ENGINEERING | AND | SCIENCE

April 1961

Research in Progress . . . page 14

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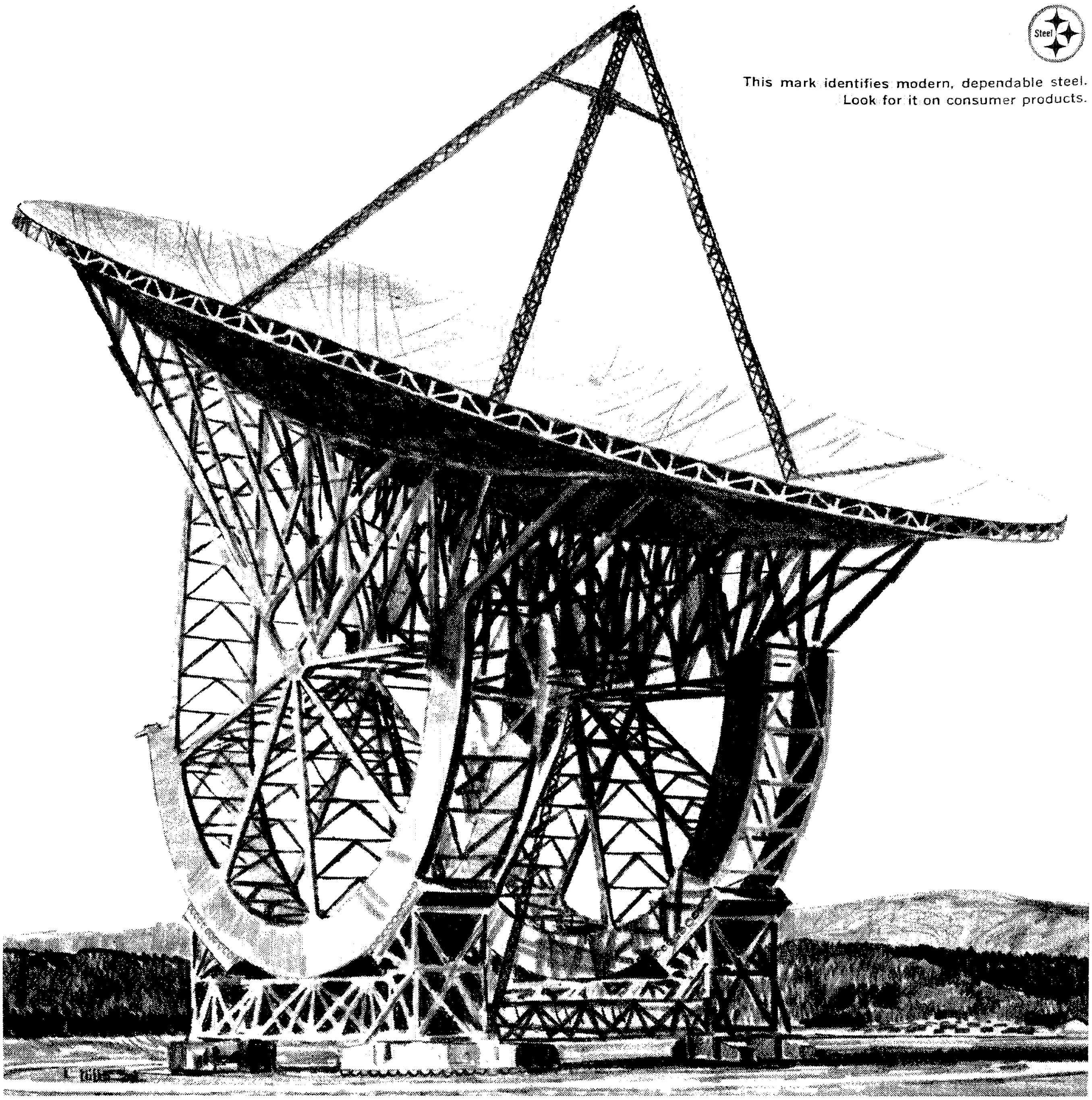

This is an artist's concept of the world's biggest radio telescope

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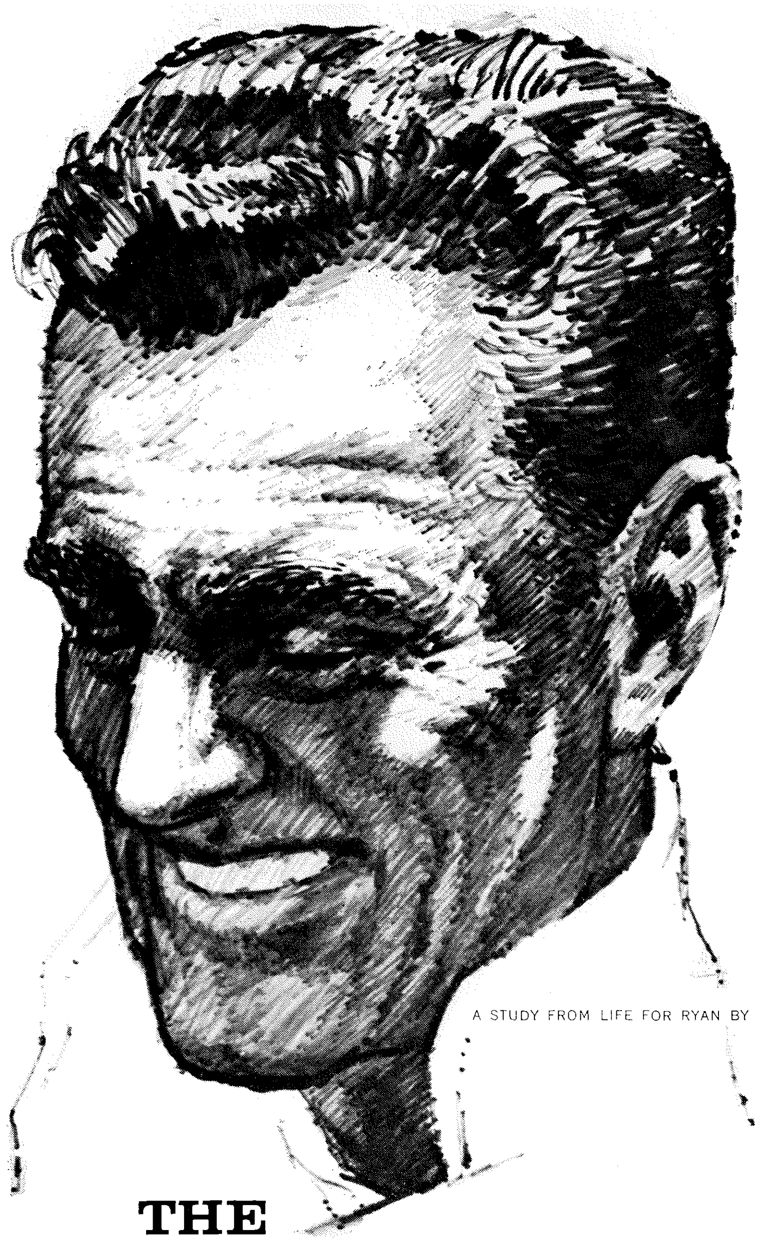

A STUDY FROM LIFE FOR RYAN BY D. MILLSAP

ENGINEERING AND SCIENCE

On Our Cover

James Bonner, professor of biology, taps a rubber tree in the Institute's Plant Research Laboratory – as part of the Caltech research program which has resulted in rapidly increasing yields of rubber from rubber trees in recent years. For a fuller account of this program, see "Research in Progress" on page 14.

News of other research in progress can be found on page 15 – a new theory of anesthetics proposed by Linus Pauling, professor of chemistry.

Arms Control

Since last summer the Institute's Carnegie Program has been bringing experts to the campus for weekly lectures and seminars on the problems of nuclear parity and arms control. On page 9 Cushing Strout, associate professor of history, presents a summary and synthesis of the views that have been presented in this program to date. Incidentally, "Scorpions in a Bottle"– the title of Dr. Strout's article – is the phrase that has been used to describe the nuclear age.

Dr. Strout, a graduate of Williams College (1947), received his MA and PhD degrees in the history of American civilization from Harvard University. He taught at Williams and at Yale before coming to Caltech in 1959. He is currently at work on a book on the American image of Europe.

Picture Credits:

Photographs by James McClanahan

APRIL 1961 VOLUME XXIV NUMBER 7

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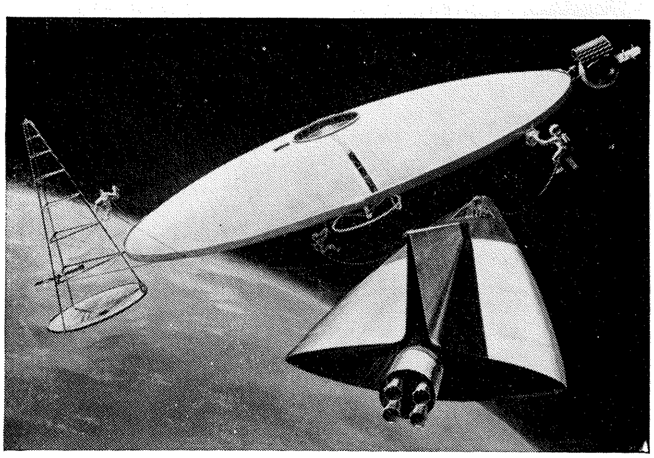
Space-age careers at Boeing



This year, engineering and science alumni will find more challenging and rewarding careers than ever at Boeing. Advanced missile and space-age programs are expanding, and the proportion of engineers and scientists to Boeing's total employment is growing steadily. Boeing programs include the Dyna-Soar boost-glide vehicle, Minuteman solid-propellant ICBM, BOMARC *defense missile system, B-52G missile bomber, KC-135 jet tanker-tranport, the Boeing 707, 720 and recently announced 727 jetliners, and lunar, orbital and interplanetary systems and advanced research projects. A few of the many immediate openings are listed below:*

DEVELOPMENT PROGRAM SUPPORT — **SEATTLE AREA**
B.S. or higher in AE, CE or ME (with any amount of experience) to perform temperature analysis and conduct studies in gas dynamics, heat transfer, ablation and gas dynamics testing.

STRUCTURAL DYNAMICS — **SEATTLE AREA**
M.S. or Ph.D. in AE or Engineering Mechanics (with at least two years research and development experience in structural dynamics, including response and stability, dynamic analysis, dynamic analysis methods or servo characteristics) to investigate response characteristics of time-variant and non-linear systems and develop methods of analysis.

MICROWAVE SYSTEMS — **WICHITA AREA**
M.S. in Electrical Engineering or Ph.D. in Physics. To accomplish basic research in the fields of microwave components and transmission systems. Studies of materials and techniques to improve wave guide systems. Assignments include laboratory and analytical research.

WEAPON SYSTEMS ANALYSIS — **SEATTLE AREA**
B.S. in AE, EE, ME or Math (with experience in testing, design or development of missile systems or subsystems, including ground support equipment and ground operational equipment) to plan and establish procedures for evaluating the results of Minuteman ICBM weapon system testing, and assist in analyzing data evolved during test programs and prepare reports incorporating this information.

AERODYNAMICS — **WICHITA AREA**
M.S. or Ph.D. in Aerodynamics. For assignments in development programs involving STOL technology, performance analysis, establishment of preliminary aerodynamic configuration, stability and control predictions, supersonic engine inlet design and testing, and internal aerodynamic investigation. These programs involve preliminary design on aircraft and missile projects.

GAS TURBINE ENGINE DESIGN — **SEATTLE AREA**
B.S. or M.S. in ME (with 5 to 10 years experience in layout and detailed design of complex mechanical assemblies involving lubrication, thermal stress, inertia stress and assembly tolerances) to perform layout and design work on gas turbine engines and their components.

PACKAGING ENGINEERING — **SEATTLE AREA**
Engineers with B.S. in ME, CE or EE to design and develop industrial and military packaging for the protection of electronic equipment and missile and aircraft components. Assignments include analyzing, evaluating and testing methods, materials and techniques for the protection of fragile and intricate items.

FACILITIES EQUIPMENT ENGINEERING — **SEATTLE AREA**
Engineers with B.S. degrees in ME, ChemE or EE, with five years minimum experience, to provide services which include equipment design, specifications, selection and operational reliability. Equipment involved may be manufacturing process and test equipment (e.g., hydraulic functional test equipment) or electronic equipment (e.g., test equipment for air-borne electronic systems.)

CERAMICS — **SEATTLE AREA**
Ceramicist with Ph.D. degree or equivalent professional background to conceive and conduct investigations of the factors influencing ductility and fracture.

BASE INSTALLATIONS — **SEATTLE AREA**
B.S. in EE or ME (with 10 years experience in architectural or engineering design, design checking or coordination, drawing delineation or equivalent activity) to review architectural and engineering drawings of guided missile base installations and comment on design, recommending revisions, preparing cost estimates, and engage in Air Force and other outside company contact work.

COMPUTER METHODS — **SEATTLE AREA**
B.S. in EE, ME or Math (with 0 to 6 years applicable experience) to find new uses for and integrate new electronic digital computing equipment with existing equipment.

ANTENNA SYSTEMS — **SEATTLE AREA**
M.S. in Electrical Engineering or Ph.D. in Physics. To accomplish basic research in the fields of surface wave antennas or large array antennas for possible air-borne application through use of the IBM 7090 Digital Computer, 231R Pace Analog Computer and other antenna laboratory equipment. Projects include such items as antennas for omnidirectional radiation pattern coverage in both horizontal and vertical polarizations.

QUALITY CONTROL — **SEATTLE AREA**
B.S. or M.S. in Electrical Engineering, Mechanical Engineering, Physics, Chemistry or Metallurgy. Advanced training in Mathematics/Probability Science helpful. Establish requirements and analyze reliability performance data; correlate performance data and design specifications; design test programs based on statistical parameters; recommend changes to product design and determine the need for changes in manufacturing process.

PLASMA PHYSICS — **SEATTLE AREA**
Experimental and theoretical physicists with Ph.D. degree in physics for the staff of the Plasma Physics Laboratory, Boeing Scientific Research Laboratories, to conduct studies in the field of basic microwave plasma physics, transport properties of plasmas and quantum plasma physics.

ELECTRONICS AND GUIDANCE SYSTEM DESIGN — **SEATTLE AREA**
B.S. in EE or ME (with EE or mechanical design experience) to evaluate flight instrument requirements for the Dyna-Soar boost-glide vehicle program, perform avionics component and system engineering, prepare source control drawings or design procurement specifications, perform technical evaluation of vendor proposals, perform design and development monitoring, evaluation and qualification testing, and system avionics integration.

TEST ENGINEER — **WICHITA AREA**
M.S. in Aeronautical, Electrical or Mechanical Engineering. For test programs covering aerodynamic, electrical, electronic, structural and mechanism projects. Assignments require planning, development monitoring and analysis of tests in laboratories and actual flights.

STRUCTURES & MECHANICAL DESIGN — **SEATTLE AREA**
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Books

The Air We Breathe

Edited by Seymour M. Farber, MD, and Roger H. L. Wilson, MD, in collaboration with John R. Goldsmith, MD, and Nello Pace, PhD

Charles C. Thomas, Publisher . . $14.00

Reviewed by A. J. Haagen-Smit, professor of biology

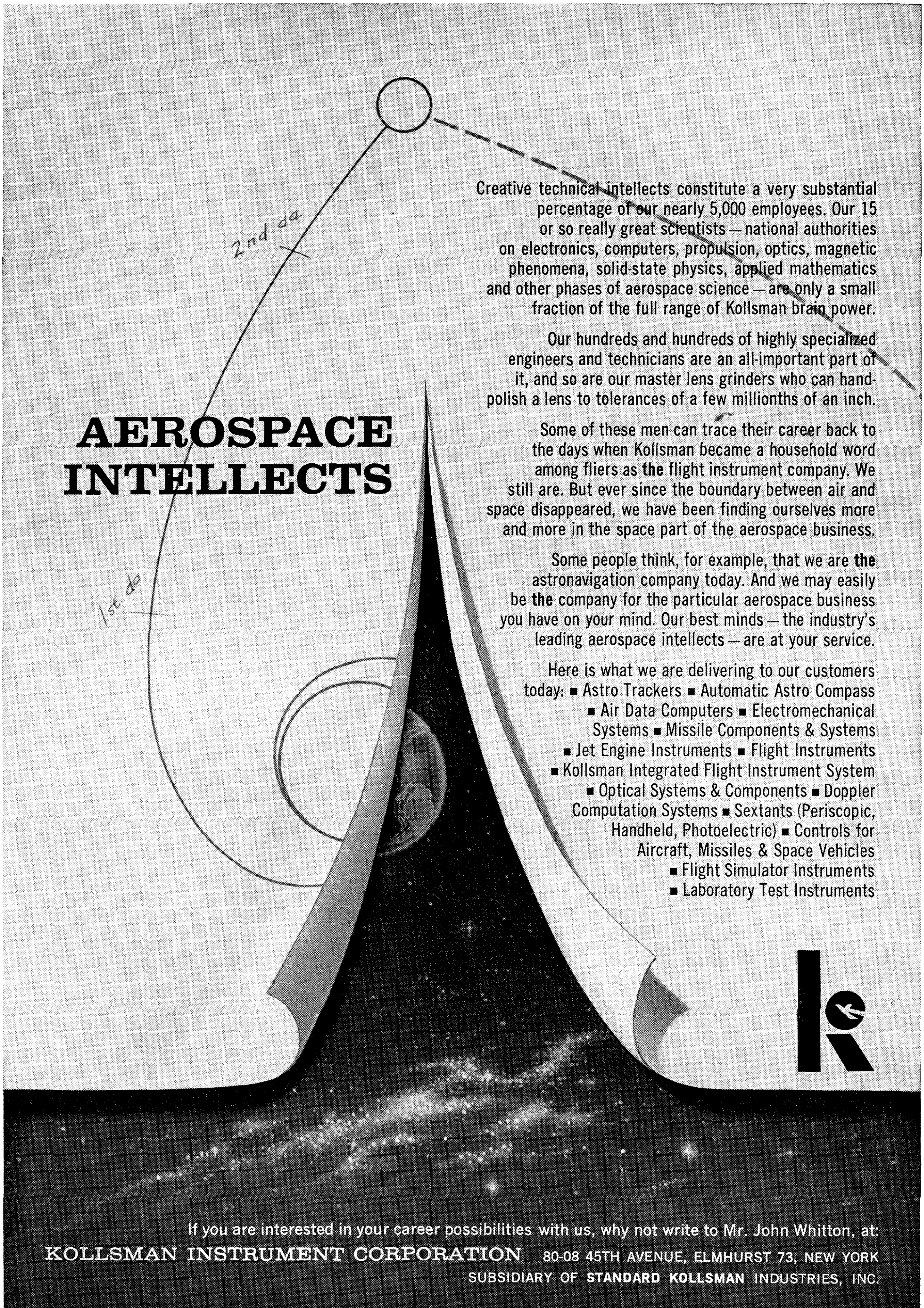
This book is the record of a symposium held at the University of California Medical Center in San Francisco last year. The book is divided into five sections which cover phases of the air pollution problem: The "normal" atmosphere and its variations; the air pollution problem of industry; urban living and air pollution – smog and fog; specific problems (such as the effects of dust on the human lung); and factors in the study and origin of lung cancer.

I had the pleasure of attending this symposium and my impression was that the organizers succeeded in making this event most pleasant. Top men in the various fields covering the impact of changes in our environment presented factual material, while at the same time these summaries were made palatable by the injection of personal views and historical details, which are not to be found in the garden variety of books on air pollution.

From A to Z

The discussion ranged from a lecture on the composition and origin of our atmosphere by Dr. Harold Urey, to the hot subject of the effect of cigarette smoking on longevity, and the controversial use of artificial ionization in ventilation or air conditioning. The problems of automobiles and smog, radioactive pollution, city planning, and other impacts of environment on our lives are briefly but intelligently covered in this record of the proceedings.

The symposium has been clearly written and is readily understandable by the educated layman. Its refreshing approach and the inclusion of partially corrected discussions adds to the value of the book and it makes clear to the reader the proper principles of how to live with and use our natural resources in the best way possible.



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SCORPIONS IN A BOTTLE

Since last summer the Carnegie Program at Caltech has been considering the perils of nuclear parity and the prospects for arms control. This is the way things stand.

by Cushing Strout

In 1945, when the United States dropped two atomic bombs on Japanese cities, there was a widespread realization that a new and menacing era had begun. Those who took dark views turned out to be right. Fifteen years later the thermonuclear arms race has provoked many to wonder, as gallows humor has it, whether posterity *is* around the corner.

A low-range megaton bomb has the explosive power of all the conventional bombs dropped on Germany and Japan in World War II. The age of missiles has made it clear that, in a total war, civilian populations would be as directly involved as the old-fashioned soldier in his trench. Bristling with weapons of an unprecedented capacity for devastation, the super-powers stand in hostile, suspicious rivalry. Other countries work to develop their own atomic and nuclear capabilities, and the diffusion of these awesome instruments inevitably increases the danger of accidental war, or a conflict between the major powers produced by the catalyst of a calculating third party.

The arms race itself has become a source of dangerous insecurity in a divided world. Its continuance also stimulates fears that the democratic welfare state will become a "garrison state," with defense spending monopolizing the national budget and the military having a disproportionate influence on policy.

Recognition of the hazards of this new world has excited growing interest in the problems of arms control. Since last summer the Carnegie Program at Caltech, organized by David C. Elliot, professor of history, has supported a steady influx of visiting experts from America and abroad on defense, disarmament, and diplomatic questions. These lectures have been open to faculty, students, and the public. Members of both scientific and humanities faculties have also met with the speakers in weekly seminars to explore further this treacherous terrain of policy, probability, and possibility.

With a large part of California's industry devoted to defense work, and the nearby Rand Corporation specializing in defense strategy, the Caltech seminars have been mainly concerned with the prospects for controlling the arms race, in the hope of keeping the dragon in his cave, blunting his claws, or moderating his fierceness. No one claims to have tamed the beast, but a lot has been learned about the difficulties of keeping him at bay.

The complexity of the problem stems from the linkage of diplomatic, military, and disarmament strategies, which must harmonize with one another. Yet each is itself a tangle of tight knots, and there is no clear set of instructions for unravelling them, or weaving them together in a solid rope that we can be sure will bear our weight across the canyon of the 1960's. It is clear, however, that in the nuclear age there is a law of diminishing returns to the process of seeking security by merely amassing armaments to deter a potential aggressor.

A strategy of deterrence based on nuclear power is not guaranteed to work; *it may fail.* An aggressor convinced of his capacity to knock out an enemy's weakly-protected retaliatory power might be tempted to launch a surprise attack. Or he might fear an impending attack and seek to strike first. Diplomatic misunderstanding, false alarms in the warning system, or irresponsibility in the chain of command might trigger off an accidental war. A third party might deliberately provoke a conflict between the major powers. An indecisive limited war, fought with conventional forces, might turn into a nuclear struggle. None of these possibilities can be ruled out.

A rational policy cannot be based on complacent assumptions about possible enemy strategies, but in preparing for the worst possibilities there is a danger of losing sight of the probabilities. Most experts do not envisage a bolt from the blue. Nuclear war is more likely to occur because of fear (whether justified or not) of an opponent's impending attack or

Carnegie Lecturer Ithiel de Sola Pool (center), professor of political science at MIT — with Caltech's David Elliot, professor of history; and John R. Weir, associate professor of psychology.

because of accident. These probabilities are what lend urgency to the need for arms control.

Experts agree that these hazards can be reduced by scrapping the all-or-nothing approach implied in John Foster Dulles's policy of "massive retaliation," which put almost sole reliance on a nuclear response (target unspecified) to any local aggression. This strategy implied that the deliberately limited character of the Korean War was a mistake, and it threatened the possibility of an American nuclear strike on Moscow, for example, as a response to Soviet aggression anywhere in the world. It narrowed the choice to total war or back-down, thus gravely crippling flexibility. It also made no sense in a time of nuclear parity, when the use of nuclear weapons would provoke a nuclear reply. A rational use of force requires a strategy of graduated deterrence that allows different levels of force to be met by appropriately limited replies.

The concept of graduated deterrence raises the vexing question of limited nuclear wars. Most experts believe that, in vital areas like Western Europe, the possibility of keeping any nuclear conflict limited is chimerical. In the last administration there was much emphasis on so-called tactical nuclear weapons as a means of "modernizing" conventional forces. This approach is defensible as part of a search for a full spectrum of deterrence, rather than for the illusory cheap security that made the Dulles doctrine so attractive to budget-balancers.

The argument for having nuclear weapons of various yields for tactical use against enemy forces is based on the need to deter or meet limited aggression in remote areas, where the risks of enlarging the scope of conflict can be minimized. But tactical nuclear forces are *not* a panacea to justify an inadequate conventional capability. Their dangers are obvious in reference to the densely populated industrial centers of Europe. Attacks there on military supply depots, railroad centers, and harbors might be called "tactical" by the generals, but nobody else — particularly the victims in nearby cities — would agree.

It would seem wise to keep nuclear weapons that are intended for tactical use sharply separated from conventional forces, and held in reserve to prevent any aggressor from being tempted to use them. Once non-conventional weapons become involved in a local conflict, it may become, in some situations, all too easy — especially under military and popular pressures for victory — to "escalate" into full-scale nuclear war.

Weapons analysts have pointed out that nuclear striking forces which are primarily effective only for an offensive blow are both vulnerable and provocative. (Air force bombers on the ground are a good example.) Visiting British strategists were especially critical of the decision in 1957 to plant Thor missiles (IRBM's) on American bases in Britain and of General Norstad's proposal of last October to put IRBM's under NATO control. These weapons — which have a range of 1500 miles and are unprotected (except by dispersion and number) from enemy retaliation — may look very provocative to the Russians in their line of fire, as if the West were planning to shoot them first.

The vulnerability and provocation of relatively unprotected nuclear striking forces (defects which have marked the American defense system until recently) will be much changed by the current development of solid-fuel, long-range missiles in submarines, concrete silos, or moving railroad cars. By providing a much more protected retaliatory power than the Strategic Air Command or other missiles offer, these new devices, because of their range, concealment, or mobility, tend to reduce the danger of surprise attack and the need for quick response in case of an accidental strike. They also lack the offensive look of relatively unprotected weapons which are primarily useful only for a first strike. But the pace of uncontrolled technological change will undoubtedly upset any "balance of terror" between rival Polaris systems, which are immune to a knockout blow by a first strike.

At this point a spectrum of solutions to the problems of arms control begins to appear. Some put their confidence in a balance of power between relatively invulnerable retaliatory weapons, with the major powers tacitly recognizing the need for unwritten restraints on provocative or belligerent actions. Others are hopeful that a realistic bargain can be struck on a fairly comprehensive multilateral disarmament treaty without jeopardizing national security. Still others are convinced that unilateral tension-reducing actions (not affecting the nuclear deterrent itself) must be taken by the United States to create an atmosphere free of the accusatory self-righteousness of "cold-war" postures (as illustrated by the recriminations over the U-2 spy-plane episode) before realistic agreements can be secured. Such steps (beginning, for example, with an offer to share medical information about space flights) would be planned to expect eventual reciprocating actions by the Russians.

These different approaches need not be inconsistent nor exclusive, but they tend to make a difference in detail. What, for example, should be done about anti-missile missiles and fallout shelters? If such a missile could be technically developed, would it improve our defense position, or tip the scales by stimulating the enemy to increase his missile force – or even to attack before he lost the chance to win? Similarly, would a public shelter program condition people to accept nuclear conflict and appear threatening, as if preparations were being made to back up a first-strike that would provoke an expected nuclear reply? Or is it needed to protect our population in case deterrence fails?

These are some of the ambiguities of the problem. It may well be that the limited military value of the proposed Nike-Zeus anti-missile would not be worth its great expense, but that it would be reasonable to have a modest shelter program, as opposed to a massive "crash" effort made in a belligerent spirit at a time of international high tension.

The coming of nuclear parity also tends to affect NATO strategy. The West has depended on American commitment to use nuclear weapons, if necessary, to deter an all-out attack on Western Europe. NATO's conventional forces (20 divisions) are needed to resist limited military probes of Allied resolution, or to control local uprisings that might flare into wider conflict. Some argue now that it is no longer credible to Russians or Europeans that an American president would invite sure nuclear destruction of American cities by giving a nuclear response to a Soviet attack on Europe. This dilemma is underlined when both sides have protected retaliatory power, because populations, rather than nuclear forces, then become vulnerable. This situation puts a premium on conventional forces, which were dangerously downgraded by the "massive retaliation" strategy.

Again there is a range of solutions to this new problem for the alliance. Some suggest an increase in conventional forces to meet possible aggression in Europe; others propose a full-fledged NATO nuclear deterrent, under a command and control designed to give the alliance as a whole the opportunity to decide upon its use. Somehow the Europeans – whether they fear that America will be too hesitant or too precipitant – must be given a sense of having their finger on the trigger, rather than being compelled to depend upon a purely American decision about the level of force to be used.

Here the issue is joined between those who feel the primary problem is to make Western deterrence more credible to the Russians and those who think it needs only to be made more credible to the Europeans. If the American guarantee of support is still good, because the Soviets could not risk mounting a serious

Carnegie Lecturer Sir Solly Zuckerman (right), professor of anatomy at the University of Birmingham – with Harrison Brown, Caltech professor of geochemistry.

Carnegie Lecturer Joseph E. Johnson, president of the Carnegie Endowment for International Peace.

attack without striking also at the major source of possible retaliation (the United States), then a vigorous but prudent American political leadership might do much by itself to allay European anxieties. Many analysts discount the probability in either case of major Soviet aggression in Europe. They argue that Khrushchev, having abandoned the Communist dogma of inevitable war, is confident that techniques of subversion and military or economic aid are sufficient to expand Soviet influence. Since 1945 the Red Army, however important as a threat in the background, has not been the spearhead of Soviet expansion.

If this diagnosis of Soviet policy is correct, the West stands a better chance of controlling the arms race by multilateral agreements on the test-ban and disarmament. These treaties do not depend on friendliness, but on the common recognition of the insecurity of the arms race. Before the U-2 episode much progress was made in narrowing the gap on inspection procedures for the test-ban. No one expects to find a foolproof system, but there is greater risk in the future diffusion of nuclear weapons if tests are not controlled.

A test-ban affecting weapons above the 20-kiloton range (the approximate size of the Hiroshima bomb) would, above all, provide a basis for estimating the good faith of the participants, and therefore of the chances for future inspected agreements on the bolder step of arms reduction itself. Unfortunately, it has been hard to strike a bargain on the test-ban because of Russian resistance to violation of their secrecy by inspection procedures (which are themselves both complicated and expensive) in return for a small step in arms control from the point of view of disarmament.

The logical next step after achievement of a successful test-ban agreement would be a disarmament treaty. Since the Acheson-Lilienthal Report of 1946, proposing internationally controlled atomic disarmament, the issue has been exploited for propaganda purposes by both sides with few serious proposals. In 1955 the Soviet Union showed a new seriousness by accepting the reality of the problem of evasion and inspection. Experts point out that it is likewise necessary for the West to recognize the legitimacy of Russian refusal to settle on inspection procedures apart from actual disarmament proposals. Any violation of the Iron Curtain is a serious military disadvantage to the Soviets, and it can be compensated only by the prospect of a substantial reduction in arms. In this respect it might be easier to take a big step.

The current Russian insistence on the goal of total disarmament, however, conflicts with the Western tendency to put its confidence in deterrence for protection. It may yet be possible to strike a bargain involving some substantial measures of gradual, phased disarmament – especially if political tensions can be reduced. Here there is controversy over how far such steps should go.

The "stable-deterrent" theorists, who seek security in a balance of power between "second-strike" forces, would prefer to lean on some nuclear weapons, on the assumption that they provide more stability than a disarmed world in which a cheater might acquire a great nuclear advantage. A few of those who argue this way seize the nettle by a plea for a strategy for *winning* a nuclear war, if deterrence fails. Others, who see no meaning in such a "victory," put their confidence in Soviet prudence, large-scale disarmament, and international police forces. Options in this area depend very largely on a reading of Soviet reactions, intentions, and policy.

American delegates at the Pugwash conferences with the Russians report that the Soviet representatives are not as sophisticated as the West about arms control problems, but they seem to be genuinely aware of the new dimension given to war by nuclear weapons and the growing dangers of nuclear diffusion and accident. The popular cliché, "You can't trust the Russians," ignores the common hazards that all nuclear powers face and the ability of the Soviets to recognize them. The Russians have only to apply the same kind of prudence the public expects them to use in recognizing the deterrent effect of the Western defense system.

The persistent whisper in the gloom at most of the seminar sessions has been: What about China? The future of negotiations to prevent the spread of nuclear weapons and to restrain the arms race is not promising without Chinese participation, but the grim consensus is that there are no current signs that China is interested in reducing the tensions of the world, or even in accepting Khrushchev's version of "peaceful co-existence." It may be, however, that the current alarming aspirations for independent nuclear capabilities on the part of the French, the Israelis, and the Chinese may mature into a sad disillusionment with the enormous expense, diplomatic rigidity, and fearful tensions that "nuclear plenty" brings. An agreement between Russia and the West might put much pressure on the Chinese to join.

The longer the world waits to become serious about arms control the more difficult it becomes to achieve. Political conflicts and fears have produced the arms race, but it has a momentum and impact of its own which politicians and citizens cannot afford to ignore. The commitment of President Kennedy's administration to the problem reflects, on the national level, the same concern that generated the Carnegie Program on arms control at Caltech.

Nearly everyone who has participated in the series has felt that the West has badly lacked leadership, preparation, and clarity about arms control measures. In the past no clear direction has been given to the problem, which has been lost sight of in the rivalry of the military services and the press of other business of the departments.

There is widespread agreement, among those with experience as scientific advisers, upon the need to focus responsibility for advice to the President in a special assistant, who meets regularly with the Secretaries of State and Defense, and for a Congressionally established agency to perform the expensive work of technical research and development. The responsibility for negotiation itself must, of course, be confined to the State Department.

The nuclear age has been described as "two scorpions in a bottle." We are all in the bottle. The pursuit of national security has led the United States to form alliances, promote foreign aid programs, and build nuclear weapons. It now demands a serious search for arms control. If this can be achieved, the struggle for competitive coexistence may then be removed from the nuclear plane, where all stand to lose, to areas where the West can work to show that history, contrary to Communist dogma, is on the side of "open societies." As armaments are reduced, it will then become necessary to develop institutions other than war for settling international disputes. The opportunity, hedged by the running out of time, awaits. Decision will be difficult, experiment perilous.

CARNEGIE PROGRAM: Science and Government

Lecturers, 1960-61

Herman Kahn, Rand Corporation — *On Thermonuclear War*

Alan Sweezy, Caltech — *The Economic Effect of a Substantial Reduction in Arms Expenditure*

Myron Rush, Rand Corporation — *Khrushchev's Strategic Views*

Dan Elsberg, Rand Corporation — *Theory and Practice of Blackmail*

Henry Rowen, Rand Corporation — *National Security and Arms Control*

Andrew Marshall, Rand Corporation — *Modes of War Initiation*

Amron Katz, Rand Corporation — *Inspection Systems*

James Digby, Rand Corporation — *Active Defense and Deterrent*

Albert Wohlstetter, Rand Corporation — *The Test Ban as a Test of Attitudes on Arms Control*

Harrison Brown, Caltech — *Moscow Pugwash Conference*

Gen. Maxwell Taylor, USA (ret.) — *A Blueprint for National Security*

M. Jules Moch, France (UN) — *Why Disarmament is Necessary, and How to Police It*

Gen. B. J. Schriever, USAF — *Air Force Space Program*

Henry A Kissinger, Harvard University — *Do We Want Disarmament?*

Warner Schilling, Columbia University — *The Decision to Make the H-Bomb*

Sir Charles Snow — *The Scientist in Government*

James R. Killian, MIT — *Science and Foreign Policy*

Edward L. Katzenbach, Jr., Cambridge Research Center — *Command and Control Problems*

C. E. Osgood, University of Illinois — *Psychological Aspects of Policy Formation*

Jerome B. Wiesner, MIT — *The Development of a Stable Defense System*

Thomas Schelling, Harvard University — *Arms Control and Military Strategy*

John Strachey, MP (UK) — *British Attitudes to the Deterrent*

John Hanessian, AUFS — *The Antarctic Treaty*

Kenneth Boulding, University of Michigan — *Conflict Resolution*

Denis Healey, MP (UK) — *NATO Strategy and Arms Control*

Daniel Lerner, MIT — *European Defense Attitudes*

Ithiel de Sola Pool, MIT — *Public Opinion and Policy*

W. K. H. Panofsky, Stanford University — *The Test Ban*

I. I. Rabi, Columbia University and Sir Solly Zuckerman, University of Birmingham — *Science and Public Policy*

Arthur Larson, Duke University — *Arms Control Through World Law*

Louis B. Sohn, Harvard University — *Zonal Inspection for Disarmament*

Joseph E. Johnson, Carnegie Endowment for International Peace — *Reflections of a Peacemonger*

A. Topchiev, USSR — *A Russian View of Pugwash*

James J. Wadsworth — *Negotiating with the Russians*

Richard Leghorn, Itek Corporation — Linus Pauling, Caltech — *Report on the Oslo Conference*

James Bonner, professor of biology, taps a six-year-old rubber tree grown from seed at Caltech.

Research in Progress

More Rubber from the Rubber Tree

For over 20 years, James Bonner, professor of biology at Caltech, has directed some portion of his time to the study of the synthesis of rubber, one of the most important materials which plants supply to man. When natural supplies of rubber were cut off during World War II, Dr. Bonner helped establish the program for the production of rubber from guayule, a native American plant. This served as a stopgap for necessary supplies while the chemical synthesis of rubber substitutes was set up on a large scale.

Dr. Bonner's interest in rubber continued until solution of the question of how rubber plants make rubber was finally achieved three years ago. Last fall he addressed the first world-wide conference on rubber in Kuala Lumpur, Malaya. The conference, sponsored by the Rubber Research Institute of Malaya, was attended by over 300 scientists, all experts on rubber. There, Dr. Bonner described how the rubber tree, one of nature's most efficient chemical factories, transforms carbon dioxide and hydrogen into the long hydrocarbon molecules which appear as rubber in the liquid latex. This knowledge has evolved in the past 12 years, from continuing research on the rubber tree – much of which has been done at Caltech by Dr. Bonner and his associates.

Actually, most of the significant knowledge about rubber synthesis has been obtained in the past four years. The cornerstone for this present knowledge is the fact that all of the carbon atoms of rubber are derived from acetate. This applies not only to rubber but also to the other isoprenoids such as the essential oils and steroids (important in people as hormones), all of which have as their molecular base the five-carbon substance isoprene.

The rapidly increasing yields of rubber from the rubber tree dramatically exemplify how science benefits practical affairs. During the past 20 years the rubber tree has been made to increase its yield five times. This has been done by painting hormones and antibiotics on the tree trunk to improve latex flow and by using new methods of tapping the latex vessels which are the latex-containing pipes in the bark of the tree. Scientists expect to double the rubber tree's output again, mainly by applying the new knowledge of the synthesis of rubber.

In the United States, synthetic rubber is widely used – partly because it is cheaper than natural rubber. In the world as a whole, however, twice as much natural rubber is used as synthetic rubber. The amounts of rubber used each year are rapidly increasing as more and more of the world's people shift from feet to seat, from walking to automobiles.

Anesthetics — A New Theory

Anesthetics, in various forms, have been used throughout the ages in an effort to relieve pain. But scientists have never been able to find out how anesthetics actually worked. The common belief is that anesthetics induce unconsciousness and insensitivity to pain by dissolving in the fatty substances of the brain and changing these substances in some unknown manner. Now a new theory has been advanced by Linus Pauling, professor of chemistry at Caltech — the first detailed molecular theory of anesthesia ever proposed.

The Pauling theory holds that anesthetics bring unconsciousness because they cause the formation of tiny crystals which reduce conductivity and interfere with the electrical activity of the brain. The action, according to this theory, takes place on the fluid part of the brain. (Brain tissue contains 78 percent water and only 12 percent fatty substances.) It is believed that only one-tenth of one percent of this fluid material needs to be converted into minute crystals to induce unconsciousness and insensitivity to pain.

The microcrystals that might be formed when anesthetics reach the brain would be much smaller than a brain cell, but large enough to contain hundreds or thousands of water molecules. Unlike ice crystals, which could damage brain tissue by expanding, these crystals do not expand.

It is known that water, in liquid form, is a conductor of electricity, but in crystals or ice it is a poor conductor. Even without an anesthetic, cooling the brain from 10 to 20 degrees below the normal temperature of 98.6 will cause unconsciousness. Dr. Pauling assumes that when brain tissue is cooled, small hydrate crystals form in the tissue, entrapping some of the ions and electrically-charged side chains of protein molecules. The formation of these microcrystals would then interfere with the electrical activity of the brain and cause unconsciousness.

The new theory indicates that molecules of an anesthetic agent such as chloroform fit into cavities in the framework of the water molecules constituting the hydrate microcrystals in such a way as to stabilize these crystals, and to allow them to form at a higher temperature, even at normal body temperature. This action would cause unconsciousness just as the cooling action does.

Dr. Pauling's theory could offer an explanation for many phenomena. For instance, divers, working under high pressure, sometimes suffer from anesthesia caused by nitrogen in the air they are breathing. Molecules of nitrogen do not interact with water molecules very strongly, but the interaction is strong enough to stabilize hydrate microcrystals when the pressure of the nitrogen is great, as it is for a diver at considerable depth. Replacing the nitrogen with helium prevents this effect, because helium atoms have a very small attraction for other molecules and therefore do not stabilize the formation of crystals.

One of the most puzzling facts about anesthesia has been that the rare gas xenon is an almost perfect anesthetic agent — and yet it is completely unreactive chemically. Its only known property is that of forming hydrate crystals — a fact that is extremely interesting in the light of Pauling's theory. As in his explanation of the action of ordinary anesthetics, the attractive action between the atoms of xenon and the molecules of water in hydrate crystals, makes xenon one of the most effective anesthetic agents known.

Another interesting feature of the new theory is that it has permitted the prediction to be made that certain mixtures of anesthetic agents should be more effective than one agent alone. The hydrate microcrystals that form in the brain have cavities of different sizes to accommodate anesthetic molecules of different sizes. The smallest chamber in which an anesthetic molecule can fit is formed by 20 water molecules, the next larger by 24, and a still larger by 28. If, as it is assumed, the hydrate microcrystals that form in the brain contain all three kinds of chambers, then anesthesia could be accomplished more easily by using mixtures of molecules of different sizes.

The Pauling theory may also have importance to other parts of the body than the brain. It is probable that hydrate microcrystals form in tissues of other parts of the body and that the properties of the tissues may then be changed to some extent.

The new theory is being subjected to more experimentation in the Caltech chemistry laboratories as a part of the research devoted to development of a detailed understanding of the properties of living organisms in terms of their molecular structure. The new findings by Dr. Pauling were developed in the course of a program of investigation of the chemical basis of mental disease, being carried out at Caltech with the support of the Ford Foundation and the National Institutes of Health.

Emissaries From the Outside World

Some undergraduate notes on recent visitations to the campus

THEOLOGIANS

Caltech students like visitors. Most of the programs which bring official visitors from the "outside world" are met with considerable enthusiasm, and such was the case with two notable visits this spring. First, seven theological students from various schools of religion on the Pacific Coast spent four days living in the student houses, and then the Yale Russian Chorus spent two days doing the same. Both groups provided Techmen with the opportunity to meet bright, dynamic college students with interests, philosophies, and personalities quite foreign to our campus.

Among the seven theologians were students of Judaism and of several branches of Protestantism. One theologian was assigned to each of the student houses, and six shared rooms with Caltech students. (The seventh was a girl.) They all ate their meals in their adopted houses, and spent most of their time in bull sessions.

Sponsored by the YMCA, the visiting theological student program runs in alternate years with a visit from some outstanding theologian. The theologians this year were intelligent and well-educated, most of them having been honor students at good liberal arts colleges. They seemed to be the counterpart in the liberal arts to Caltech students in the sciences.

The theologians exhibited a firm understanding of philosophy, and the overzealous, non-believing Techmen gave them an opportunity to display their education most brilliantly. Whenever the discussions became too loud or too emotional, the visitors displayed a cultured command of themselves and the situation. Strangely enough, it was usually the supposedly rationalistic Caltech students who tended to become excited and emotional.

The most impressive thing about the theologians was the type of philosophical systems they put forth. For the most part, Caltech students who were expecting fundamentalistic, "hell-fire and brimstone" evangelists whom they could rake over the coals, were sadly disappointed. One theologian did profess a Calvinistic philosophy which he had (to *his* satisfaction at least) combined with the study of physics. He believed that "God's call" had been for him to devote half of his energies to religion and half to science, and so he attempted to devote certain hours to thinking like a scientist, and certain other hours to thinking like a theologian.

Several of the visitors had surprisingly sophisticated philosophies which they had formed with cognizance of the traditional atheistic and agnostic arguments. They had built their religious systems to bypass the major first-level objections that many Caltech students have committed to memory.

Most of the theologians looked upon religion as a means to producing a better world, as an effective measure against forces working contrary to man's general welfare. Physics graduate students, flying the colors of logical positivism, seemed drawn like flies into arguments with this philosophy. Their argument was that one shouldn't make assumptions about the universe (namely, the existence of God) when these assumptions are unnecessary. The theologians' answer was that religion performs a service to man which is necessary for his happiness — a service which no simpler system (one without religion) can perform.

One theologian said flatly that the question of the actual existence of God was irrelevant, since the primary function of belief is to provide an individual with motivation to live by a sound ethical system.

Another theologian admitted quite frankly that he wasn't certain that God existed outside of man's mind, but that he had accepted religion anyway because of the beneficial influence it has on people.

A third theologian said that only through religion will vast numbers of people be made ethical enough to make possible a smooth-running society.

Although most of the theologians were convinced of the actual existence of God, nearly all agreed that this was almost an academic point, and certainly secondary to the service that belief performs.

One theologian summarized the whole new approach to theology by relating it to modern physics. He pointed out that science has defined subatomic particles by their actions and properties, rather than by their actual substance. Likewise, modern religion, said the theologian, defines God by His function and the effect that belief in Him has upon the world. If and when we discover the physical construction of the electron, concludes the theologian, our discovery will not alter the properties of it; the same argument applies to God and religion.

After the first few discussions, even the most enthusiastic Caltech atheists ceased trying to argue their traditional points against religion. Many Techmen finally concluded that the theologians professing this reformed theology were cheating by arguing morality rather than religion. The theologians were told that a scientific, logical approach didn't allow one to believe in something because it is convenient; certainly such a philosophy would ruin science. Yet even the most dedicated atheist gave the theologians credit for a good try, and respected them for forcing him to argue religion on a higher plane than he had before.

In turn, the theologians enjoyed their stay at Caltech. Most admitted that their philosophies had never been attacked so vigorously. More important, they agreed that Caltech students were less hostile to their philosophies than they had anticipated, and several of the theologians expressed a desire to come again.

CHORISTERS

With the Yale Russian Chorus (also brought to the campus by the Caltech YMCA) Techmen had an entirely different experience. Most of the chorus members, all undergraduate or graduate students at Yale, had traveled to Russia during the previous summer, under the sponsorship of the State Department. The chorus would sing spontaneously on the streets of Moscow, and then would mingle with the Russians they had attracted. Techmen were full of questions about Russia, and the Yalies tried to answer them all.

The worst aspect of the Yale visit was the tendency of many of the younger choristers to consider Caltech as a hotel, and to treat Caltech students in the same manner one hotel guest treats another. Besides being slightly aloof, the Yale freshmen were a little trying in their attempts to be sophisticated. Fortunately, Yalies definitely improve with age. The older students were friendly and outgoing.

On the final night of their stay, the choristers presented a two-hour concert, with all of the numbers (except for some encores) sung in Russian. The concert was probably the best musical event Caltech has had in years and the predominantly Caltech audience expressed its appreciation by calling the chorus back for six encores. This display of appreciation, warmly received by the visitors from Yale, provided the impetus for a very successful spontaneous party after the concert with the Yalies. The chorus sang and talked freely, and even the Yale freshmen seemed not quite so concerned with being collegiate.

Generally speaking, the visit gave Caltech a better understanding of Yale and what it represents, though some Techmen were reminded of why they had picked Caltech instead of the Ivy League.

— Roger Noll '62

The Yale Russian Chorus gives a concert in Caltech's Culbertson Hall.

ANTHROPOLOGIST

Explaining that she found Techmen to be "self-contained, rational, cheerful, inner-directed, and career-oriented," Dr. Margaret Mead summed up her opinions on Caltech students after three days of close observation as a guest on the YMCA's Leaders of America Program this month. Despite her tight program, Dr. Mead did discover many things about Techmen, and although she said that she was "not a critic," she did make a few observations on the problems that Caltech students, as a group, seem to have.

Techmen, explained Dr. Mead, are ". . . on the whole, youngsters who have been pretty dissociated from the world they have come from. They learn to think extraordinarily early . . . They've learned to figure everything out." As a result of the Techman's ability to analyze, Dr. Mead continued, he is apt to become isolated from the rest of the race.

This is the problem, and Dr. Mead's suggested solution is to try to find some kind of dilutant that will enable the Caltech student to overcome this isolation. Dr. Mead noted that the Institute attempts to provide this dilutant through its humanities requirements, but she suspected that the humanities here were probably given to us only in the form of the written word – something we have had since we were two years old, and, therefore, not as useful as such other forms of the humanities as ballet (*ballet*?) or art, where life and movement is portrayed.

Dr. Mead admitted, however, that it would probably be easier to "meet the rest of the race" by another means, and one dearer to the Techman's heart – girls. What kind of girls, and how to meet them is, of course, another problem – but Dr. Mead discussed that too.

As far as the Techman's methods for meeting girls are concerned, Dr. Mead merely noted that she had never seen less ambitious Romeos in her life. The Techman, she explained, wants girls to appear and disappear at his wish and is unwilling to go out and find them himself. Techmen, she noted, are also picky about what kind of girls they want as well: "Dartmouth boys want girls. Caltech boys want girls that they think Caltech boys should have."

Dr. Mead then proceeded to discuss just what types of girls Caltech boys should have. She described the ideal girl for a Techman as one who does not want to get married right away. Techmen want to learn something before getting married, and they want their future wives to learn too. "This is one group in the country who want bright wives. This is unique and should be cultivated."

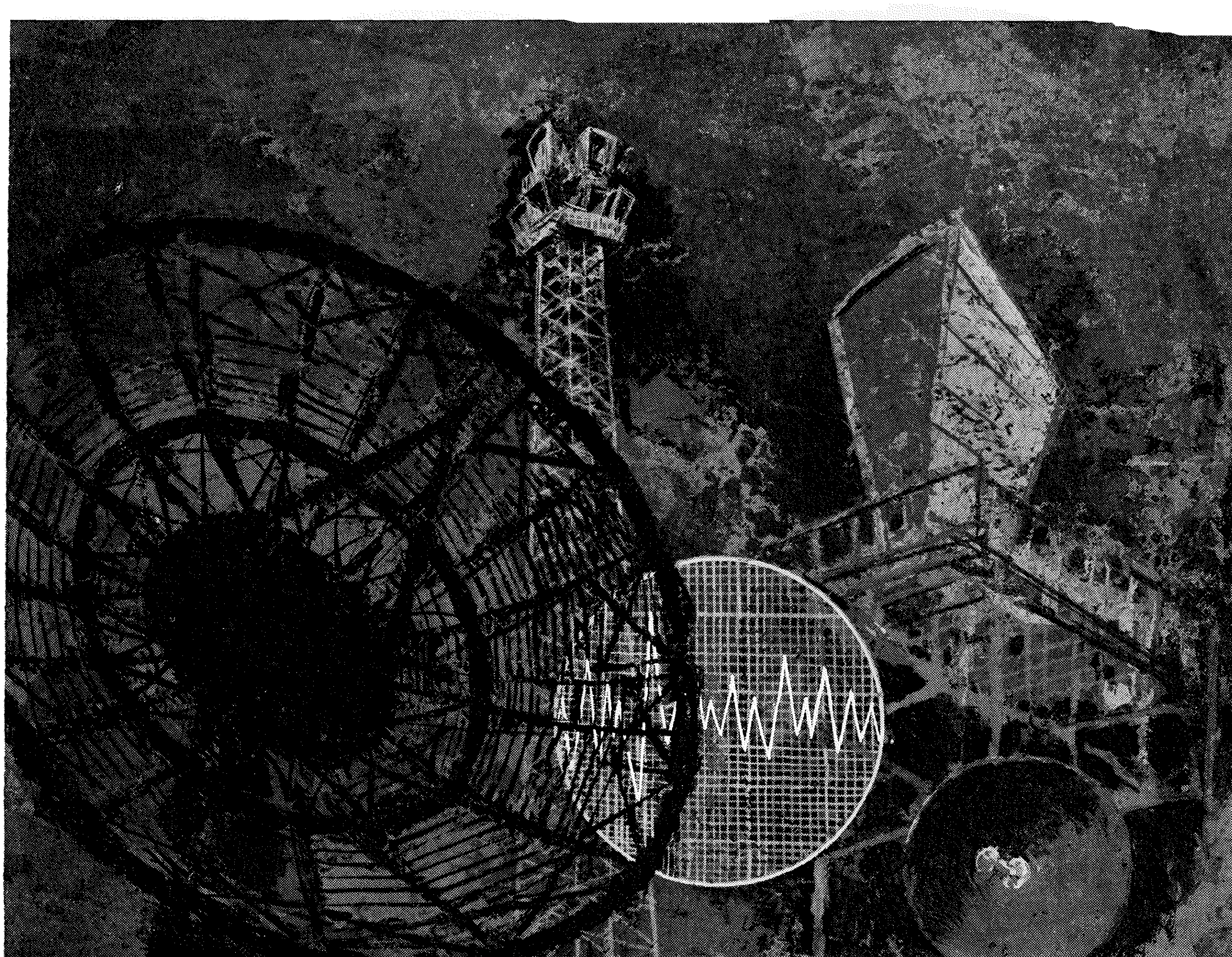
The girl should have some mental capacities, or some sort of gift as well. The problems involved in getting this sort of girl, as can be seen, are serious. Dr. Mead described a survey she took to see if many girls would want to marry a physicist. Very few did. The solution that Dr. Mead proposes is a familiar one, but this is perhaps the first time that it has been proposed seriously. She suggests that a high-level girls college be established on the West Coast. (As mentioned, Caltech students have been considering the idea of turning Tournament Park into a girls school since the 1930's.)

Another interesting situation in which Dr. Mead analyzed the Techman's feelings is in regard to whether or not Pasadena can be called a "college town." First of all, said Dr. Mead, a college town is one that "fights the students all the time." The students at a college, she explained, want the town to know that the college exists. Most important, however, is that in a college town, the university is the town's way of touching with the future. Pasadena, Dr. Mead continued, tends to ignore both the college and the students, thus giving the impression, at least to some of the students, that it really isn't a college town.

It is interesting that Dr. Mead's opinions on the girls' college and Pasadena seem to correlate with opinions that many Techmen have had for a long time. The solution is simple: Let's move Caltech and bring on the girls!

– Richard Karp '64

Margaret Mead, on campus as one of the YMCA's Leaders of America, discusses the natives with Robert Ryan, Resident Associate of Page House.



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The Month at Caltech

National Academy of Sciences

Renato Dulbecco, professor of biology at Caltech, was elected a member of the National Academy of Sciences this month. Election to the Academy, one of the highest scientific honors in the nation, is in recognition of outstanding achievement in scientific research, and membership is limited to 500 American citizens and 50 foreign associates. There are now 36 Caltech staff members in the Academy.

Dr. Dulbecco was born in Catanzaro, Italy, and received his MD from the University of Torino in 1936, at the age of 22. After graduation he was obliged to serve a year and a half in the Army, and in 1938 he returned to the University as an assistant professor in the department of pathology. During the war he served as a medical officer in the Italian Army, and in 1945 he again returned to the University, where he spent two years in the study of physics.

Renato Dulbecco, professor of biology

Dulbecco came to the U.S. in 1947 to work with S. E. Luria in the department of bacteriology at Indiana University, on studies of the action of radiation on bacteriophage, the viruses found in the human body that attack bacteria. He came to Caltech in 1949 to continue his work on bacteriophage under Max Delbruck, professor of biology. In 1951 he decided to apply his combined training in medicine, histology, physics, and bacteriophage to the field of animal virology, hoping to make this hitherto purely medical subject available for the study of fundamental questions in biology.

For many years viruses had been studied chemically and medically, but never very much biologically until E. L. Ellis and Max Delbruck began working with bacterial viruses at Caltech in about 1937. Dulbecco carried over this biological viewpoint to the study of animal viruses and developed techniques which made it possible, for the first time, to make quantitative studies of them. Starting with the development, in 1952, of an accurate and highly sensitive bio-assay method, he was able to study the life cycle of viruses in single cells, to isolate mutants, to analyze the consequences of simultaneously infecting single cells with different viruses, and to make some progress in our understanding of the first steps in tumor production by viruses. Dulbecco is today a leader in animal virus research, and his laboratory is recognized around the world as an outstanding center of such research.

Max Mason

Max Mason, former chairman of the Observatory Council which supervised construction of the Palomar Observatory, died in a Claremont, Calif., sanitarium on March 22, of a cerebral hemorrhage. He was 83 years old.

continued on page 22

The Month . . . *continued*

Dr. Mason was a member of the Caltech executive council, which operated the Institute, from 1936 to 1945, and was a Caltech trustee from 1945 to 1951.

Born in Madison, Wisconsin, Mason was graduated from the University of Wisconsin, and received his PhD in mathematics from the University of Gottingen, Germany, in 1903. After teaching at MIT and Yale, he returned to the University of Wisconsin, where he eventually took the chair of mathematical physics.

As a member of the National Research Council during the first World War, he invented several submarine detection devices, including the hydrophone, which was used to hunt submarines and also for navigation.

Dr. Mason became president of the University of Chicago in 1925, and in 1928 joined the Rockefeller Foundation as its director of natural sciences. He was president of the foundation from 1929 to 1936, when he came to Caltech as vice chairman of the Observatory Council. He became chairman in 1940 and remained as head of the council until it was disbanded in 1948 upon completion of the 200-inch telescope at Palomar. From 1948 to 1950 he was a research associate in astrophysics at Caltech and retired in 1950.

Tuition — Going Up

Annual tuition charges for undergraduate and graduate students at the Institute will be increased from $1275 to $1575 for the academic year beginning in September 1962. The last adjustment was made in 1959 when tuition rose from $900 to $1275.

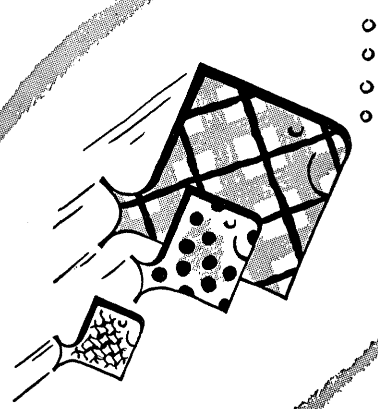
The increase was voted by the Board of Trustees in order to meet steadily rising costs of education at the Institute. The deferred payment plan now in operation will be adjusted to the new tuition charge and an effort will be made to increase the number of scholarships available. Said President DuBridge: "It continues to be our aim to see that no qualified undergraduate student shall be excluded from Caltech for financial reasons alone."

California Institute Associates

Simon Ramo PhD '36, executive vice president and secretary of Thompson Ramo Wooldridge, Inc., has been elected vice president of the California Institute Associates. Preston Hotchkis, Los Angeles attorney, who has served previously as secretary and member of the board of directors, was elected treasurer. William Clayton continues to serve as president.

The California Institute Associates are a group of public spirited citizens interested in the advancement of learning, who were incorporated in 1926 as a non-profit organization for the purpose of promoting interests of the California Institute of Technology.

there's room to GO and GROW—



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Alumni News

Caltech Alumni Fund

The Caltech Development Program recently concluded was an unqualified success. The alumni can be proud of their part: All told, over $2,300,000 was raised from alumni sources.

The Alumni Fund was the vehicle for alumni contributions to the Development Program. We can now chalk up success for this third project undertaken by the Fund.

Initially, the Alumni Fund was established to raise money for a gymnasium and swimming pool. When this goal had been achieved, with the substantial aid of the Scott Brown estate, the Fund was next directed toward raising funds for endowing four undergraduate scholarships. This second goal was achieved, and to date the endowment has provided full tuition for 22 "scholar years." Four new grants covering tuition are being made each year.

Now we face the question of how our continuing financial support can be of most help to the Institute. The Alumni Fund is managed by the Board of Directors of the Alumni Association, with advisory assistance from the Alumni Fund Council and the Institute. It is the combined opinion of these three groups that the next goal for the Alumni Fund should be the establishment of an unrestricted Alumni Endowment Fund for use by the Institute at its discretion.

Present plans call for getting under way next fall. The two remaining spring issues of *E & S* will elaborate further as plans develop. The Board solicits comments and suggestions relative to the Fund; wherever possible they will be incorporated. Please address these to F. G. Crawford, care of the Alumni Office at Caltech.

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

Save the date of June 7 for the
Annual Alumni Meeting and Dinner

Caltech Varsity Game Scores

Baseball

March 28	Claremont-Harvey Mudd	8	Caltech	2
April 1	Azusa College	17	Caltech	3
April 3	Caltech	9	La Verne	7
April 5	Whittier	16	Caltech	3
April 8	Occidental	14	Caltech	1
	Occidental	18	Caltech	4
April 12	Pomona	14	Caltech	2
April 15	Whittier	12	Caltech	1
	Whittier	16	Caltech	2

Tennis

March 30	Caltech	6	Cal Western	1
April 8	UC Riverside	7½	Caltech	1½
April 15	Caltech	6½	Whittier	2½

Swimming

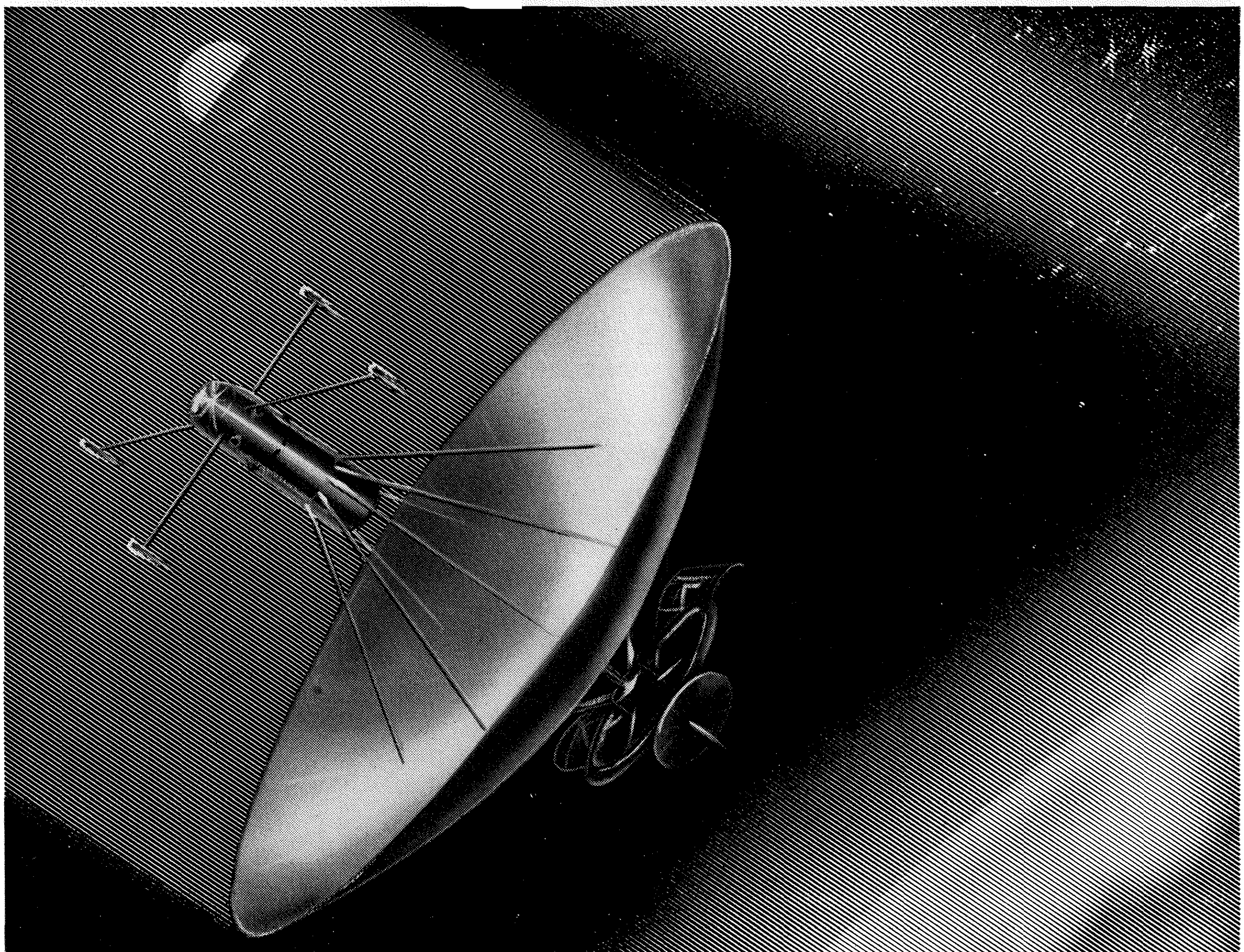
April 3	University of Arizona	65	Caltech	30
April 7	Caltech	73	Whittier	21
April 13	Caltech	76	Claremont-Harvey Mudd	19
April 14	Caltech	48	Long Beach State	47

Track

March 31	Whittier	96	Caltech	30
April 8	Pepperdine	89		
	Caltech	51		
	Cal Western	37		
	UC Riverside	33		
	Caltech Frosh	18		
	Cal Baptist	9		
April 15	Pomona	94	Caltech	37

Golf

March 27	Claremont-Harvey Mudd	36	Caltech	18
March 31	Pomona	32	Caltech	22
April 7	Caltech	28	Whittier	26



Personals

1918

Clarence N. Ward died on January 20 of arteriosclerotic heart disease. He had been retired since June 1959 from his position as an instructor in engineering at Los Angeles City College. He is survived by his wife and mother.

1929

William G. Young, PhD, professor of chemistry and dean of the physical sciences at the University of California in Los Angeles, has been awarded the first Richard C. Tolman Medal of the Southern California Section of the American Chemical Society. The award was given to Dr. Young in recognition of his *outstanding achievement and continuing* efforts in raising the competence of chemists, through activities of the Society which have enhanced the quality of chemistry teaching, and through his production of outstanding students; and in recognition of his pioneering contributions to physical-organic chemistry, especially in the area of fundamental studies of allylic rearrangements.

The late Dr. Tolman, for whom the medal is named, was one of the nation's top atomic scientists. He came to Caltech in 1921 as professor of physical chemistry and mathematical physics. He left temporarily in 1940 to serve as vice chairman of the National Defense Research Committee, and later headed the declassification board of the U.S. Atomic Energy Commission. He returned to Caltech in 1946. Dr. Tolman died in 1948.

1930

L. Sprague de Camp has added a new book to his impressive list. *The Heroic Age of American Invention* was published last month by Doubleday & Company.

1932

John A. Leermakers, PhD, is now associate director of the Kodak Research Laboratories in Rochester, N.Y. He has been assistant director since 1947. John joined Kodak as a chemist in 1934. The Leermakers have three sons.

Myron L. Crater, chief steam power plant engineer for the city of Glendale, died on February 24 of septicemia and arthritis of the hip. He leaves his wife and two daughters, Marjorie Rusler and Margaret Crater, and his brother, *Wilbur D. Crater*, BS '42.

1933

Dwight O. North, PhD, fellow on the technical staff of the RCA Laboratories

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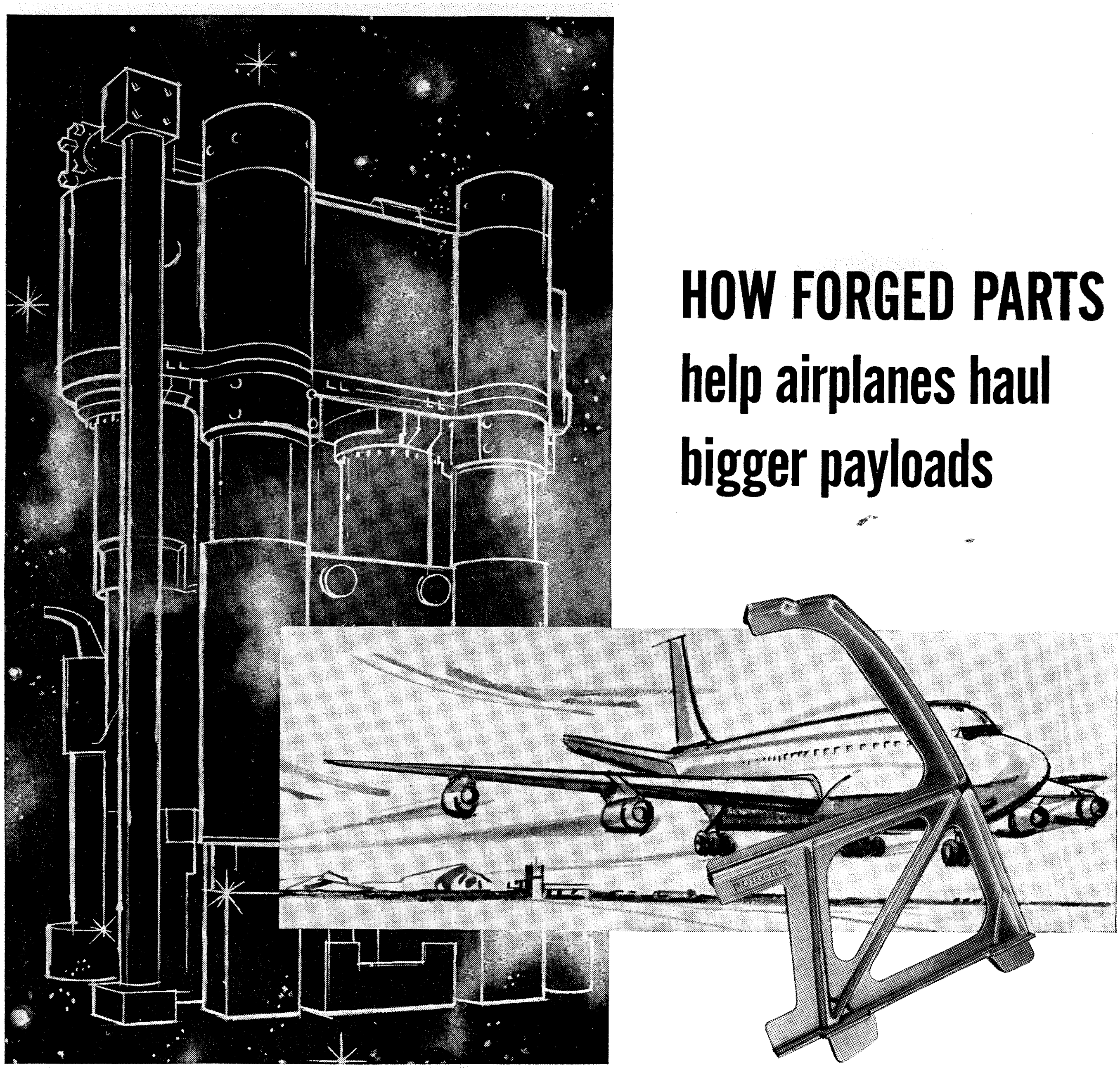
HOW FORGED PARTS help airplanes haul bigger payloads



In an airliner, every pound of weight saved is worth hundreds of dollars . . . in revenue-making payload. And in military aircraft, pounds saved mean added miles-per-hour . . . or added load carried.

In commercial products . . . trucks, cars, materials-handling equipment . . . the pounds of dead weight you eliminate by using forgings make money year-after-year for the operator. The forging process lets you put the metal exactly where you need it to carry the load, withstand shock or vibration, endure torsion. And with not a surplus ounce of non-working weight going along just for the ride.

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in New York, is the recipient of the David Sarnoff Outstanding Achievement Award in Science for "his insight in interpreting the role of a theorist at the RCA Laboratories and for resourcefulness in translating theory into practical results." The award consists of a gold medal, a citation and a cash prize.

1934

Paul Dane, AE '41, is now vice president of a new company, Science Management Corporation, in Denver. He was formerly senior military member of the advisory group for aeronautical research and development at the North Atlantic Treaty Organization headquarters in Paris. Paul was also responsible for the establishment and development of the department of thermodynamics at the Air Force Academy in Colorado Springs.

1943

Ralph G. H. Siu, PhD, technical director of research and development in the research and engineering division of the Office of the Quartermaster General of the U. S. Army, received a Career Service Award from the National Civil Service League on March 21 in Washington, D.C. The awards are given to Federal employees for competence, character, and outstanding achievement. Ralph is considered the key scientist in the radiation preservation of foods. He has served as a technical advisor to the Congressional Panel on the Peaceful Uses of Atomic Energy, and to the National Academy of Sciences.

1944

Knox T. Millsaps, PhD, chief scientist of the Air Force Research Division and executive director of the Air Force Office of Scientific Research, recently received the Arthur S. Flemming Award which is given to outstanding civil servants in technical or scientific fields.

Floyd W. Preston writes from the University of Kansas where he is associate professor of petroleum engineering, that:

"We left Venezuela in January after a stay of two years. During this stay I was a consultant to the Oficina Tecnica de Hidrocarburos of the Ministry of Mines and Hydrocarbons of the Venezuelan Government. At this time I was developing a series of engineering programs for the digital computer in the Ministry. Living in Venezuela was expensive but very enjoyable. The climate is one of the most wonderful in the world. Our four sons enjoyed their stay immensely."

"The date, January 20, is also a memorable one for us because on that day we boarded the ship *Santa Maria* and spent 14 days aboard on its wanderings through the South Atlantic, instead of the scheduled four. Many of our possessions still are on board the ship and we will return to Miami soon to recover them."

Enrique Silgado, MS, is professor of geophysics at the University of Lima in Peru, where he received his PhD in 1959. The Silgados have added a son to their family.

David R. Jones is group supervisor at the California Research Corporation in charge of diesel engine lubricating oil development projects. He writes that he now has six children: boy, 15; boy, 14; girl, 10; girl, 9; girl, 7; and boy, 21 months.

1947

Lt. Col. George R. Vanden Heuvel, MS, assistant for installation and checkout at the directorate of ballistic missiles of the U.S. Air Force in Inglewood, has been awarded the Air Force Commendation Medal for exceptionally meritorious conduct in the performance of outstanding service. The Vanden Heuvels have four children; George, 19; David, 16; Christopher, 12; and Cynthia, 10.

Robert Belyea, treasurer of the Belyea Company, Inc., in New Jersey, has also been vice president of the school board and is now a member of the planning board. The Belyeas have three daughters: Marie, 13; Wendy, 11; and Carolyn, 6. Bob also has a small farm of 20 acres for the benefit of his two horses.

1949

David Liberman, PhD '55, staff member of the Los Alamos Scientific Laboratory, writes that he was married on February 4 to Mrs. Elisabeth Settlage.

1954

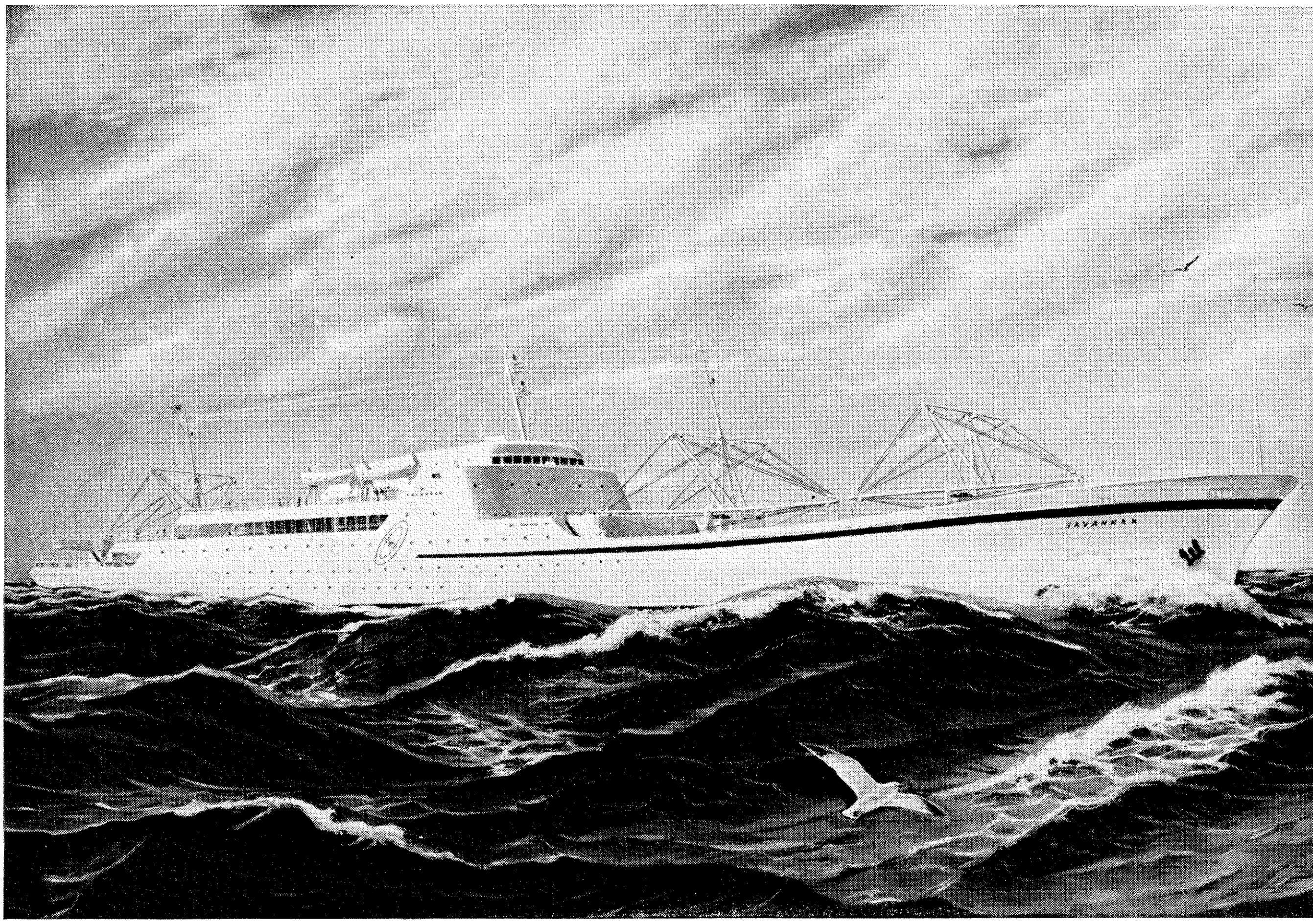
John C. Day is a senior methods programmer on 709 and 7090 computers for the applied programming department of the IBM corporation in New York City. He writes: "My wife and I have spent most of this past winter raising our two girls (Debbie, 5, and Kathy, 3), attending Methodist church activities, and digging out of one snowstorm after another. Having learned our lesson, we hope to return to Southern California at the end of this year."

1958

Lawrence Kittiver, MS, who is on the technical staff at the Hughes Aircraft Company, writes that he now has three daughters.

1959

Charles Ranunkel, MS, is now working as a sales engineer for Minneapolis Honeywell's French subsidiary in Paris.



The Nuclear Ship Savannah is capable of sailing 350,000 nautical miles without refueling. Her uranium oxide fuel is packaged in tubes of Nickel Stainless Steel, more than 5,000 of them. In all, engineers specified 200,000 pounds of Nickel Stainless Steel for use in the ship's reactor... to meet the demands of high operating pressures and temperatures, and to provide much-needed strength and corrosion resistance in this critical application.

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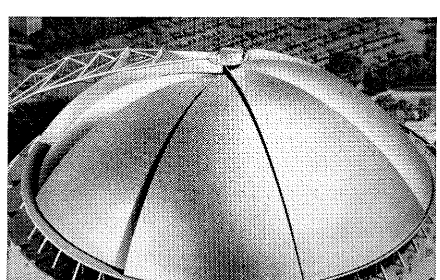
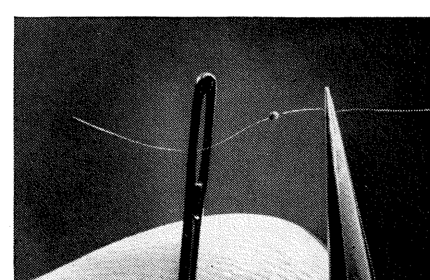


New push-button roof of Nickel Stainless Steel turns a weatherproof auditorium into an open-air stadium in a matter of seconds. The dome will provide years of carefree beauty. That's because stainless steel with Nickel in it is one of the most durable of metals. It's corrosion-resisting all the way through.



Needle's eye reveals relative size of a Thermistor, a tiny bead made with Nickel oxide—used to measure temperatures in and beyond the earth's atmosphere. The Nickel oxide helps develop electrical properties for the accurate recording of temperature changes as small as 1/50th of a degree!

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Twenty-fourth Annual Alumni Seminar

Saturday, May 6, 1961

Dinner and Evening Program

Huntington-Sheraton Hotel, Pasadena

"THE ORDERLY SCIENTIST IN THE DISORDERLY WORLD" – PHILIP S. FOGG

Philip Fogg is president and board chairman of Consolidated Electrodynamics Corporation, a subsidiary of the Bell and Howell Company. In the course of his career he has had many opportunities to observe scientific people, both in scientific and non-scientific environments. As a graduate of Stanford and the Harvard Graduate School of Business Administration, he has a strong background in economic theory and social science. As a professor of business economics at Caltech, he had 11 years to observe scientists in the raw – namely, Caltech undergraduates – and their reaction to the less rigorous discipline of economics. As head of a highly technical organization, he is in a unique position to analyze the impact of scientific people on the world of business and commerce and vice versa.

Special Exhibits

Caltech Development Program Exhibit – Public Affairs Room – Tandem Accelerator Demonstration – Frictionless Motion Demonstration – Keck Engineering Laboratories Open House (Water Resources, Environmental Health and Materials.)

Outstanding Lecture Program

Three morning and three afternoon periods, each with four simultaneous lectures. Each lecture will be given twice during the day.

Alumni outside of southern California who wish to attend the Seminar should write the Alumni Office for reservations.

Seminar Lectures

PROOFS OF RELATIVITY
9:30 A.M. and 11:45 A.M.
H. P. Robertson, Professor of Mathematical Physics

Relativity has proceeded deductively, from theory to experiment. To what extent is the reverse inductive process now applicable? Can we derive the structure of space-time? If not, what further tests should be undertaken in these days of cosmotrons, satellites, and space-science Olympiads? Dr. Robertson reviews these exciting questions with sidelights on such issues as the Clock Paradox, the Nebular Redshift and the Big Bang vs. Eternal Boredom theories of the expansion of the Universe.

IS THERE WATER ON THE MOON?
9:30 A.M. and 11:45 A.M.
Bruce C. Murray, Research Fellow, Division of Geological Sciences.

Since water is considered essential for life, its possible occurrence on the moon is intriguing. Dr. Murray believes that the permanently shaded areas, which are extremely cold, will collect water as ice despite the nearly perfect vacuum on the lunar surface. Ice may also occur on the moon in dust accumulations, which would provide a possible environment for the survival of microscopic life.

WHAT SHOULD SPACE COST?
9:30 A.M. and 11:45 A.M.
Eberhardt Rechtin, Director, Deep Space Instrumentation Program, JPL.

Space exploration is expensive, and the efficient use of men and money is critical. We may achieve either great progress or great waste, and affect the livelihood of thousands in the process. Mr. Rechtin will discuss the optimization of space results, using such current cost yardsticks as dollars per orbited pound, "bits per buck," and probable flight-value per dollar.

AMERICA, THE MENACE OF THE FUTURE
9:30 A.M. and 11:45 A.M.
Cushing Strout, Associate Professor of History

What are the sources of "Anti-Americanism," especially among the intellectual classes of Western Europe? How is it related to European and American policy and culture? What myths does it lean upon and promote? Can anything be done about it? Dr. Strout will discuss these provocative questions which are related to studies for his forthcoming book.

THE MONTE CARLO METHOD
10:45 A.M. and 3:15 P.M.
John Todd, Professor of Mathematics

Automatic computing equipment has made possible the widespread application of the Monte Carlo method, which uses pseudo-random numbers for solving extremely difficult problems in mathematics, biology and physics. It is an experimental procedure which has long been known but was not very effective in manual use. Professor Todd stresses the great progress that has been made in the various fields of atomic energy through the potent combination of high speed computers and the Monte Carlo method.

OXYGEN ISOTOPES,
THE FOOTPRINTS OF TIME
10:45 A.M. and 3:15 P.M.
Irene Goddard, Chemist, Division of Geological Sciences

How old is the ice 1400 feet deep in the Greenland ice cap, and what was the weather like when it was formed? Is the rain the same in all plains? Can snow from Mt. Baldy or the South Pole be identified? These are some of the questions which Dr. Goddard has helped to answer by studies of the oxygen isotopes.

LIVING ON CRACKED ICE
10:45 A.M. and 3:15 P.M.

C. J. Pings, Associate Professor of Chemical Engineering

Science and national defense provide increasing incentives for geological and engineering research in the polar regions. In furthering such work Dr. Pings has spent part of several summers in the crevasses of a Greenland glacier, making measurements of movement, strain, and temperature. He will discuss his research and his experiences in camping on the Greenland ice cap.

IS WORLD DISARMAMENT POSSIBLE?
10:45 A.M. and 3:15 P.M.
David C. Elliot, Professor of History

The perplexing problems of arms control, arms limitation and disarmament are subjects of Institute-wide studies in the Carnegie Science and Government Program. Dr. Elliot who administers these studies will discuss the possibilities, implications, and consequences developed in this important search for a new security system.

HOW DOES A FISH SWIM?
2:15 P.M. and 4:15 P.M.
T. Y. Wu, Associate Professor of Applied Mechanics

The motion of a swimming fish is a scientific mystery that has only recently yielded to analysis. Two flexible models capable of wave-like motion have been used in the experiments, one a thin plate and the other a model fish. These have permitted the evaluation of swimming efficiency and the qualitative effects of skin softness on skin friction.

THE BALLET OF BIG MOLECULES
2:15 P.M. and 4:15 P.M.
James Bonner, Professor of Biology

To a biologist DNA is the choreography of life, written in a self-reproducing script. This script directs the RNA, which governs the enzyme molecules which in turn regulate the growth of the cells from which all living matter is constructed. Since DNA, RNA, and enzymes are all large molecules, and since their intricately-ordered movements constitute living matter, Dr. Bonner views life as the ballet of the big molecules.

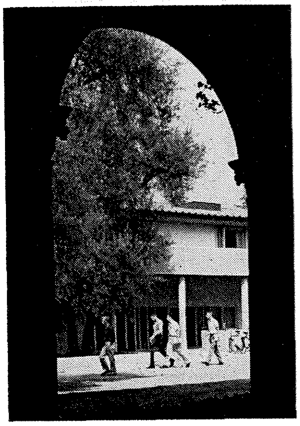
NEW VIEWS OF THE SUN
2:15 P.M. and 4:15 P.M.
Robert B. Leighton, Professor of Physics

New techniques for measuring the magnetic and velocity field of the sun's atmosphere have revealed that the atmosphere oscillates locally with a five-minute period. Dr. Leighton will discuss this and other interesting features of the sun.

BERLIN – HOSTAGE AND LIVE BAIT
2:15 P.M. and 4:15 P.M.
Heinz E. Ellersieck, Associate Professor of History

Berlin is a symbol of both East and West, and plays a key role in several cold wars. As the spoils of World War II, it is torn between the victors in that war. And yet, it is not simply booty – it also commands its conquerors. Dr. Ellersieck, a recent visitor to Eastern Europe, will discuss this paradox and how Berlin's very vulnerability is its protection.

CALTECH CALENDAR



ALUMNI EVENTS

May 6	Annual Alumni Seminar Day
June 7	Annual Alumni Meeting and Dinner

ATHLETIC SCHEDULE

Tennis

April 25
Occidental at Caltech

April 29
Claremont-Harvey Mudd at Claremont

May 6
Pomona at Pomona

May 12
Conference Tourn. at Redlands

Baseball

April 26
Redlands at Caltech

April 28
Pasadena College at Caltech

May 3
Chapman at Caltech

Swimming

April 28
Occidental at Caltech

May 3
Conference Prelim. at Caltech

May 4
Conf. Diving Finals at Caltech

May 5
Conference Meet at Caltech

FRIDAY EVENING DEMONSTRATION LECTURES

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

April 28
Spectroscopy – What Can Light Tell Us About the Structure of Matter?
—Mostofa El-Sayed

May 5
Rock Magnetism
—Charles Helsley

May 12
The Outermost 100 Miles of the Earth
—Frank Press

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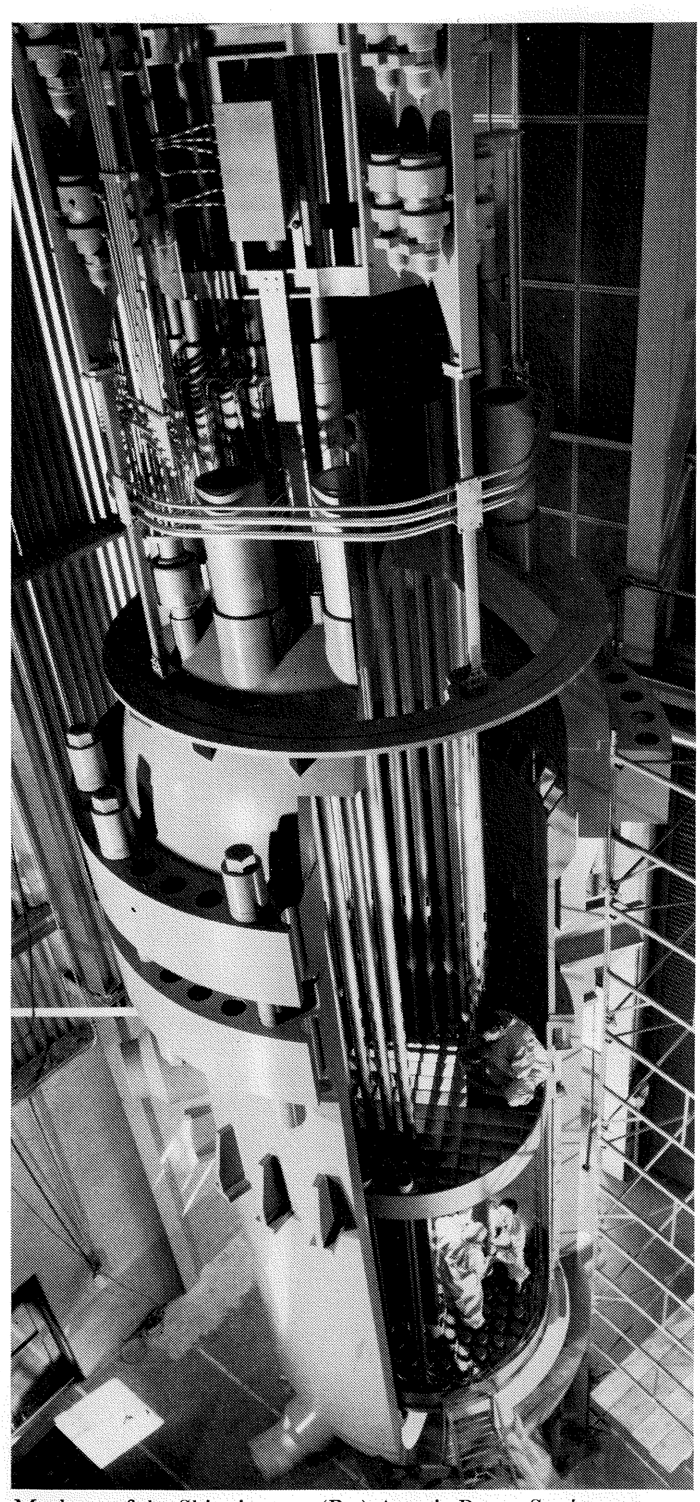
If your sights are set  on nuclear power–



Mock-up of the Shippingport (Pa.) Atomic Power Station reactor which was designed and developed by the Westinghouse Electric Corporation under the direction of and in technical cooperation with the Naval Reactors Branch, U.S. Atomic Energy Commission.

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*One of a series**

Interview with General Electric's Charles F. Savage Consultant—Engineering Professional Relations

How Professional Societies Help Develop Young Engineers

Q. Mr. Savage, should young engineers join professional engineering societies?

A. By all means. Once engineers have graduated from college they are immediately "on the outside looking in," so to speak, of a new social circle to which they must earn their right to belong. Joining a professional or technical society represents a good entree.

Q. How do these societies help young engineers?

A. The members of these societies—mature, knowledgeable men—have an obligation to instruct those who follow after them. Engineers and scientists—as professional people—are custodians of a specialized body or fund of knowledge to which they have three definite responsibilities. The first is to *generate* new knowledge and add to this total fund. The second is to *utilize* this fund of knowledge in service to society. The third is to *teach* this knowledge to others, including young engineers.

Q. Specifically, what benefits accrue from belonging to these groups?

A. There are many. For the young engineer, affiliation serves the practical purpose of exposing his work to appraisal by other scientists and engineers. Most important, however, technical societies enable young engineers to learn of work crucial to their own. These organizations are a prime source of ideas — meeting colleagues and talking with them, reading reports, attending meetings and lectures. And, for the young engineer, recognition of his accomplishments by associates and organizations generally heads the list of his aspirations. He derives satisfaction from knowing that he has been identified in his field.

Q. What contribution is the young engineer expected to make as an active member of technical and professional societies?

A. First of all, he should become active in helping promote the objectives of a society by preparing and presenting timely, well-conceived technical papers. He should also become active in organizational administration. This is self-development at work, for such efforts can enhance the personal stature and reputation of the individual. And, I might add that professional development is a continuous process, starting prior to entering college and progressing beyond retirement. Professional aspirations may change but learning covers a person's entire life span. And, of course, there are dues to be paid. The amount is graduated in terms of professional stature gained and should always be considered as a personal investment in his future.

Q. How do you go about joining professional groups?

A. While still in school, join student chapters of societies right on campus. Once an engineer is out working in industry, he should contact local chapters of technical and professional societies, or find out about them from fellow engineers.

Q. Does General Electric encourage participation in technical and professional societies?

A. It certainly does. General Electric progress is built upon creative ideas and innovations. The Company goes to great lengths to establish a climate and incentive to yield these results. One way to get ideas is to encourage employees to join professional societies. Why? Because General Electric shares in recognition accorded any of its individual employees, as well as the common pool of knowledge that these engineers build up. It can't help but profit by encouraging such association, which sparks and stimulates contributions.

Right now, sizeable numbers of General Electric employees, at all levels in the Company, belong to engineering societies, hold responsible offices, serve on working committees and handle important assignments. Many are recognized for their outstanding contributions by honor and medal awards.

These general observations emphasize that General Electric does encourage participation. In indication of the importance of this view, the Company usually defrays a portion of the expense accrued by the men involved in supporting the activities of these various organizations. Remember, our goal is to see every man advance to the full limit of his capabilities. Encouraging him to join Professional Societies is one way to help him do so.

Mr. Savage has copies of the booklet "Your First 5 Years" published by the Engineers' Council for Professional Development which you may have for the asking. Simply write to Mr. C. F. Savage, Section 959-12, General Electric Co., Schenectady 5, N. Y.

***LOOK FOR** other interviews discussing: Salary • Why Companies have Training Programs • How to Get the Job You Want.

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