandering matter, in the form of comets and asteriods, have been more important than we have so far imagined in shaping the surface features of the earth.

From these speculations on the fundamental nature of man's environment the conference turned to consider how our expanding knowledge enables us increasingly to manipulate the conditions under which we live. Three specialized views of the state and prospect of today's technology were presented. Sir William Penney, chairman of the United Kingdom's Atomic Energy Authority, noted that in power-poor Great Britain atomic energy is now widely applied and holds great promise for the future. In the next few years, however, he indicated that the United States would take a commanding world lead in nuclear power production, which has proved to be economically competitive with other power-generating means in this country.

George E. Mueller, NASA associate director for manned space flight, in evaluating exploration of the solar system at a time when man is about to take the big jump to the moon, said that the space program has become a powerful force which will bring technological, social, and economic rewards.

John R. Pierce, director of research for Bell Telephone Laboratories, predicted that the effects of modern communication systems will best be seen in rapid social unification of emerging nations. In more advanced countries communications will play a great role in meeting the complex demands of growing population and urban concentration.

The second day of the conference was devoted to what has become, in the last few years, an emergent scientific area full of hope and anxiety for its impact on man himself—the new biology. James F. Crow, head of the laboratory of genetics at the University of Wisconsin and a distinguished population geneticist, dealt with the new knowledge of heredity and evolution; he evaluated the rates and magnitudes of effects on human evolution to be expected from applications of the new biology and made a case for the importance and feasibility of humanity's preparing to direct man's own evolution.

Professor J. Z. Young of University College, London, discussed the probable future course of the collection and transmission of information by man. Memory and learning make it possible for each individual to receive detailed information, not from two parents only, but from many other humans, often distant in time and space. From its beginnings in speech to the establishment of vast memory stores in the form of books and computers, this has probably been the main agent responsible for the astonishingly rapid development in human life and society in the last 10,000 years. Future changes in human life promise further improvements in the extracorporeal information store and in its use.

"As we understand life, we can control life," remarked Caltech professor of biophysics Robert Sinsheimer in opening the afternoon session. This understanding is increasing with astonishing rapidity. How far will it go? We can now assume that we will eventually create a self-reproducing cell. On the way to this achievement the determination of sex, the control of arthritic pain, and genetic therapy for diabetes are among the likely possibilities.

Will mind, sensation, and consciousness yield to the same analytical approach? Neal E. Miller, professor of behavioral sciences at Rockefeller University, suggested that human behavior is subject to natural laws and susceptible to scientific study. If we are able, either through the analysis of human behavior or through the study of the human brain, to understand these mysteries, we will face some awesome choices. But, as Sinsheimer noted, it may be that we have no choice, but are just "passengers on a fantastic street-car called evolution."

Robert Morison, director of the division of biological sciences at Cornell, pointed out some of the ways in which scientific progress is already drastically changing traditional social patterns. In regard to the transfer of information, for example, the family is already losing its traditional role as the main repository of knowledge in society. It may well lose much of its biological function too. How will our social institutions evolve to accommodate themselves to new conditions?

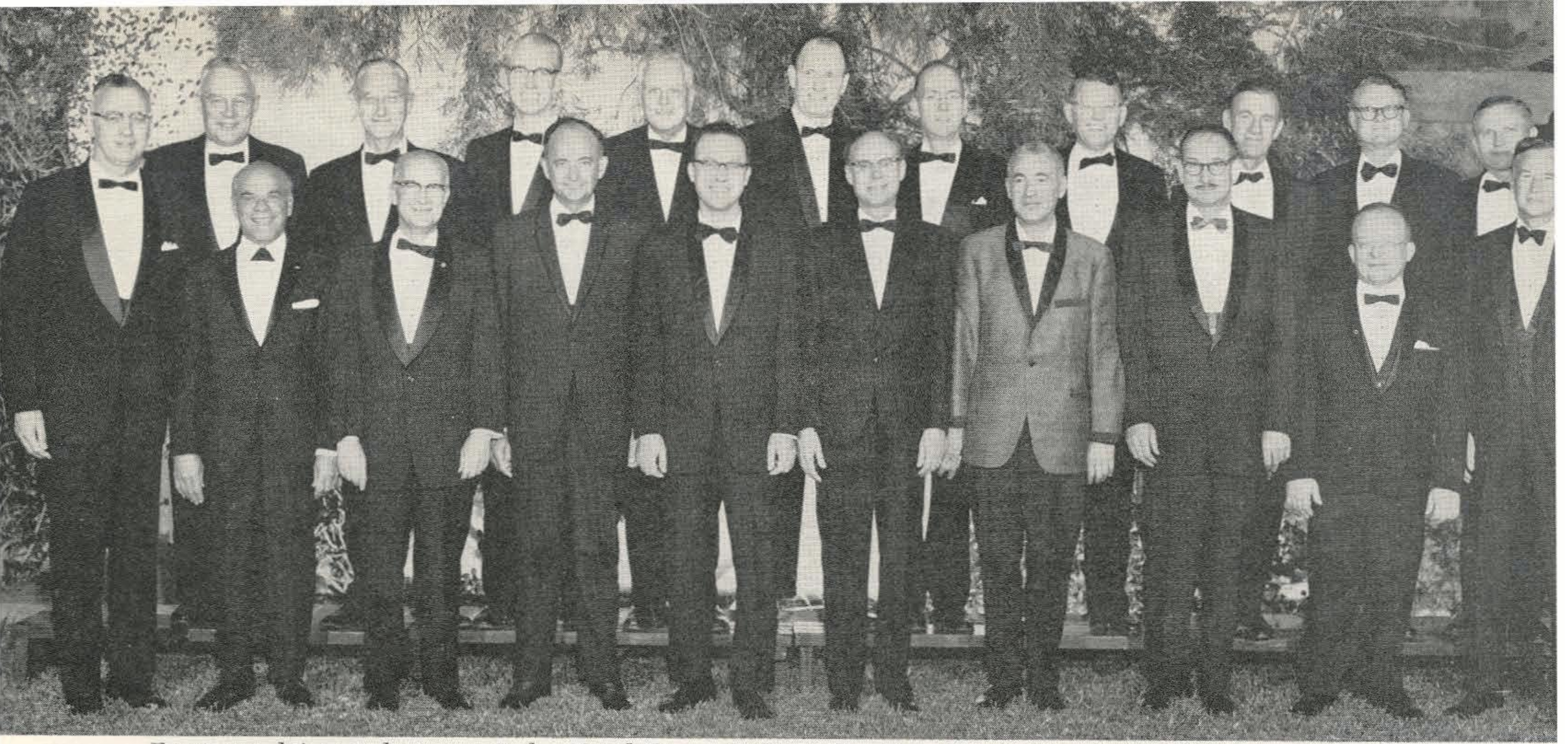
On Thursday morning Asa Briggs, dean of the school of social studies at the University of Sussex, England, added historical perspective to these prophetic flights by describing how in 1850 and again in 1900 men looked at their past and prophesied their future. Noting the prediction in 1900 that phrenology would be the science of the future, he pointed up the difficulty of distinguishing between fruitful paths of enquiry and the blind alleys of human curiosity. He suggested that the university was a proper vantage point from which to review our prospects in 1966.

Daniel Bell, professor of sociology at Columbia, went even further in stressing the role of the university. Characterizing our contemporary "post-industrial" society as one in which white-collar workers outnumber blue-collar workers, he envisioned a significant shift in the power structure from the empirical to the theoretical. When this change takes place, Bell suggested, the university will become the primary institution of a new society.

Herbert J. Muller, professor of English and government at the University of Indiana, asserted that there is a basis for decisions that will have to be made, pointing out that while values are "scientifically unchaste," scientist and humanist both accept as absolute values such things as health, physical well-being, play, comradeliness; and the satisfaction of the aesthetic sense, creative impulse, and natural curiosity. These values, he said, will exist as long as we assume that human existence is worthwhile. Nevertheless, the power that modern technology has given man is infinitely greater than ever before, and exercise of that power has too often not been responsive to those values. *Can* we direct our technology to truly civilized, humane ends?

A discussion on Thursday afternoon had Don K. Price, dean of the Harvard graduate school of public administration; James Bonner, Caltech professor of biology; Murray Gell-Mann; Carl Kaysen, director of the Institute for Advanced Study; and Simon Ramo, vice-chairman of TRW, Inc., trying to define some of the ramifications of technological progress. They concluded that man's social attitudes would have to be reorganized in the next few years and agreed that new decision-making agencies must be developed to cope with future problems in determining public policy. It may be that the university, which operates within demanding self-imposed rules that do attempt to recognize primary human values, will provide the model for the decision-making institutions of the future.

The closing session on Thursday evening dealt with the specific problem of how formal education will have to adapt itself to the kind of world the other speakers foresaw. Lord James of Rusholme, vice-chancellor of the University of York, England, saw science outstripping other fields, with a resulting alienation between scientist and non-scientist. He foresaw the greatest problem of this alienation as overcoming growing specialization in science—a specialization which cripples the scientist in other fields. To overcome this limitation he suggests a more general, even superficial, education for the scientist in non-scientific fields, and a broader exposure to science for the non-scientist to prepare him to live in a scientific world. To implement this new kind of education, more and better teachers—people who consider teaching and self-education their primary job—are needed. "In the last resort, if our education is to get better, as it must, it will get better because it is carried on by more educated, more sensitive, and more humane people who are not afraid to emphasize the social relevance of the subjects they teach."



Front row, left to right: Louis Rader, Frank Capra, William Shockley, Joseph Charyk, Donald Glaser, John Pierce, Saul Winstein, Edwin McMillan, W. K. H. Panofsky, E. Bright Wilson, Jr. Back row: Richard Folsom, James Boyd, James Fletcher, Kenneth Pitzer, Francis Clauser, Charles Townes, H. Guyford Stever, Walter Munk, David Mason, Frank Borman. Not present for the picture: Horace Davenport, Ruben Mettler, L. Eugene Root.

DISTINGUISHED ALUMNI

Awards are given for outstanding achievement

For the first time in its 75-year history Caltech presented distinguished service awards, for outstanding achievement in their chosen fields, to 23 of its alumni at the 75th Anniversary Dinner, October 25.

"It was clearly a presumptuous action we took," said President DuBridge, "when we decided to pick from among 9,906 alumni 23 who had attained rather special distinction . . . We eliminated from the list of candidates those whom we had already honored by making them members of the faculty or of the board of trustees . . . No one denies that we could easily have found 23 more who also deserved recognition. Some of them we hope to recognize on future occasions. But these 23 are all men of whom any institution could be proud. And we are proud of them."

FRANK BORMAN, MS '57

"Alumnus of West Point and Caltech, former fighter pilot and faculty member at the U.S. Military Academy, he became one of that highly select group of men chosen to be astronauts. His flight in Gemini 7 is the longest manned orbital flight yet made, and he won high praise for his courageous and skillfull direction of its complex operation."

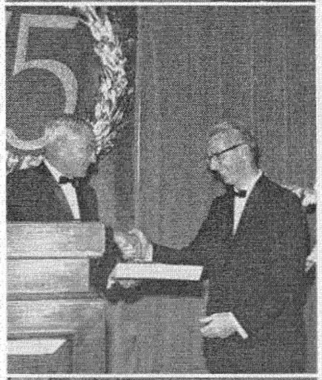
JAMES BOYD '27

"A Caltech graduate whose favorite subject was economics, he became a geologist. He served as Dean of the Faculty at the Colorado School of Mines and later as Director of the U.S. Bureau of Mines. Now, as President of the Copper Range Company, he practices with imagination and skill both economics and geology."

FRANK CAPRA '18

"The dean of motion picture directors, winner of many Academy Awards as director or producer, his creations include some of the most popular and memorable films ever made. He demonstrates that a Caltech education is not a fatal handicap to a distinguished career in the arts."



Top to bottom: Charyk, Clauser, Henry Borsook accepting the award for Davenport, Fletcher, Folsom, Glaser.

JOSEPH V. CHARYK, MS '43, PhD '46

"Aeronautical scientist and statesman, he served the United States Air Force as Chief Scientist, as Assistant Secretary for Research and Development, and as Under Secretary. When the Communications Satellite Corporation was formed, he became the first president of one of the most exciting and far-reaching enterprises in the world—bringing the achievements of space technology to the benefit of all people."

FRANCIS H. CLAUSER '34, MS '35, PhD '37

"An aeronautical engineer with wide experience in industry, as well as in teaching and administration, he moved from the Douglas Aircraft Company to the chairmanship of the aeronautics department of the Johns Hopkins University, and is now the Vice-Chancellor of the new University of California at Santa Cruz. Caltech welcomes him as a valued colleague and competitior."

HORACE W. DAVENPORT '35, PhD '39

"A product of both Caltech and Oxford, he has carried on the great tradition set by his teacher, Henry Borsook, by making distinguished contributions in physiology and biochemistry and at the same time cultivating his interests in art and literature."

JAMES C. FLETCHER, PhD '48

"A highly successful executive and director of research divisions at the Hughes Aircraft Company and the Space Technology Laboratory, he organized the Space Electronics Corporation and served as its president and board chairman. In 1964 he was called to the distinguished position as President of the University of Utah."

RICHARD G. FOLSOM '28, MS '29, PhD '32

"Designer and research investigator of hydraulic machines and hydraulic systems, he served as Professor of Mechanical Engineering and Fluid Mechanics at the University of California at Berkeley. His administrative talents as head of the department there led to his selection as President of the Rensselaer Polytechnic Institute. Under his leadership the oldest civilian engineering school in the country is reaching new heights of excellence."

DONALD A. GLASER, PhD '50

"Nobel Laureate in Physics, inventor of the bubble chamber for detecting atomic particles with which he has made many discoveries in high energy physics, he has now turned his great talents to biology and is Professor of Physics and Molecular Biology at the University of California at Berkeley."

DAVID M. MASON '43, MS '47, PhD '49

"A chemical engineer with three degrees from Caltech, he is now Professor and Executive Head of the Department of Chemical Engineering at Stanford University, which he has made into one of the world's leading groups in that field."

EDWIN M. MCMILLAN '28, MS '29

"A physicist who won the Nobel Prize in Chemistry, he made possible great advances in the design and use of particle accelerators and made important discoveries in the chemistry of the transuranium elements. He is Professor of Physics and Director of the Lawrence Radiation Laboratory at the University of California at Berkeley, one of the world's great research centers in high energy physics."

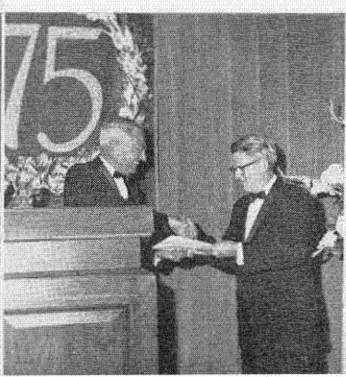
RUBEN F. METTLER '44, MS '47, PhD '49

"Designer and developer of weapons systems in air defense tactics, an authority on airborne electronics systems, formerly head of the Systems Department at the Hughes Aircraft Company and now president of Thompson-Ramo-Wooldridge Systems, he is one of the brilliant young leaders in the aerospace industry."

WALTER H. MUNK '39, MS '40

"A man who knows what the wild waves are saying, he has learned their secrets by applying modern statistical theory to wave propagation in solid and fluid bodies. Recently he has built an outstanding Institute of Geophysics and Planetary Physics at La Jolla."

Mason



McMillan

Mettler

Munk

W. K. H. PANOFSKY, PhD '42

"A distinguished researcher in high energy physics and a leader in the development of particle accelerators, he is presently Professor of Physics at Stanford University and Director of the Stanford Linear Accelerator Center. In this capacity he is responsible for the design, construction and operation of one of the world's great nuclear facilities, the two-mile long electron accelerator now nearing completion at Palo Alto."

JOHN R. PIERCE '33, MS '34, PhD '36

"Executive Director of the Research-Communications Sciences Division of the Bell Telephone Laboratories, a recipient of the President's Medal for Science, an authority on electrons, waves and messages, and a pioneer in satellite communications, he is also a gifted expositor of modern science and technology."

KENNETH S. PITZER '35

"A physical chemist who served his country as Research Director of the Office of Scientific Research and Development during the war, he has continued his productive scientific research while making a brilliant career as an educational administrator, first as Dean at the University of California and now as President of Rice University."

LOUIS T. RADER, MS '35, PhD '38

"Vice-President and General Manager of the Industrial Process Control Division of the General Electric Company, an expert on computers and on people as well, he is an electrical engineer who has been a professor but has devoted most of his talents and energy to the development of new and creative enterprises in industry."

L. EUGENE ROOT, MS (ME) '33, MS (Ae) '34

"An aeronautical engineer whose career spans developments from the DC2 through the Agena rocket, he has made outstanding contributions to the development of space power plants, space probes and satellites. He continues his leadership in this field as President of the Lockheed Missiles and Space Company."

WILLIAM B. SHOCKLEY '32

"A Nobel Laureate for his fundamental discoveries in solid state physics, he caused a revolution in the electronics industry by making possible the development of the transistor. He has worked at the Bell Laboratories, in many agencies of the federal government, and is now Alexander M. Poniatoff Professor of Engineering Science at Stanford University."

H. GUYFORD STEVER, PhD '41

"A wizard with a Geiger counter, he served the M.I.T. Radiation Laboratory during the war, was Chief Scientist of the Air Force, and held several professorial and administrative posts at M.I.T. In 1965 he became President of the Carnegie Institute of Technology and is now the architect of a new university complex there."

CHARLES H. TOWNES, PhD '39

"Nobel Laureate, developer of the maser principle of stimulated emission of electromagnetic radiation, he served Columbia University as Professor and Chairman of the Physics Department, and M.I.T. as Professor and Provost, and now serves as Institute Professor. His wide-ranging talents are in continuous demand by many key government agencies."

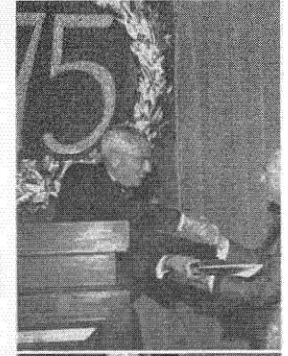
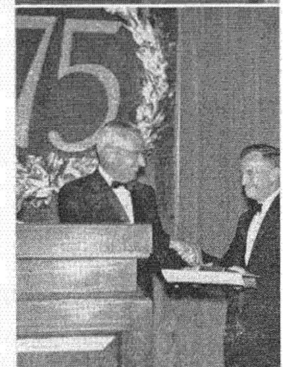
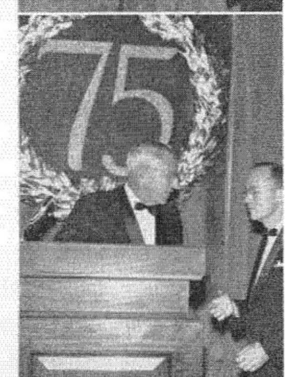
E. BRIGHT WILSON, JR., PhD '33

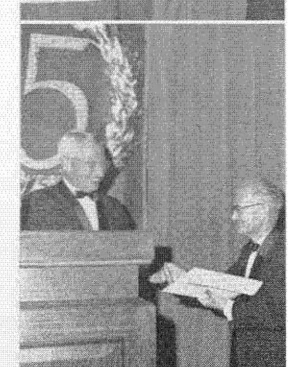
"A chemist who has made outstanding contributions in the field of molecular structure and molecular spectroscopy, he has done pioneering work in microwave spectroscopy and has advanced our knowledge of the barriers to internal rotation in molecules. As Theodore William Richards Professor of Chemistry at Harvard University he has inspired and trained an unusually large number of young chemists who have become leaders in their field."

SAUL WINSTEIN, PhD '38

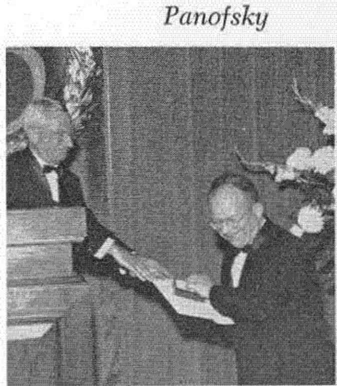
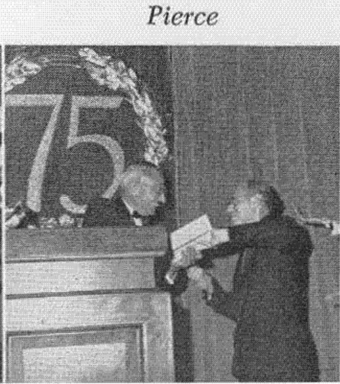
"Professor of Chemistry at UCLA and one of the world's foremost authorities in the field of chemical reaction mechanisms, his classic research has repeatedly provided evidence that the dynamics of chemical change are systematic, rather than whimsical, natural phenomena."

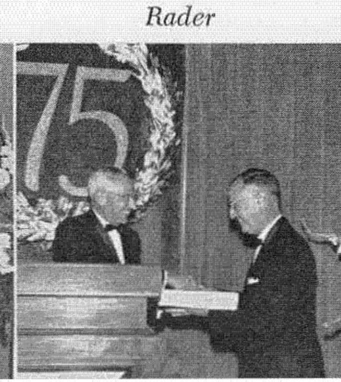
Top to bottom: Winstein, Wilson, Townes, Stever, Shockley, Herschel Brown accepting the award for Root.




Panofsky *Pierce* *Pitzer* *Rader*



THE ROOTS OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY II

by Imra W. Buwalda

By 1907 Throop Polytechnic Institute was financially solvent. It had a plant worth $350,000, an enrollment of 529 students, a competent faculty, and an exceptionally strong and able board of trustees. The school had established enthusiastic local rapport, and it had gained national recognition for the quality of its training. Its board was now determined to develop an outstanding college of science and engineering.

The trustees realized, however, that they faced some immediate and major problems in making the change. One was the academic quality of Throop's students. In a frank statement to the board, President Walter Edwards reported that while . . . "there never has been a time when we have not had many students of whom any school would be proud, and some who were really brilliant . . . in the very nature of things a manual training school must attract an exceptionally large number of students of inferior scholastic and literary attainments."

Another problem was the school's location. Pasadena's population had grown from 5,000 in 1891 to 30,000 in 1908, and Throop was now in the heart of the business district, where property was too expensive for expansion and where it had become "too noisy and bustling for academic purposes."

In 1905 the trustees had appointed a committee to find a suitable new location. Two years later they accepted the committee's recommendation to buy 22 acres of the Rancho San Pasqual and appointed architect Myron Hunt to draw up building plans for the new campus.

But the greatest hurdle facing the board was financial—how to meet the enormous expense of developing a first-rate scientific institute, worthy to be called "The MIT of the West."

These concerns must have been on the mind of board chairman Norman Bridge when he called on his friend George Ellery Hale one evening in the fall of 1906. Hale was not yet a member of Throop's board of trustees; he was elected on August 7, 1907. But the great astronomer and founder of Mt. Wilson Observatory had for some time been serving as ex-officio advisor to the trustees. According to Mrs. Hale, Bridge seemed almost desperate when he asked, "What can we *do* to become a really first-class college of science and engineering?" Hale's immediate response was: "Scrap practically the whole thing and start all over."

Hale's advice had a great impact on the trustees, for although they had decided to feature the College, apparently they planned to develop it as a part of the existing school, with its Grammar, Academy, Normal, and Commercial schools. But the impact on the school's administrative officers and faculty was shattering, and their confusion, resentment, anger, and dismay soon spread to the community in general. It was a time of conflicting rumors that made headlines, and of high-powered lobbying of individual trustees. Everyone agreed that the college should be expanded; everyone fought for the survival of his own school.

continued on page 24

Second in a series of articles on the early years of Caltech adapted from a manuscript by Mrs. J. P. Buwalda.

President Edwards (center) and faculty in 1901.

The Rain in Maine is Plainly

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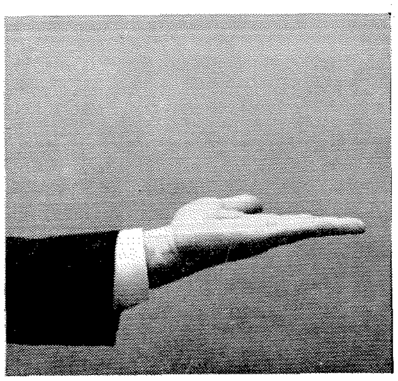

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Anyway, we attended to an interesting detail recently—the effect of rain on the microwave link between a communications satellite and our pioneer ground station antenna at Andover, Maine.

If we could but measure the rain's effect, we could improve the design of satellite ground stations. The question was how.

Well, you often have to take your laboratory tools where you find them, 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.

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But it also opened the door—or the heavens—to a whole new technology which we are now busily exploring in every detail.

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* * *

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*The definitions and derivation, plus further information on satellite transmission degradation due to rainfall, may be found in the Bell System Technical Journal, Vol. XLIV, No. 7, Sept., 1965, p. 1528, which is available in most scientific and engineering libraries.

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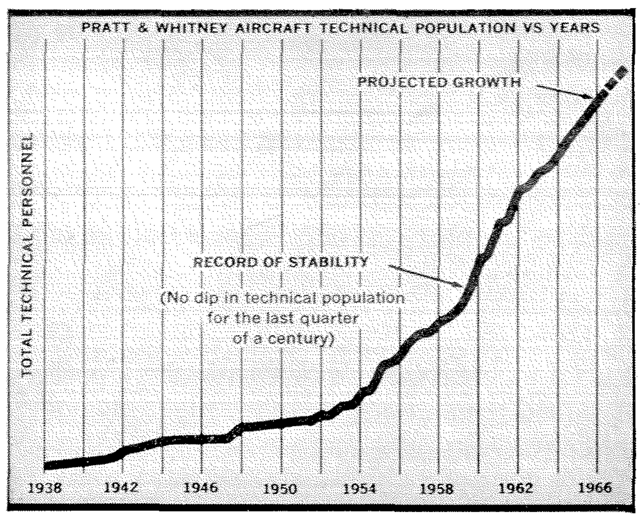

Take a look at the above chart; then a good long look at Pratt & Whitney Aircraft—where technical careers offer exciting growth, continuing challenge, and lasting stability—where engineers and scientists are recognized as the major reason for the Company's continued success.

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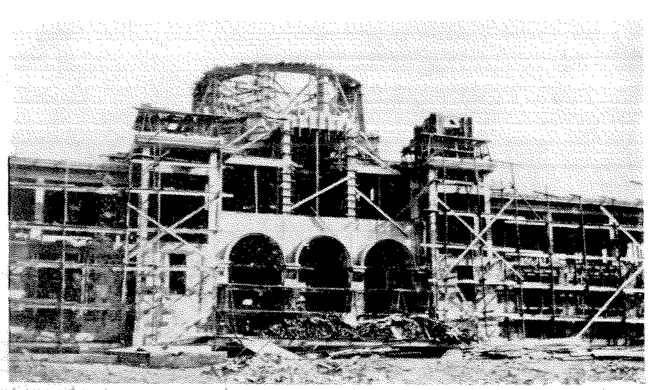
President Edwards was willing to see the Normal and Commercial schools go, but fought hard to save the Academy and the Grammar School. Arthur Chamberlain, dean of the Normal School, would sacrifice all schools except his own, which he envisioned as the future "Teachers' College of Columbia of the West." Both of these men later resigned in disappointment and bitterness as the schools they worked to save became casualties of Throop's gradual conversion into a college.

In April 1907 the trustees took their first official step toward college status when they voted "to make Throop Institute a high-grade technical school." Its first department was to be a college of electrical engineering. A month later they passed a motion that "the elementary school should be removed before next year." Two months later they appointed a new president, James A. B. Scherer, at a salary of $5,000.

George Ellery Hale was the moving spirit behind all this change. It was Hale who found Throop its new president. He met Scherer on shipboard when they were both on their way to Europe in the spring of 1907. Scherer, an ordained Lutheran minister, was at that time president of Newberry College in South Carolina. He was an authority on Japan, where he had served five years as a missionary. Following his missionary service, he became pastor of the First Lutheran Church in Charleston, South Carolina, and then president of the little Lutheran college in Newberry.

This was an improbable background for a president of a science and engineering college, but Hale recognized in Scherer other qualities to recommend him for the position. He was famous as the greatest orator in the South; he had been a successful fundraiser and builder during his administration at Newberry; and he was a promoter who was willing to take the tremendous gamble to "start all over." According to Hale's widow, Hale decided that since the first goal of the school was simply to survive, it would do well to have an aggressive young president like Scherer and to recruit outstanding engineers and scientists for the faculty.



Pasadena Hall (Throop) under construction in 1910.

Scherer was inaugurated on November 19, 1908. During the next two years, the Institute eliminated all schools except the Academy and the College. On the strong recommendation of President Scherer, the trustees decided to keep the Academy on a two-year trial basis. Their serious intention to continue the Academy is indicated by the fact that they commissioned Myron Hunt to build a student residence hall on the North Los Robles property that, before it was finished, cost $45,000. (This same building was later moved to the present campus and used as The Old Dorm and The Greasy Spoon until it was replaced by Winnett Center.)

But Throop Academy was doomed, for by 1911 there were 30 polytechnic high schools in southern California. The final blow came when Pasadena voted a $475,000 bond issue to establish a polytechnic high school of its own. On April 8, 1911, the board voted to discontinue the Academy.

Scherer sincerely believed in the pioneering development of a first-class college of science and engineering in burgeoning southern California, and he was challenged by the opportunity to help create "something entirely new in American education." "Here shall be a school," he wrote, "content with nothing lower than the best; resolved to set itself fixedly toward its ideas regardless of educational tradition when these might hamper its growth, yet eager to conserve whatever may help it forward in fulfillment of its destiny."

The proposed combining of the humanities with engineering and science was the theme of many of his public addresses. "You and I shall see it in our day," he said, "when Oxford shall shake hands with Pittsburgh."

In his first address to his faculty, he said, "It is the ambition of the government of Throop so to correlate and unify a course of study as to add, eventually, something new and vital to educational policies in America . . . It is hoped that every man in the faculty may have time for individual research. Throop will be measured in the educational world precisely as it succeeds or fails in this particular."

Architect Myron Hunt visited 25 American campuses before completing his plans for Throop's building program. On February 21, 1908, the *Los Angeles Times* reported: "Plans for an educational plant to cost between $2,000,000 and $3,000,000 and to surpass all existing institutions of the kind in the world will be submitted to the Trustees of

Throop Polytechnic Institute in Pasadena at a banquet tonight in Hotel Green . . ."

Hunt's master plans for the campus featured a central building. He had not only managed to save the 40 beautiful oak trees on the property but had featured them. He had placed the central building at the highest point and planned the grading to accentuate it. The proposed building was a handsome structure, facing a central mall running to Wilson Avenue.

By the fall, however, President Scherer had arrived, and he had very definite ideas of his own regarding the "Electrical and Central Building." There followed a long and sometimes bitter struggle between the brilliantly talented and temperamental young architect and the aggressively opinionated, and also temperamental, young president.

The compromise plans for the central building, as finally adopted by the trustees in 1909, were probably more Scherer than Hunt. Myron Hunt considered the building an architectural monstrosity, describing its style as "Newberry, plus the addition of a ridiculous, hard-to-reach tower room." The tower-room library, object of Myron Hunt's greatest scorn, "was modeled," President Scherer proudly reported, "after the Radcliffe Camera at Oxford University especially to accommodate the Library."

Though he had lost in the struggle for the adoption of his plans for the building, Myron Hunt did succeed in having the talented young sculptor, A. Sterling Calder, retained (at $3,500) to create "decorative sculpture" over the wide western front entrance to the building.

Three thousand people attended the dedication ceremonies for Pasadena Hall on June 8, 1910. The new building had been financed by prominent citizens of Pasadena, with Throop's trustees—notably Arthur Fleming—the major contributors. Fleming had also donated funds for the entire cost of the new campus. The consensus was that Pasadena Hall was the most beautiful building on the Pacific Coast. "The building is wonderful," reported the *Los Angeles Daily News.* "There are 62 large class and lecture rooms, with offices adjoining them."

Throop Institute, now a college exclusively, opened on its new campus on Wednesday, September 21, 1910. Less than six months later, however, the Institute faced one of the greatest crises in its early years. The morning papers of January 29, 1911, reported that the California State Legislature, then in session, would in all probability establish in or near Los Angeles an institute of technology modeled after MIT. The new university would have an immediate appropriation of a million dollars in addi-

continued on page 26

tion to large gifts of real estate already assured from local citizens.

This was alarming news to the young and struggling Throop, which could ill afford competition for both faculty and students with a tax-supported and tuition-free college of engineering and science in southern California. In an emergency meeting held that evening, the board of trustees authorized President Scherer to offer Throop to the state as the "proper foundation for the new school," if agreement could be reached on its administration and the protection of its high standards.

Scherer acted swiftly and effectively. On the following day, newspaper accounts reported both Mark Keppel's Senate Bill 921, "to set up the California Institute of Technology to be located in or near Los Angeles," and Scherer's proposal "for the state to take over Throop." On the same day, Scherer met with a group of southern California leaders, who enthusiastically endorsed the Throop plan. With this backing, he hurried to Sacramento where he persuaded Mark Keppel, superintendent of the Los Angeles County Schools, and the southern California legislators to meet on February 4 with Throop trustees and local leaders to discuss a substitute measure.

The new bill, drawn up by Keppel and Scherer and unanimously approved at the February 4 meeting, was presented to the state legislature on February 7. Scherer worked hard to gain public and official support for the substitute act. He wooed—and thought he had won—the support of Berkeley's President Benjamin Ide Wheeler and Stanford's David Starr Jordan. He prepared a pamphlet, *Hard Facts,* about "the California Institute of Technology now known as Throop Polytechnic Institute," and had it distributed to the state legislators and the press. He became an effective lobbyist, as did faculty members Clinton Judy and Royal Sorensen, who appeared with him at the hearings in Sacramento.

The bill was enthusiastically supported in southern California. But strong opposition was gathering in the north, for neither the regents, the administration, nor the alumni of the University of California liked the idea of a competing school in southern California. When an attempt to amend the bill in such a way as to put the new school under the university board of regents was firmly rejected by Scherer and the Throop trustees, Berkeley's President Wheeler appeared in Sacramento at a hearing of the education committee to oppose it.

In a brave attempt to dispel opposition at its source, Scherer asked for, and was granted, permission to explain the bill at an assembly on the Berkeley campus. An inspired speaker, he was warmly applauded by the students. But the university forces were squaring off for battle. The San Francisco alumni organized in opposition to the bill, and more than a thousand Berkeley students attended a mass protest meeting in the Greek Theater.

The Southern California Alumni Association strongly opposed the stand of the alumni association of Berkeley: "We urge the Throop Bill . . . The demand for greater educational facilities in this portion of the State is so insistent that if not met now, public opinion, which is now friendly to our great university, will accept your gage of battle, fight for, and get two."

Scherer received many offers of support from the legislators, he later reported to the Throop trustees, if "we would either surrender the control of the Institute to the Regents of the University of California, or consent to a lowering of our standards."

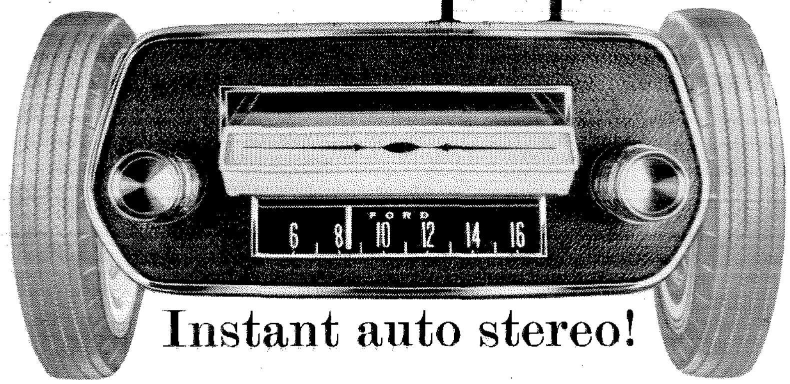
The measure was finally voted down on March 11, 1911, by the narrow margin of 24 to 21. Although its supporters felt they could round up enough votes to pass a motion for reconsideration, the Throop trustees had had quite enough, and they wired President Scherer to withdraw the offer.

The "Sacramento Episode," distressing as it was at the time, resulted in incalculable gains both to the Institute and to President Scherer personally. Publicity, not only statewide but national in scope, accomplished in a month or so what otherwise might have taken years. Throop Institute suddenly became well known; Scherer was acclaimed in the local press as "hero of the struggle" to obtain a state university for southern California. Throop received a further endowment of $250,000 shortly after the affair, and by the June 2, 1912, commencement, Scherer was able to announce that "all debts were cancelled."

Throop's most urgent needs at the end of the period 1907-1913 were "the very great need for an increased endowment" and for two new buildings, a chemistry building and a central library, for Pasadena Hall was bursting at the seams.

These were the transition years when Throop established itself as a college. When it opened on the new campus in 1910, it had an undergraduate enrollment of 31 students, of whom 15 were freshmen, carefully selected out of the 33 who had applied for admission. By 1913, the enrollment had increased to 51. On April 30, 1913, the trustees voted to change the name of Throop Polytechnic Institute to Throop College of Technology.

snap! concert! pop!



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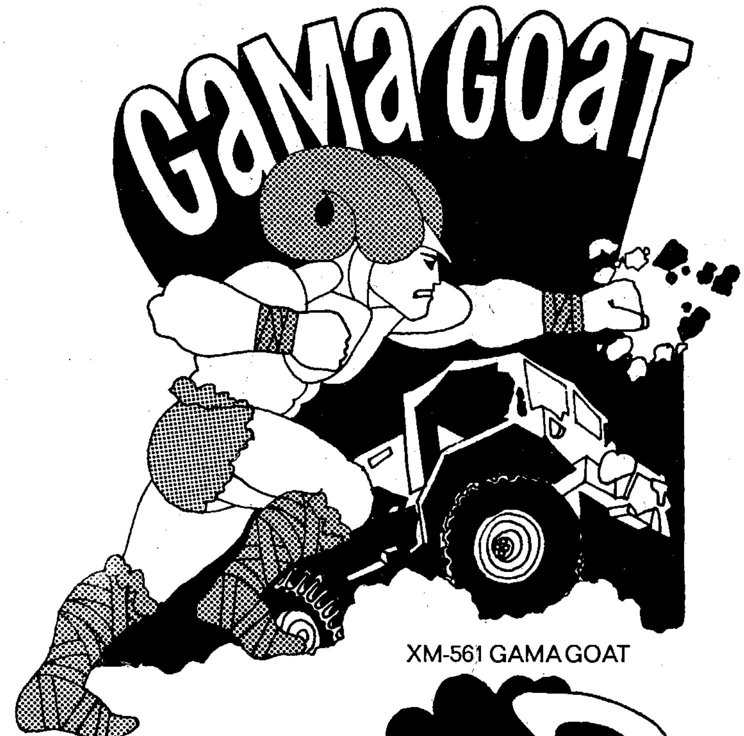

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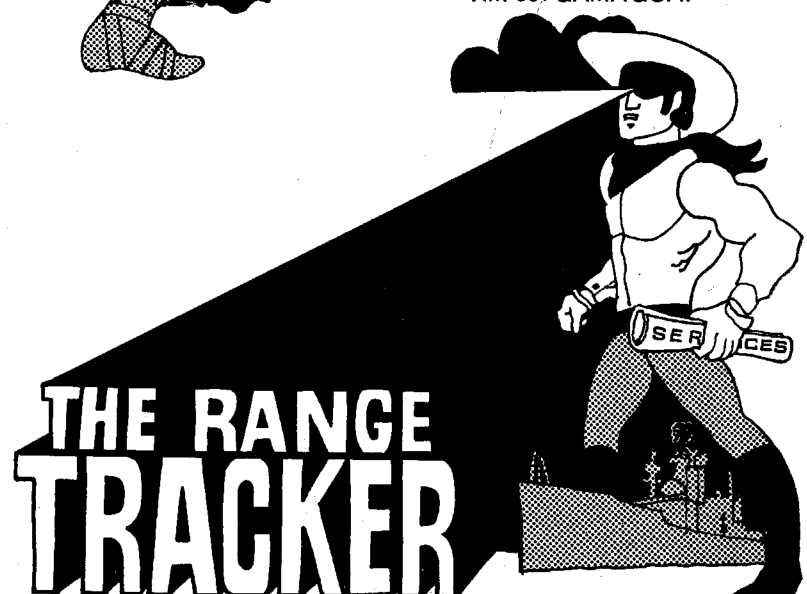

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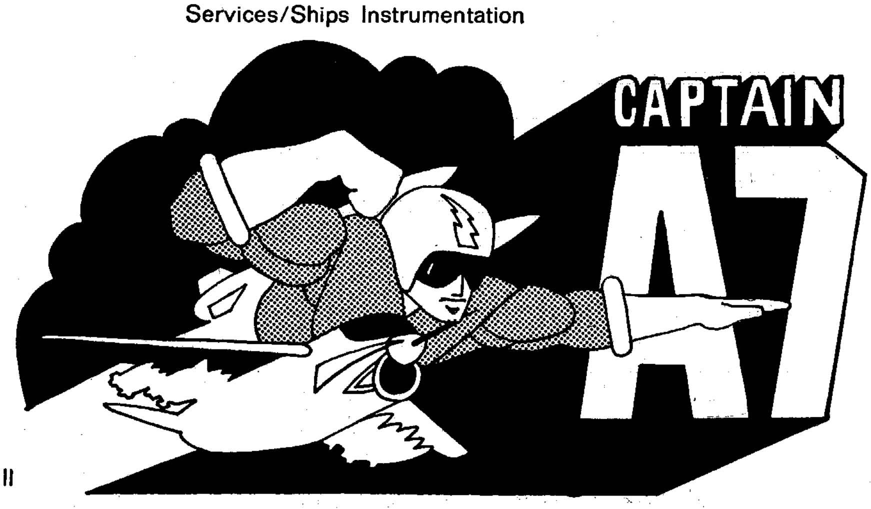

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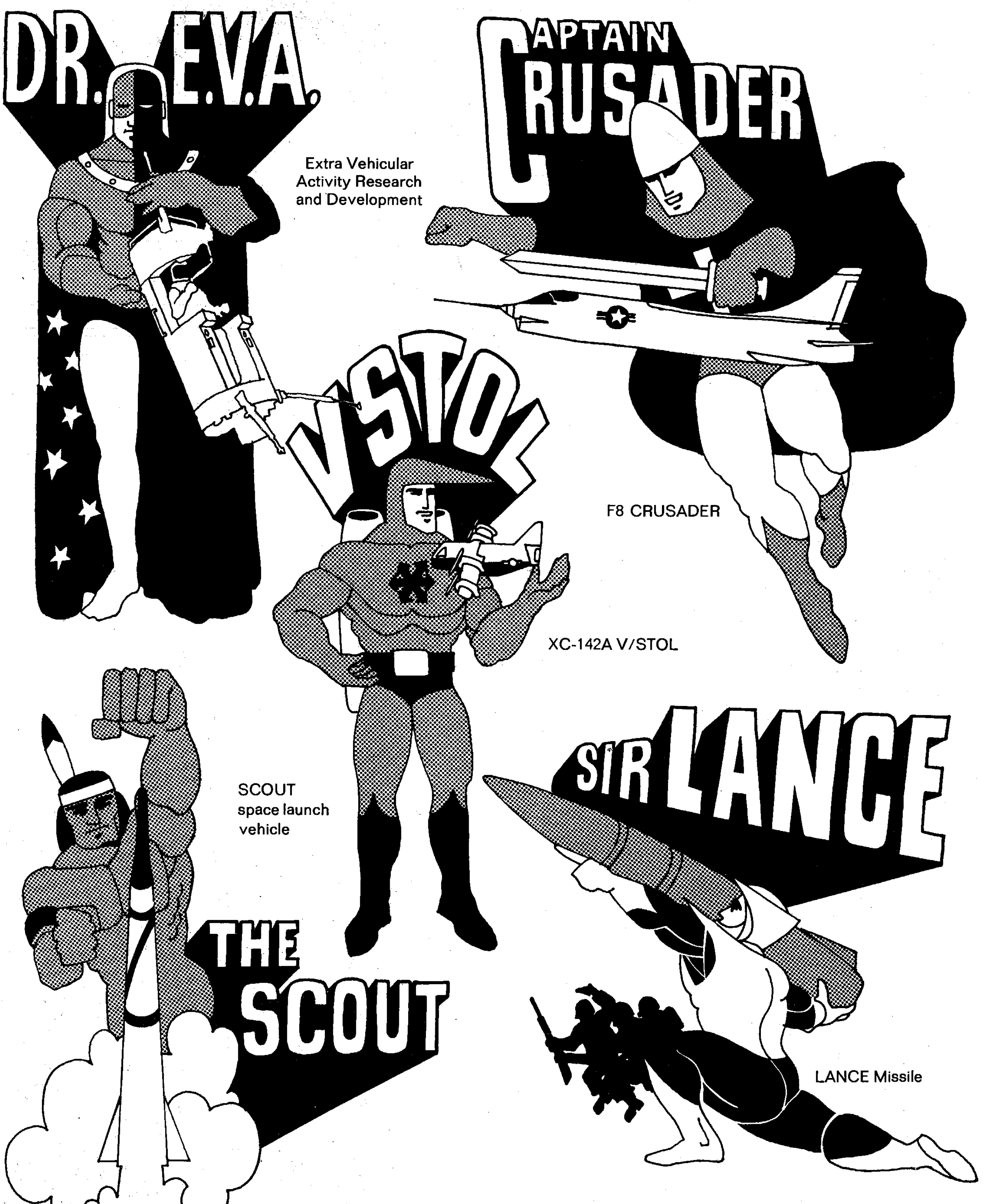
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Extra Vehicular Activity Research and Development
CAPTAIN CRUSADER
F8 CRUSADER
VSTOL
XC-142A V/STOL
SCOUT space launch vehicle
THE SCOUT
SIR LANCE
LANCE Missile

OUR CHEAPEST SOURCE OF ADDITIONAL WATER

by Jack E. McKee

Even before the turn of the century southern California planners recognized that local water supplies would be insufficient to support the expected population of the area. To supplement the limited local supply, which might be adequate for no more than a few hundred thousand people, they went first to the Owens Valley (in 1907), then to the Colorado River (in 1939), and are now going to northern California and to demineralization of sea water.

Because each new attempt to get additional water results in more expense, it is surprising that so little attention has been paid to another, very economical source: re-use of that imported water we have paid so much to get. We have become accustomed to discharging once-used water into the ocean, but there is good evidence that this is a needless waste of a precious commodity.

For use in an urban environment, water must be adequate in quantity and potable in quality. The water supply system should be so reliable that it will not be disrupted for more than a few days by earthquakes, floods, power outages, or even acts of war. Preferably there should be multiple sources of supply, and they should originate as close to the area as possible. The water system of Berlin, for example, could not be destroyed by Allied bombing in World War II because it comprised hundreds of wells within the city limits. Even during the Berlin blockade of 1949 the Russians could not shut off the water supply. How many large American cities could retain their sources of water when surrounded by hostile forces? In assessing alternative sources of supply, it behooves us to give strong weight to reliability in both peace and war.

Potability of water in the United States is judged largely by the United States Public Health Service Drinking Water Standards of 1962, which have been adopted by, and are generally enforced by, the various state and local health departments. Some of these standards are mandatory; others are non-mandatory but strongly recommended. Where alternative supplies of better quality are not economically available, water that exceeds one or more of the recommended limits may be utilized. In 1965, for example, raw Colorado River water contained an average of 712 milligrams per liter of total dissolved solids (vs a USPHS recommended limit of 500 mg/1) and a sulfate concentration of 306 mg/1 (vs 250 mg/1 recommended). Yet, as we all know, Colorado River water is accepted and used thankfully by millions of residents of southern California, with no apparent detrimental effects. Some local water supplies, such as Ventura's, which contains over 1,200 mg/1 of total dissolved solids, appear to be more than adequate for municipal needs.

In addition to ample quantity, firm reliability, and healthful potability, a water supply should also be economic. Despite the fact that water is, by far, our cheapest domestic commodity (it is delivered to our taps for less than 10 cents per metric ton), the total cost of water for a large metropolitan area is enormous because we use and need so much of it. Given a choice of alternative supplies, we should naturally favor the least costly source, within the parameters of reliability and potability. But this choice brings up the question of how much economic value can be placed on better quality and improved reliability. In 1963, for example, a report to the San Diego County Water Authority by a group of consulting engineers indicated that the hardness and dissolved solids in Colorado River water (as compared with purer, northern California water) would cost the users an additional $23 per 1,000 cubic meters over the base cost. Hence, quality as well as quantity must be considered in comparing the total costs of alternative supplies.

The dynamics of a water system can be repre-

continued on page 34

Dr. McKee is professor of environmental health engineering in Caltech's Keck Engineering Laboratories. His article has been adapted from a talk given to the annual meeting of the Los Angeles section of the American Society of Civil Engineers on October 12, 1966.

HOWARD HUGHES DOCTORAL FELLOWSHIPS. Applications for the Howard Hughes Doctoral Fellowships in engineering, physics, or mathematics are now available for the academic year beginning in Autumn 1967.

The program offers the qualified candidate an outstanding opportunity for study and research at a selected university, plus professional industrial summer experience at a Hughes facility. Each Doctoral Fellowship includes tuition, books and thesis preparation expenses, plus stipend ranging from $2,200 to $3,100, depending upon the Program year and the number of candidate's dependents. Full salary is paid the Fellow during his summer work at Hughes. Salaries are reviewed periodically and increased with the growth of the individual. Fellowships are awarded to outstanding students who have completed a master's degree (or equivalent) and have been accepted as a candidate for the doctoral degree.

HUGHES MASTERS FELLOWSHIPS. Approximately 100 new awards for '67-'68 are available to qualified applicants with a baccalaureate degree in engineering, mathematics or physics. Most of these awards are Work-Study Fellowships; a very limited number are Full-Study. Upon completion of the Masters Program, Fellows are eligible to apply for and are given special consideration for a Hughes Doctoral Fellowship.

Fellows who associate with a Company facility in the Los Angeles area usually attend the University of Southern California or the University of California, Los Angeles. Tuition, books and other academic expenses are paid by the Company, plus a stipend ranging from $500 to $850 for the academic year. A significant advantage offered by the Work-Study Program is the opportunity to acquire professional experience working with highly competent engineers and scientists while pursuing the M.S. degree. Selected Fellows have the option to work in several different assignments during the Fellowship period to help them decide on their field of concentration and optimum work assignment.

Fellows earn full salary during the summer and pro-rata salary for 24 hours work a week during the academic year. The combined salary and stipend enables Fellow to enjoy an income in excess of $6,500 per year during his two years as a Work-Study Fellow. Salaries are increased commensurate with professional growth and Fellows are eligible for regular Company benefits.

Work assignments are matched closely to the Fellow's interests. Primary emphasis at Hughes is research and development in the field of electronics for application to defense systems and space technology. Fields of interest include stability and trajectory analysis, energy conversion, structural design and analysis — computer and reliability technology, circuit and information theory, plasma electronics, microminiaturization, and human factor analysis — research, development and product design on such devices as parametric amplifiers, masers and lasers, microwave tubes, antenna arrays, electron-tube and solid-state displays, and components — design analysis, integration and testing of space and airborne missile and vehicle systems, infrared search and tracking systems, and computer, data processing and display systems — theoretical and experimental work in solid-state and ion physics.

Citizenship: American citizenship and eligibility for security clearance are required.

Closing date for all applications: Early application is advisable. All materials should be postmarked not later than February 1 for the Doctoral Fellowships, and March 1 for the Masters Fellowships.

How to apply: To apply for either the Doctoral or Masters Fellowship, write to: Mr. James C. Cox, Manager, Personnel Administration — Corporate Industrial Relations, Hughes Aircraft Company, P.O. Box 90515, Los Angeles, California 90009.

Hughes Fellowship Programs

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sented by the simple "water equation," which says that over a long period of time, such as several decades, the output must equal the input, or for shorter time intervals, such as a year:

$$\text{Output} = \text{input} \pm \text{change in storage.}$$

This equation relates not only to quantity but also to quality, not only to volumes of water in cubic meters but also to weights of solids in kilograms or metric tons. Over an extended period of time, the simple form of the equation for any area, urban or rural, must be in balance.

If the output or usage exceeds the input for many years with respect to water volume, a drought or acute water shortage is inevitable. Conversely, if the input of dissolved salts in the water supply and the additions of solids from the use of such water exceed the weight in the output, salts and other solids will accumulate in the environmental system. This problem has been especially acute in many areas of irrigated agriculture. It may also become severe in urban environments if adequate measures are not taken to remove or minimize liquid wastes.

In the water equation for the coastal basin of southern California a large part of the total input comes from rainfall, and, similarly, a substantial portion of the output occurs as evaporation and transpiration. Some of the output is attributable to surface runoff, ground-water seepage, and possibly some deep percolation, but the major avenue of output in addition to evaporation and transpiration is discharge of waste water to the ocean.

Requirements for waste water disposal to the ocean or at inland locations are predicated on the subsequent beneficial uses of the receiving waters. Such discharges are subject to careful supervision by the California Regional Water Quality Control Boards. A primary factor in the various requirements promulgated by the Regional Boards is protection of human health and public water supplies. Consideration is also given to the preservation of aquatic and marine life; to the quality of water needed for irrigation and industrial purposes; and to esthetic factors related to bathing, boating, and other water sports. Within the constraints and boundary conditions that result from the requirements of the Regional Boards to protect beneficial uses of the receiving waters, recognition must be given also to economic factors, because waste disposal (like water supply) is a costly undertaking.

How much water is needed?

In the coastal basin of southern California it is estimated that an ultimate mixed agricultural, residential, business, commercial, and industrial economy will have a net annual water requirement (in addition to rainfall) of about 700 mm or 0.7 of a meter. For an ultimate habitable and useful area of about 1,100,000 hectares, the total ultimate water requirement will be 7.7 cubic kilometers per year.

The present sources of local and imported water supply provide a safe yearly yield of 3.3 cubic kilometers (assuming full use of the original Colorado

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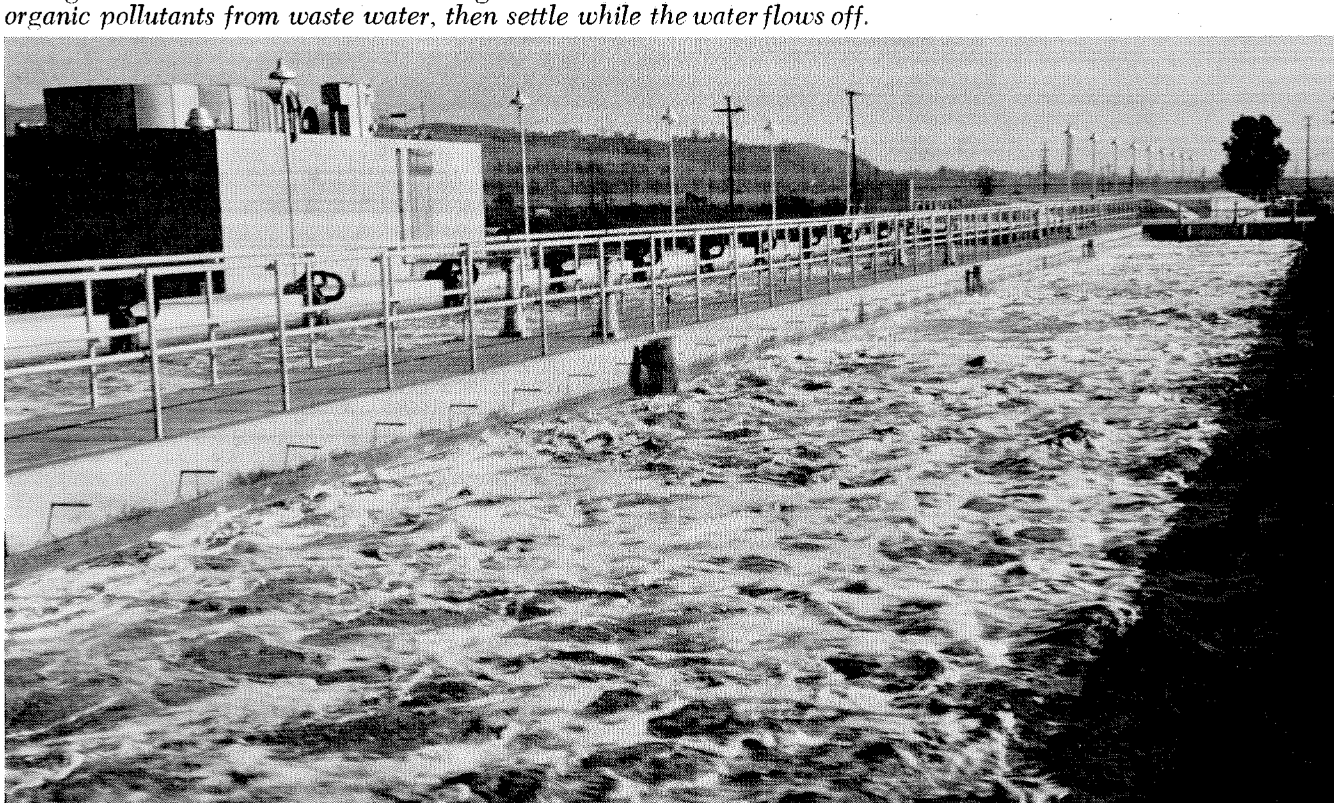
Biological cultures in this activated-sludge aeration tank at Whittier Narrows Water Reclamation Plant remove organic pollutants from waste water, then settle while the water flows off.



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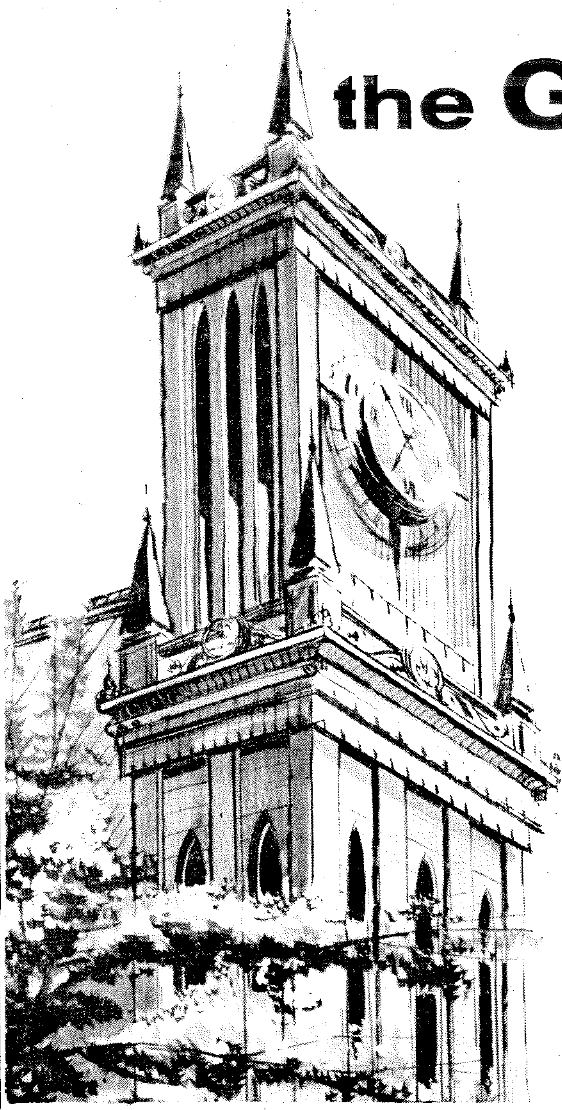

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River entitlement) and the new aqueduct from northern California will provide about 2.7 cubic kilometers, giving a total water supply potential of 6.0 cubic kilometers, or 1.7 cubic kilometers short of the ultimate yearly requirement. It is not too early for us to look for ways to augment the present supplies and to provide insurance, through a diversity of sources, to protect against acts of nature or war.

The discharge of municipal waste water and fresh liquid industrial effluents to the ocean in southern California totalled approximately 1.2 cubic kilometers in 1965, or about 35 percent of the total fresh water used in the basin. Furthermore, ocean discharge amounted to more than 55 percent of the total importation through the Colorado and Owens aqueducts. It is logical, therefore, that we should inquire into the rationale of importing water 400 to 700 kilometers, or even further under the California Water Plan, using it once, and then discharging it, still fresh, to the ocean. Reclamation of some of this water would help to meet the ultimate water requirements of this region.

The chemical, physical, and biological quality of municipal waste water depends on the mineral content of the originating water supply and the substances added by municipal use, most of which can be removed by conventional activated-sludge treatment (where organic pollutants are adsorbed and utilized by biological cultures, which are then easily separated from the water). The water from the activated-sludge plants at Hyperion and Whittier Narrows, for example, meets all of the specific mineral standards of the USPHS (both mandatory and recommended); it exceeds some other drinking water standards, but they can be met by various secondary treatments.

Underground water storage

Los Angeles, Orange, San Bernardino, Riverside, and Ventura Counties are fortunate, indeed, to have voluminous ground-water basins. San Diego County, on the other hand, has only a few very small underground basins. It is estimated that the storage capacity of ground-water basins in the south coastal area, in a depth of about three meters above and below the present water tables, amounts to about 60 cubic kilometers, or about an eight-year supply of water at the ultimate demand. Hence, these ground-water basins represent a tremendous economic asset in being able to provide voluminous storage close to the area of use. Furthermore, they serve as insurance against disruptions of the imported supplies.

Ground-water basins can serve another important function in the water equation for southern California. The passage of water through soil is one of the most effective and economical purifying mechanisms known to man. Research by the City of Los Angeles, the Los Angeles County Flood Control District, and Caltech has demonstrated conclusively that Hyperion effluent can be purified by filtration and chlorination for injection into confined aquifers with no hazard to health and with replenishment of potable ground-water reserves. Additional research at Whittier Narrows by Los Angeles County Sanitation Districts, the Los Angeles County Flood Control District, and Caltech has shown that normal activated-sludge effluent water can be percolated intermittently into unconfined aquifers for the effective and safe recharge of ground-water basins.

Europeans, and especially Germans, are far ahead of us in utilizing soil for the purification of water. Indeed, there are very few municipal water supplies in Germany that do not involve some type of ground-water travel. Germans don't believe that any water is fit to drink if it hasn't passed through soil. Near Dortmund, for example, water from the Ruhr River, heavily polluted with municipal and industrial wastes, is diverted into a series of spreading basins, percolated through soil, and collected by infiltration galleries for pumping to the city. In West Berlin, polluted water from the River Spree is passed through a microstrainer, diverted through a tortuous channel filled with bullrushes, then percolated through spreading basins into the sandy soil. The spreading basins are ringed by scores of shallow wells from which the water is pumped into a treatment plant for the removal of iron and manganese and thence to the municipal distribution system.

There is no question that intermittent percolation and even saturated flow of water through soil are generally efficacious in the improvement and stabilization of water quality through the mechanisms of filtration, adsorption, biodegradation, and ion exchange. In some soils and underground formations, however, flowing water may pick up undesirable constituents such as iron, manganese, and sulfides; but these impurities can readily be removed by topside treatment processes. It must be recognized, parenthetically, that travel through soil does not decrease the total dissolved solids and in some cases may increase them slightly. A major advantage of

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water reclamation through ground-water recharge is the fact that such water loses its identity and blends with natural ground water.

Not all of the municipal and industrial waste waters of the south coastal basin are amenable to reclamation by ground-water recharge. In some areas total dissolved solids are excessive because of brines from oil production or seawater infiltration or the regeneration of ion-exchange resins. In other regions, industrial processes discharge chromates, borates, fluorides, and other minerals that are difficult to remove by treatment processes and that travel through the soil with little or no change.

It has been estimated by the California Department of Water Resources, and others, that about half of the present municipal waste water in the south coastal basin is suitable in quality for reclamation by ground-water recharge. Hence, the safe yearly yield of ground-water basins could be increased by about 0.6 of a cubic kilometer, based on the present water equation. In the future, when the full quota of northern California water is being used, the total quantity of waste water may be expected to increase to about 2.8 cubic kilometers, of which about 60 percent, or 1.7 cubic kilometers could be reclaimed. This increment should be sufficient to meet southern California's ultimate water requirement.

What will it cost?

How much will renovated water cost in comparison with alternative sources of suppy? True cost figures are difficult to ascertain, not so much for waste-water reclamation as for the present and planned future sources. True total cost figures include bond redemption over a reasonable period, interest on outstanding indebtedness at prevailing rates, operation and maintenance, power, and insurance. For any year, the actual cost of water is the total outlay for all expenses divided by the total volume of water produced. Digging out such figures is difficult indeed.

Estimated Total Costs for Water

Source	Approximate Cost ($ per 1,000 cubic meters)
Local run-off and ground water	3 - 10
Owens Aqueduct	15 - 20
Colorado River Aqueduct	28 - 45
California Water Plan	60 - 160
Sea water demineralization	85 - 170
Reclaimed water (including subsequent repumping)	20 - 30

The price charged by the Metropolitan Water District for Colorado River water is increasing. For the present fiscal year it varies from $13.80 per 1,000 cubic meters for untreated water used for agriculture or replenishment, to $32.40 for softened and filtered water for municipal use. In addition, however, the Metropolitan Water District receives revenue from taxes levied against member agencies. The true total cost is presently about $36 per 1,000 cubic meters, but it may vary between $28 and $45.

To determine the true total cost of water from northern California is almost impossible. Initially this water will probably cost in excess of $160 per 1,000 cubic meters, but after deliveries approach the full capacity of the system, total costs may drop as low as $60.

The demineralization of sea water in presently operating plants costs in excess of $300 per 1,000 cubic meters. A large plant proposed by the Metropolitan Water District in conjunction with nuclear power production is expected to lower this cost to $57 at sea level or about $70 at the Diemer filtration plant. These figures, however, are based on charging all possible costs against electric power production and amortization of capital costs at 3.5 percent interest for 30 years. With more equitable allocation of costs, with realistic interest rates, and with recognition that mechanical equipment of this type will be obsolescent in 20 years or less, the true cost of demineralization will range from $85 to $170 per 1,000 cubic meters.

For waste-water reclamation, true total cost data are more realistic and better documented. Total costs at the Whittier Narrows Water Reclamation Plant run about $12 per 1,000 cubic meters, and the total cost of spreading for ground-water recharge is about $4. To this expense should be added about $4 for repumping into a water system, or a total of $20. Rendering Hyperion effluent suitable for ground-water injection is estimated at $20, to which $8 should be added for actual injection and subsequent repumping, or $28 per 1,000 cubic meters for the true total cost of this water supply.

It is apparent, therefore, that the true total cost of potable good-quality water reclaimed from waste water is slightly cheaper than Colorado River water and considerably less costly than northern California or demineralized sea water. Moreover, with more than 25 percent of the imported water recoverable through ground-water recharging, southern California's foreseeable water needs can be met with existing (including northern California water) facilities.

PERSONALS

1919

EDWARD T. VAN DEUSEN died September 9 in San Diego, following a long illness. He was 69. In 1947 he retired from the insurance business in Los Angeles to live on his mountain ranch near Julian. Van Deusen was one of the 100 qualified Marine flyers in World War I, and became a flight instructor during World War II. He is survived by his wife, Paulina, a daughter, and four grandchildren.

1920

MARK A. SAWYER died in June after a long illness. He lived in Laguna Beach, where he retired in 1961 after a 40-year career with the Pacific Telephone and Telegraph Company. Sawyer, who was protection engineer at the time of his retirement, had for many years been active in the American Institute of Electrical Engineers. He leaves his wife, Ruth, and one son.

1926

JEN-CHIEH HUANG writes that he had "the great fortune" to be back on the Caltech campus last August after 40 years. Huang is president of the China Merchants Steam Navigation Corp. in Taipei, Formosa, and has a daughter majoring in physics at Tunghai University in Taiwan.

1927

MARSHALL A. BALDWIN sends word that he will retire this month from the Standard Oil Company of California, after 38 years with the organization. He began as cost analyst at the Richmond, Calif., refinery and retires from his position as benefits advisor in the personnel department. Baldwin and his wife plan to travel and, he reports, to attend the 40th class reunion at Caltech next June.

1928

CHARLES F. LEWIS, who has been chief metallurgist for the Cook Heat Treating Co. in Houston since 1936, has been installed as a trustee of the American Society for Metals. In 1964 he was cited by the society as "Texas Metals Man-of-the-Year" in recognition of his leadership in the city's metalworking community, his outstanding contributions to education, and his participation in ASM since 1929.

1929

JAMES C. SCULLIN died on September 12 in Glendale at the age of 59. He was president and owner of the Cardinal Machine Company, which he started 30 years ago. Scullin began his career as a design engineer with the Hughes Tool Co. and became head of the New Departure Bearing Company's southern California division before forming his own company. He leaves his wife, Beatrice, two sons, a daughter, and three grandchildren.

1932

J. WILFRED PATTERSON, PhD, died on September 25 at the Palo Alto-Stanford Hospital. A self-employed consulting engineer, he had lived on the peninsula for the past 16 years. He is survived by his wife, Helene, a son, two daughters, and five grandchildren.

JOSHUA L. SOSKE, MS, PhD, '35, executive head of the department of geophysics at Stanford, died on October 18 after a brief illness. An internationally known consulting geophysicist, Soske had been at Stanford since 1951. From 1935 to 1951 he was president and chief geophysicist for the Geophysical Engineering Corp. in Pasadena and had been on the Caltech faculty before that time. He had also served as a professional advisor to the Philippine government, oil companies, research laboratories, and engineering firms. Soske is survived by his wife, Helga, three daughters, and two sons.

JAMES C. MOUZON, PhD, professor and director of the college of engineering Brazilian program at the University of Michigan, recently received an honorary doctor of science degree from Southern Methodist University—one of 14 alumni to be so honored at the school's 50th anniversary celebration. Mouzon has been at Michigan since 1957, served as associate dean of engineering from 1960 to 1966, and was director of the Ford Foundation-sponsored engineering faculty development program.

1933

DONALD F. POULSON, PhD '36, is on sabbatical leave from Yale University and will be in Canberra, Australia, conducting research on physiological genetics of Drosophila at the Institute of Entomology, CSIRO. He plans to return to New Haven in September 1967.

WILLIAM W. MOORE, MS '34, senior consulting partner in the San Francisco office of Dames & Moore, has been elected to the board of direction of the American Society of Civil Engineers representing southwestern United States and Hawaii.

1935

NORWOOD L. SIMMONS JR., MS, has been appointed manager of product planning for the Eastman Kodak Company's motion picture and education markets division in Rochester. He has been with Kodak since 1937, most recently as marketing director of the New York City region. Simmons, his wife, Helen, and their five children have moved to Rochester.

1938

MUNSON W. DODD, MS '46, who has been an engineer with the Metropolitan Water District of southern California since 1946, has been named principal engineer for the civil and structural sections.

1942

EVERETT P. TOMLINSON, PhD, a member of the research staff of the Forrestal Research Center in Princeton, N.J., represented Caltech in the academic procession of the 200th anniversary convocation of Rutgers University in New Brunswick on September 22.

1943

NORMAN NEWSOME JR., MS, has been named advisor to the operations manager of Esso Exploration, Inc., in New York City. He and his wife and five children have moved from New Orleans, where he has been production engineer for the Humble Oil & Refining Company. Both organizations are affiliates of the Standard Oil Company of New Jersey, for which Newsome has worked since 1946.

1944

ALFRED G. KNUDSON JR., MD, PhD '56, has been selected as a professor of medicine and a member of the planning team for the new $161 million Stony Brook Medical Center on Long Island, N.Y. He will be involved in the basic academic planning that will determine the direction of the program and character of the facilities of the center, and will teach the basic life sciences to graduate students when the center begins its programs in the early 1970's. Knudson was formerly chairman of the department of biology at the City of Hope Medical Center in Duarte, Calif.

ROBERT NAHAS, president of the Peralta Land Company in Castro Valley, Calif., has been praised for his part in the new $30 million Coliseum project in Oakland by *The Sporting News*, October 1, 1966, "If you had to limit credit for the . . . Coliseum to one man you doubtless would settle on Coliseum, Inc.'s president, Robert T. Nahas."

TEDDY F. WALKOWICZ, MS, an associate of the Rockefeller Family & Associates of New York City, has been elected a director of the Cerro Corporation in New York City.

1945

MARK M. MACOMBER, a commander in the U.S. Navy, writes that he received his PhD in June from Ohio State University in Columbus. He was assigned to the surveys and basic data office of the Defense Intelligence Agency, Mapping, Charting, and Geodesy Directorate in Washington, D.C. The Macombers have two sons and a daughter.

1947

FRANK R. BOWERMAN, MS '48, has joined the Aerojet-General Corporation as assistant to the vice president–development. He was formerly assistant chief engineer for the Los Angeles County Sanitation districts and 1965 winner of the American Public Works Association award for noteworthy achievements in sanitation.

JERRY DONAHUE, PhD, has been appointed professor of chemistry at the University of Pennsylvania. He goes to Philadelphia from the University of Southern California, where he has been chairman of the department of chemistry since 1963 *and on the faculty* since *1953.*

1948

MAX GARBER has been elected vice president, marketing, at Huggins Laboratories, Inc. in Sunnyvale, Calif. He has been director of marketing for the company. Garber and his wife, Lorraine, and their two daughters live in Sunnyvale.

1949

DANIEL T. FINKBEINER II, PhD, chairman of the department of mathematics at Kenyon College in Ohio, was recently guest speaker for a mathematics colloquium at Miami University in Oxford. Ohio. Finkbeiner has been on the Kenyon faculty since 1951 and before that taught at Yale. He is vice chairman of the Ohio section of the Mathematical Association of America.

HARRY GRUENBERG, PhD, is in Denmark at the Laboratory of Electromagnetics Theory (associated with the Technical University of Denmark) on a Fulbright research grant. He and his wife plan to return to Syracuse, N.Y., next June.

1951

RAYMOND A. SJODIN, MD, a member of the faculty of the University of Maryland's School of Medicine, has recently been promoted to professor of biophysics. Sjodin is responsible for the discovery of basic mechanisms underlying the electrical activity of nerve and muscle cells.

continued on page 43

Address Unknown

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

1906
Norton, Frank E.

1907
Miller, James C., Jr.

1911
Lewis, Stanley M.

1920
Suman, George O., Sr.

1921
Arnold, Jesse

1922
Cox, Edwin P.

1923
Neil, W. Harvey
Skinner, Richmond H.

1924
Carr, John
Henderson, William G.
Lovering, Frank R.
Tracy, Willard H.
Waldo, Cornelius T.
Young, David R.

1925
Waller, Conrad J.
Winckel, Edmond E.

1926
Chang, Hung-Yuan
Chase, Carl T.
Huang, Y. H.
Yang, Kai Jin

1927
Evjen, Haakon M.
Hall, Ray I.
Marsland, John E.
Moore, Bernard N.
Peterson, Frank F.

1928
Chou, P'ei-Yuan
Martin, Francis C.
Thacker, Ralph S.
Wingfield, Baker

1929
Briggs, Thomas H., Jr.
Burns, Martin C.
Espinosa, Julius Nelson
also known as:
Nelson, Julius
Lynn, Laurence E.
Robinson, True W.
Sandberg, Edward C.
Wolfe, Karl M.

1930
Allison, Donald K.
Chao, Chung-Yao
Kelley, William
Moyers, Frank N.
White, Dudley

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

1932
Schroder, L. D.

1933
Downie, Arthur J.
Koch, A. Arthur
Larsen, William A.
Michal, Edwin B.
Murdock, Keith A.
Plank, Dick A.
Rice, Winston R.
Shappell, Maple D.
Smith, Warren H.

1934
Bridget, Francis J.
Harshberger, John D.
Jerome, Clayton C.
Liu, Yun Pu
Moore, Morton E.
Sargent, Marston C.

1935
Bertram, Edward A.
Huang, Fun-Chang
Mathews, E. S.
McNeal, Don
Ricketts, Donald H.

1936
Chu, Djen-Yuen
Meng, Chao-Ying
Ohashi, George Y.
Tan, Chia-chen
Van Riper, Dale H.
Young, Larry L.

1937
Burnight, Thomas R.
Cheng, Ju-Yung
Easton, Anthony
Fan, Hsu Tsi
Jones, Paul F.
Lotzkar, Harry
Maginnis, Jack
Munier, Alfred E.
Nojima, Noble
Odell, Raymond H.
Servet, Abdurahim
Shaw, Thomas N.

1938
Goodman, Hyman D.
Gross, Arthur G.
Gutierrez, Arnulfo G.
Kanemitsu, Sunao
Li, Yuan-Chen
Lowe, Frank C.
Osborn, George H.
Rhett, William
Rynearson, Garn A.
Tsao, Chi-Cheng
Wang, Tsun-Kuei
Watson, James W.
Woodbury, William W.

1939
Aime, Edgar A.
Burns, Martin C.
Green, William M.
Griffiths, John R.
Liang, Carr Chia-Chang
Weinstein, Joseph
Wilson, Harry D.

1940
Batu, Buhtar
Baumgarten, Erwin
Compton, Arthur M.
Dilworth, John A.
Gentner, William E.
Gibson, Arville C.
Green, William J.
Hsu, Chang-Pen
Karubian, Ruhollah Y.
King, James L.
Lovoff, Adolph
Menis, Luigi
Tao, Shih Chen
Torrey, Preston C.
Wang, Tsung-Su

1941
Chang, Chieh-Chien
Clark, Morris R.
Dieter, Darrell W.
Easley, Samuel J.
Geitz, Robert C.
Hardenbergh, George A.
Harvey, Donald L.
Helmick, Benjamin W.
Hubbard, Jack M.
Kuo, I. Cheng
Levitt, Leo C.
Nicholson, George H.
Robinson, Frederick G.
Standridge, Clyde T.
Vaughn, Richard
Wolfe, Samuel
Yui, En-Ying

1942
Bebe, Mehmet F.
Devault, Robert T.
Drake, John A.
Emre, Orhan M.
Given, Frank I.
Go, Chong-Hu
Ip, Ching-U
Johnston, William C.
Latter, Richard
Levin, Daniel
Martinez, Victor H.
Rhyne, Russell F.
Schauer, Eric H.

1943
Angel, Edgar P.
Brown, James M.
Bryant, Eschol A.
Burlington, William J.
Colvin, James H.
Eaton, Warren V., Jr.
Gaffney, Thomas A.
Gould, Jack E.
Hamilton, William M.
Hillyard, Roy L.
Johnsen, Edwin G.
Kane, Richard F.
King, Edward G.
Koch, Robert H.
Kong, Robert W.
LaForge, Gene R.
Leeds, William L.
Leonard, James H.
Ling, Shih-Sang
Lundquist, Roland E.
Mampell, Klaus
Mataya, Jack L.
McNeil, Raymond F.
McRae, A. D.
Mixsell, Joseph W.
Mowery, Irl H., Jr.
Nesley, William L.
Neuschwander, Leo Z.
O'Brien, Robert E.
Patterson, Charles M.
Pearson, John E.
Rhoades, Walter F., Jr.
Rivers, Nairn E.
Roberts, Fred B.
Rupert, James W., Jr.
Scholz, Dan R.
Shannon, Leslie A.
Smitherman, Thomas B.
Sweeney, William E.
Tindle, Albert W., Jr.
Vicente, Ernesto
Waldrop, Nathan S.
Walsh, Joseph R.
Washburn, Courtland L.
Weis, William T.
Wheeler, Rodney S.
Wood, Stanley G.

1944
Alpan, Rasit H.
Baranowski, John J.
Barriga, Francisco D.
Bell, William E.
Benjamin, Donald G.
Berkant, Mehmet N.
Birlik, Ertugrul
Burch, Joseph E.
Burke, William G.
Cebeci, Ahmed
Clendenen, Frank B.
Cooke, Charles M.
De Medeiros, Carlos A.
Fu, Ch'eng Yi
Harrison, Charles P.
Hu, Ning
Hudson, Thomas A.
Johnson, William M.
Labanauskas, Paul J.
Leenerts, Lester O.
Mattinson, Carl O.
Onstad, Merrill E.
Pi, Te-Hsien
Ridlehuber, Jim M.
Shults, Mayo G.
Stanford, Harry W.
Stein, Roberto L.
Sullivan, Richard B.
Sunalp, Halit
Tanyildiz, R. S.
Trimble, William M.
Unayral, Nustafa A.
Wadsworth, Joseph F., Jr.
Wight, D. Roger
Williams, Robert S.
Wolf, Paul L.
Writt, John J.
Yik, George

1945
Ari, Victor A.
Budney, George S.
Bunze, Harry F.
Fanz, Martin C.
Fox, Harrison W.
Gibson, Charles E.
Green, James B.
Grossling, Bernardo F.
Ho, Chung Pen
Jenkins, Robert P.
Levy, Charles N.
Loo, Shih-Wei
Magneson, Norman J.
Rice, Jonathan F.
Tseu, Payson S.
Turkbas, Necat
Yank, Frank A.

1946
Allison, Charles W., Jr.
Austin, Benjamin
Behroon, Khosrow
Bowen, Mark E.
Brinkhaus, Harvey H.
Burger, Glenn W.
Chen, KeYuan
Colley, Joseph P.
Davis, William E., III
Dethier, Bernard
Dougherty, Charles B.
Dyson, Jerome P.
Esner, David R.
Foster, R. Bruce
Freire, Luis E.
Halvorson, George G.
Hoffman, Charles C.
Ingram, Wilbur A.
Jacobsen, John R.
Lewis, Frederick J.
Lowery, Robert H.
Maxwell, Frederick W.
Nixon, Stanley R.
Olsen, Leslie R.
Prasad, K. V. Krishna
Rice, Jerry H.
Salbach, Carl K.
Shepard, Elmer R.
Sledge, Edward C.
Smith, Harvey F.
Srinivasan, Nateson
Stephenson, Robert E.
Tung, Yu-Sin
Webb, Milton G.

1947
Asher, Rolland S.
Atencio, Adolfo J.
Brown, Raymond A.
Clarke, Fredric B.
Clements, Robert E.
Clock, Raymond M.
Collins, Hugh H.
Dagnall, Brian D.
Darling, Rodney O.
Hsu, Chi-Nan
Huang, Ea-Qua
King, Emmett T.
Lane, James F.
Leo, Fiorello R.
MacAlister, Robert S.
Manoukian, John
Martin, Sidney T.
McClellan, Thomas R.
Molloy, Michael K.
Moorehead, Basil E. A.
Olson, Raymond L.
Orr, John L.
Page, Myron E.
Ray, Kamalesh
Rust, Clayton A.
Sappington, Merrill H.
Schroeder, Henry W.
Summers, James L.
Thompson, Russell A., Jr
Torgerson, Warren S.
Veale, Joseph E.
Wan, Pao Kang
Wellman, Alonzo H., Jr.
Wimberly, Clifford M.
Winters, Edward B., Jr.
Ying, Lai-Chao

1948
Agnew, Haddon W.
Au, Yin-Ching
Buhler, James L.
Bunce, James A.
Chu, Tao-Hung
Clark, Albert R.
Collins, Burgess F.
Cotton, Mitchell L.
Crawford, William D.
Dickson, Edwin B.
Eldin, Hamed K.
Herold, Henry L.
Holm, John D.
Hsiao, Chien
Hsieh, Chia Lin
Latson, Harvey H., Jr.
Lawton, G.
Leavenworth, Cameron D.
Mason, Herman A.
Oberman, Carl R.
Oliver, Edward D.
Reed, Arthur W.
Rhynard, Wayne E.
Sims, William E.
Stein, Paul G.
Swain, John S.
Tang, Yu-Wei
Voelker, William H.
White, Richard S., III
Williams, Donald B.
Winniford, Robert S.
Woods, Marion C.
Wray, Robert M.
Yanak, Joseph D.

1949
Abramovitz, Marvin
Barker, Edwin F., Jr.
Bauman, John L., Jr.
Baumann, Laurence I.
Bottenberg, William R.
Brown, John R.
Bryan, Wharton W.
Cheng, Che-Min
Clendening, Herbert C.
Cooper, Harold D.
Dodge, John A.
Foster, Francis C.
Galstan, Robert H.
Hardy, Donald J.
Heiman, Jarvin R.
Krasin, Fred E.
Krauss, Max
Leroux, Pierre J.
Lowrey, Richard O.
MacKinnon, Neil A.
McElligott, Richard H.
Mitchell, Max O.
Parker, Dan M.
Petty, Charles C.
Rinehart, Marion C.
Ringness, William M.
Saari, Albert E.
Sinker, Robert A.
Vrabec, Dale
Wilkening, John W.
Yu, Sien-Chiue

1950
Alexander, Joseph B.
Brody, Julian
Bryan, William C.
Edelstein, Leonard
Gimpel, Donald J.
Li, Chung Hsien
Mayner, Gerald S.
McDaniel, Edward F.
McMillan, Robert
Missman, Rolland A., Jr.
Montemezzi, Marco A.
Pao, Wen Kwe
Paulson, Robert W.
Petzold, Robert F.
Schmidt, Howard R.
Schneider, William P.
Tang, You-Chi
Whitehill, Norris D.
Wilkes, John D.

1951
Arosemena, Ricardo M.
Blanchard, Dean M.
Chong, Kwok-Ying
Davison, Walter F.
Goodell, Howard C.
Hawk, Riddell L.
Lafdjian, Jacob P.
Lo, Shih-Chun
Padgett, Joseph E., Jr.
Palmer, John M., Jr.
Stern, Edward A.
Summers, Allan J.

1952
Abbott, John R.
Arcoulis, Elias G.
Bissett, Charles F.
Bucy, Smith V.
Engholm, Bernard A.
Harrison, Marvin E.
Jaugey, Michel
Lunday, Adrian C.
Meyer, Robert F.
Primbs, Charles L.
Pruett, Jeter A.
Robieux, Jean
Robison, William C.
Roy, Nikhilesh
Shelly, Thomas L.
Sutton, Donald E.
Weber, Ernesto J.
Wiberg, Edgar
Wilson, Howard E.
Woods, Joseph F.
Zacha, Richard B.

1953
Averre, William V.
Bhanjdeo, Swaroop C.
Clark, David J.
Crespo, Manuel J.
Lennox, Stuart G.
Peters, Alphonse P.
Robinson, Winthrop P.
Robkin, Morris A.
Rochefort, Joseph J., Jr.
Schroeder, Norman M.
Wilburn, Norman P.

1954
Coughlin, John T., II
Dambrine, Christian P.
Feuchtwang, Thomas E.
Guebert, Wesley R.
Gutierrez, Reinaldo V.
Heiser, David
Jimenez, Herberto
Quiel, Norwald R.
Rogers, Berdine H.
Seele, Gordon D.
Smith, David H.
Vandenkerckhove, Jean A.

1955
Huber, William E.
Moore, William T.

1956
Bandt, Kermit M.
Edwards, Robert W.
Feige, Jacques
Kelly, James L.
Kontaratos, Antonios N.
MacDuffie, Duncan E.
McAllister, Don F.
Rubalcava, Hector
Spence, William N.
Tang, Chung-Liang
Truong, Tran N.

1957
Flertzheim, Henry A., Jr.
Goebel, Charles V.
Hall, George E.
Harris, Daniel E.
Heiser, William H.
Howie, Archibald
Jensen, Roy A.
Savage, James C.
Schwartz, Lowell M.
Stuteville, Joseph E.
Uhthoff, John C.

1958
Ackley, David A.
Chang, Berken
Dundzila, Antanas V.
Gardner, John L., Jr.
Horowitz, Daniel H.
Jones, Laurence G.
Khamis, Mitri G.
Knight, Harold G.
Saffouri, Mohammad H.
Wille, Milton G.

1959
Baekelandt, Victor
Bailey, John S.
Byun, Chai B.
Cheng, Hung
Fisher, David E.
Guillemet, Michel P.
Idriss, Izzat M.
Lewyn, Lanny L.
Monroe, Louis L.
Roth, Stanley
Weber, Walter V., Jr.

1960
Banta, Brent
Cauley, Joseph M.
Farha, Norman S.
Mauger, Richard L.
Nissen, David H.
Pelton, Walter E.
Rubin, Arthur M.
Schmus, William R.
Sinoff, William A.
Weber, Christian C.

1961
Allen, Charles A.
DeVilbiss, Alan J.
Dombey, Norman
Kastan, Peter
Lindner, Milton S.
Marks, Ian D.
McLennan, Miles W.
Pollock, Gerald D.
Richter, Rolf
Smith, Warren D.
Snively, Frank T.
Steinberg, Charles M.
Wilkinson, John F.

1962
Davis, James I.
Dorlhac, Jean-Pierre
Dubois, Jean Claude
Hammond, Peter W.
Johnson, James H.
King, William C.
Lutz, Raymond P.
Marr, Harold E., III
Meirelles, Osorio C.
Svenson, Raynold A.
Trevarthen, Colwyn B.
Wik, Dennis R.

1963
Conroy, Bruce L.
Francis, William F.
Hannon, Michael J. A.
McCoy, James E.
Pyle, Jay C.
Tong, Pin
Wu, John Y.

1964
Aborn, Bruce J.
Delfosse, Claude M.
Hartle, James B.
Howenstine, Robert J.
Hsiung, Chien-hain
Kanus, Karl H.
Lipson, Arthur D.
McKinley, John H.
Schoene, William J.
Storwick, Robert M.

1965
Aimelet, Bernard A.
Aperghis, Gerassimos G.
Austin, Philip R.
Casanova, Jose C.
Kercher, James R.
Lagorce, Michel A.
Liang, Alexander Chen-Che
Mori, Hidehiko
Sayegh, Samir D.
Spring, William G.
Stephens, Melvin M., II

1966
Mitescu, Catalin D.

Personals . . . *continued*

1956

G. LOUIS FLETCHER, MS '57, has been named district engineer for the San Bernardino Valley Municipal Water District. He will be involved in an accelerated program of ground water basin study and in all phases of engineering work for the district. Fletcher was formerly with the Hydro Conduit Corporation in Azusa.

1959

ROLF ENGLEMAN JR., PhD, has a year's leave of absence to study molecular spectroscopy at the National Research Council of Canada in Ottawa. He is with the Los Alamos Scientific Laboratory.

1961

HENRY ARCHER THIESSEN, MS '62, has joined the staff of the Los Alamos Scientific Laboratory in New Mexico as an experimental physicist in the medium energy physics division. He recently completed the requirements for a PhD at Caltech which he will receive in June.

1962

JOHN GOLDEN and his wife announce the birth of their first child, James Harris, on August 2. John is a member of the applied mathematics research group at the RCA Laboratories in Princeton, N.J. He writes that JOHN WILKINSON '61, PhD '65, visited him recently and is now at the University of Waterloo in Ontario, Canada, for his second year as assistant professor of mathematics.

1964

RONALD G. FINDLAY and his wife, Lynda, recently completed 10 weeks' training at Lincoln University in Pennsylvania for the Peace Corp Volunteers and have been assigned to British Honduras.

1965

VERNON L. BLISS has been commissioned a second lieutenant in the U.S. Air Force and has been assigned to the University of Oklahoma in Norman for training as a weather officer.

1966

SUSAN KAYSER, PhD, the first woman to receive a PhD in astrophysics from Caltech, has joined a research team at the Belfer Graduate School of Science at Yeshiva University in New York, where she will be working with A.G.W. Cameron, professor of space physics.

ROBERT A. SCHAAR, who died in a drowning accident in Pasadena in July, has had a book collection established in his memory by his classmates. His own books will form the nucleus of the collection and will be augmented by gifts from his family and friends.

CALTECH CALENDAR

November

22 Parents' Day

24 - 27 Thanksgiving Recess

28 Lecture: Maarten Schmidt—"Quasars and the Universe." Beckman, 8:15 p.m.

29 Poetry reading: George Starbuck, Dabney Lounge, 8 p.m.

30 ASCIT-YMCA Assembly speaker: Wesley J. Liebeler—"The Warren Commission Report Under Attack: A Responsible Appraisal." Winnett Lounge, 11 a.m.

December

1 Concert: Caltech Glee Club. Athenaeum, Hall of the Associates, 8:15 p.m.

1-4 Drama: Nina Foch in John Houseman's "The Honourable Estate." Beckman, 8:30 Matinee Sunday, 2:30 p.m.

3 Students' Day

5 Lecture: Fred Thompson—"What's in the Brain That Ink May Character?" Beckman, 8:15 p.m.

7 ASCIT Assembly movie: "Andes to Amazon." Beckman, 8 p.m.

18 Christmas Vacation.

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(2) Inform you of possible opportunities from time to time.

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Please send me: (Check one)

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☐ A form indicating a desire to keep watch of opportunities although I am not contemplating a change.

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

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

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