ENGINEERING | AND | SCIENCE

FEBRUARY/1954

Chemical Biology . . . page 9

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

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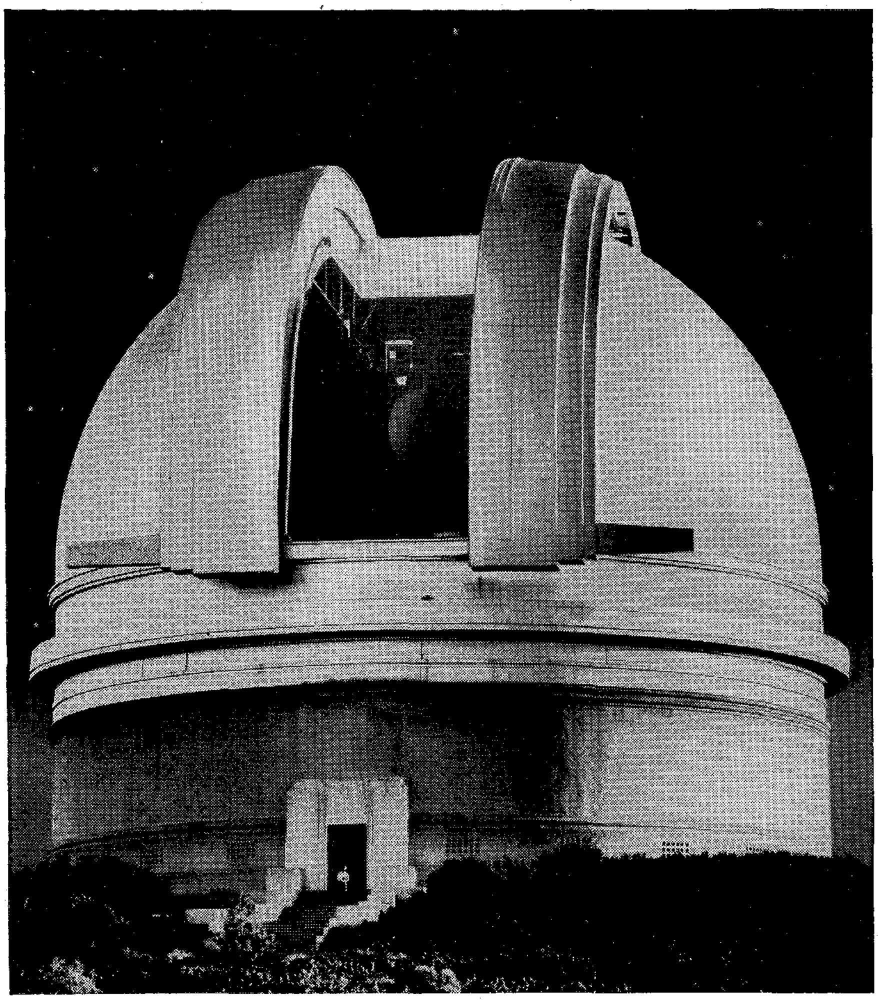

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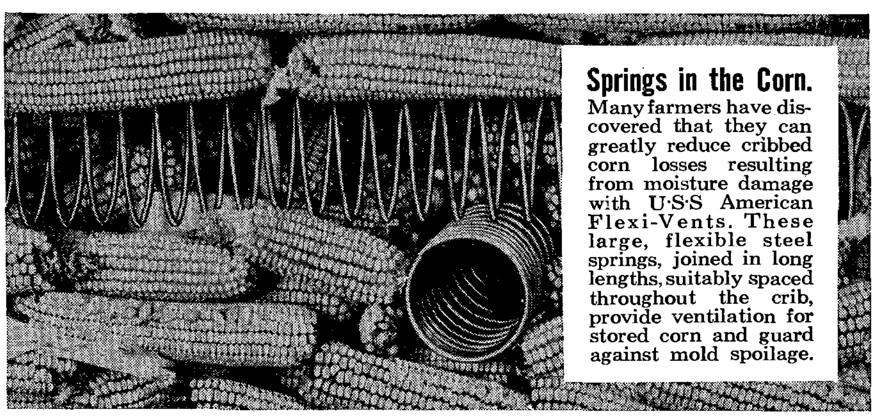

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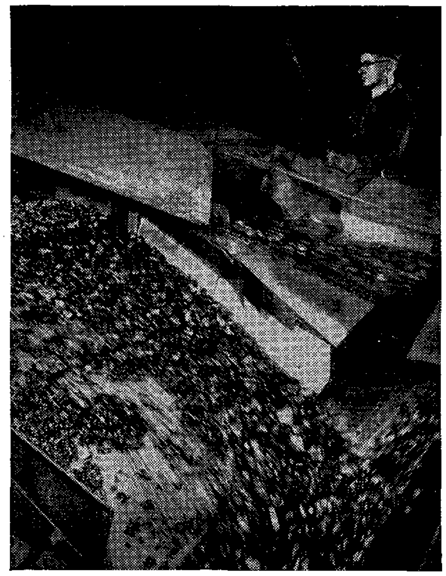

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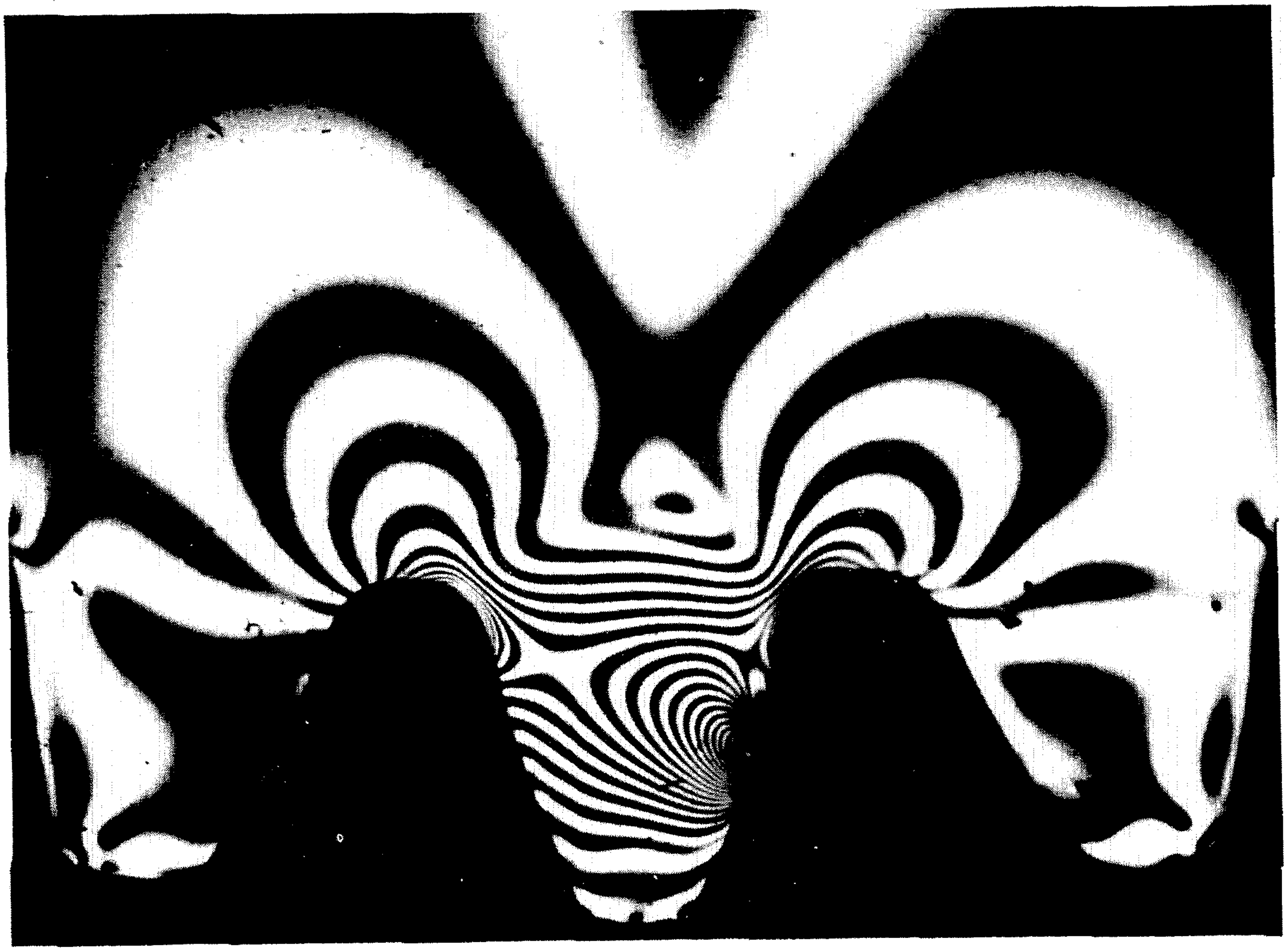

ENGINEERING AND SCIENCE

IN THIS ISSUE

On the cover this month are George Beadle and Linus Pauling, the men in charge of Caltech's chemical biology program.

Chemical biology is not a new science: it's merely the name given to work in chemistry that is of biological interest, and work in biology in which the chemical approach is used. Collaboration between the fields of chemistry and biology has always been particularly active here at Caltech—thanks largely to the fact that George Beadle, head of the Biology Division, is a chemically-minded biologist; while Linus Pauling, head of the Chemistry Division, is a biologically-minded chemist.

For the past seven years the Rockefeller Foundation has been supporting the Caltech work in chemical biology. Now, with a new conditional Rockefeller grant of $1,500,000, it looks as if the program can go ahead on something like a permanent basis. The story of the program is on page 9 of this issue.

The Challenge of Man's Future, on page 16 of this issue, has been adapted from a forthcoming book by Harrison Brown, Caltech Professor of Geochemistry. The book—*The Challenge of Man's Future*, is due to be published on March 19 by The Viking Press. Meantime, the sample we're running in this, and in the next issue of *E&S*, ought to whet your appetite.

PICTURE CREDITS

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BOOKS

SARTRE: HIS PHILOSOPHY AND PSYCHOANALYSIS
by Alfred Stern*
Liberal Arts Press, N.Y. $4.50

Reviewed by Hunter Mead
Professor of
Philosophy & Psychology

I MUST ADMIT that I began Dr. Stern's book with considerable prejudice. Like most Americans. I knew existentialism only at second hand from reviewers and references in serious magazines, plus having read one of Sartre's novels and having seen the film based on his novel *The Chips Are Down.*

These inadequate sources had given me a distorted picture of the whole existentialist movement, again probably the view of most Americans. Neither the pessimism nor the obscenity which characterizes much existentialist thought had bothered me particularly, and I had even become accustomed to regarding nausea as something of profound metaphysical significance. What I had felt, however, was that the movement was basically a war-born phenomenon, and that like all such phenomena had to be judged strictly within that narrow historical setting.

This volume of Dr. Stern's has not only convinced me of my error, but has made me recant to the degree that I now regard existentialism as a really significant development in European thought.

While Stern points out how much of Sartre's thought is derivative, and quite properly chides him for not acknowledging the sources he uses so heavily, the fact remains that this remarkable Frenchman, while still in his thirties, was able to give voice to the feelings and ideas of innumerable younger Europeans. And it seems to me probable that his writings will continue to reflect these feelings and ideas for more than the one generation which produced them.

Would Sartre's philosophy have been produced if there had been no World War II? Since the general outline of his thought was in existence before the war, the answer seems to be yes. Would he have found the audience he did had there been no war, or at least if France had not known German occupation for several years? Possibly not; at least it seems unlikely he would have found his audience so quickly. Are the pornography and the emphasis upon physiological function an essential part of his philosophy? Apparently the pornography is not really essential, but certainly bodily functions and states (*e.g.*, nausea) are basic to his thinking. And certainly no contemporary thinker has revealed so clearly both the basis and the metaphysical-ethical implications of *anxiety*.

It is of course now quite fashionable to acknowledge that this is an age of anxiety, that anxiety is the most pervasive psychological problem of our day, and so on. But Sartre, it seems to me, reveals unique insight in his treatment of anxiety as central in modern living, particularly among free men. He shows that anxiety is the inevitable price which we pay for freedom and intellectual emancipation, and, unlike most writers (particularly psychologists) who discuss anxiety, he sees no cure for it.

In this sense (as in several others) his philosophy is pessimistic, and as Dr. Stern points out, his psychoanalysis is anything but a therapy. At most the existential psychoanalyst would merely try to get his patients to accept anxiety as normal, and perhaps try to aid them in learning to live with this state.

But exactly what is existentialism —what are its fundamental ideas and frames of references? Well, that is Dr. Stern's story—and in my opinion he tells it admirably. Whether Sartre will have any new converts as a result of this book is doubtful; certainly Dr. Stern is not out to make converts, and he points out the inadequacies, even the failures, of Sartre's thought very plainly.

But reading this volume will increase almost anyone's understanding of an important part of European thought. One can only wish it were required reading for those persons in our government who are in charge of our efforts to keep France within the European defense community and to persuade the younger generation of Frenchmen that their destiny lies outside the Soviet orbit. Sartre is not a Communist, and not even a fellow traveller, as Dr. Stern shows. But a perusal of this book makes some American efforts to keep France securely on our side seem as naive as those traditional stories about the birds and the bees.

*Associate Professor of Language and Philosophy

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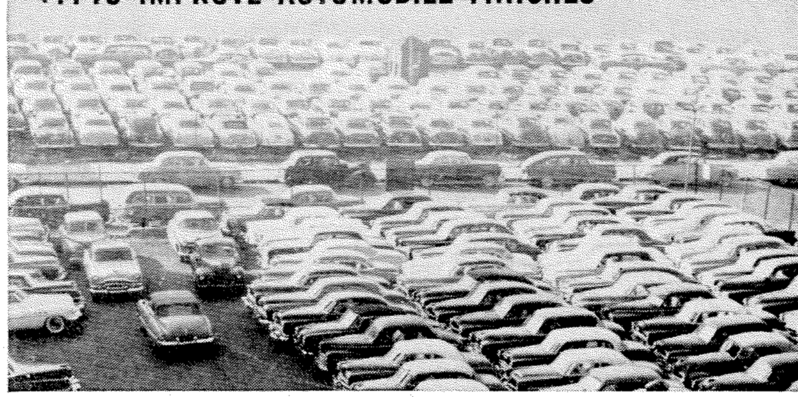

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CHEMICAL BIOLOGY

Collaboration between biology and chemistry at Caltech has already resulted in some impressive discoveries. Now a new grant promises to put the program on a long-term basis.

THE ROCKEFELLER FOUNDATION last month made a conditional grant of $1,500,000 to the Institute for research in chemical biology—the condition being that the Institute match the Foundation's $1,500,000 in a period of three years.

This means that if the Institute can raise approximately $100,000 every two months for the next three years—from individuals, corporations or foundations—the Rockefeller Foundation will contribute an equal amount toward the support of chemical biology at Caltech.

This new grant is actually a continuation and an extension of support provided by the Rockefeller Foundation for several years. Present work in chemical biology here is being conducted in part on a $700,000, seven-year Rockefeller grant, available at the rate of $100,000 a year.

Chemical biology is, of course, no new branch of science. It is merely the name given to that work in chemistry which is of biological interest—and to that work in biology in which the chemical approach is used to solve biological problems.

Though this collaboration between chemistry and biology is certainly not unique to Caltech, it is nevertheless in full and vigorous operation here, and is proving to be an increasingly productive field of research.

From the chemical side, Caltech's chemical biology program includes:

1. Organic chemistry—the chemistry of the compounds of carbon, which occurs in practically all of the substances which constitute living matter.

2. The principles of molecular structure, as these apply to compounds of biological importance—particularly the proteins and the nucleic acids. These are key substances in all living systems. They are enormously complex. They have never been synthesized, and their structure is not known, but they are essential to the progress of biology.

Proteins form a vital part of the protoplasm of all plants and animals. Their presence in cells and tissues (and therefore in man's food materials) is essential to the continuance of life.

Nucleic acid is considered to play an important part in the synthesis of protein, with which it usually occurs combined. According to the most recent studies (page 11) it may be the substance out of which genes are made. It may also be the key to reproduction.

3. Immunochemistry—studies of the structure and action of antigens and antibodies.

4. Enzyme chemistry—attempts to discover and isolate enzymes, the catalysts responsible for many of the chemical reactions of living organisms.

5. Disease in relation to molecular abnormalities. This unique field of research has developed from the discovery four years ago in the Caltech chemistry laboratories, that some forms of anemia are based upon abnormalities of the hemoglobin molecule.

From the biological end the Caltech chemical biology program covers:

1. The physiology of plants and animals.

2. Biochemistry—the chemical reactions which take place in living organisms.

3. Certain chemical aspects of embryology (such as the mechanism of fertilization).

4. Chemical genetics—studies of the genes, the units of heredity, and what they do in relation to the development of form and function in an organism.

5. Immunogenetics—the investigation of how genes are related to the antigens that are of importance in blood groups, skin grafting, and immunity to disease.

6. Bio-organic chemistry—the chemistry of naturally occurring compounds.

7. Virology—studies of viruses, the smallest known entities that can reproduce themselves.

8. Some aspects of plant and animal ecology.

In general this program involves an attempt to uncover basic principles rather than to attack specific practical problems. The researchers are trying to determine the structure of genes and the mechanism of their action rather than to develop commercially profitable mutants; to obtain a fundamental understanding of viruses and antibodies rather than to prepare an antiserum for a particular disease; to learn the basis of the physiological activity of drugs in terms of their molecular structure rather than to find a new bacteriostatic substance.

Nevertheless, practical discoveries are often made incidentally in the course of fundamental investigations. In fact, the Caltech workers hope that in the course of this fundamental research new ideas will be developed which will provide the basis for clinical research on such medical problems as those presented by neoplastic, cardiovascular, and virus diseases.

Several impressive discoveries have taken place in chemical biology in recent years.

The structure of proteins

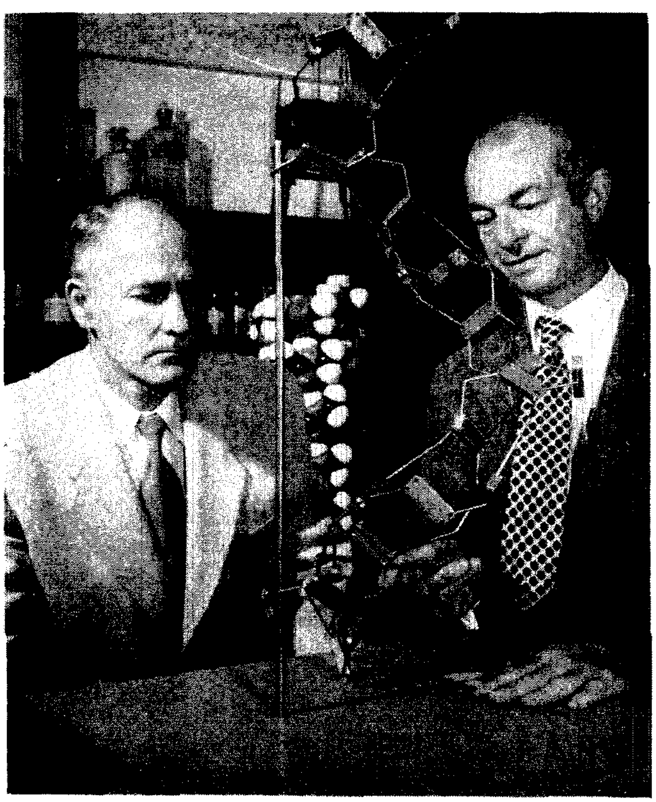
In 1951 Dr. Linus Pauling, chairman of the Caltech Division of Chemistry and Chemical Engineering, and Dr. Robert B. Corey, Professor of Structural Chemistry, reported their discoveries of the essential atomic structure of several proteins—including those found in bone, muscle, and red blood cells.

One of the most important problems in the field of biochemistry is to find out how proteins, the principal building blocks of the body, are put together.

The major components of all living cells are proteins, fats, carbohydrates, salt and water. Though all of them are essential, the proteins among these are responsible for many of the activities which we associate primarily with living things—and in this respect, they may be considered more important than any of the other components of living cells.

Some of the most important proteins include hair, silk, wool, horns, fingernails and feathers. The major components of skin and muscle are proteins; so are the major components of hemoglobin and the antibodies found in the blood. In addition, both the viruses and the genes either contain proteins or are closely associated with them.

Altogether, there are thousands of different kinds of proteins in the human body. Unlike the molecules of most other chemicals, which consist of a score or two of individual atoms, protein molecules are made up of thousands—sometimes millions—of individual atoms.



George W. Beadle, chairman of the Caltech Division of Biology, and Linus Pauling, chairman of the Division of Chemistry and Chemical Engineering. Pauling is pointing out details of bonding in a proposed protein structure.

Dr. Renato Dulbecco, Associate Professor of Biology. His new technique for studying animal viruses made it possible to isolate, for the first time, genetically pure strains of the three known types of polio virus.

each occupying a specific place in the architecture of the molecule.

The first great advance toward an understanding of protein structure was made in 1900 when Emil Fischer, a German, found that a protein molecule is composed of simpler substances known as amino acids (of which there are 24 in all), and that the amino acids, in turn, are linked together into larger groups known as peptides, and the peptides are linked together into even larger groups known as polypeptides.

The problem of determining the structure of proteins then became one of finding the sequence of various amino acids in the chain and the way in which the chain is coiled.

Instead of trying to study the complicated proteins directly, Pauling and Corey, some fifteen years ago, began to investigate the crystal structure of the amino acids, of simple peptides, and of other simple substances related to proteins. In this way they were ultimately able to obtain enough structural information to permit the precise prediction of reasonable configurations of the structure of several proteins.

Virus research

In 1952 Dr. Renato Dulbecco, then a Senior Research Fellow in Biology (now Associate Professor), developed a new technique for studying those viruses which attack animal tissue (as compared with those which attack only plants, or bacteria). These are the viruses which cause such diseases as smallpox, shingles, influenza and poliomyelitis. Formerly, animal viruses could be studied only by the slow and expensive process of infecting monkeys or (at less cost) chicken embryos.

Dulbecco's new technique is to grow a single layer of animal tissue cells in a nutrient medium in a small dish and then to introduce a weak suspension of virus particles. If a single virus attacks a tissue cell it will multiply and produce a small visible area of dead cells. Thus the number of virus particles in the original suspension can be counted and the progeny from any single virus can be "bred" for further study.

This technique is analogous to the "plaque count" technique so widely used for study of the viruses that attack bacteria.

The importance of this development has already been demonstrated. Last year, applying the plaque technique to polio virus, Caltech researchers were able to isolate for the first time genetically pure strains of the three known types of polio virus. This means that it is now possible to start intensive studies of the development and hereditary properties of that virus.

Nucleic acid

In 1953, J. D. Watson, then at the Cavendish Laboratory in Cambridge (and now Senior Research Fellow in Biology at Caltech), and F. H. C. Crick proposed a molecular structure for desoxyribonucleic acid (DNA). This chemical is found largely in the chromosomes, and recently has come to be thought of prime importance in living systems. Various types of biological experimentation indicate a close relationship—if not identity—with the gene itself, the unit of heredity.

The Watson-Crick structure consists of two (not one, as had previously been proposed) polynucleotide chains helically coiled around a common axis. A polynucleotide is a long chain molecule formed by the regular union of nucleotides (units containing sugar, phosphate, and purine or pyrimidine bases).

The DNA structure has four bases; two of these—adenine and guanine—are purines; and two—thymine and cytosine—are pyrimidines. The two chains are held together transversely by hydrogen bonds between bases in such a way that guanine is bonded to cytosine and adenine to thymine. The phosphate residues are on the outside of the helix.

The DNA structure is of particular interest because it indicates how it might carry out the essential operation required of genetic material—that of exact self-duplication. The feature that appears to have special biological significance is the complementary nature of the two components of the double helix. The structure presumes that specificity is determined by base composition and order; when the specificity of one chain is fixed, that of the other is determined in a complementary way. Presumably during nucleic acid biosynthesis the two complementary components of the helix separate and each directs the synthesis, not of another chain exactly like itself, but rather of a complementary counterpart.

Chemistry at Caltech

Research in chemistry at Caltech began in 1913—the year that Arthur A. Noyes, then Acting President of the Massachusetts Institute of Technology and Director of its Research Laboratory of Physical Chemistry, became associated with this institution. The first unit of the Gates Chemical Laboratory was constructed in 1916, the second unit in 1927, and the Crellin Laboratory in 1937.

For six years Dr. Noyes divided his time between Caltech and MIT. In 1919 he began to spend full time here, and teaching and research in chemistry expanded vigorously. Dr. Noyes, a physical chemist, concentrated on the inorganic aspects of the science, and aspiring chemists came from all over the country to study under him.

Among these was Linus Pauling, a graduate of Oregon State Agricultural College. After three years of advanced study under Noyes, Pauling was so interested in the physical aspects of chemistry that he considered becoming an atomic physicist. On a National Research Fellowship he spent a year in Munich, studying theoretical physics under Arnold Summerfeld. In the following year he studied with Niels Bohr in Copenhagen and Erwin Schroedinger in Zurich.

But chemistry was still his chief interest. In 1931, when he was 30 years old, he become a full professor at Caltech, and when Dr. Noyes died in 1936, Pauling was chosen to succeed him as chairman of the Division of Chemistry and Chemical Engineering.

Under Pauling the division began to expand its studies in organic chemistry. With the support of several grants and an endowment fund of $1,000,000 from the Rockefeller Foundation, the field of organic chemistry was soon as strong as inorganic chemistry at Caltech. And, under Pauling's influence, it concentrated on the organic chemistry of substances of biological importance, such as antibodies and hemoglobin.

Biology

Changes were taking place in the Division of Biology at Caltech, too. Work in biology got under way here in 1928, when the first unit of the William G. Kerckhoff Laboratories of the Biological Sciences was built (the second being added in 1938).

Thomas Hunt Morgan came from Columbia University to organize the Division of Biology at Caltech. The presence of the famous geneticist here attracted students and faculty interested in this branch of biology. Among these was George W. Beadle, a graduate of the University of Nebraska, with a Ph.D. from Cornell University, who came to Caltech as a National Research Fellow. Beadle worked in Dr. Morgan's laboratory from 1930 to 1936, went to Stanford University for 10 years, then returned to Caltech in 1945 as chairman of the Division of Biology.

In the years when Pauling was becoming interested in the biological aspects of chemistry, Beadle was concerned with the chemical aspects of biology. At Stanford, his research with the bread mold, *Neurospora*, did much to establish the chemical nature of gene action—and to encourage the development of the now thriving field of chemical genetics.

It was inevitable that, with Beadle and Pauling in charge, the Divisions of Chemistry and Biology at Caltech would work together closely. In 1946, in fact, shortly after Beadle became chairman of Biology, he and Pauling outlined their first joint program of research on the fundamental problems of biology and medicine.

This program has been supported, to date, by the Rockefeller Foundation's $700,000 seven-year grant, as well as by a number of grants from foundations, private sponsors, government agencies, and other organizations.

Gifts and bequests of the late Norman W. Church have now provided a fund of approximately $1,000,000 for the construction of a new chemical biology laboratory (*E&S*—February 1953) adjacent to the Crellin and Kerckhoff buildings, and with connections planned to both of them. Construction of the Norman W. Church Laboratory of Chemical Biology should get under way this year.

To date, $1,500,000 has been authorized for the construction of the Church Laboratory—though the cost of building will probably be closer to $2,000,000. When funds can be found for the purpose, it is also planned to build a 90 x 50 foot connection between the Kerckhoff and Church Laboratories. The estimated cost of this wing is $600,000. It would contain a general stockroom for the Division of Biology and, in addition to laboratories for general use, specialized laboratories for the virus research that is now being carried on partly in

James D. Watson, Senior Research Fellow in Biology. With F. H. C. Crick, he has proposed a molecular structure for desoxyribonucleic acid (DNA) — a chemical which is closely related to, if not identical with, the gene. A model of the DNA structure is in the lower right hand corner of this picture; Watson is examining a possible structure for another form of nucleic acid — ribosenucleic acid (RNA).

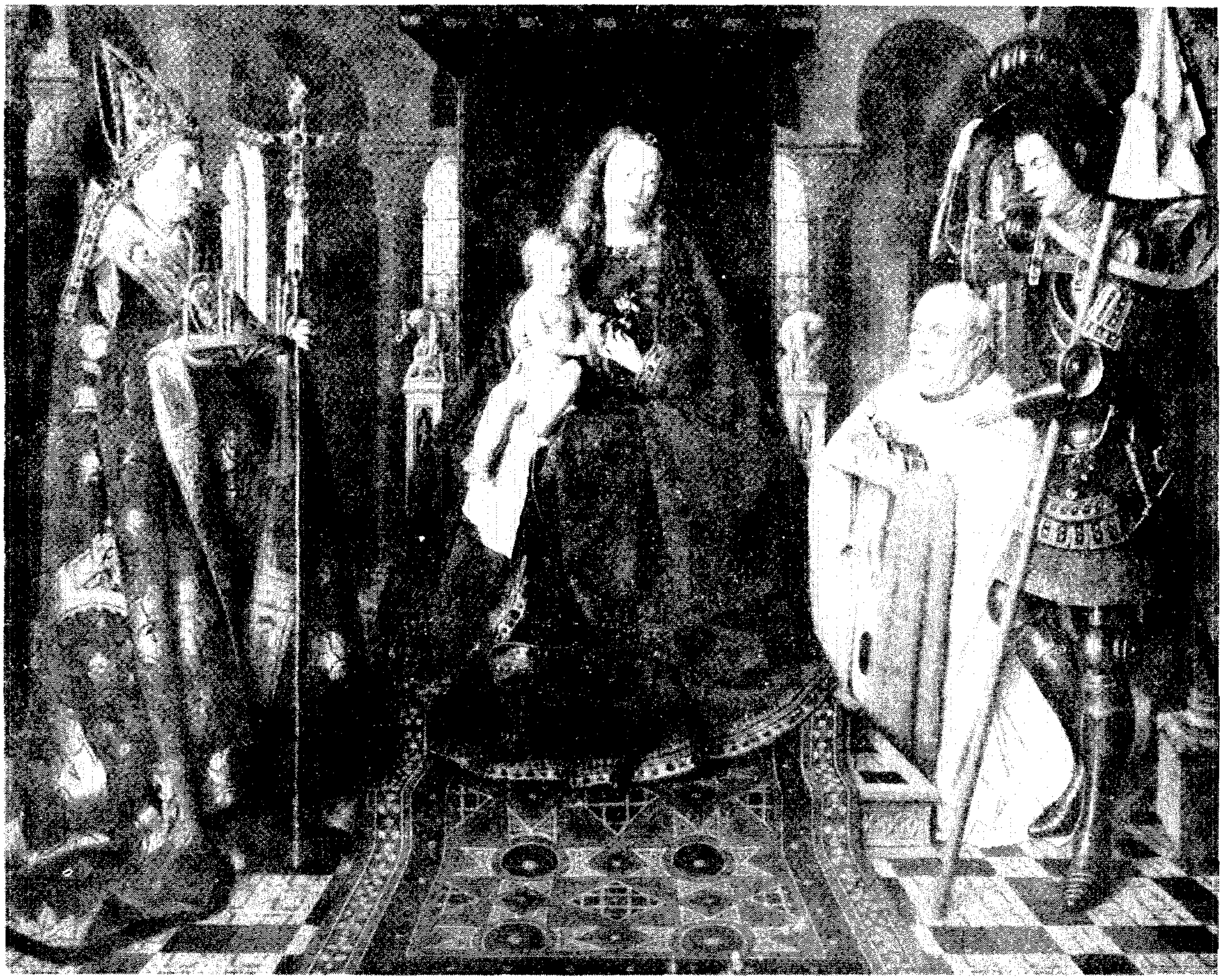
inadequate space in the Kerckhoff Laboratories, and partly in space borrowed from the Huntington Memorial Hospital Medical Research Institute.

These proposed additions to the physical plant, however, must come from a source other than the new Rockefeller grant—and other than the matching $1,500,000 which the Institute hopes to raise. These funds are urgently needed for increasing costs of research and training programs, normal salary increases, and a modest increase in activities.

Most important of all, the new Rockefeller grant will be used for long-term projects. If the chemical biology program at Caltech is to be effective, its support must be on a long-term basis. In order to attract high-calibre faculty men it is necessary to offer tenure. On the average, this means that support should be available for a period of 15 to 25 years. Short-term support, like that provided by the National Institutes of Health, the National Science Foundation, the Office of Naval Research, and the Atomic Energy Commission, cannot be used safely to underwrite tenure appointments. Short-term support, besides, is usually designated for fairly specific activities.

Support from the Rockefeller Foundation, besides being long-term, can be used catalytically for supporting ventures in their speculative beginning stages, and for supporting non-fashionable work in areas which are important, but in which project funds are not available. At Caltech, as at similar institutions, experience has shown that a laboratory engaged in basic research—where the turn of a given investigation and its needs cannot be foreseen far in advance—must have flexibility in the use of funds for effective operation.

Experience over the past seven years, during which time the chemical biology program has existed in its present form, indicates that if a capital sum of $3,000,000 is added to present funds, the future of the program should be assured for a period of 15 to 25 years.



The Madonna of Canon van der Paele, painted by Jan van Eyck in 1436, shows that spectacles were then in use.

THE INVENTION OF SPECTACLES

by E. C. WATSON

ALTHOUGH THE ANCIENTS were apparently more familiar with optics than with any other branch of physics, and although mirrors and burning glasses are very old —and the magnifying power of such glasses was observed quite early—it may safely be said that the lens as an optical instrument was practically unknown up to A.D. 1270. The question of whether the ancients had any knowledge of the theory and use of dioptric instruments, such as lenses, telescopes, and microscopes, has been examined exhaustively by Professor Thomas Henri Martin, Dean of the Faculty of Letters of the University of Rennes, and his conclusion is definitely a negative one.

There is good reason to believe that spectacles were invented in Italy near the end of the thirteenth century. Their inventor was most probably Salvino d'Armato degli Armati of Florence, who died in 1317. The evidence for this identification, as summarized by E. Wilde, Charles Singer, and George Sarton is as follows:

1. The naturalist, poet, and scholar, Francesco Redi, published in 1678 and again in 1690 a manuscript dated 1289, in which was the following passage: "I find myself so pressed by age that I can neither write nor read without those glasses they call spectacles, lately invented, to the great advantage of poor old men when their sight grows weak."

2. Bernard De Gordon, a physician at Montpellier, in his *Lilium medicinae* (1303), in recommending an eye-salve, says, "It is of such great value that it will make an enfeebled old man read tiny letters without spectacles."

3. Giordano Da Rivalto, a Dominican friar of Pisa, in a sermon delivered on February 23, 1305, said that "it is not twenty years since there was discovered the art of making spectacles to see better, one of the best and most necessary of arts . . . I have myself seen and spoken to the man who first discovered and made them."

4. A Latin chronicle of 1313 or thereabouts, which was originally in the library of the monastery of St. Catharine at Pisa, but which is now lost, stated that "Brother Alexander of Spina, a modest and good man, knew how to make anything which he had seen or heard of. He made spectacles, which had been previously made by someone who was unwilling to communicate his knowledge, while he himself was only too glad and willing to do so."

Portrait of a Clergyman (with glasses), by Quinton Massys, was painted in about 1515.

Altar screen by Michael Wohlgemuth (1434-1519) in the church of St. James in Rothenburg, Germany.

5. An epitaph in the church of Santa Maria Maggiore in Florence reads as follows: "Here lies Salvino d'Armato degli Armati of Florence, inventor of spectacles. May God pardon his sins. Anno D. MCCCXVII."

The first spectacles may have consisted of two lenses suspended by pieces of leather from a cap. The form with which we are now familiar probably dates from the early fifteenth century.

Spectacles and artists

After their invention, the use of spectacles spread slowly over Europe. This fact can be demonstrated by a study of old paintings as well as in other ways.

The *Madonna of Canon van der Paele*, executed by Jan van Eyck in 1436, clearly shows a pair of spectacles. This fine painting now hangs in the Municipal Museum, Bruges, Belgium. Other early paintings of note in which spectacles or eye-glasses are clearly depicted include an altar screen by Michael Wohlgemuth (1434-1519) in the church of St. James in Rothenburg, Germany (above), and the *Portrait of a Clergyman* painted by Quinten Massys about 1515, which was in the Liechtenstein Gallery at Vienna (left).

One of a series of articles devoted to reproductions of prints, drawings and paintings of interest in the history of science—drawn from the famous collection of E. C. Watson, Professor of Physics and Dean of the Faculty of the California Institute.

THE CHALLENGE OF MAN'S FUTURE

WHEN WE LOOK at the world situation solely from the point of view of technological and energetic feasibility, we must conclude that the resources available to man permit him, in principle, to provide adequately for a very large population for a very long period of time.

There are, of course, physical limitations of some sort which will determine the maximum number of human beings who can live on the earth's surface. But at the present time we are far from the ultimate limit of the number of persons who could be provided for.

If we were willing to be crowded together closely enough, to eat foods which would bear little resemblance to the foods we eat today, and to be deprived of simple but satisfying luxuries such as fireplaces, gardens, and lawns, a world population of 50 billion persons would not be out of the question. And if we really put our minds to the problem we could construct floating islands where people might live and where algae farms could function, and perhaps 100 billion persons could be provided for. If we set strict limits to physical activities so that caloric requirements could be kept at very low levels, perhaps we could provide for 200 billion persons.

At this point the reader is probably saying to himself that he would have little desire to live in such a world, and he can rest assured that the author is thinking exactly the same thing. But a substantial fraction of humanity today is behaving as if it would like to create such a world. It is behaving as if it were engaged in a contest to test nature's willingness to support humanity and, if it had its way, it would not rest content until the earth were covered completely and to a considerable depth with a writhing mass of human beings, much as a dead cow is covered with a pulsating mass of maggots.

For population densities to reach levels much higher than those which exist in present-day agrarian cultures, a great deal of technology is required. India, for example, could not possibly support her existing high population density without the benefit of the knowledge and materials she obtains from the industrialized society of the West. Without the existence of an industrialized society somewhere in the world, disease could not be effectively controlled and there would be no transportation adequate to the shipment of food from areas of surplus to areas of deficiency.

As is indicated in an earlier chapter, within a period of time which is very short compared with the total span of human history, supplies of fossil fuels will almost certainly be exhausted. This loss will make man completely dependent upon waterpower, atomic energy, and solar energy—including that made available by burning vegetation—for driving his machines. There are no fundamental physical laws which prevent such a transition, and it is quite possible that society will be able to make the change smoothly. But it is a transition that will happen only once during the lifetime of the human species. We are quickly approaching the point where, if machine civilization should, because of some catastrophe, stop functioning, it will probably never again come into existence.

It is not difficult to see why this should be so if we compare the resources and procedures of the past with those of the present.

Our ancestors had available large resources of high-grade ores and fuels that could be processed by the most primitive technology—crystals of copper and pieces of coal that lay on the surface of the earth, easily mined iron, and petroleum in generous pools reached by shallow drilling. Now we must dig huge caverns and follow

This article has been adapted from the concluding chapter of the book, The Challenge of Man's Future, by Harrison Brown, to be published March 19, 1954, by The Viking Press

Population figures and living standards are still on the rise. How long can it last? A considered analysis of what's ahead for all of us.

by HARRISON BROWN

seams ever further underground, drill oil wells thousands of feet deep, many of them under the bed of the ocean, and find ways of extracting elements from the leanest of ores—procedures that are possible only because of our highly complex modern techniques, and practical only to an intricately mechanized culture which could not have been developed without the high-grade resources that are so rapidly vanishing.

As our dependence shifts to such resources as low-grade ores, rock, seawater, and the sun, the conversion of energy into useful work will require ever more intricate technical activity, which would be impossible in the absence of a variety of complex machines and their products—all of which are the result of our intricate industrial civilization, and which would be impossible without it. Thus, if a machine civilization were to stop functioning as the result of some catastrophe, it is difficult to see how man would again be able to start along the path of industrialization with the resources that would then be available to him.

Should a great catastrophe strike mankind, the agrarian cultures which exist at the time will clearly stand the greatest chance of survival and will probably inherit the earth. Indeed, the less a given society has been influenced by machine civilization, the greater will be the probability of its survival. Although agrarian societies offer little security to the individual, they are nevertheless far more stable than industrial ones from a long-range point of view.

Is it possible to visualize a catastrophe of sufficient magnitude to obliterate industrial civilization? Here the answer must clearly be in the affirmative, for, in 1954, it takes no extraordinary imagination to foresee such a situation.

It must be emphasized, however, that industrial civilization can come to an end even in the absence of a major catastrophe. Continuance of a vigorous machine culture beyond another century or so is clearly dependent upon the development and utilization of atomic or solar power. If these sources of newly applied energy are to be available in time, the basic research and development must be pursued actively during the coming decades. And even if the knowledge is available soon enough, it is quite possible that the political and economic situation in the world at the time the new transition becomes necessary will be of such a nature that the transition will be effectively hindered.

At the present time a part of the world is agrarian and another part is either already industrialized or in the process of industrialization. It appears most unlikely that these two greatly different ways of life can co-exist for long. A world containing two major patterns of existence is fundamentally unstable—either the agrarian regions of the world will industrialize or, in the long run, the industrial regions will revert to agrarian existence.

That the agrarian regions of the world will attempt to industrialize is unquestionable. We see about us today signs of revolution, of reorganization, and of reorientation of goals leading toward the creation of local counterparts of Western machine culture.

The search for greater personal security, longer life, and more material possessions will force the agrarian regions of the world to attempt to industrialize. But the probability of their succeeding in the absence of a major world catastrophe in the near future is small. There are clearly paths that could lead to a successful transition in the world as a whole. But the nature of man makes remote the possibility that the steps necessary for complete transition will be taken. The picture would change considerably if Western machine civilization were to collapse, thus giving the present agrarian cultures room into which they could expand.

Collapse of machine civilization would be accompanied by starvation, disease, and death on a scale difficult to comprehend. In the absence of adequate sanitation facilities, the ability to inoculate against disease, facilities for food transportation and storage, factories for producing items which are essential to the maintenance of life, the death rate would reduce the population to a level far below that which could be supported by a stable agrarian society which practices intensive agricultural techniques. There would be such violent competition for food that savagery would be the heritage of the survivors. Human life would be confined once again to those areas which can be most easily cultivated, watered, and fertilized, and the principles enunciated by Malthus would once again become the major force operating upon human populations. Only very slowly would the number of persons climb to the level which could be supported by a world-wide agrarian culture—about 5 billion.

The agrarian society of the future

The characteristics of the agrarian society of the future would probably be very much like those of most parts of China today or like those of societies which existed in Europe as late as the early eighteenth century. The ratio of available food to total population would be low. There would be no large-scale industries, for metals would be practically non-existent and the only sources of energy would be wood and waterpower. Lack of adequate supplies of metals would prevent the widespread use of electricity. Although parts of society would benefit from accumulated knowledge concerning public health and human biology, death rates would be high. Antibiotics and vaccines would be non-existent. Birth rates would almost certainly lie close to the biological maximum.

Although machine civilization as it exists at the present time is unstable and may revert to an agrarian culture, it is important that we examine ways and means whereby stability in a world industrial society might be achieved. Can we imagine a sequence of events that might lead eventually to industrialization of all peoples of the world? And can we further imagine political, economic, and social structures that would permit the resultant society to maintain a long-range stability?

The most immediate danger

Perhaps the most immediate danger to confront machine civilization is war. It is clear that industrial civilization cannot afford the luxury of many more wars. It is conceivable that the next war could so shatter it that it would be unable to recover. On the other hand, it is also conceivable that it could survive two or three more. But in any case, the number which can be tolerated is finite, and each conflict will decrease further the probability that industrial civilization will continue to exist.

Wars in the past have been fought for varieties of causes, for resources such as water, agricultural land, and ore deposits, for outlets to markets, to discard yokes of enslavement and to sever colonial bonds, to further religious, economic, and political creeds, to obtain power for power's sake. They have been fought over the pursuit of military security and over real or imagined threats to security. The causes of past wars have indeed been manifold, and the potential causes of future wars are equally numerous.

A fighting chance

No matter how we look at the picture, the threat of war is the greatest immediate danger confronting industrial civilization. The possibility of man's eliminating war as an instrument of national policy indeed appears remote, and to the extent that this is so it seems likely that industrial civilization is doomed to extinction. Nevertheless, the picture is not completely black, for we can conceive of ways and means not only of eliminating specific causes of war but of eliminating war itself. The fact that we are able to recognize these problems and conceive of solutions gives some hope that man's intelligence may save him in the future as it has saved him in the past. Remote though this possibility may be, it is the one to which those of us can cling who are unprepared to admit that man's destiny is, *a priori*, an ignominious one.

For the purpose of our discussion, let us assume that war and the possibility of war between existing industrialized nations disappear from the earth, though this seems most unlikely. Would the problems of survival of industrial civilization be solved? It is clear that they would not. Elimination of war, although it is an absolutely necessary condition for survival, is by no means a sufficient condition. In truth, the task of eliminating war, difficult though it may appear, pales into insignificance beside the further problems that will confront us.

Controlling rates of population growth

One of the most important, from both a short-range and a long-range point of view, is that of controlling rates of population growth and at the same time permitting human beings to take full advantage of the benefits of public health and modern medicine. Here there can be no escaping the fact that if starvation is to be eliminated, if the average child is to stand a reasonable chance of living out the normal life span with which he is endowed at birth, family sizes must be limited. The limitation in birth rates must arise from the utilization of contraceptive techniques or abortions or a combination of the two practices.

We know that by proper application of technology the earth could support a considerably larger population than now exists. But no matter where we place the limit of the number of persons that can be comfortably supported, at some point in history population growth must stop. And if population growth is to stop without our having excessively high death rates, we must reconcile ourselves to the fact that artificial means must be applied to limit birth rates.

CONTINUED ON PAGE 34

THE MONTH AT CALTECH

President-Elect Beadle

DR. GEORGE W. BEADLE, professor of biology and chairman of the Caltech Division of Biology, became president-elect of the American Association for the Advancement of Science last month. He will serve as president-elect for a year, and will then succeed Dr. Warren Weaver of the Rockefeller Foundation as president of the organization.

Dr. Beadle will be the fourth Caltech faculty member to serve as A.A.A.S. president. The others were Arthur Amos Noyes (1927), Robert A. Millikan (1929), and Thomas Hunt Morgan (1930).

A geneticist, Dr. Beadle is noted for his revolutionary development, in 1940 with Dr. E. L. Tatum, of the use of the bread mold *Neurospora* as a simple and effective research tool for the study not only of heredity but of problems in biochemistry as well. This followed from their discovery, using *Neurospora*, that genes control the synthesis of vitamins and amino acids in the living cell. Previously, Dr. Beadle had made many contributions in the genetics of corn and of the fruit fly, *Drosophila melanogaster*.

His work has been recognized with honorary DSc degrees from Yale, Nebraska, and Northwestern, and in a number of awards. These include the Lasker Award of the American Public Health Association in 1950, the Dyer Lectureship Award of the National Institutes of Health in 1951, and the Gold Medal of the Emil Christian Hansen Foundation of Copenhagen in 1953. He was elected to the National Academy of Sciences in 1944.

He has been chairman of the Biology Division at Caltech since 1946, when he came to the Institute from Stanford University, where he had been professor of biology. Prior to joining the Stanford faculty in 1937, he had taught at Harvard for a year and spent five years (1931-36) in research and teaching at Caltech.

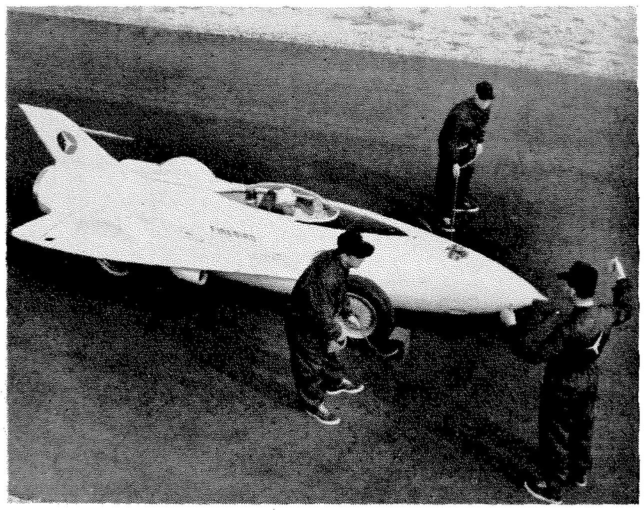
A native of Wahoo, Nebr., he received his BS and MS degrees from the University of Nebraska and his PhD, in 1931, from Cornell University.

Firebird

THE FIRST GAS turbine automobile ever to be built and tested in the United States made its debut at the General Motors Motorama in New York last month. Known as the XP-21 Firebird, the experimental car was produced by General Motors with a strong assist from Caltech.

Underlying the unique aerodynamic styling of the car is a series of special wind tunnel tests developed at Caltech. To make it completely streamlined the car had to have a tail fin or some flat vertical surface behind its center of gravity, to hold it on course when in motion. The final design of the Firebird was worked out after a scale model of the car had been given wind tunnel tests at Caltech, under the direction of Dr. Peter Kyropoulos, associate professor of mechanical engineering.

The Firebird is not being touted as any "car of tomorrow"; it's merely a laboratory on wheels, built to further study the commercial possibilities of the gas turbine.



General Motors' XP-21 Firebird, an experimental gas turbine car, gets a road test.

The car will be on view locally when the GM Motorama comes to Los Angeles on March 5. Its mechanical anatomy, the reverse of the conventional automobile, includes a 35-gallon glass fiber-plastic fuel tank in the nose ahead of the driver. The engine, consisting of two mechanically independent parts, is behind the driver. These two parts are called the gasifier section and the power section. The gasifier section provides a source of compressed hot gas, and the energy from this gas is delivered by the power section to the car's rear wheels. Thus, the gasifier section replaces the engine and torque converter pump in a conventional automobile, while the power section replaces the torque converter turbine, transmission, and rear axle gears.

R. F. McLean, Caltech '43, a member of the GM styling staff, served as coordinator of the Firebird project.

Visiting Professors

VISITING PROFESSORS at the Institute this term include Drs. K. E. Bullen, geophysics; D. Dwight Davis, vertebrate paleontology; H. C. van de Hulst, astrophysics; Luna B. Leopold, geology; Barbara McClintock, biology; William Shockley and Victor F. Weisskopf, physics; and John W. Williams, chemistry.

Dr. Bullen, on leave from the University of Sydney, Australia, where he is professor of applied mathematics, is devoting his time at Caltech to seismological studies.

Dr. Davis is curator of the Division of Vertebrate Anatomy of the Museum of Natural History in Chicago.

Dr. van de Hulst, who is doing research and teaching at Caltech in radio astronomy and galactic structure, is on leave from the University of Leyden, the Netherlands, where he is professor extraordinary.

Dr. Leopold, a geologist with the Water Resources Division, U. S. Geological Survey, is doing experimental work in hydrodynamics at Caltech and teaching geomorphology.

Dr. McClintock, an investigator for the Department of Genetics of the Carnegie Institution of Washington, is continuing her genetic studies here.

Dr. Shockley, Caltech '32, comes from the Bell Telephone Laboratories in Murray Hill, New Jersey, and Dr. Weisskopf from the Massachusetts Institute of Technology, where he is a professor of physics.

Dr. Williams, professor of chemistry at the University of Wisconsin, is engaged in studies of protein chemistry.

New Trustee

MR. JOHN E. BARBER has been elected to the Institute Board of Trustees. A charter member and past-president of the California Institute Associates, Mr. Barber was associated for many years with the United States Steel Corporation in executive capacities in the Columbia-Geneva Steel Division at San Francisco, and the Consolidated Western Steel Division at Los Angeles.

Carl Braun

CARL FRANKLIN BRAUN, a trustee of the California Institute and founder and president of the C. F. Braun engineering firm in Alhambra, died on February 4 of a heart attack.

C. F. Braun & Co. is one of the country's largest companies building oil refineries and chemical plants.

Mr. Braun, a native of Oakland, received a BS in mechanical engineering from Stanford University, and an LLD from Occidental College. He established the Braun Co. in San Francisco in 1909, and moved it to Alhambra in 1922. It has designed and constructed chemical plants valued at $300,000,000.

Mr. Braun was a director of the Friends of the Huntington Library, a trustee of Claremont Men's College, and a consulting professor of the Stanford Graduate School of Business. He had also previously served as director of the California Institute Associates.

Associate President

SHANNON CRANDALL, JR., president of the California Hardware Company of Los Angeles, has been elected president of the California Institute Associates, succeeding Charles S. Jones, president of the Richfield Oil Company.

Also elected were William Clayton, president of the Clayton Manufacturing Company, El Monte, who will serve as third vice-president; and two new members of the Board of Directors: Jerome K. Doolan, vice-president of the Bechtel Corporation, Los Angeles, and Robert L. Minckler, president of the General Petroleum Corporation.

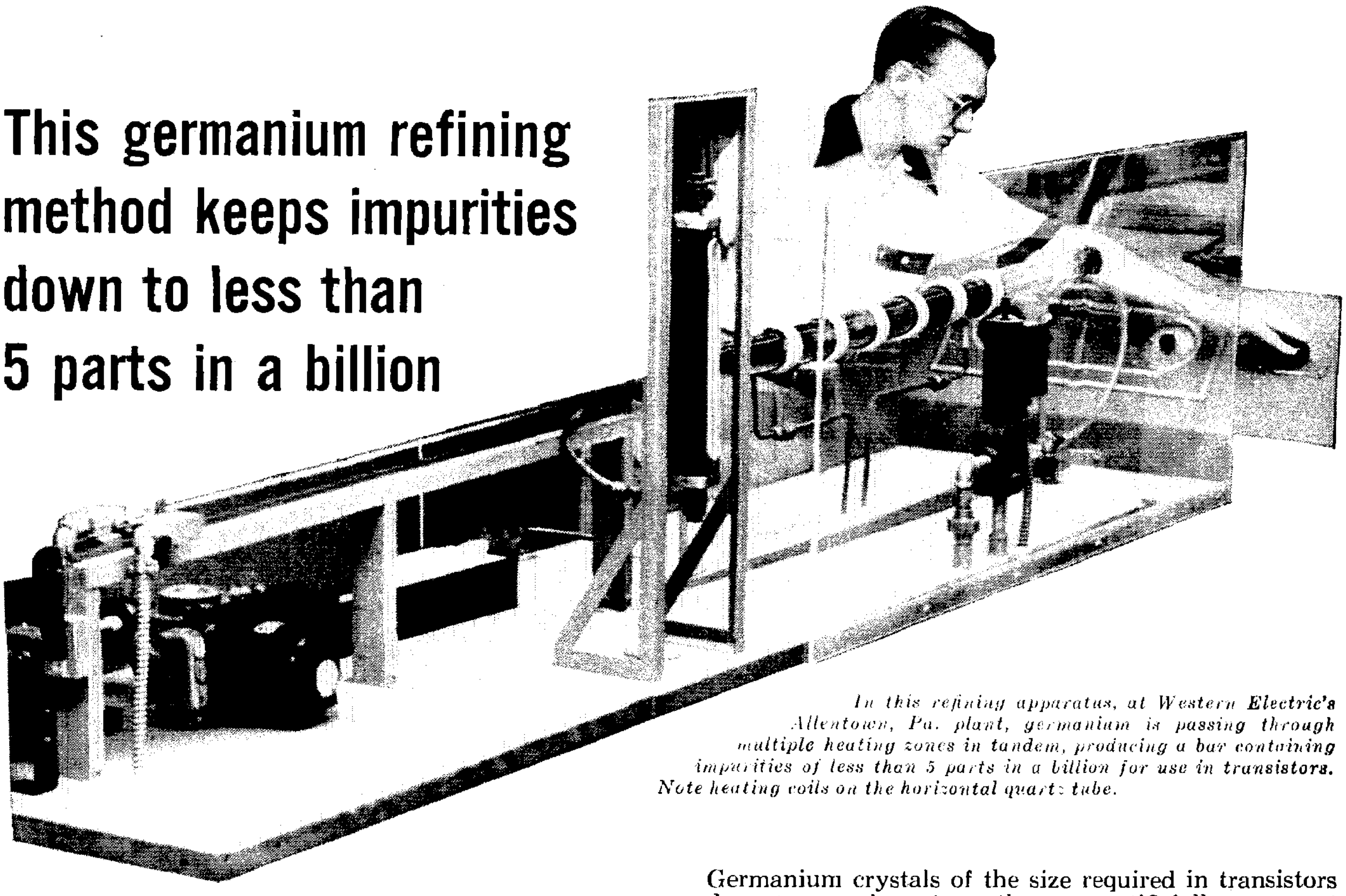
Re-elected were Archibald B. Young, first vice-president; Seeley G. Mudd, second vice-president; Alexander King, secretary; Herbert L. Hahn, treasurer; and H. H. G. Nash, assistant secretary and assistant treasurer.

New Seismo Station

THE FOURTEENTH in the network of auxiliary seismological stations operated by the Caltech Seismological Laboratory has now gone into operation. The new station is located at the Isabella Dam, a project of the U. S. Army Corps of Engineers on the upper Kern River.

Like the other installations in the Caltech network, the Isabella Dam station is equipped with one of the short period recording seismographs developed by Dr. Hugo Benioff to record local earthquakes. Routine work connected with the operation of the seismograph will be handled by resident engineers at the Isabella Dam project.

This germanium refining method keeps impurities down to less than 5 parts in a billion



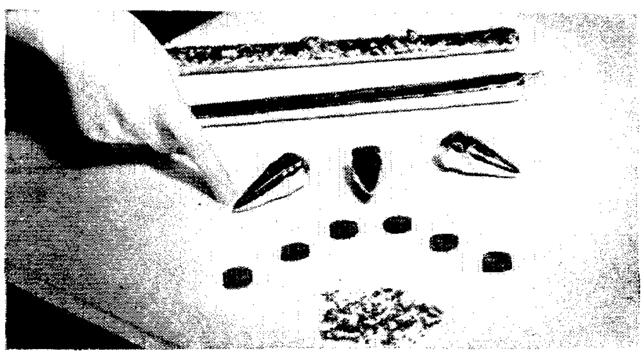
In this refining apparatus, at Western Electric's Allentown, Pa. plant, germanium is passing through multiple heating zones in tandem, producing a bar containing impurities of less than 5 parts in a billion for use in transistors. Note heating coils on the horizontal quartz tube.

A new method of metal refining, currently in use at the Western Electric plant at Allentown, results in the production of germanium that is better than 99.9999995% pure – the highest degree of purity ever attained in a manufactured product.

The need for germanium of such exceptional purity came about when research by Bell Telephone Laboratories in the field of semi-conductors led to the development of transistors, which are manufactured by Western Electric.

The transistor is a tiny crystal device which can amplify and oscillate. It reduces space requirements and power consumption to a minimum.

Various forms which germanium takes before being used in transistors are shown in this photo. Bar at top is an ingot of germanium after reduction from germanium dioxide. Next is shown the germanium ingot after the zone refining process used by Western Electric. Below the ingots are shown 3 germanium crystals grown by machine, 6 slices cut from these crystals, and several hundred germanium wafers ready for assembly into transistors.



Germanium crystals of the size required in transistors do not occur in nature; they are artificially grown at Western Electric. At this stage in transistor manufacture, other elements are introduced in microscopic quantities to aid in controlling the flow of electrons through the germanium. But before these elements can be introduced, it is necessary to start with germanium of exceptional purity, so that the impurities will not interfere with the elements that are deliberately added.

So Bell Telephone Laboratories devised an entirely new method of purification, known as zone refining, which was developed to a high-production stage by Western Electric engineers.

In zone refining a bar of germanium is passed through a heat zone so that a molten section traverses the length of the bar carrying the impurities with it and leaving behind a solidified section of higher purity. By the use of multiple heating zones in tandem, a number of molten sections traverse the bar. Each reduces the impurity content thus producing a bar which contains impurities in the amount of less than five parts per billion.

Because of the importance of the transistor in electronics, the zone refining process – like so many other Western Electric developments – has been made available to companies licensed by Western Electric to manufacture transistors.

This is one more example of creative engineering by Western Electric men. Engineers of all skills – mechanical, electrical, chemical, industrial, metallurgical, and civil – are needed to help us show the way in fundamental manufacturing techniques.

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

Manufacturing plants in Chicago, Ill. • Kearny, N. J. • Baltimore, Md. • Indianapolis, Ind. • Allentown & Laureldale, Pa. • Burlington, Greensboro & Winston-Salem, N. C. • Buffalo, N. Y. • Haverhill & Lawrence, Mass. • Lincoln, Neb. • St. Paul & Duluth, Minn. Distributing Centers in 29 cities and Installation headquarters in 15 cities. Company headquarters, 195 Broadway, New York City.

THE CALTECH ALUMNI

IV. Occupation and Income

by JOHN R. WEIR

IN PREVIOUS ARTICLES we have discussed certain aspects of the survey relating to the occupations of our alumni We have pointed out that the great majority have followed the specific field in which they got their training, have been in it ever since they left school, and intend to continue in it for the rest of their working careers. If they were to leave it, it would be only for another specialty within the fields of science or engineering. They are in positions of importance and influence, and have the responsibility of directing and controlling other people as project leaders, supervisors, administrators, and executives. They consider themselves more successful than the average, and if they had it all to do over again, would go back to the same school and major in the same field.

In this article we will complete the vocational picture of our Caltech alumni with a discussion of fields of employment and income medians and distributions.

Occupational Fields	% PhDs	% Es	% MSs	% BSs	% Caltech
Research and Development	40	38	34	20	30
Administration	6	6	13	19	15
Design	1	9	11	14	11
Teaching	36	2	7	2	9
Production and Operation		4	5	7	5
Military	2	31	7	3	5
Construction and Maintenance		1	3	8	5
Other	15	9	20	27	20

As the table shows, our Bachelors are about evenly distributed among Research and Development, Administration, and Design. Only 2 percent are in Teaching. This distribution also holds for alumni with Master's degrees. Among the PhD's, 40 percent are in Research and Development, and 36 percent are in Teaching. About three times as many Bachelors as PhD's are in the field of Administration. Other occupational fields in which the number of alumni were so small as to be not significant were: student, selling and advertising, field work, consulting, laboratory, law, insurance, medicine, statistics.

From another standpoint, almost all of our alumni are in positions requiring leadership and administrative skill. A quarter of the alumni have from 1 to 5 people responsible to them, a quarter 6 through 19, a quarter 20 through 199, and 7 percent have over 200 responsible to them. Approximately 80 percent thus have one or more people responsible to them. This figure points to the need for executive and administrative training as an essential component in the education and training of the young scientist or engineer.

Earned income

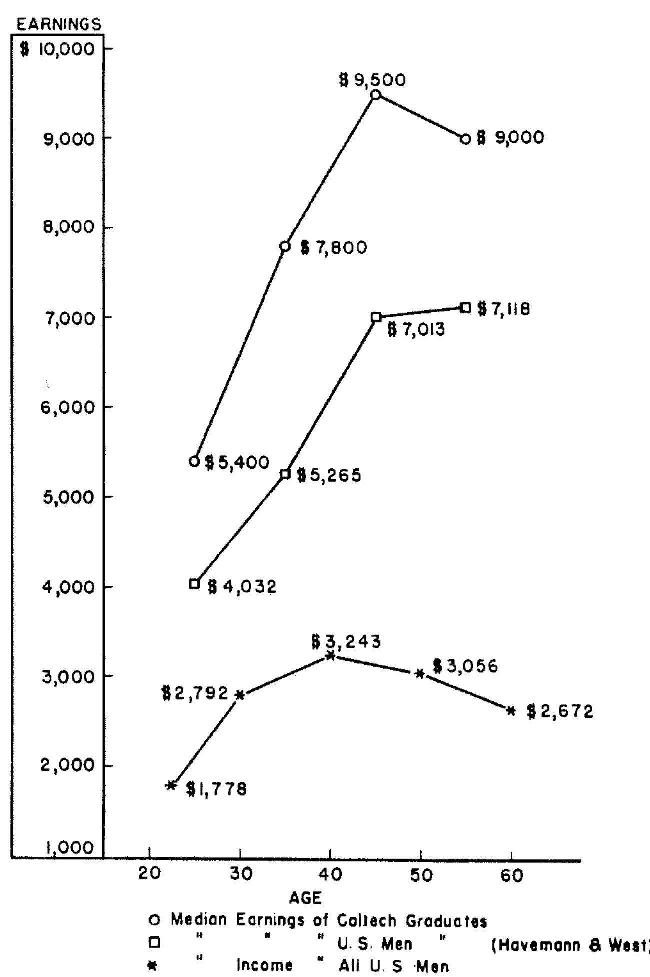
The median earned income for the Caltech alumni as reported in the fall of 1952 was $7,000 per year. Havemann and West report median earnings for three different groups which permit significant comparisons with this figure. They give the median earnings for U. S. college graduates as $5,345, the median earnings for professional men (construction, engineering, architecture) as $5,472, and the median earnings for the graduates of seventeen technical schools as $6,135.*

* The actual figures given by Havemann and West are, respectively, $4,689, $4,800, and $5,382. The data for the Havemann and West survey, however, were gathered in 1948, and a correction must be made for the inflation that has occurred between that time and the fall of 1952, when our data were gathered. A comparison was made between the annual surveys of professional scientific salaries by the Los Alamos Scientific Laboratory and the index of the cost of living of the United States Bureau of Labor Statistics. In each case the averages had risen 14 percent from 1948 to 1952, so it was considered safe to assume that a correction of 14 percent for the Havemann and West figures would make them comparable to our 1952 data. This correction has been made in every case where we compare our data with Havemann and West.

It is also possible to estimate an approximate median earnings figure for all scientists and engineers in the United States by combining figures from the Los Alamos Scientific Laboratory Survey of Professional Scientific Salaries for 1952 and from the National Society of Professional Engineers' Report for 1952-53. This estimated median, based on reports from 30.000 scientists and 12.000 engineers, comes to $6.946 per year.

The chart below shows earned income by age for Caltech alumni, U. S. college graduates, and U. S. males. The advantage of a college education is obvious. Also, the advantage of a Caltech education in science and engineering is clear, and these differences become even more impressive if we recall the extreme youthfulness of the Caltech alumni. For example, of the 12,000 engineers mentioned above, only 13 percent got their degrees after 1946, whereas 50 percent of the Caltech alumni got their degrees after this date. As our alumni grow older, the tendency for earnings to increase with age will have the effect of raising the Caltech median considerably above where it is now. (The down curve beginning at age 50 can probably best be understood as reflecting the changes initiated at the California Institute in the middle twenties under the influence of Drs. Hale, Noyes, and Millikan.)

A DEGREE PAYS OFF AT ANY AGE



Income from consulting activities

Our Caltech graduates do not get much income from consulting fees. Only 7 percent earn more than $1,000 a year from this activity—and this 7 percent includes those whose sole earned income is from consulting practice. What consulting income there is, is mainly concentrated in the PhD group. Twenty-three percent of them report some income here, contrasted with only 8 percent of the BS's and MS's. This lack of consulting activity is probably largely determined by the youthfulness of our alumni, as consulting activities tend to increase with age and experience in the field, and with the development of a professional reputation.

Consulting Income

None	88.7%
$100 to $500	2.6
$500 to $800	1.8
$1,000 to $5,000	5.0
$5,000 to $100,000	1.9

It is equally true that few of our alumni have income from inherited wealth or large investments. Only 12 percent receive more than $1,000 per year from sources other than occupational and consulting activities.

Total income

If all sources of income are combined, we get a total income median of $7,900 for Caltech alumni. Havemann and West give the median total income for U. S. graduates as $6,140, indicating a $1,700 advantage for the Caltech grad. The Caltech distribution runs as follows:

Total Income

Under $5,000	12.4%
$5,000 to $8,000	37.2
$8,000 to $11,000	29.1
$11,000 to $40,000	20.4
$40,000 and over	.9

If grouped by years out of BS, and according to highest degree earned, the following medians obtain:

Median Total Income
By Years Out of BS, by Highest Degree Earned

	BS	MS	PhD
1 through 10 years	5,700	6,000	6,900
11 through 20 years	9,000	9,000	8,400
21 through 30 years	10,100	10,500	11,000
Over 30 years	10,800	*	11,500

* insufficient sample

And here again as our alumni get older as a group, all of these medians will be higher, and the gap between the Caltech alumni and the other groups noted for comparison will widen considerably.

Do advanced degrees help?

One would expect that the extra effort and expense entailed in obtaining an advanced degree would reflect itself in an increase in income; that is, a PhD ought to have a considerably larger income than a Bachelor. However, a comparison of earned income for various degrees reveals that such is not the case. The chart below shows the median earned income for PhD's, MS's and BS's by years since they obtained their BS degree. The line for the PhD's is mostly on the bottom. Only during the first few years of employment do they earn more than the Bachelors. From then on they are considerably lower.

The median earned income for all Bachelors and Masters is $7,000. For PhD's it is $7,500. Do these figures contradict the chart below, as well as the comments made in the preceding paragraph? Actually they do not. There is a disproportionately large number of BS's and MS's in the early year (low income) age groups which depresses their medians. We could make more valid comparisons and draw more meaningful conclusions if this depressive effect were removed. Doing this gives an "adjusted" median earned income for Bachelors and Masters of $7,980.*

Our PhD's earn an average $500 a year *less* than our BS's, although they have had four additional years of advanced education! Is there a penalty for knowing too much? Yes, in a sense, there is. Thirty-six percent of our PhD's go into teaching, and the earned income of these teachers is relatively so low that it drags the median for all PhD's down below that for the BS's. It's the same old story—society doesn't reward knowledge and scholarship for itself alone.

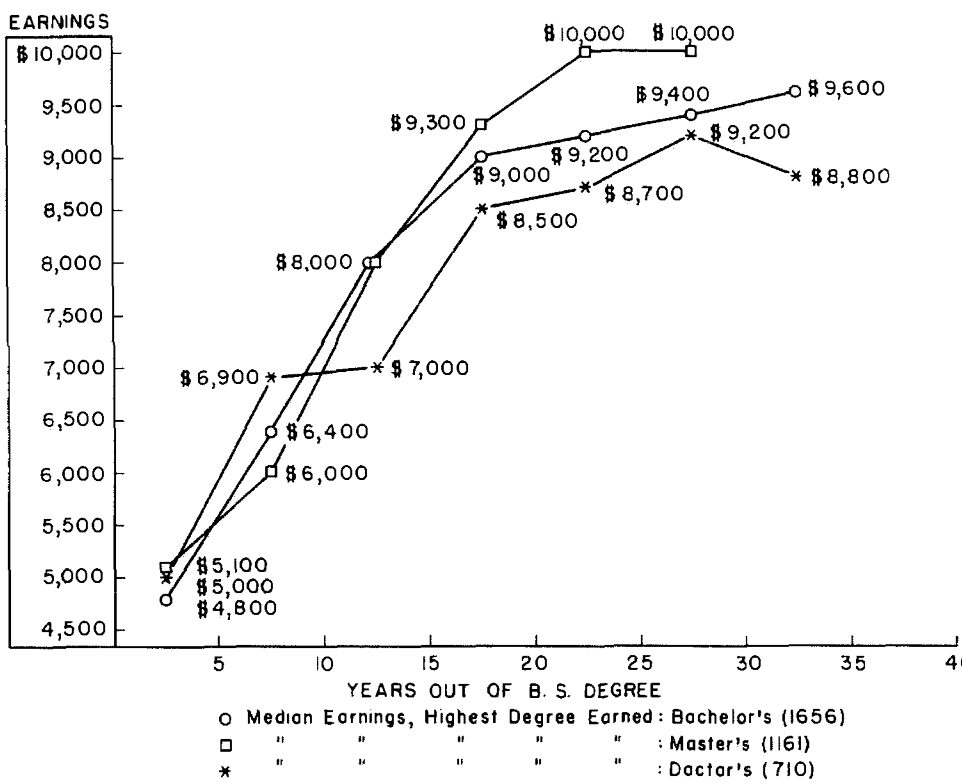
Teaching or industry?

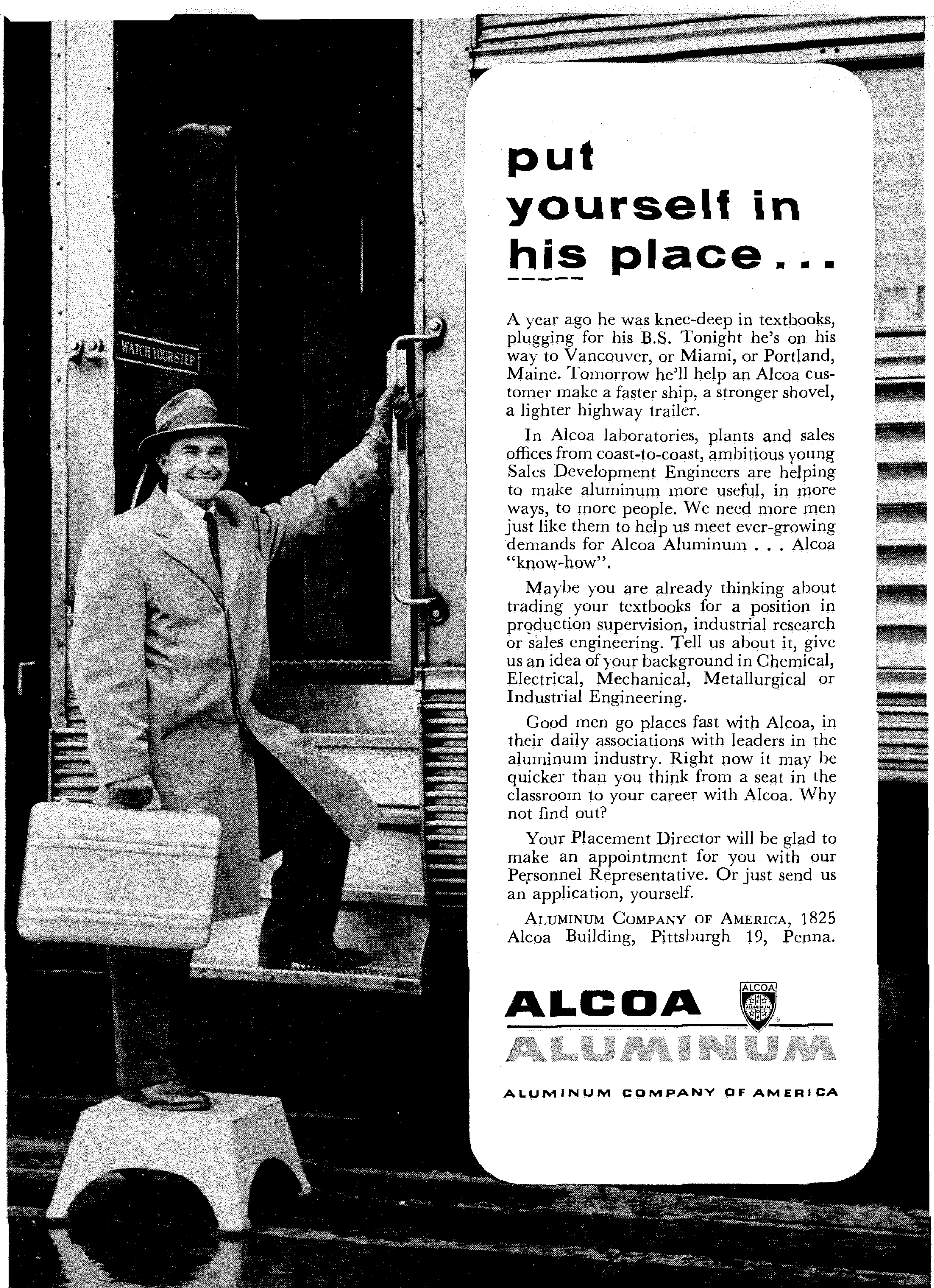
Only 9 percent of our alumni are in teaching—2 percent of the BS's, and 36 percent of the PhD's. Nevertheless, the relative earnings available in "teaching versus industry" are an ever-present concern of many of our alumni; so some comparisons may be quite welcome.

* This adjustment was made by equalizing the number of BS's or MS's with the number of PhD's in each group. Over-all medians for BS's or MS's were then estimated from these now-equalized groups.

EARNINGS BY DEGREE

An advanced degree doesn't mean a higher income





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In order to avoid complications, comparisons will be limited to the PhD's.

One thing is certain. The PhD's certainly represent a high degree of scholastic ability. Almost the entire group reports A and B grades—and within this group, more of the A students tend to go into teaching.

Grades of Teaching and Non-Teaching PhD's

	Teaching	Non-teaching
Mostly As	58%	14%
Mostly Bs	36	45
Mostly Cs	6	11

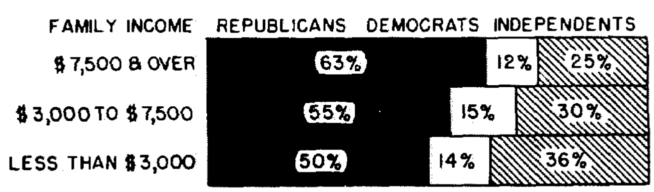
The median earned income for the teaching PhD's (7 percent of the Caltech sample) is $6,500. For the non-teaching PhD's (12 percent of the sample) it is $8,200—a difference of $1,700 a year. If additional income from consulting, books, lectures, etc. is included, the teachers report $7,600 total income versus $9,000 for the non-teachers—a difference of $1,400.

While a person making $7,600 a year could hardly be called poverty-stricken, even in these times of inflation, there certainly is a significant financial sacrifice entailed if one enters the academic field. It would indeed be interesting to identify the true motivations leading to the decision to accept such a sacrifice.

Politics

As most studies show, there is a relationship between the amount of money one has and his political affiliation: The higher the income the greater the affiliation with the Republican party. The Caltech alumni are no exception. They show a definite, though minor, correlation between income and Republicanism.

FAMILY INCOME AND POLITICAL PARTY



Religion

Havemann and West found that the Jewish members of their sample reported earning more money than the Protestants and Catholics. This is not true for the Caltech alumni. The Caltech Protestant graduates tend to have the higher incomes. This difference might be explained by the fact that Caltech has had very few Jewish graduates until recently; thus, they are relatively young and as yet have not realized their potentialities to a degree comparable with the rest of the Caltech alumni.

College finances

Havemann and West reported that, in general, the students who had their parents' financial support in college cashed in later on the security and prestige which this seemed to give them. The median income for those who worked their way through school was about 10 percent below the median for those whose families had put them through. The opposite is true for our alumni. Those who earned the majority of their expenses at Caltech report a median total income $300 greater than do those who earned a quarter or less of their college expenses. Apparently our alumni are more likely to get their jobs and income by determination and hard work than through family position and influence.

Median Total Income of Self-Help and Family-Supported Men

	CIT	U.S.
Earned none to ¼ of college expenses	$7,700	$6,014
Earned ¼ to ½ of college expenses	8,000	5,694
Earned ½ to all of college expenses	8,000	5,507

Extra-curricular activiites

An item of considerable importance and interest to the Caltech student is the matter of the relative importance of grades versus extra-curricular activities in their contribution to success in later life. Would it be better for him to forego all extra-curricular activities, student body offices, clubs, etc., and concentrate on his books, becoming a 100 percent dyed-in-the-wool snake? Or should he study just enough to get by, and spend most of his time on extra-curricular activities, learning how to win friends and influence people?

This is a constant problem, and up to the present time we have had no adequate empirical data on which to base conclusions. However, the results of our survey now permit us to draw some tentative conclusions on this matter.

The median total income for our graduates who report getting mostly As is $8,100 a year. The median total income for those who report getting mostly Cs is $7,500—or $600 less a year, and hardly what one would call a profound difference. If we look at those of our alumni who report participation in four or more activities, we find that their median total income is $8,800 a year. But those who report no extra-curricular activities while in school have a median of $7,200—a difference of $1,600, and almost three times the difference between high and low grades!

If these two items are combined, even more interesting relationships are revealed. Let's divide the alumni into four groups: All-Around Students—those who report getting mostly As and indulging in four or more extra-curricular activities; Big Men on Campus—those who get mostly Cs, but who were in four or more extra-curricular activities; Snakes—those who report getting mostly As but who did not take part in any extra-curricular activities; and Those Who Just Sat There—graduates who report getting mostly Cs and who were not in any extra-curricular activities.

Grades, activities and income

The median earnings of these four groups are shown in the chart below. The All-Around Students have the highest income. Those Who Just Sat There the lowest. If we compare the Big Man on Campus with the Snake, it appears that if you have to take your choice between grades and activities, you'd better take the activities. But an even better solution is to combine good grades with at least a few activities.

This is quite different from the way it is among the U. S. college graduates as reported by Havemann and West. While extra-curricular activities appear to be very important in relation to the later success of the Caltech graduate, they make little difference for the U. S. graduate. On the other hand, while grades seem to make relatively little difference for the Caltech graduate, they are very important for the U. S. graduate.

Grades probably make more difference among the U. S. college graduates because there are large differences in scholastic ability within this group. Grades don't make much difference at Caltech, because all of our students are A students when compared with the U. S. college group.

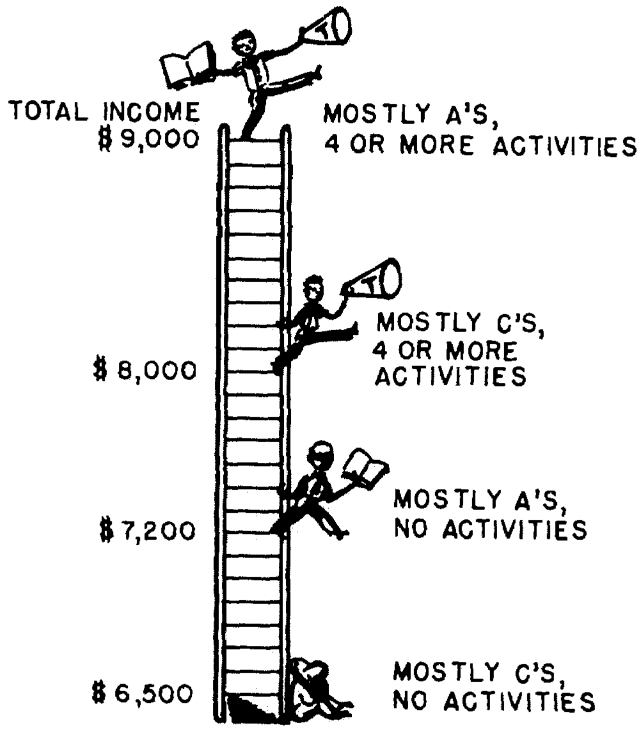
The factor that seems to differentiate significantly among Caltech graduates is their participation in extra-curricular activities—that is, their capacity and willingness to assume group leadership, participate in group activities, and find fun and relaxation in social and cultural pursuits in addition to their academic work. To obtain material rewards in life, it is not only important to know something, but it is even more important to be able to communicate this knowledge to others, and to cooperate with them in its application and development. It seems reasonable to assume that participation in extra-curricular activities might be a rough measure of such communication ability and social facility.

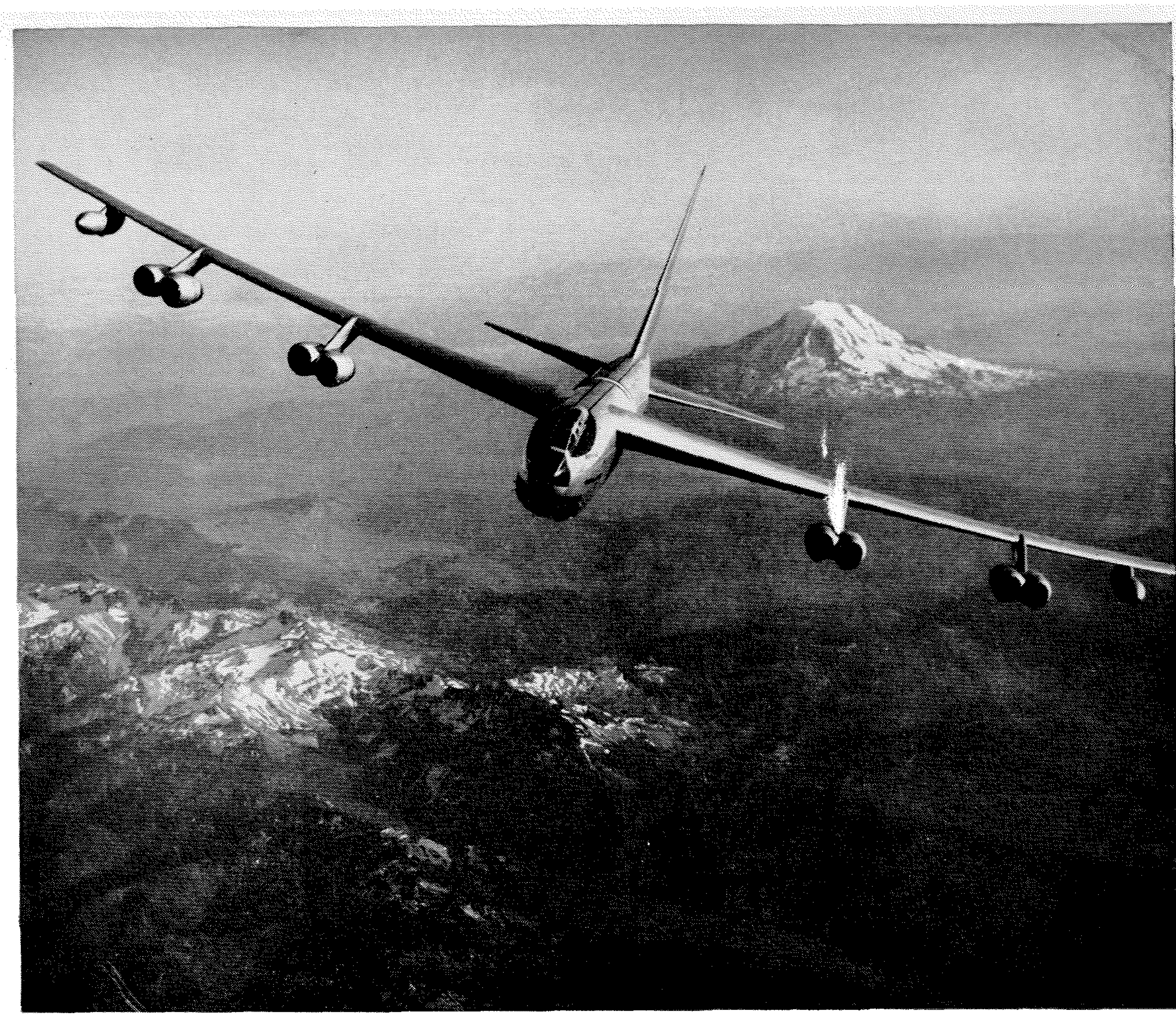
GPA and vocational success

These facts indicate that while our system of grades and grade point averages may be valuable for our own administrative purposes, it has little value as a measure for predicting subsequent vocational success. If we want a method of making such predictions we might do better to base our grading system on extra-curricular activity. It would seem to be only a mild exaggeration to say that anyone able to get a degree from Caltech will

THE CALTECH LADDER OF SUCCESS

The All-Around Student gets to the top, but Those Who Just Sat There still sit there — on the bottom





find his earnings directly related to his capacity to establish adequate interpersonal relationships, assume leadership responsibility and understand and enjoy activities outside of his field of specialization.

Civic activities

The median earned income for all Caltech alumni reporting no participation in civic activities is $5,000; for those participating in five or more, it is $8,200—a difference of $3,200!

Earnings	*Civic activities engaged in*		
	None	1 through 4	5 or more
Less than $3,000	23%	9%	5%
$3,000 to $5,000	19	12	5
$5,000 to $7.500	30	36	29
$7.500 and over	28	54	61

The difference in medians mentioned above is twice the difference between no extra-curricular activities and four or more, five times that between C grades and A grades, and seven times the difference between BS's and PhD's.

How can we account for this difference—the largest we have found? The most plausible explanation would be to assume a close relationship between civic activities and extra-curricular activities. That is, a person with the interest and capacity to participate in extra-curricular activities as a student would also tend to be active in civic affairs as an alumnus. The following figures support this hypothesis.

Civic Activities	*Extra-curricular activities*		
	None	1 through 3	4 or more
None	4%	2%	1%
1 through 4	66	62	50
5 or more	30	36	49

The earlier comments made concerning the hows and whys for the contribution of extra-curricular activities to high earnings is even more relevant here. The Caltech alumnus who accepts the social and cultural responsibilities, the obligation to assume leadership, and the obligation to contribute to his community and state—all in proportion to his training and capacity—is also an alumnus with a relatively high income. It is an oft-stated assumption that the person who has the awareness and willingness to assume civic and social responsibility will be a happier and more productive person. This is certainly the reasoning behind the Humanities program at Caltech. Apparently it also leads to higher income—a very persuasive testimonial for breadth of interest and activity.

Putting the income differences we have been discussing into a rank order table highlights some of the interesting results of this part of our survey.

Advantage of:	
Five or more civic affairs over no civic affairs	$3,200
A grades and 4 extra-curricular activities over C grades and no extra-curricular activities	2,500
Non-teaching PhD over teaching PhD	1,700
Caltech graduates over U. S. college graduates	1,655
Four extra-curricular activities over no activities	1,600
Caltech graduates over U. S. professionals (Construction, engineering, architecture)	1,528
B.S. (adjusted*) over teaching PhD	1,480
Caltech graduates over graduates of 17 technical schools	865
A grades over C grades	600
B.S. (adjusted*) over PhD's	500
Self-help over family supported	300
Non-teaching PhD's over BS (adjusted*)	220
Caltech graduates over scientists and engineers according to Los Alamos and National Society of Professional Engineers surveys	54

* see footnote on p. 26

Perhaps the most dramatic relationships revealed are the large differences for civic and extra-curricular activities, and the small differences for grades and degrees. At least for Caltech graduates, it isn't how much you know that counts—it's how well you use what you know.

This is the fourth in a series of articles on the alumni survey. Next month Dr. Weir, the man responsible for the survey, will compare the alumni who majored in science with those who majored in engineering.

This conclusion is inescapable. We can avoid talking about it, moralists may try to convince us to the contrary, laws may be passed forbidding us to talk about it, fear of pressure groups may prevent political leaders from discussing the subject, but the conclusion cannot be denied on any rational basis. Either population-control measures must be both widely and wisely used, or we must reconcile ourselves to a world where starvation is everywhere, where life expectancy at birth is less than 30 years, where infants stand a better chance of dying than of living during the first year following birth, where women are little more than machines for breeding, pumping child after child into an inhospitable world, spending the greater part of their adult lives in a state of pregnancy.

The extent to which human beings avoid discussing conception control is truly incredible. Volume after volume has been written, and conference after conference has been held on the subject of increasing world food production, and arguments have raged over whether or not food production can be increased sufficiently rapidly to keep pace with population increase. Huge efforts have been made to improve public health in many of the underdeveloped areas. Yet if anyone, in an official or semi-official capacity, is so bold as to suggest that the approach is one-sided, paralysis sets in. The minority pressure groups start to work on the hapless individual, and soon he claims that his remarks were misinterpreted.

Conception control — unnatural?

Some of those who fight against conception control do so on the ground that it is "unnatural." Yet what could be more unnatural than appendectomies or injections of penicillin? And, for that matter, is not agriculture itself unnatural? Certainly a potato field growing in Western Europe is one of the most unnatural things in the world. The plant is not indigenous; forests were removed so that the plot could be cultivated; plants which prefer to grow there are uprooted so that the potato can thrive without competition; artificial fertilizers are applied to the ground; insecticides disturb the balance of insect life. Clearly, once man invented agriculture he moved into an unnatural world, and, as his knowledge has increased, his dependence upon unnatural surroundings has increased. Those who maintain that conception control should not be used because it is unnatural would be far more consistent if they urged simultaneously abolishment of all clothing, antiseptics, antibiotics, vaccinations, and hospitals, together with all artificial practices which enable man to extract food from the soil.

A second sector of the world which vigorously opposes contraception is the group which maintains that such practices are contrary to the precepts of religion. This concept indeed places man in an interesting light, representing him as one who, though he was created with the means of alleviating suffering by modifying the effects of natural processes (as he proves every time he puts on an overcoat or takes a pill), yet believes that he is obeying the will of his Creator when he refuses to establish and maintain a balance between resources and population by the simplest and most humane of all possible ways.

The outlook is all the more interesting in view of the fact that it is the children who suffer the most in regions where the ratios of food to population are very low. When I walk through such regions, where birth rates are at a biological maximum, and I see dirt-encrusted, malnourished, disease-ridden children, I know that this is not the sort of world advocated by the One who said, "Suffer little children to come unto me, and forbid them not, for of such is the Kingdom of Heaven."

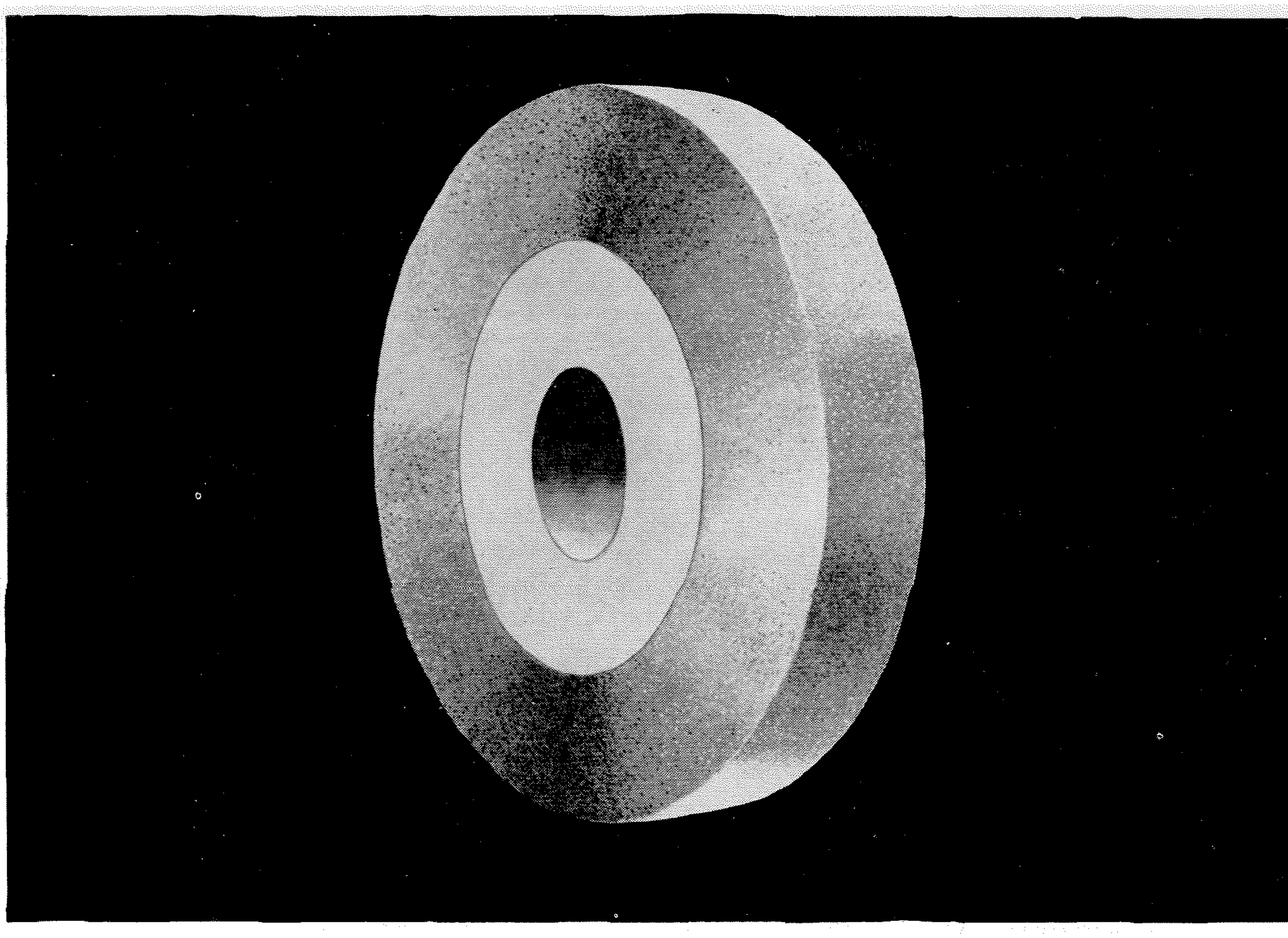
The Church knows this too, but offers only these choices to underprivileged groups: an almost impossible degree of continence, the difficult spacing of intercourse according to the principle of the highly unreliable "rhythm theory" (reluctantly accepted but not encouraged by some religionists), or the spawning of children who, *a priori*, cannot be supported and are doomed to die in filth and misery.

The guilty ones

Who, then, are the guilty ones in this grisly drama? Are they the parents, whose love for each other is perhaps the one tolerable aspect of an otherwise bleak and miserable existence? Or are they those who pass laws and issue edicts prohibiting the spread of contraceptive knowledge and, in so doing, help to perpetuate the misery and unhappiness which exists? Or, perhaps, are they the persons, whose name is legion, who are frightened by the creedists and in their fright refuse to take action.

The members of the third group, which actively opposes contraception, do so not because of any deep conviction that such practices are either sinful or "unnatural," but rather for the straightforward and unfortunate reason that they want their particular group, whether it be nation, race, or adherents to a creed, to become more populous. This motivation was partly responsible for many of the actions and attitudes in Italy during Mussolini's time and is responsible for existing official attitudes toward birth control in the Soviet Union. The leaders of the Catholic Church undoubtedly recognize that if adherents to the faith are able to maintain a substantial difference in birth rate between Catholics and non-Catholics, the proportion of Catholics in the population as a whole is likely to increase. Similar thoughts probably determine in part the attitude of numerous groups of people.

In recent years a new attitude toward birth control has appeared in several underdeveloped areas—the fear that industrialized nations are attempting to exterminate them by propagandizing contraceptive techniques. This, of course, is a blind, unreasoning fear—but no more



HIDDEN HENCHMAN . . .

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HEADQUARTERS FOR TECHNICAL AND BUSINESS INFORMATION unreasoning than most other attitudes which prevail. This particular attitude will probably increase in importance in years to come, nurtured by existing race struggles and by the conflict between the Soviet Union and the West.

In view of the diversity of the attitudes which result in active opposition to family-limitation techniques, there is serious question that human populations in the world as a whole will ever be stabilized. Indeed, a convincing argument can be presented to the effect that the population of the world can never be stabilized over a long period of time by a willful decrease of the birth rate. At the moment, however, important though the problem of ultimate stabilization is, the most pressing problem confronting us is whether or not the growth potentials of the underdeveloped areas can be decreased to the point where such areas can undergo industrialzation without undue population pressures being built up in the process.

It is possible to imagine a process whereby areas such as India might industrialize at a rate greater than the rate of population increase, but it is possible to imagine such a process only if the rate of population increase normally associated with industrialization is in some way greatly lessened. Let us make the drastic assumption, for the purpose of discussion, that organized opposition to dissemination of birth control information can be ignored, and let us attempt to visualize a program whereby birth rates might, under the circumstances, be lowered more rapidly than death rates within the framework of an industrialization process.

New techniques of birth control

As is pointed out in an earlier chapter, new techniques of birth control which are on the horizon offer considerable promise of being both inexpensive and applicable within the social structure of many of the underdeveloped areas. It is quite possible that within the next few years injections will be available which will produce sterility for a period of several months. Further, it is quite possible that drugs will be available which will prevent, without serious side effects, implantation of a fertilized egg upon the wall of the uterus. Let us assume that such drugs are available—as they almost certainly can be, given adequate research and development. We must then ask: It is possible to establish techniques that would secure both widespread use and widespread acceptance?

The degree of personal opposition to contraceptive techniques will vary greatly from culture to culture and from area to area. In Jamaica, for example, one would have to combat the belief that "a woman must give birth to all of the babies she has in her" if she is to remain healthy. In Puerto Rico one would be confronted with the desire for children as symbols of virility. In Asia one would be confronted with the desire for male children, for additional farm hands, and for the security which is believed to be brought by large families. Nevertheless, in spite of such individual opposition, there is evidence that in most such areas there is a large proportion of women who do not want to become pregnant—or at least not so frequently.

Although effective contraceptives can probably be made quite inexpensively by Western standards, it is doubtful that the cost will ever be brought down to the point where they can be easily afforded by persons who are as poverty-stricken as those in the greater part of India today. This means that if birth control is to be really effective prior to the completion of the industrial transition it must be made a part of government policy, and, in particular, birth-control programs should be incorporated as integral parts of the public-health programs that are established.

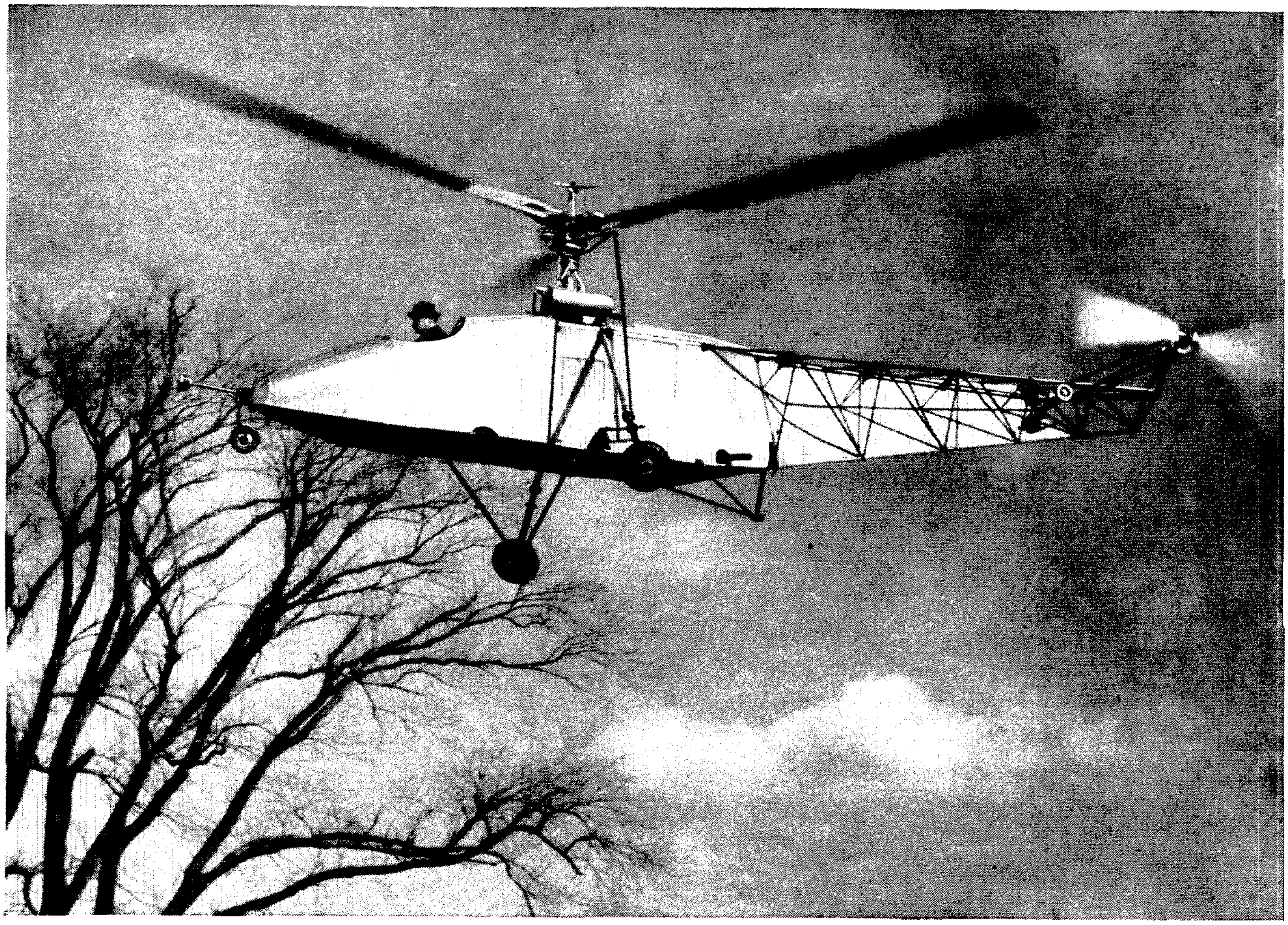
Government birth-control programs

Major birth-control programs can rationally be given priority over many aspects of public-health programs, for lowered birth rates automatically result in improved public health. Less frequent exposure to childbearing results in lowered female mortality. Smaller family sizes result in better nutrition and lowered infant mortality. In addition, the lowered food requirement for an individual family results in generally lowered adult mortality. Thus, a major birth-control program can in itself be looked upon as a major public-health program.

In each area where comprehensive family-limitation programs are established, considerable social research will be necessary in order to ascertain the most satisfactory approaches for gaining general acceptance of the new ideas. Incentives must be devised and new educational approaches must be used. There must be social experimentation on a vast scale. There will be failures, of course, but, given sufficient imagination and effort, it is likely that there will also be successes.

There are persons who maintain that no amount of effort can succeed in lowering birth rates more rapidly than the rate of decrease that has been associated with industrialization processes in the past. Such views might well prove to be correct, but it seems more likely at the present time that such views are wrong. In any event, sound predictions of success or failure on the basis of existing knowledge are impossible. We shall never know whether or not success is possible until a vigorous effort is made and our ingenuity and imagination have been wholeheartedly applied to the problem. If we succeed there will be hope. If we fail, the prospects for successful transition of the underdeveloped areas to stable industrial societies will be so remote as to border on the impossible.

The second, and concluding, part of this extract from Harrison Brown's forthcoming book, "The Challenge of Man's Future," will appear next month.



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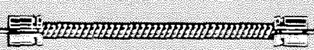

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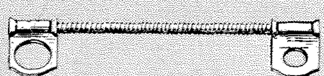

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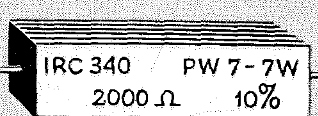

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ALUMNI NEWS

Alumni Seminar

THE SEVENTEENTH Annual Alumni Seminar will be held this year on Saturday, April 3. C. V. Newton '34 is the Alumni Association director in charge of the event, and the detailed planning is in the hands of a committee headed by Hugh C. Carter '49.

Arrangement of the program is being handled by Willis R. Donahue '34, Don D. Davidson '38, Manfred Eimer '47, and John Fee '51. Donald D. Mon '47 in charge of printing, Otto Sass '30 is handling the catering, Richard M. Roehm '48 the registration, and Ernest B. Hugg '29 is in charge of Institute Relations.

Speakers for the daytime program are still being lined up, but arrangements have already been completed to have Dan Kimball, ex-Secretary of the Navy, and now president of the Aerojet General Corp., as the main speaker at the evening dinner. Mr. Kimball will talk on "The Obligation of the Normal Citizen to Understand the Workings of His Government."

Alumni Dinner

THE ALUMNI ASSOCIATION will hold its next dinner meeting on Tuesday, March 16, at the Rodger Young Auditorium, 936 West Washington Boulevard, Los Angeles.

Main speaker is to be Charles A. McKeand, Director of Employee Relations for the Merchants and Manufacturers Association of Los Angeles. His talk, "Putting Technical Ideas in Motion," will concern the problems faced by the engineer and scientist in trying to communicate technical ideas.

Prof. Hallett Smith, chairman of the Division of Humanities at Caltech, will also speak at the dinner—on current Institute plans for adding to the Humanities curriculum.

Dinner will be served at 6:30, though the bar opens at 5:30. Reservations should be in the Alumni Office by March 10.

Notes

THE ALUMNI OFFICE hereby extends its thanks to all those who wrote in with information on the Lost Alumni listed in our January issue.

Latest bulletin on the Alumni Swimming Pool and the new gymnasium going up in Tournament Park: Plans have been completed and have gone out to contractors for bids. They are due back March 2.

PERSONALS

1918

Ralph T. Taylor is now assistant supervisor for the State Division of Architecture in charge of supervision of public school construction for the 13 southern counties of the state. Formerly in charge of field supervision, Ralph moves into the slot vacated by *Ernest Maag* '26 (see below).

1921

Edward F. Forgy is still assistant sales manager of the motor and control division at the Westinghouse Corporation in Buffalo, New York. His son Ed has just returned to Fort Ord from Korea. Son John was married last year and is now in the Army.

1922

Francis L. Hopper, after spending the holidays with grandchildren in San Francisco, visited the Institute and spent ten days in southern California renewing old acquaintances. Hop is still with the Bell Laboratories in Winston-Salem, North Carolina, working with military electronic systems for guided missiles, antiaircraft fire control, and underwater sound.

1925

Frank Clayton, chief plant engineer at Convair in Fort Worth, Texas, has been elected to a three-year term as state director of the Texas Society of Professional Engineers.

Neal D. Smith, formerly executive assistant in the public relations department of the Lockheed Aircraft Corp. in Burbank, has now become county administrator of Sonoma County. He's living in Santa Rosa, Calif.

1926

Ernest Maag has been made supervisor for the State Division of Architecture in charge of supervision of public school construction for the 13 southern California counties. He was formerly assistant supervisor of the southern division. His work involves the supervision of design and construction for all school districts in this area.

1927

Robert Creveling writes from Albuquerque, New Mexico, where he's working for the Sandia Corporation, that he got his MS in 1952—25 years after graduation from Caltech—from the University of New Mexico, where his wife Letitia graduated in 1928, and his daughter Letitia II almost graduated this year. Instead, she married an Air Force lieutenant and is now in Tucson, where he's taking flight training. The Crevelings' other daughter, Patsy, is now in high school.

George E. Moore has just been elected chairman of the Division of Electron Physics of the American Physical Society. Now living in Summit, New Jersey, the Moores have three children—a daughter, Kathleen, who is a freshman at Panzer College in Orange, N. J., and two boys, Stephen and John, in high school.

1928

William L. Olsen died on January 15. A resident of San Marino, he had been Los Angeles County engineer since graduating from Caltech, and was engineer for planning the Arroyo Seco Parkway and Angeles Crest Bridge, on the Angeles Crest Highway. Surviving him are his widow, Mrs. Wilma L. Olsen, art supervisor of San Gabriel City Schools; a son, David; his mother, Mrs. Andrew Olsen of Sierra Madre; and a sister Mrs. Clarence Wilson of Pasadena.

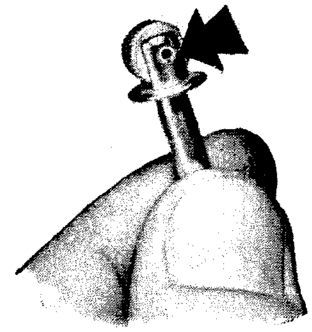
1929

Col. Laurence E. Lynn of Sacramento recently received the Legion of Merit in Korea for "exceptionally meritorious conduct in performance of outstanding service" as IX Corps engineer from April 1 to October 20, 1953. He entered the Army in 1940 and served in Europe in World War II. He is now commander of the 24th Engineer Group on the Korean peninsula.

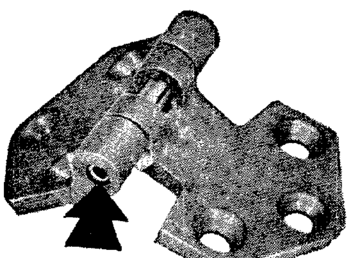
1930

Edward M. Thorndike, PhD, who is professor of physics, and chairman of the department at Queens College, N. Y., starts a year of sabbatical leave this month.

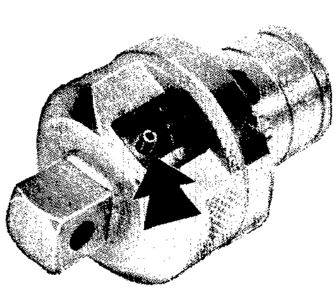
Truman H. Kuhn, professor of geology



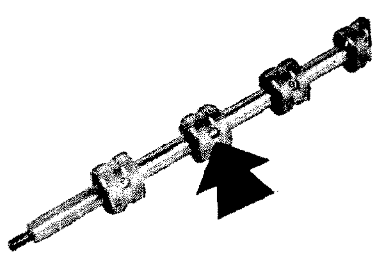
Replacing a rivet



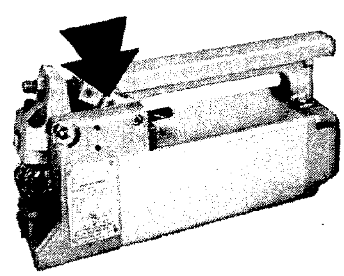
. . . a hinge pin



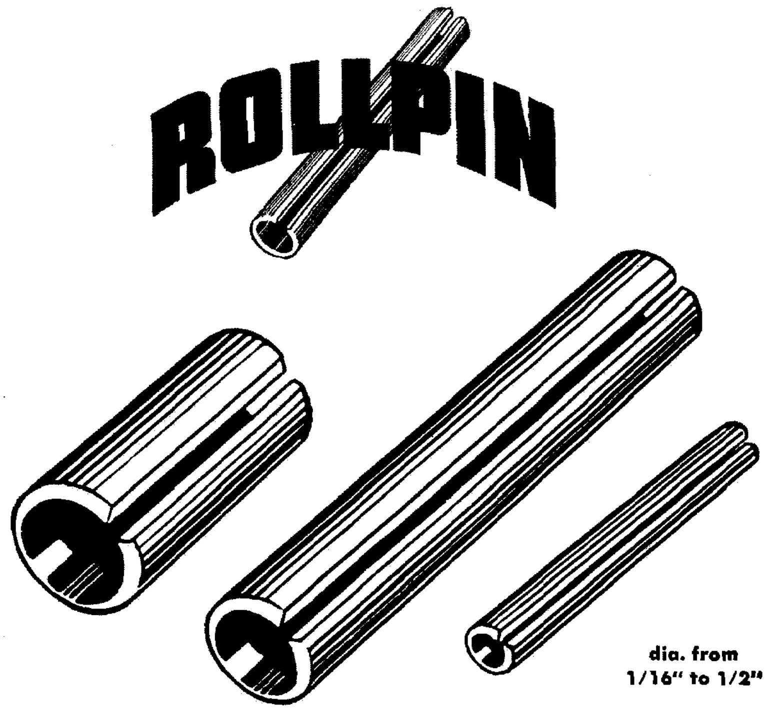
. . . a stop pin



. . . a set screw



. . . a bolt and nut



dia. from
1/16" to 1/2"

. . . a modern fastener that saves time and money on thousands of applications

Rollpin is a hollow, split, cylindrically formed pin with chamfered ends. It is simply driven into holes drilled to normal production tolerances. Because Rollpin is slightly larger than standard sized holes, it compresses as inserted. It is self-locking—and vibration-proof—because of the constant pressure it exerts against hole walls. Its shear strength exceeds that of a cold rolled pin of the same diameter. Rollpin is readily removed with a drift or pin punch—and can be reused.

Because of its versatility—and the production economies it makes possible—Rollpin is finding wide usage in almost every phase of manufacturing activity. Write for design information on the Rollpin. It will enable you to cut costs for many applications where use of rivets, set screws, dowels, and straight, serrated or cotter type pins create installation or performance problems.

ELASTIC STOP NUT CORPORATION OF AMERICA

2330 Vauxhall Road, Union, New Jersey

Elastic Stop Nuts with the famous red collar are another ESNA product

ESNA

and dean of the graduate school at the Colorado School of Mines in Golden, Colorado, recently returned from a trip to Turkey, where he estimated the chromium reserves of a Turkish mining company.

1934

John F. Pearne, still practicing patent law as a partner in the firm of Evans & McCoy in Cleveland, writes that he still hasn't been able to uncover a single Tech alumnus in that area, and has about decided that there aren't any. (*Are there?*)

1936

Wilson H. Bucknell was recently named chief engineer and operating head of the generator division of the O'Keefe & Merritt Company, Los Angeles. Buck has been instrumental in the development of several unique and highly efficient engine-generator sets, which are now being volume-produced at O'Keefe & Merritt for the military. In this connection he has just completed a comprehensive six-week tour of Army Engineer Field Maintenance establishments in Japan and Korea.

Kenyon T. Bush, formerly superintendent of the Grasselli Chemicals department in La Porte, Texas, is now assistant production manager.

1937

Richard T. Brice, Ph.D., is with the Otis Elevator Co. in New York City. At the moment he's defense manager, in charge of administering contracts for national defense items. A little over a year ago the Brices moved into a new home in West Orange, N. J.

Stanley vanVoorhees is the inventor of the first power-driven skis to take you uphill. As reported in the December issue of *Science and Mechanics*, Stan conceived the idea of "regulation skis rigged with hill-climbing traction belts and powered by a back-packed gasoline engine with flexible drive shafts at each ski.

1938

Wesley T. Butterworth, M.S., writes from Galena, Ohio, that his ten-year-old son Richard had polio this spring, but has fully recovered by now. Wes is a member of the school board in Galena's Big Walnut District, is also a member of the executive board of the local IAS chapter.

Stephen J. Jennings, M.S., has been transferred by General Electric from their analytical engineering section in Schenectady, New York, to the aircraft gas turbine division in Cincinnati, Ohio.

J. Kneeland Nunan, M.S., was recently elected president of Consolidated Vacuum Corporation of Rochester, New York, a subsidiary of Consolidated Engineering Corporation of Pasadena.

1939

John C. Evvard, Ph.D. '43, now chief of the supersonic propulsion division of the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics, presented a paper ("Transition-Point Fluctuations in Supersonic Flow") at the annual meeting of the Institute of Aeronautical Sciences in New York last month. John went to work for the NACA Aeronautical Laboratory at Langley Field, Virginia, in June 1942, and transferred to the Lewis Flight Propulsion Laboratory in Cleveland, Ohio, in October of the same year. He's living in Strongsville, Ohio, with his wife, Jean, and their son.

James Rainwater has been professor of physics at Columbia University since 1952, and is doing research with Nevis 385 MEV proton synchrocyclotron. Jim has been married since 1942 and now has four children (three boys and one girl)—the oldest, 7 years, and the youngest, 20 months.

1940

H. E. Heywood, M.S., has been assistant chief engineer of the Toledo, Ohio, plant of the National Supply Company for the past five years. They are national manufacturers of oil field machinery. Late this year he'll be moving to Gainesville, Texas, to become manager of a new plant National is building there.

Ray Richards has been appointed head of the field service planning department, field service division, at Lockheed Aircraft Corporation. He joined the company in 1940.

1941

Frederick W. Clarke reports among his "honors and possessions" one wife, Mary G.; two boys, Freddie (6) and George (2); and two companies—Rogers and Clarke, which makes lenses, and Optical Machinery, Inc., which makes lens grinding equipment. The Clarkes live in Rockford, Illinois.

1942

Joe Franzini, Engr. '44, and his wife announced the arrival of Cheryl Ann on January 13. The Franzinis now have two daughters and two sons. Joe is still a member of the civil engineering faculty at Stanford University.

1943

Lawrence Raymond Pugh announces that he has formally changed his last name to Rockwood. At the same time, he's leaving

PERSONALS . . . CONTINUED

his job with Beckman Instruments in Pasadena, to become plant manager of Electro-Measurment Inc. in Portland, Oregon.

1944

Paul S. Winter is director of the Afghan Institute of Technology in Kabul, Afghanistan.

1945

K. Martin Stevenson is on the technical staff at the Hughes Research and Development Corp. in Culver City.

1946

Howard W. Morgan, Jr. writes that he's out of the Navy at last with a full lieutenant promotion. Right now he's a sales engineer with Anaconda Wire and Cable in the Cincinnati, Ohio, office.

David C. Lincoln, M.S. '47, with the Sperry Gyroscope Company in Great Neck, New York, since 1949, was recently promoted to the new position of engineering section head for missile control systems in the Flight Controls Engineering Department.

Lt. Col. Henry L. Gephart, M.S., is now assigned to the design branch of the aircraft laboratory at the Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.

1947

W. C. Cooley, MS, has been a technical engineer with the aircraft nuclear propulsion department of the General Electric Company in Cincinnati, Ohio, since March, 1953. He received the degree of Doctor of Science in mechanical engineering at MIT in June, 1951.

Morris Feigen, MS, is on the technical staff of the Hughes Research and Development Laboratories in Culver City.

Roger D. Stuck is teaching at Warren Wilson College, Black Mountain, N. C. He writes that his wife Christine, and children Dean and Phyllis are thriving--and that he will be too, as soon as a broken arm mends up.

Manfred Eimer, M.S. '48, Ph.D. '53, is now in the reasearch analysis section at the Jet Propulsion Laboratory in Pasadena.

1948

John R. B. Whittlesey, M.S. '50 has been studying for his Ph.D. in mathematical statistics for two and a half years at the University of North Carolina. He's currently a research assistant under a grant from the Ford Foundation, says he's maintaining an interest in quantum theory and in psychometrics, has recently published a note in the *Duke Journal of Parapsychology*—and may soon be drafted.

Sol Matt, M.S., received his Ph.D. from Ohio State University on December 18.

Ed Hall, MS, writes that they're expecting a baby on the Ides of March. He's still at the Wright-Patterson Air Force Base in Ohio, "trying to develop rockets that go faster, higher and further than anything previously known to man."

1949

Emmett P. Monroe, MS, received his M.D. degree in 1953, is now interning at Akron City Hospital in Ohio, and plans to enter general practice next summer—location still unknown. The Monroes are living in Cuyahoga Falls, Ohio, and have two daughters--Janise, 3, and Lisa, 1.

Clayton M. Zieman, PhD, was recently made professor of electrical engineering and head of the department of electrical engineering at the United States Air Force Institute of Technology ,at Wright-Patterson Air Force Base, Ohio.

Murray S. Bornstein, MS, returned from Europe a year ago after completing a two-year contract as a Corps of Engineers civilian employee. He's spent the past year working for Hardesty & Hanover, New York bridge consultants, as a structural designer. "Not married yet," says Murray, "and no good prospects. Future plans depend on the whim of the draft board."

1949

Frank H. Dickey, Ph.D., has joined the Continental Oil Company as a consultant in theoretical research and will make his headquarters at Ponca City, Oklahoma. Frank has been a chemistry instructor at the University of California at Berkeley for the past two years, and before that, studied for a year in Sweden on a Guggenheim Foundation Fellowship.

1950

Shigeru I. Honda finished his requirements for his PhD in plant physiology from the University of Wisconsin last October. He is now on a Fulbright fellowship at the Botany School of the University of Sydney, Australia.

Richard Scott Pierce, PhD '52, now studying at Harvard under a Frank B. Jewett postdoctoral fellowship, has been named to receive a Jewett fellowship for a second year. He is currently engaged in research on the analysis of automata and lattice ordered rings.

Henry Shapiro, M.S. '51, Engr. '52 was recently advanced to the position of Chief of Applied Mechanics at the Propulsion Research Corporation in Los Angeles.

1951

Ulrich Merten and the former Kathy Williams were married in St. Louis last November. *Kent Stratton* '51 came from Oak Ridge, Tennessee, to be best man. Mert is still at Washington University in St. Louis, working on a PhD in radiochemistry.

Carl A. Hirsch is now working for The Parsons Co., Frederick, Maryland.

1952

Bill Irwin and his wife announce the arrival of a son, Michael William, on December 30, 1953. Bill is a field engineer at Induflux Testing Service in Los Angeles.

1953

Arthur E. Britt is now a member of the technical staff of the Hughes Research and Development Laboratories in Culver City.

Bill Blodgett is working as a field engineer for the Sperry Gyroscope Co. on the Skysweeper, a radar-controlled AA gun. Right now he's at Aberdeen Proving Ground, Maryland, though he's due to move on to Fort Bliss, Texas, by about next month. "After that," says Bill, "who knows? May even get back to Pasadena for a few months—or go overseas."

Alphonse Peters is working as a cost engineer for the Goodyear Atomic Corp. in Portsmouth, Ohio.

Donald E. Coles, PhD, now a research fellow in aeronautics at Tech, is the winner of this year's Lawrence Sperry Award from the Institute of Aeronautical Sciences. The award is made for a notable contribution by a young man to the advancement of aeronautics. Don is the third Caltech graduate to receive this award—*Allen Puckett*, PhD '49, having won it in 1948, and *Dean Chapman* '44, PhD '48, won it last year. Don was cited this year for his experimental and theoretical contributions to the basic knowledge of turbulent skin friction and heat transfer at supersonic speeds.

Joseph D. Gleckler, M.S., is working for Procter & Gamble, in the company's Long Beach plant.

Swaroop BhanjDeo is doing graduate work in geology at Stanford.

Donald O. Emerson is now a graduate assistant at Penn State.

Patrick J. Fazio is working in the geological department of the Shell Oil Company in Los Angeles.

Richard A. Knapp has a job with the Cerro de Pasco Copper Corp. in Morococha, Peru.

CALTECH CALENDAR

February, 1954

ATHLETIC SCHEDULE

BASKETBALL

February 18, 4:15 p.m.
L. A. State vs Caltech at Armory

February 20, 7:30 p.m.
Redlands vs. Caltech at P.C.C.

February 23, 8:15 p.m.
Occidental vs. Caltech at P.C.C.

February 26, 8:15 p.m.
Caltech at Pomona

TRACK

February 20, 2:00 p.m.
Interhouse Meet

February 27, 2:00 p.m.
Pasadena College, Chapman and Westmont at Caltech

March 6, 1:30 p.m.
Conference Relays at Pomona

BASEBALL

February 23, 4:15 p.m.
Nazarenes at Caltech

March 1, 4:15 p.m.
Muir at Caltech

March 6, 2:15 p.m.
Cal Poly (SLO) at Caltech

TENNIS

February 20, 1:30 p.m.
Pomona at Caltech

Febraury 27, 1:30 p.m.
Occidental at Caltech

March 6, 1:30 p.m.
Whittier at Caltech

GOLF

February 19, 1:30 p.m.
Muir at Brookside

February 26, 1:30 p.m.
P.C.C. at Brookside

March 5, 1:30 p.m.
L. A. State at Caltech

ALUMNI ACTIVITIES

March 17	Dinner Meeting
April 3	Alumni Seminar Day
June 9	Annual Meeting
June 26	Annual Picnic

DEMONSTRATION LECTURES

Friday Evenings
7:30 p.m. — 201 Bridge

Feb. 19—"Liquid Air," by Professor E. C. Watson

Feb. 26—"The Expanding Universe," by Professor H. P. Robertson

March 5—"Longevity Under Adversity in Conifers" by Professor E. Schulman

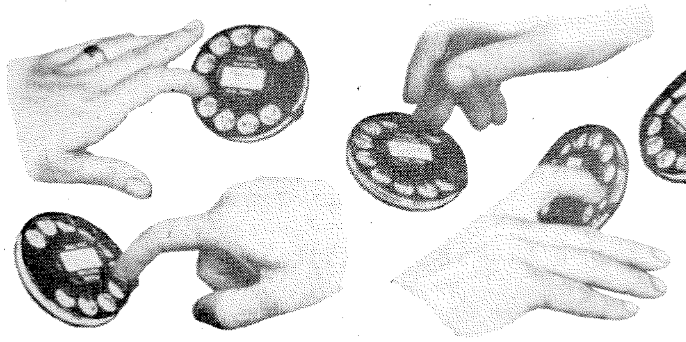
Y.M.C.A. FILM SERIES

7:30 p.m. — Culbertson Hall

Feb. 21—"The Passion of Saint Joan"

March 7—"Saints and Sinners"

PHOTOGRAPHY AT WORK—No. 7 in a Kodak Series



Photography reads the meters *2500 an hour!*

Dial a call—an accurate register counts it—then each month photography records the total, precisely right, ready for correct billing.

TWENTY-FOUR hours a day, hundreds of thousands of dial phones click their demands in many central exchanges of the New York Telephone Company.

Little meters keep careful tally of the calls. Then the night before each bill is dated, photography reads the up-to-the-minute totals in a fraction of the time it could be done in any other way. Here is an idea that offers businesses everywhere simplification in copying readings on meters, dials or other recording instrumentation.

Photography fits this task especially well for two reasons. It is lightning fast. It can't make a mistake.

This is another example of the ways photography saves time, cuts costs, reduces error, improves output. In large businesses—small businesses—photography can do big jobs. In fact, today so many new applications of photography exist that graduates in the physical sciences and in engineering find them valuable tools in their new occupations. Other graduates—together with returning servicemen—have been led to find positions with the Eastman Kodak Company.

If you are interested, write to Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

Eastman Kodak Company
Rochester 4, N. Y.

At New York Telephone Company exchanges a unique camera records the dial message register readings—up to 25 at a clip—saving countless man-hours of labor, assuring utmost accuracy and at the same time providing a permanent record.

Kodak
TRADE-MARK

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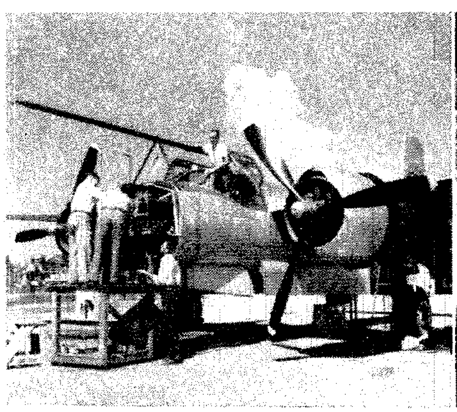
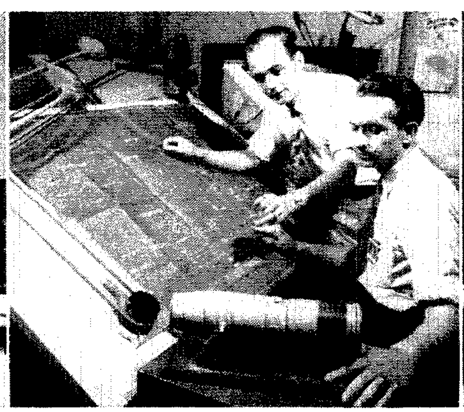
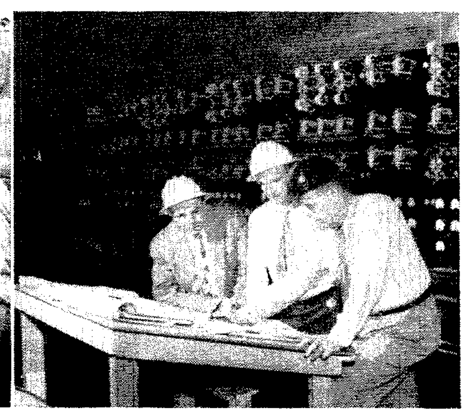
Sound engineering is one of the foundation stones of General Electric's leadership in the electrical industry. The importance of the role of the engineer has been recognized from the very beginning of the Company. Since 1892, G.E.'s Engineering Program—the oldest on-the-job training program in industry—has been affording young engineers widespread opportunities for professional development.

Besides the engineering fields briefly described here, career opportunities with a bright future are waiting for engineers in other important fields at General Electric . . . in manufacturing engineering . . . sales engineering . . . installation and service engineering . . . advertising . . . administration . . . other specialties in engineering.

If you are an engineer interested in building a career with an expanding and ever-growing Company see your college placement director for the next visit of the G-E representative on your campus. Meanwhile, for further information on opportunities with G.E., write to College Editor, Dept. 2-123, General Electric Co., Schenectady 5, N. Y.







DEVELOPMENT ENGINEERING—Development engineers are continually obtaining and assessing new basic engineering and scientific knowledge to make possible new developments. They serve as consultants to help in the solutions of engineering problems, which often require research, experimentation, and the development of a new product or component.

DESIGN ENGINEERING—To maintain leadership in the electrical field, design engineers are constantly striving to develop new and better products. Their skill is largely responsible for the steam and gas turbines, motors, heat pump, control equipment, and many other products. In electronics, they design equipment for television broadcasting and reception, radar, and other electronic equipment.

APPLICATION ENGINEERING—Since much equipment today is designed for a specific use, the application engineer must have a broad knowledge of the industry for which a particular product is being designed. Because G-E products are widely used throughout industry, imagination, determination and a sound knowledge of engineering are important assets in this ever-growing field.

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