ENGINEERING | AND | SCIENCE

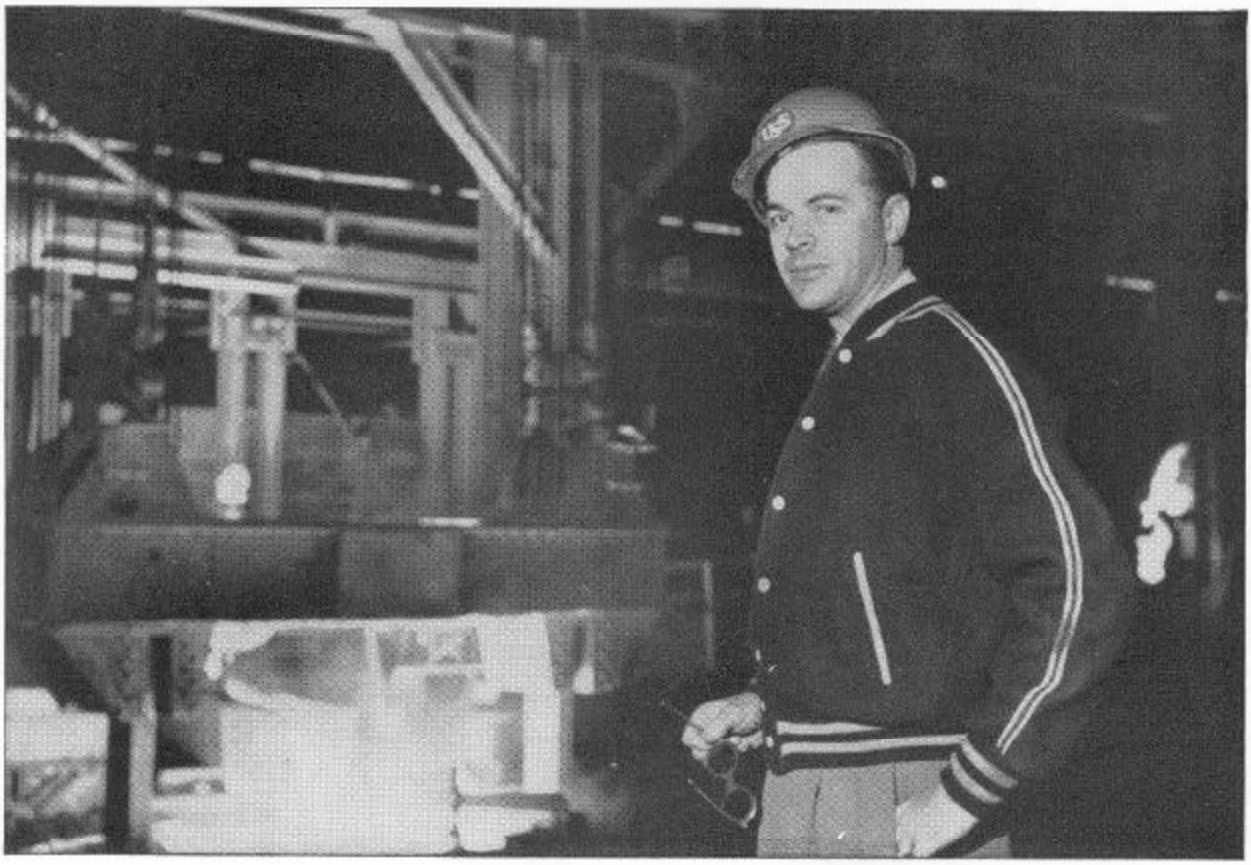
JUNE/1956

Commencement . . . page 17

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

Richard S. Crowell, class of '48,
speaks from experience when he says . . .

"There's plenty of chance for advancement at U. S. Steel for today's engineer."



Immediately following his graduation as a B. S. in Metallurgical Engineering, Richard Crowell was recruited by the chief metallurgist of U.S. Steel's Clairton works. By 1951 he received his third promotion to Engineer-Operating Practices in the Open Hearth Division at Clairton. Recently he had his sixth promotion to his current position as Superintendent of Clairton's Open Hearth Department.

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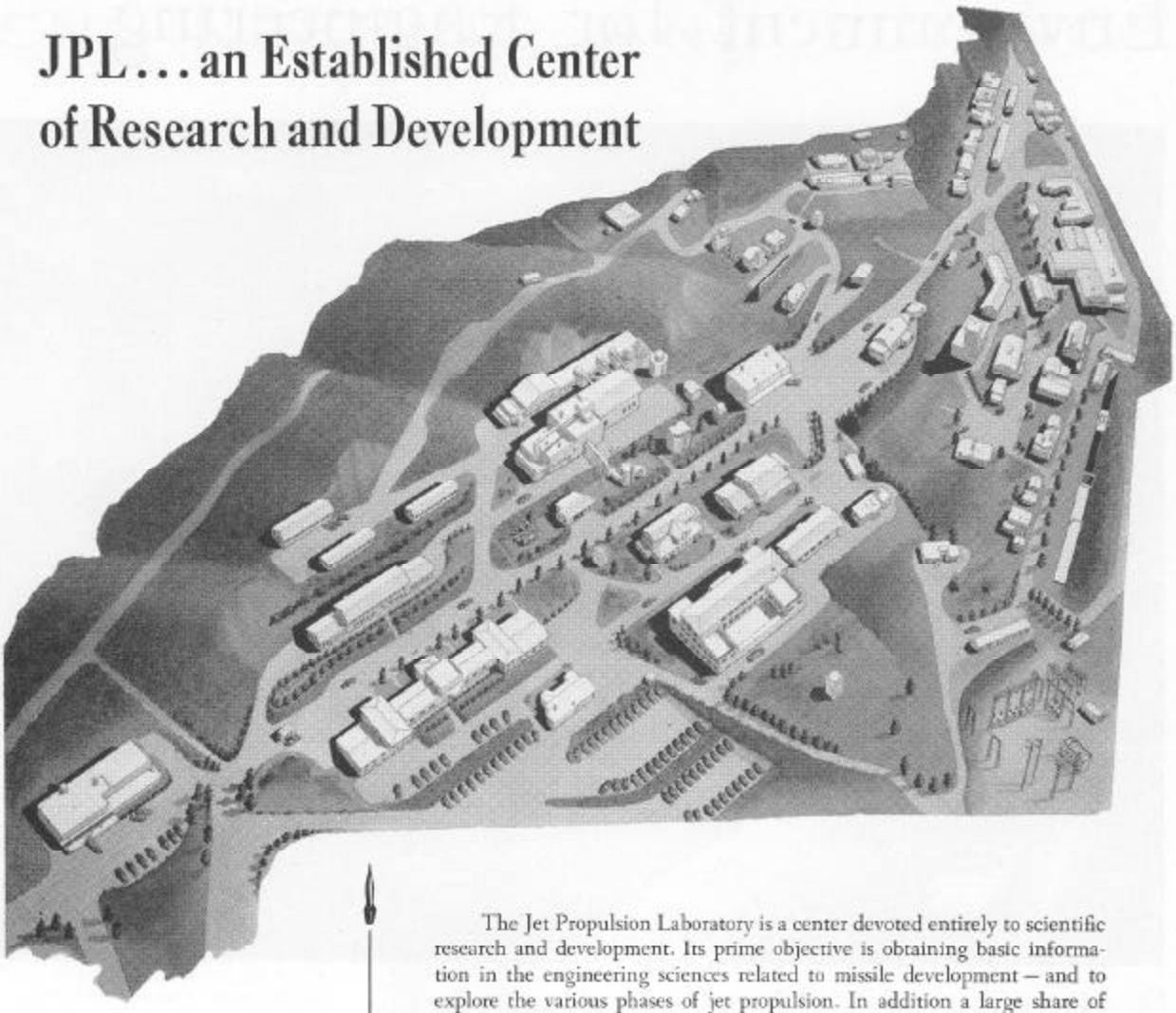

The Jet Propulsion Laboratory is a center devoted entirely to scientific research and development. Its prime objective is obtaining basic information in the engineering sciences related to missile development — and to explore the various phases of jet propulsion. In addition a large share of its program is devoted to fundamental research in practically all of the physical sciences.

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ENGINEERING AND SCIENCE

IN THIS ISSUE

On our cover this month are a few of the members of the class of 1956, waiting for the signal to take their place in the academic procession at Commencement. For some other views of the 1956 Commencement see pages 17-19.

Henry Allen Moe, whose Commencement address, *Science and Wisdom,* appears on page 13, has been secretary-general of the John Simon Guggenheim Foundation since 1924. A former Rhodes scholar, he was a reporter on the St. Paul *Dispatch and Pioneer Press* before he went on to a distinguished international career and was admitted to the New York Bar and the Inner Temple for London barristers.

The remarkable picture of the Milky Way on pages 24 and 25 is the work of a husband and wife who are now working as computers in the Lund Observatory in Sweden. Martin and Tatjana Keskula are now Swedish citizens; they came to Sweden in 1944 —refugees from Tallin, Estonia, where Martin was city engineer. Their picture of the Milky Way took two years to finish. The original is at the Lund Observatory; our reproduction was made from a copy recently presented to the Mount Wilson and Palomar Observatories.

PICTURE CREDITS

Cover	Tom Harvey
p. 17	Elton Sewell
pps. 18, 19	Tom Harvey
	Elton Sewell
	M. J. Wood
p. 29	Walter W. Girdner
p. 30	M. J. Wood

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CONTENTS

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BOOKS

RUSSIAN JOURNEY
by William O. Douglas
Doubleday & Company, N.Y. $4.50

THE CALTECH community got a preview of this book when Justice Douglas visited the campus in February, on the YMCA's Leaders of America program. Now, here is the complete account of Douglas's trip to the Soviet Union in the summer of 1955, which pretty much took him from one end of the country to the other. As a report on Russia, and as a travel book, it's in a class by itself.

I AM A MATHEMATICIAN
by Norbert Wiener
Doubleday & Co., N.Y. $5.00

Reviewed by F. Bohnenblust
Professor of Mathematics

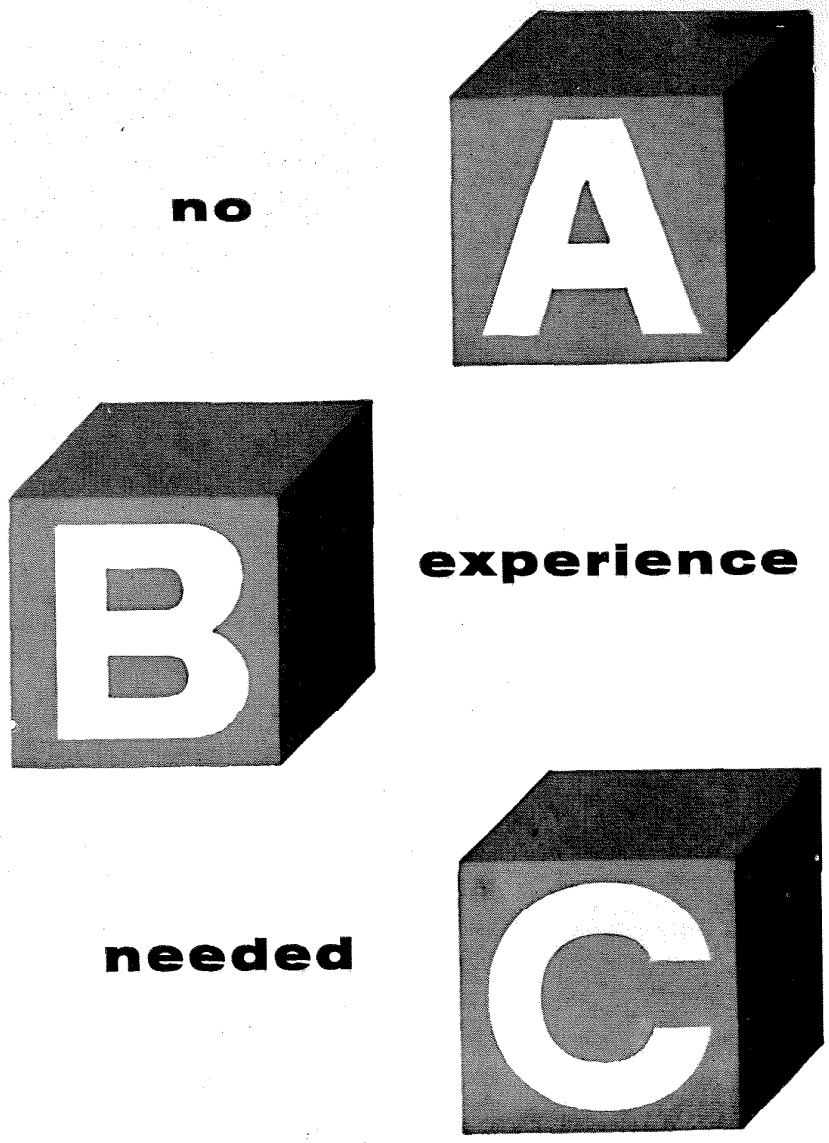
DR. NORBERT WIENER is outstanding among contemporary mathematicians. He is, perhaps, most widely known for his book on *Cybernetics*, but his contributions to modern mathematics have opened many other new fields of investigations. *I Am a Mathematician* is the second volume of Wiener's autobiography — the first volume, *Ex-Prodigy*, having appeared in 1953. In *Ex-Prodigy* the problems of his childhood and the emotional conflicts with a brilliant, dominant father create the necessary background for a sympathetic understanding of the character and ambitions of the author. Unfortunately, the drama of human relations is less forceful in *I Am a Mathematician*.

This volume begins at the moment Dr. Wiener enters his professional world as a young mathematician seeking a proper field for his abilities and struggling for recognition. It is progressively more episodic in character; it deals less with the elations of first discoveries and his emotional difficulties, and more with a play-by-play account of the events of his life and of his achievements through his years of maturity to his present-day position as a leader in the field of Analysis. Dr. Wiener repeatedly attempts to describe the significance of his work, which is known to professionals and will remain obscure to the layman.

As a result of his work and of his extensive travels in America, Europe, China and India, Dr. Wiener has met most leading mathematicians. The sketches of their personalities and of his experiences, often deft, amusing or penetrating, add greatly to the interest of the book.

WHAT IS SCIENCE?
edited by James R. Newman
Simon & Schuster $4.95

A COLLECTION of 12 essays in which as many scientists, and social scientists, attempt to explain their particular fields to the layman. Impressive as they are, the discussions, in general, seem to require more than a layman's interest or understanding of the reader. Among the authors represented are Bertrand Russell (Science and Human Life), Hermann Bondi (Astronomy and Cosmology), Edward U. Condon (Physics), John Read (Chemistry), Julian Huxley (Evolution and Genetics), Clyde Kluckhohn (Anthropology) and Erich Fromm (Psychoanalysis).



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LETTERS

Grad students' views on "The Caltech Undergraduate"

Concerning "The Caltech Undergraduate—and What You Can Do with Him" (*E & S, May 1956*), we should like to voice our objection to the *apparent* meaning of this letter!

One point of contention is the objection to the uniqueness of Caltech, and the statement that the outside world thinks that if you go to Caltech you're queer unless proven otherwise. Who is the outside world to Mr. Trapnell? Is it the technical community into which he will undoubtedly be received very eagerly when he completes his education at Caltech?

Furthermore, if a student at Caltech can get by while participating in a "fantastic" number of social events and studying as little as possible, then he is undoubtedly living up to the expectations of the faculty at the time he was accepted—and *God knows they expect plenty.*

As for what the school is doing for the students, the list is far too long and well known to reproduce here. Leave it be said that the Institute's policy of financial aid to the students is unparalleled in any university known to us. Caltech's student houses are the finest example we can find of giving a group of young men complete freedom to work and play and learn to live in tune with their fellow men.

Finally, we conclude that Mr. Trapnell is merely indulging in one of the Caltech man's favorite sports —griping—when he says, "Where in the hell am I going anyway?" This problem is universal. Does *anyone* know where he's going?

Have faith, young man, have faith!

Bob Perpall '52
Jim McCloud '55

A reply from Mr. Trapnell

I think you missed the point!

In the first place I like it here at Caltech; I would hardly give thought to going anywhere else. As you point out in your third paragraph, this is a wonderful place to go to school—and this is, in fact, "what all the shootin' is about."

However, if you don't think that a lot of graduate and undergraduate students share the views expressed in my article, then you just haven't been around long enough—or haven't kept your ears open. On the other hand, you are apparently familiar enough with the fact that griping is "one of the Caltech man's favorite sports." Now, if you will take another look at my article, I think you will find that what I was trying to do was raise the problem out of the "favorite sport" level so that we can take a look at what's underneath.

Fritz Trapnell '56

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FORECASTING THE FUTURE?

A noted astronomer takes issue with some of the "dire prognostications" of Sir Charles Darwin

by FRED HOYLE
Visiting Professor in Theoretical Cosmology

READERS OF Sir Charles Darwin's challenging article, "Forecasting the Future" (*E & S—April 1956*), can scarcely avoid wondering whether any answer can be given to it. Indeed I suspect Sir Charles of deliberately trying to provoke us all into offering some answer to his dire prognostications. At all events this is the effect his cheerful pessimism had on me, so I resolved to set down what counter-arguments I could think of.

First, a brief repetition of the argument itself. It is convenient to group the ideas under several headings.

(1) Animal populations are governed by food supplies, the number of animals of a particular type that are alive at a given time being just the number that can be supported with the food supply available at that time. Let the food supply increase and the number of animals increases. Let the food supply decrease and the number of animals decreases, starvation being the controlling factor.

(2) During the last 6,000 years or so, and particularly during the last few centuries, human knowledge has developed in an astounding degree. With increasing knowledge have come improved techniques, and with improved techniques has come a sharp increase of food production. Always accompanying the increase of food production there has been an increase of human population. Indeed, the rise of human population has followed the availability of food so consistently and closely that one cannot avoid the unpleasant suspicion that the human animal is responding to biological conditions in a manner not a whit different from that of other animals.

(3) The argument that improvements of technique will always keep pace with the rising human population is arrant nonsense. The human population is rising so rapidly today that *if the rate is maintained*, the amount of standing room on the surface of the Earth will be reduced in about 1100 years to a ration of one square yard per person; in 5,000 years the mass of humanity will exceed the mass of the Earth itself; while in about 11,000 years humanity will exceed the mass of the whole universe visible with the 200-inch Hale telescope.

(4) The rate of increase of the human population must therefore decline. The word 'must' is unqualified. What will cause the decline—starvation or a voluntary decrease of the birth rate?

(5) Decline through starvation is a natural process, the natural law whereby animal populations are governed. A decline through a voluntary decision by the human species will require some powerful basis in emotion and logic if it is to compete in strength with natural law. It is to be doubted whether any such strong basis will be found.

(6) Even if a voluntary limitation of the birth rate were seriously considered, it is doubtful whether it would be accepted by the whole of humanity. Those who accepted it would limit their numbers, while those who were unwilling to accept it would increase their numbers. The effect would be that those who refused limitation of numbers would automatically swallow up the others, so that in the result there would be no controlled check at all on the human population.

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LEE De FOREST

Appropriately qualified to speak for aeronautics and other fields in which his own scientific achievements play an important part, Dr. Lee de Forest gives helpful counsel to young graduates headed for successful, rewarding careers.

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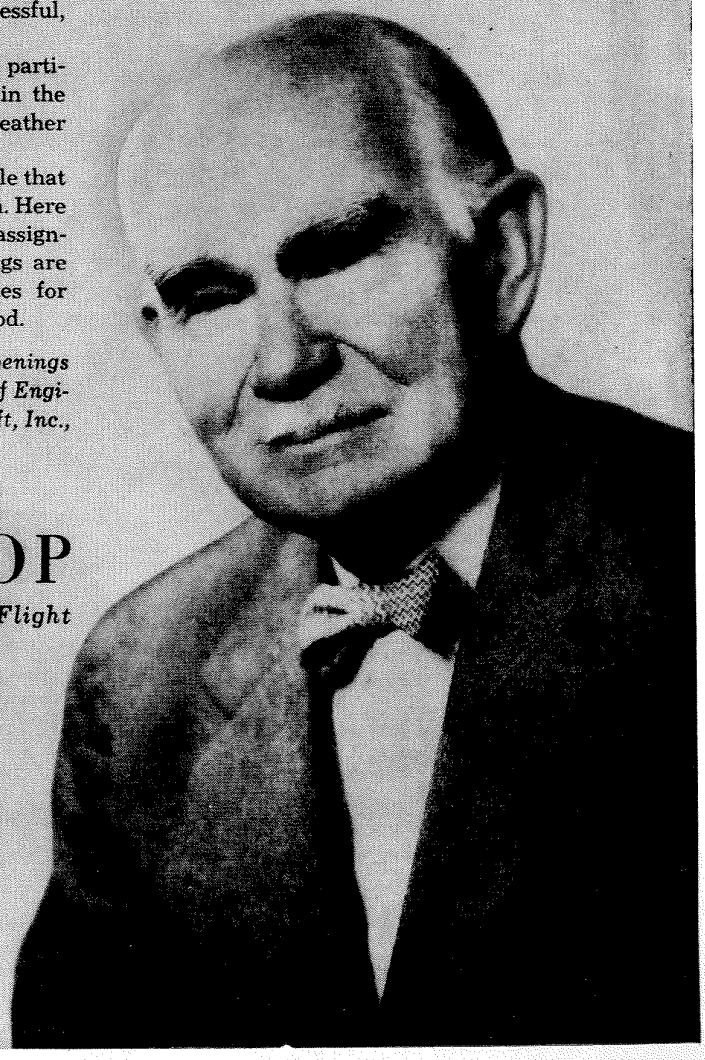

*A statement by Dr. Lee de Forest, pioneer in radio.

(7) The conclusion is that the human being is an animal and that at root he lives like an animal, controlled by exactly the same natural processes as other animals. The rise of food production occasioned by improved techniques cannot continue indefinitely. We live today in an exceptional age, a Golden Age, in which for a little time the inexorable march of natural law is not immediately apparent. Sooner or later, however, perhaps in a century, perhaps in half a dozen centuries, man will be forced to conform to the self-same conditions that the rest of the animal kingdom conforms to. Eventually he must return to a semi-bestial existence.

This is a powerful argument, but it seems to me that not all of its links are of the same strength. Points (3) and (4) are quite unassailable, point (2) is, I think, correct, point (1) I would accept with some reservation. On the other hand, point (6) seems to me to be a *non-sequitur*, while the last sentence of (5) seems open to serious question. Since the final conclusion turns on the acceptance of (5) and (6), I do not feel that the conclusion is logically compelling. It may, of course, turn out to be correct, nonetheless.

The ideas underlying point (6) would be correct under conditions of primitive technology but do not seem to me to be consistent with modern technology. A community that adjusts its population in a rational manner cannot nowadays be overwhelmed by sheer force of numbers, but only by a superior technology. And this is not likely to be possessed by an overpopulated community. Rather is the situation the other way round; an overpopulated community with large concentrations of humanity would be more vulnerable to modern weapons.

Starvation is not the only way

The reservation I have about point (1) is that I do not believe starvation to be the *only way* in which populations become adjusted to food supplies. I have read on good biological authority that certain species of songbirds automatically limit their populations without starvation's necessarily intervening. The territory available for food is divided not into a number of units equal to the number of contending birds, but into the number that can adequately provide enough food for the rearing of a brood of chicks. If the number of contenders exceeds the number of territorial units, then fighting takes place until the birds are separated into two groups, those with territory and those without. The ones with territory breed, while those without territory do not. In this way the birth rate is automatically governed to the availability of food, and this is done without the starvation of unsuccessful birds, since enough feeding grounds are left over to support the latter.

I mention this example at length because it comes near the crux of the whole business. It must be granted that a feedback has to exist between food supplies and population, but this feedback need not involve starvation. Starvation is a crude form of control in which the feedback mechanism operates directly on the population. If the population gets too large, individuals die, thereby reducing the population. In the case of the birds, no individuals die. The feedback is a more sensitive system in which the food supplies operate on the birth rate, which then affects the population at one stage removed, as it were. Instead of the excess of individuals dying, they simply are not born.

Human feedback processes

Herein lies the root of my disagreement with Sir Charles. I think there is evidence to show that humans are susceptible to even more subtle feedback processes than are the birds. For instance, I think the fact that Sir Charles wrote his article, that I am writing this reply, that Harrison Brown wrote his book, *The Challenge of Man's Future*, are all examples of feedback. Once a man grasps the unassailable qualities of points (3) and (4), some sort of feedback along these lines becomes inevitable. Should this happen to men on a sufficiently large scale, Sir Charles will have the "strong basis" that he requires in point (5).

Of course the feedback may not happen on a large enough scale to produce important effects, but I think there are some considerable indications that it may. An appreciation of the seriousness of (3) and (4) is undoubtedly growing very rapidly; indeed, there is every reason to suspect that the growth has some similarities to a chain reaction. If this is so, then the feedback will almost certainly win out, for the reason that the characteristic multiplication time of the chain reaction (probably one or two years) is far shorter than the characteristic time of the rise of population (about 70 years).

An example of feedback can be given that has controlled the birth rate of a whole nation. During the last 30 years there has been a stability of the birth rate in Britain. This stability is not governed by starvation, but by the threat of a lowered standard of living—a far more subtle feedback than is required if points (3) and (4) are to exercise their influence on the world population.

In conclusion I would like to stress that nothing that I have said is intended to minimize the problems raised by Sir Charles Darwin. These problems are in my view far more important, and lie far deeper in the fabric of civilization, than are and do the Communist-Anti-Communist issues we hear so much about in the daily paper. Mankind in its public discussions seems to have a penchant for irrelevancy. Where I do not agree with Sir Charles is in the position that because the problems are severe they are well-nigh incapable of solution.

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SCIENCE AND WISDOM

The 1956 Commencement Address

by HENRY ALLEN MOE
Secretary-General of the
John Simon Guggenheim Memorial Foundation

AT LEAST to the layman like myself, today the scientist, as scientist, seems to be stepping high, wide and handsome. Like the artists of the Italian Renaissance, when art flourished under the twin stimuli of popular enthusiasm and princely financial support, you, the scientists of today, have caught the popular imagination, and, no less, make appeal to the benevolent impulses of the rich and the urgent necessities of government. This is fine, for you and for everybody. You deserve it; for in your science, in your important—important for everybody—search for new scientific truth, things are going well for you, and you are moving forward. Science has its method for going forward and you know the method. You do not know all the methods, but the larger aspects of the method of science you do know.

Once outside your science, however—outside in the world, where, if you proceed at all, you proceed by value judgments and where you, like the rest of us, live most of your lives—you are like the rest of us. There are those who say that, in the present day, you affect the course of the world more than do the rest of us. There are those who say—and some say it without approval—that, as scientist citizens, you have a preponderantly greater weight *per capita* than the rest of us. But I do not disapprove, *provided that* you have wisdom and do not think that the sciences will give you all the answers, or even the most important parts of them. They will not, for the simple reason that in most areas in which you live your lives, there is no applicable science, and there may never be.

Perhaps, therefore, a person like myself with a training and a long experience so different from most of yours may have something to say with enough validity to go into your thinking. I ask you to believe that this is said very modestly: it may or may not be so. Of that, you will judge when I have done.

At this point perhaps I ought to say, to reassure you, that I am not going to say that, for wisdom, humanistic education is the only answer. Nor am I going to raise what has become the usual hue and cry, that science is the devil and humanistic learning the savior.

What then will I say about science and the road to wisdom? Assuredly, I will not say that science is not the road. Assuredly, I shall not say that science may not be as much a part of humanistic learning as, for example, literary criticism may be. Assuredly I shall not say that there is any conflict between the learning of science and the learning of the so-called humane and liberal studies. In the world of value where we all live most of our lives, the humanities are not the only teachers of values, nor the principal teachers, as often is claimed.

Assuredly, I do say that the study of science, any science, can be humanistic, and be as liberal as the study of, say, Greek sculpture of the age of Pericles, and can teach us just as much about the world of value. Assuredly, I do say that study of Greek sculpture of the age of Pericles can be as narrowing, can be as non-humanistic, as the study of the properties of prime numbers can be—but either study is not necessarily narrowing in either instance. The main point is that the pursuit of any study into and for itself alone makes a situation from which no great things can come.

The humanities relate only to a part of the life of

man, only to a part. Like the humanities, science relates only to a part of the life of man, only to a part. To think any other way is nonsense. To think that science and the humanities are separate, is equal nonsense. To think that they are naturally at war with each other is the way to more nonsense. Science is not isolated in the lives of men, nor is it isolable. Like everything else experienced—everything else—it is only a part of the matrix in which we live our lives.

John Livingston Lowes explained this in *The Road to Xanadu*: ". . . the imagination voyaging through chaos and reducing it to clarity and order is the symbol of all the quests which lend glory to our dust."

"All the quests," be it noted; and be it noted also that "the imagination voyaging through chaos and reducing it to clarity and order" is what lends "glory to our dust' and makes all scholarship and all art worthy of the best in men.

Einstein's new universe

This is what Dr. Einstein did when, by a few deductions out of scientific observation, he saw the universe anew a few deductions out of scientific observation plus a feeling, which I can only describe as aesthetic, for symmetry.

He reduced to clarity and order a large segment of the matrix in which we live our lives. It was scientific, *yes*: It was humanistic, equally *yes*. No thinking men's lives, not even—if I may fragment my statement this way—their non-scientific, humanistic lives, can ever be the same after Einstein's daring symbolism of observation, deduction and generalization.

The trouble is not with Einstein's science, the trouble is with the humanists who do not see the humanistic values in the imaginative Einsteinian voyage through a segment of chaos, a voyage which reduced that segment to clarity and order. They do not see because they do not understand that, in the post-Einstein world, their aesthetics, their philosophy, even some of their values, never can be the same.

The new knowledge exposed the limitations of their values, as pathbreaking new knewledge always has done, and, what philosophers ought always to know, the extent of the contingent nature of their values. I say "contingent," for what ought to be the queen of the humanities, philosophy, is viable, has present-day life, only if it encompasses the new knowledge and the new understanding of the physical world, as of all worlds. Philosophy is contingent upon mastery of knowledge: if it has not that mastery, reasonably up-to-date, it can only be a rehash of the old or a battle of words.

The classical antiquity of Greece and Rome, added to the patrimony of Palestine, has long supplied us with a moral and intellectual heritage—and a great and still viable heritage it is. But as far back as in the city of Alexandria in Egypt, under the Ptolemies, that inheritance was worked over, largely mechanically one must say, into a series of erudite and complex commentaries contributing practically nothing to that besetting question of the mind: Where do we go from here?

Thus it is that the adjective Alexandrine, even in the ancient world, was applied to narrow erudition for the sake of such erudition, learning for the sake of being learned in a field; and it was applied, it ought to be remembered, not to scientists but to humanists. And I shall say that, viewed from where I sit in a foundation office, the term Alexandrine has much more general application now to non-scientists — in the 20th century United States—than it has to scientists of the 20th century. The reason may be that, whereas the scientist generally has some education other than scientific, and generally can understand the humanist, the non-scientist rarely has any knowledge of science beyond the fragmented, headlined bits he dimly is aware of from the popular periodical press. He simply does not have the intellectual tools to open for him any vistas of what science has done, does, and will do to his Alexandrine learning. What Galileo said of philosophy still relates to all branches of knowledge, "True philosophy expounds nature to us; but she can be understood only by him who has learned the speech and the symbols in which she speaks to us."

The narrow view

But neither is all well with the scientists. From where I sit again, it sometimes looks as if a seemingly sothought scientific prudence—that is, the thought that the narrower the problem the more safely scientific it will be—coupled with what seems like indifference, leads to choice of narrow problems in which there is no risk and, indeed, which do not demand much ability, nor much work, for solution. But having said this I must go on to say that, while this is not a besetting sin only of the scientists, still it comes home to me the more because at least you know what some of your big problems are.

Alexander Pope was inclined to think that "The proper study of mankind is man." There is much to be said for his aphorism and certainly there are no "outs" to it if it be understood to refer to the great questions of man's mind. To the extent that you do not tackle them, you too are Alexandrine. To the extent, also, that you limit yourself only to what you can prove by demonstration, experiment and observation, you are doing less than your best to bring order out of chaos. For, if I mistake not, the best of you are usually a bit ahead of your data. But this statement, like most statements, needs qualification to make complete sense; and the needed qualification is that the best of you are—as you ought to be—undogmatic about those matters where you are ahead of your data, and regard them, at best, as hypotheses to test with additional data.

This is what I did not understand when, long ago, I sailed from Norfolk, Virginia, for Europe with a cargo of steel rails under a magnetic compass. As we cleared

the Virginia Capes the fog closed in so thickly that no sight of any celestial body could be had to check our compass error. In these circumstances I retired to my room to calculate, mathematically, what that probable compass error was; and I gave a compass course to the captain in accordance with my calculations. He, knowing little mathematics, could only approve, for this was before the days of radio bearings; and on my calculated course we steamed for six days without a sight of anything celestial or terrestrial. At the end of the sixth day, when confidently, even dogmatically, I thought we were comfortably on the modified great circle course, the captain ordered soundings and in an hour it was clear that we were not where I thought we were, but a few miles off the tip of Cape Race, Newfoundland. I had conceived the problem narrowly and had thought I could solve it from the point of view of one discipline; but the captain had the wisdom of the sea and solved it with all he had—my calculations, his knowledge of the set of the Gulf Stream, the feel of the breeze, the temperature of the water, the chop of the sea, and I don't know what else besides. It gave me a lesson I never have forgotten, nor should you.

Specialization plus wisdom

I am, you see, talking about, pleading for, wisdom added to specialization, and, in this place, specifically for wisdom and science, wisdom added to science. There is, alas, no method and no formula for the acquisition of wisdom. But while there are no sure-fire methods for the acquisition of wisdom, there are sure-fire methods for its non-acquisition.

One of these is narrow specialization in education. I know, I know well, that you, like the rest of us, have to specialize and acquire detailed knowledge. Still, somehow, for wisdom, you like the rest of us also have to acquire the capacity for coordinating, for seeing relationships; and you can neither coordinate nor see relationships if you have nothing, or too little, else, to coordinate and see relationships with. For, assuredly, without a certain inclusiveness of vision, pathbreaking steps, seldom, if ever, are taken. Without a certain inclusiveness of vision, the road ahead appears to be the only road worth travelling. But this, all history shows, is not so. For if you cannot see the territory contiguous with yours, you cannot know what it may contain of value for you or anybody else.

So far as known to me, none of the world's great men—great, that is, in things of the mind and spirit—were specialists solely at the times they achieved greatness, although they might well have had to be specialized when young. And I freely concede that the conditions seeming to require early specialization today look more persuasive than they seem to have been in earlier and perhaps simpler days. Nevertheless, it should not be forgotten that Copernicus was lawyer, theologian and astronomer; Maimonides was jewel trader, physician, rabbinical scholar and philosopher; Voltaire was poet, historiographer, and political thinker; Jefferson was farmer, botanist, natural philosopher, political thinker and politician. Benjamin Franklin was practically everything! Churchill is journalist, man-of-letters, statesman and somewhat of an artist and bricklayer. Leonardo was engineer, painter, sculptor, musician and poet. Thomas Aquinas was a pupil of Albertus Magnus, known as *doctor universalis*—theologian, ancient historian, mineralogist. Newton was mathematician, physicist, theologian, and a first-rate Warden of the Mint. Darwin studied theology and medicine, was entomologist, geologist, and from this varied background became the author of his great work *On the Origin of Species.*

These are all individuals, and I think it needs no argument in this place to sustain the thesis that all knowledge and all understanding are the results of the intellectual processes *only* of individual persons. Whatever the results—good or evil—they all start with an individual. I think this needs no argument, despite the recognition that, nowadays especially, some work of the mind—but by no means all—has to be done by teams. For I am not saying that a pathbreaking work of the mind is necessarily one mind's work. Ever since creative work of the mind began, it has always been so that no mind, great or small, has gone it alone. Shakespeare doubtless was a good listener to other men's ideas and, according to some, was a very skillful plagiarist, or at least was a fine adapter to his own purposes of others' work. And, more likely than not, the most original men are both—a thought I think I had better not develop any further.

Freedom of mind

It also, I think, needs no argument to sustain the thesis that such individual development can only take place where the mind of man is free. We see this through all history; in the history of Babylonian mathematics and astronomy under the earliest codes of law that safeguarded the rights of the individual to think. We see it in the history of Arabic medicine and algebra, before Islam became a set of doctrines to be taken on credence and a code of law to be applied rigidly and blindly.

The conditions of freedom prevailed also in ancient Greece, and thus there the mind of men also soared as the eagle flies. They prevailed also in ancient Palestine, else Christ would not have been possible. Such were also the conditions in ancient Rome when the rule of law achieved a firm expression and the concepts of equity and justice and freedom of thought were both developed and applied to be every man's due. Such were *not* the conditions of Europe's Middle Ages when, for many centuries, the letter — the rule book of life, in modern terms—killed inspiration and progress: It was then that the world of Europe, mistrustful of reason, trustful of revelation, weary of argument and apathetic to the wonder of the capacity of men's minds, stamped free inquiry as a sin. And until the stagnation of the Middle Ages went by the boards in the re-found free-

dom of the Renaissance, the search for truth was hopeless. But again the conditions were right in Tudor and revolutionary England; and such again, and most decidedly, were the conditions here in 18th century North America.

I have the Middle East and the old Arabic learning very much on my mind these days; for I have recently come home from there. I had been given what the Navy calls a roving commission to find out what I could about the present state of higher education in the Middle East. After I got out there, it came to me that I was not as ignorant, nor as unqualified for the assignment, as I had thought—for one reason and that was because, in a very modest sense, I am a historian of the law of Rome. The ancient Roman Law, I should explain, the writ of the Roman Law ran all through the territory that we now call the Middle East.

It was not that I studied or learned, last autumn in the Middle East, anything that I had not known in the way of a lawyer's specialized learning about the law of the sale of goods or of commercial practice, or of any other branch of the law, in ancient Egypt or Phoenicia. It was rather that as a historian of the Roman law I could not help becoming aware, out there, of the intellectual scope of the men who made the Roman Law the force for civilization that it was in the ancient world.

History, recorded history, is long in the Middle East —five thousand years or so; and the sensing of past values of past civilizations gives a man a certain perspective on his own.

Past and present

Contrasting the present with the great Middle Eastern past, I asked myself *why*. In the Middle East, I stress again, the present has deep roots. What happened to the deep roots of the law? And lest I seem legally parochial, I call to witness that one cannot look at a clock without being in debt to the method developed in ancient Babylon for reckoning time; one cannot read or write a western language without being in debt to what went on in Byblos in ancient Phoenicia; for it was there that our western alphabet, if not invented, was certainly developed to be the sharp intellectual tool we know. When, at the site of ancient Babylon, I was viewing the old irrigation ditches, dating from at least the time of Daniel—he of the lion's den—I asked an American reclamation engineer how far off his modern surveys showed them to be: he said they were off, in vertical distance, at most only fractions of an inch over hundreds of miles of extent.

And again I asked *why*: I asked why they could do it and did it then, and why not now?

I could not find complete answers out there, nor have I been able to find them in scholarly works since my return. But one thing is clear and it is this:

Just as in our Western world the pathbreaking steps have always been taken by men who were free to think and by nobody else; and, just as in our Western world the pathbreaking steps have not been taken by men who wore the blinders of one discipline, so it was in the great periods of the historic Middle East.

Omar Khayyam, he of the *Rubaiyat*—in Fitzgerald's translation, he of "a loaf of bread, a jug of wine—and thou"—was also and perhaps principally a mathematician. His *Algebra* is a first-rate pathbreaking work, including a kind of analytical geometry as it was conceived before Descartes, at a period when the systems of co-ordinates and mathematical notations were not established. He was also a superior political thinker and astronomer.

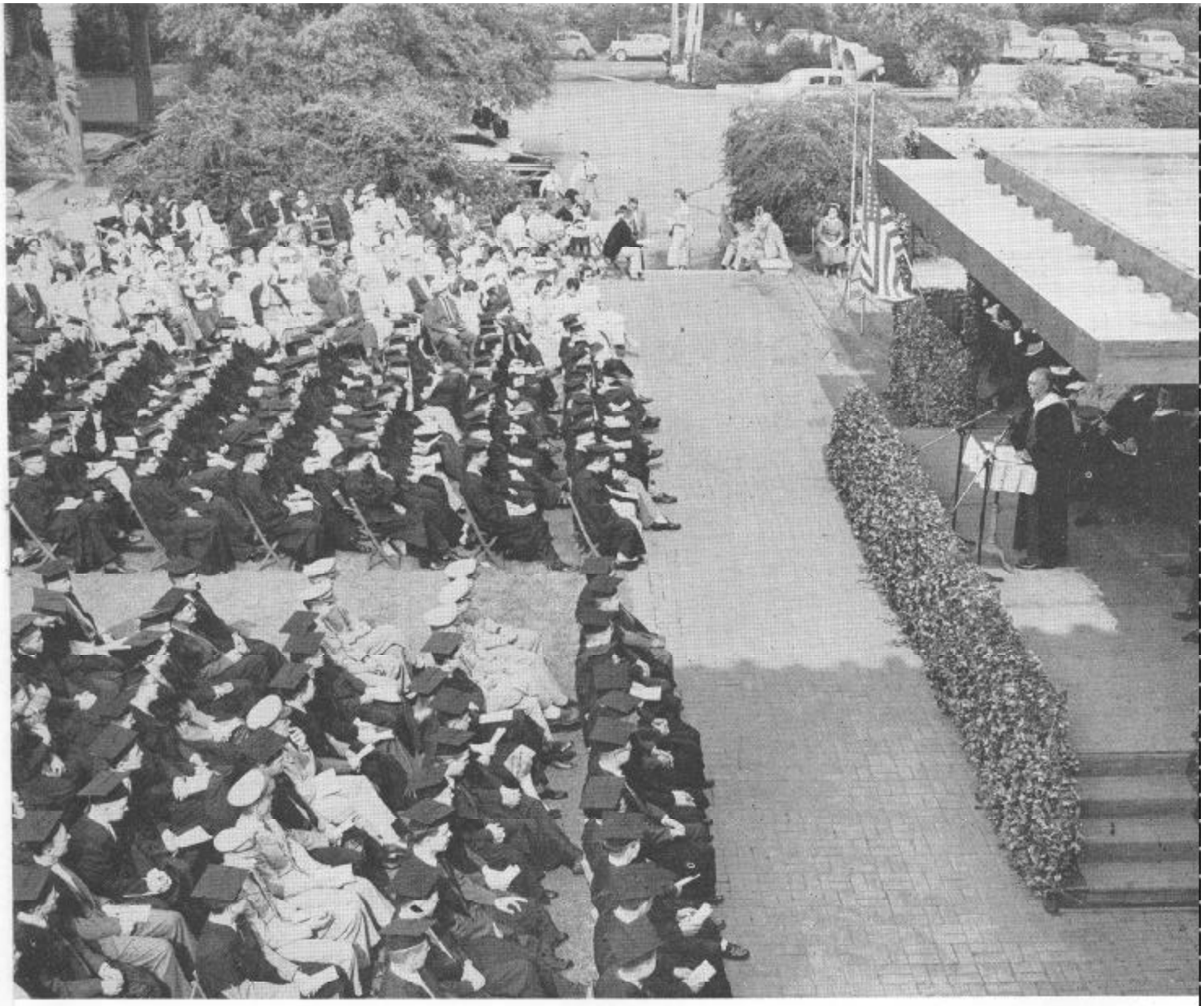
The great jurists of the Roman Law were rhetoricians in the ancient and honorable sense of that word, sometimes governors of provinces, sometimes quaestors—that is, secretaries of the Roman Treasury in our terms—as well as lawyers. All of them, as Mr. Justice Holmes was fond of saying of men for whose judgments he had respect, had formed their inductions as jurists out of experience in other fields, under the burden of responsibility.

Wideness of vision

So it was in the great and historic past of the Mediterranean, so it is in our own era, and so therefore I expect it to continue to be. The pathbreaking steps of the human mind are not taken by specialists who are specialists only. They are taken, always, by specialists who have a wideness of vision, who see relationships, who can coordinate the observations and deductions of fields besides their own. If to this capacity to see relationships, there be added precision of expression, purity of diction, fine wit, concern for the spirit of man, then the labor of those who have those abilities, in the difficult and obscure field of final principles, surely will rise to heights otherwise impossible. Then they, like Omar Khayyam, will not only advance knowledge but will also have attained to wisdom; and they, and only they, will place their intellectual and spiritual signatures on their days.

There is another facet to the lesson that specialization is not enough which I learned in the perspective of the history of the Middle East. It is this:

Beginning in the 19th century, the Middle East eagerly took to Western inventions; but those inventions, it now is clear, did not produce for them the good things they seemed to produce for the West. By Western inventions I mean not only the tractor, the bull-dozer and the motor car, but also, for example, secular education, technical education, and the ballot box. And the reason that the western inventions did not produce for the Middle East what they seemed, to some, to produce for the West is clear; and some men of the Middle East said it to me clearly: "We know we could not achieve your material position—let alone your other positions—without the breadth of your education which you have and which we used to have but have no more." That is, ladies and gentlemen, a message from the cradle of our civilization.



COMMENCEMENT 1956

AT CALTECH'S 62nd annual Commencement on June 8, a total of 311 degrees were awarded—125 Bachelors of Science, 104 Masters of Science, 13 Engineers and 69 Doctors of Philosophy.

Of the 37 seniors who graduated with honor, 11 received both academic honor and Student Body Honor Keys: Howard Berg, Thomas Bergeman, Myron Black, Lyman Fretwell, Raymond Orbach, William Kirkwood, Jr., and John Young. Honor Keys were awarded to 14 men in all.

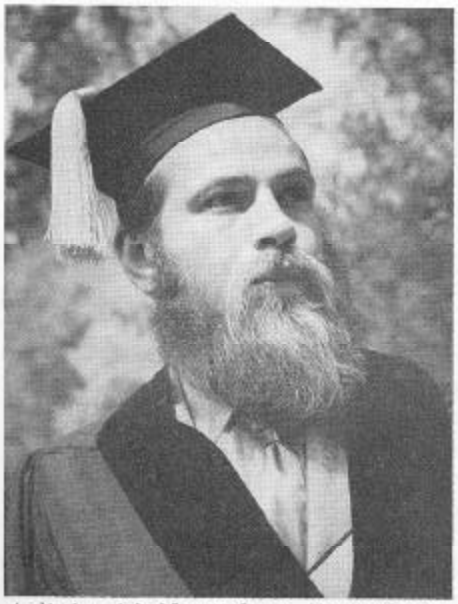
The Frederic W. Hinrichs, Jr., Memorial Award for the most outstanding senior this year went to Howard Berg, and the Thomas Hunt Morgan Memorial Award was given to Robert Metzenberg, Jr., as the most outstanding graduate student in biology receiving his PhD.

Getting set for the ceremony—students, above, and faculty, below.

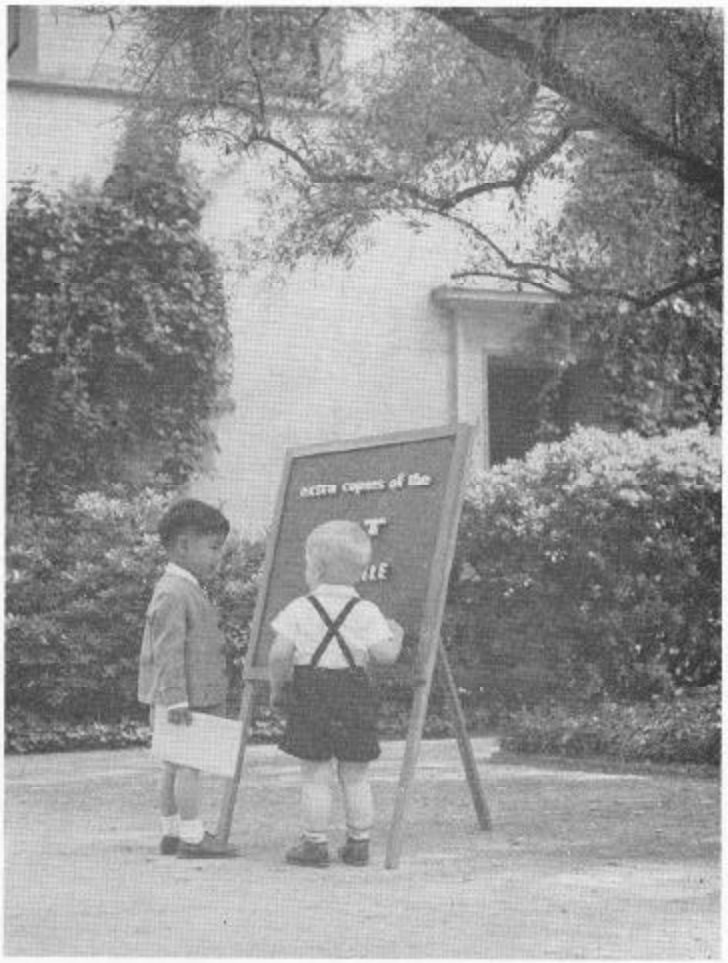
The cap-and-gown concession relaxes after a rush of business.

A distinguished graduate, Howard Berg, Hinrichs Award winner.

Some disinterested spectators swap stories during the ceremony.



A distinguishable graduate, Forest Carter, PhD in chemistry.



THE RELATION OF SCIENCE AND RELIGION

Some fresh observations on an old problem

by RICHARD P. FEYNMAN

IN THIS AGE of specialization men who thoroughly know one field are often incompetent to discuss another. The great problems of the relations between one and another aspect of human activity have for this reason been discussed less and less in public. When we look at the past great debates on these subjects we feel jealous of those times, for we should have liked the excitement of such argument. The old problems, such as the relation of science and religion, are still with us, and I believe present as difficult dilemmas as ever, but they are not often publicly discussed because of the limitations of specialization.

But I have been interested in this problem for a long time and would like to discuss it. In view of my very evident lack of knowledge and understanding of religion (a lack which will grow more apparent as we proceed), I will organize the discussion in this way: I will suppose that not one man but a group of men are discussing the problem, that the group consists of specialists in many fields—the various sciences, the various religions and so on—and that we are going to discuss the problem from various sides, like a panel. Each is to give his point of view, which may be molded and modified by the later discussion. Further, I imagine that someone has been chosen by lot to be the first to present his views, and I am he so chosen.

I would start by presenting the panel with a problem: A young man, brought up in a religious family, studies a science, and as a result he comes to doubt—and perhaps later to disbelieve in—his father's God. Now, this is not an isolated example; it happens time and time again. Although I have no statistics on this, I believe that many scientists—in fact, I actually believe that more than half of the scientists—really disbelieve in their father's God; that is, they don't believe in a God in a conventional sense.

Now, since the belief in a God is a central feature of religion, this problem that I have selected points up most strongly the problem of the relation of science and religion. Why does this young man come to disbelieve?

The first answer we might hear is very simple: You see, he is taught by scientists, and (as I have just pointed out) they are all atheists at heart, so the evil is spread from one to another. But if you can entertain this view, I think you know less of science than I know of religion.

Another answer may be that a little knowledge is dangerous; this young man has learned a little bit and thinks he knows it all, but soon he will grow out of this sophomoric sophistication and come to realize that the world is more complicated, and he will begin again to understand that there must be a God.

I don't think it is necessary that he come out of it. There are many scientists—men who hope to call themselves mature—who still don't believe in God. In fact, as I would like to explain later, the answer is not that the young man thinks he knows it all—it is the exact opposite.

A third answer you might get is that this young man really doesn't understand science correctly. I do not believe that science can disprove the existence of God; I think that is impossible. And if it is impossible, is not a belief in science and in a God—an ordinary God of religion—a consistent possibility?

Yes, it is consistent. Despite the fact that I said that more than half of the scientists don't believe in God, many scientists *do* believe in both science and God, in a perfectly consistent way. But this consistency, although possible, is not easy to attain, and I would like to try to discuss two things: Why it is not easy to attain, and whether it is worth attempting to attain it.

"The Relation of Science and Religion" is a transcript of a talk given by Dr. Feynman at the Caltech YMCA Lunch Forum on May 2, 1956.

When I say "believe in God," of course, it is always a puzzle—what is God? What I mean is the kind of personal God, characteristic of the western religions, to whom you pray and who has something to do with creating the universe and guiding you in morals.

For the student, when he learns about science, there are two sources of difficulty in trying to weld science and religion together. The first source of difficulty is this—that it is imperative in science to doubt; it is absolutely necessary, for progress in science, to have uncertainty as a fundamental part of your inner nature. To make progress in understanding we must remain modest and allow that we do not know. Nothing is certain or proved beyond all doubt. You investigate for curiosity, because it is *unknown*, not because you know the answer. And as you develop more information in the sciences, it is not that you are finding out the truth, but that you are finding out that this or that is more or less likely.

That is, if we investigate further, we find that the statements of science are not of what is true and what is not true, but statements of what is known to different degrees of certainty: "It is very much more likely that so and so is true than that it is not true;" or "such and such is almost certain but there is still a little bit of doubt;" or—at the other extreme—"well, we really don't know." Every one of the concepts of science is on a scale graduated somewhere between, but at neither end of, absolute falsity or absolute truth.

It is necessary, I believe, to accept this idea, not only for science, but also for other things; it is of great value to acknowledge ignorance. It is a fact that when we make decisions in our life we don't necessarily know that we are making them correctly; we only think that we are doing the best we can—and that is what we should do.

Attitude of uncertainty

I think that when we know that we actually do live in uncertainty, then we ought to admit it; it is of great value to realize that we do not know the answers to different questions. This attitude of mind—this attitude of uncertainty—is vital to the scientist, and it is this attitude of mind which the student must first acquire. It becomes a habit of thought. Once acquired, one cannot retreat from it any more.

What happens, then, is that the young man begins to doubt everything because he cannot have it as absolute truth. So the question changes a little bit from "Is there a God?" to "How sure is it that there is a God?" This very subtle change is a great stroke and represents a parting of the ways between science and religion. I do not believe a real scientist can ever believe in the same way again. Although there are scientists who believe in God, I do not believe that they think of God in the same way as religious people do. If they are consistent with their science, I think that they say something like this to themselves: "I am almost certain there is a God. The doubt is very small." That is quite different from saying, "I know that there is a God." I do not believe that a scientist can ever obtain that view—that really religious understanding, that real knowledge that there is a God that absolute certainty which religious people have.

Of course this process of doubt does not always start by attacking the question of the existence of God. Usually special tenets, such as the question of an after-life, or details of the religious doctrine, such as details of Christ's life, come under scrutiny first. It is more interesting, however, to go right into the central problem in a frank way, and to discuss the more extreme view which doubts the existence of God.

Once the question has been removed from the absolute, and gets to sliding on the scale of uncertainty, it may end up in very different positions. In many cases it comes out very close to being certain. But on the other hand, for some, the net result of close scrutiny of the theory his father held of God may be the claim that it is almost certainly wrong.

Belief in God—and the facts of science

That brings us to the second difficulty our student has in trying to weld science and religion: Why does it often end up that the belief in God—at least, the God of the religious type—is considered to be very unreasonable, very unlikely? I think that the answer has to do with the scientific things—the facts or partial facts—that the man learns.

For instance, the size of the universe is very impressive, with us on a tiny particle whirling around the sun, among a hundred thousand million suns in this galaxy, itself among a billion galaxies.

Again, there is the close relation of biological man to the animals, and of one form of life to another. Man is a latecomer in a vast evolving drama; can the rest be but a scaffolding for his creation?

Yet again, there are the atoms of which all appears to be constructed, following immutable laws. Nothing can escape it; the stars are made of the same stuff, and the animals are made of the same stuff, but in such complexity as to mysteriously appear alive—like man himself.

It is a great adventure to contemplate the universe beyond man, to think of what it means without man—as it was for the great part of its long history, and as it is in the great majority of places. When this objective view is finally attained, and the mystery and majesty of matter are appreciated, to then turn the objective eye back on man viewed as matter, to see life as part of the universal mystery of greatest depth, is to sense an experience which is rarely described. It usually ends in laughter, delight in the futility of trying to understand. These scientific views end in awe and mystery, lost at the edge in uncertainty, but they appear to be so deep and so impressive that the theory that it is all arranged simply as a stage for God to watch

man's struggle for good and evil seems to be inadequate.

So let us suppose that this is the case of our particular student, and the conviction grows so that he believes that individual prayer, for example, is not heard. (I am not trying to disprove the reality of God; I am trying to give you some idea of—some sympathy for—the reasons why many come to think that prayer is meaningless.) Of course, as a result of this doubt, the pattern of doubting is turned next to ethical problems. because, in the religion which he learned, moral problems were connected with the word of God, and if the God doesn't exist, what is his word? But rather surprisingly, I think, the moral problems ultimately come out relatively unscathed; at first perhaps the student may decide that a few little things were wrong, but he often reverses his opinion later, and ends with no fundamentally different moral view.

There seems to be a kind of independence in these ideas. In the end, it is possible to doubt the divinity of Christ, and yet to believe firmly that it is a good thing to do unto your neighbor as you would have him do unto you. It is possible to have both these views at the same time; and I would say that I hope you will find that my atheistic scientific colleagues often carry themselves well in society.

Communism and the scientific viewpoint

I would like to remark, in passing, since the word "atheism" is so closely connected with "communism," that the communist views are the antithesis of the scientific, in the sense that in communism the answers are given to all the questions—political questions as well as moral ones—without discussion and without doubt. The scientific viewpoint is the exact opposite of this; that is, all questions must be doubted and discussed; we must argue everything out—observe things, check them, and so change them. The democratic government is much closer to this idea, because there is discussion and a chance of modification. One doesn't launch the ship in a definite direction. It is true that if you have a tyranny of ideas, so that you know exactly what has to be true, you act very decisively, and it looks good—for a while. But soon the ship is heading in the wrong direction, and no one can modify the direction any more. So the uncertainties of life in a democracy are, I think, much more consistent with science.

Although science makes some impact on many religious ideas, it does not affect the moral content. Religion has many aspects; it answers all kinds of questions. First, for example, it answers questions about what things are, where they come from, what man is, what God is—the properties of God, and so on. Let me call this the metaphysical aspect of religion. It also tells us another thing—how to behave. Leave out of this the idea of how to behave in certain ceremonies, and what rites to perform; I mean it tells us how to behave in life in general, in a moral way. It gives answers to moral questions; it gives a moral and ethical code. Let me call this the ethical aspect of religion.

Now, we know that, even with moral values granted, human beings are very weak; they must be reminded of the moral values in order that they may be able to follow their consciences. It is not simply a matter of having a right conscience; it is also a question of maintaining strength to do what you know is right. And it is necessary that religion give strength and comfort and the inspiration to follow these moral views. This is the inspirational aspect of religion. It gives inspiration not only for moral conduct—it gives inspiration for the arts and for all kinds of great thoughts and actions as well.

Interconnections

These three aspects of religion are interconnected, and it is generally felt, in view of this close integration of ideas, that to attack one feature of the system is to attack the whole structure. The three aspects are connected more or less as follows: The moral aspect, the moral code, is the word of God—which involves us in a metaphysical question. Then the inspiration comes because one is working the will of God; one is for God; partly one feels that one is with God. And this is a great inspiration because it brings one's actions in contact with the universe at large.

So these three things are very well interconnected. The difficulty is this: that science occasionally conflicts with the first of the three categories—the metaphysical aspect of religion. For instance, in the past there was an argument about whether the earth was the center of the universe—whether the earth moved around the sun or stayed still. The result of all this was a terrible strife and difficulty, but it was finally resolved—with religion retreating in this particular case. More recently there was a conflict over the question of whether man has animal ancestry.

The result in many of these situations is a retreat of the religious metaphysical view, but nevertheless, there is no collapse of the religion. And further, there seems to be no appreciable or fundamental change in the moral view.

After all, the earth moves around the sun—isn't it best to turn the other cheek? Does it make any difference whether the earth is standing still or moving around the sun? We can expect conflict again. Science is developing and new things will be found out which will be in disagreement with the present-day metaphysical theory of certain religions. In fact, even with all the past retreats of religion, there is still real conflict for particular individuals when they learn about the science and they have heard about the religion. The thing has not been integrated very well; there are real conflicts here—and yet morals are not affected.

As a matter of fact, the conflict is doubly difficult in this metaphysical region. Firstly, the facts may be in conflict, but even if the facts were not in conflict, the

attitude is different. The spirit of uncertainty in science is an attitude toward the metaphysical questions that is quite different from the certainty and faith that is demanded in religion. There is definitely a conflict, I believe—both in fact and in spirit—over the metaphysical aspects of religion.

In my opinion, it is not possible for religion to find a set of metaphysical ideas which will be guaranteed not to get into conflicts with an ever-advancing and always-changing science which is going into an unknown. We don't know how to answer the questions; it is impossible to find an answer which someday will not be found to be wrong. The difficulty arises because science and religion are both trying to answer questions in the same realm here.

Science and moral questions

On the other hand, I don't believe that a real conflict with science will arise in the ethical aspect, because I believe that moral questions are outside of the scientific realm.

Let me give three or four arguments to show why I believe this. In the first place, there have been conflicts in the past between the scientific and the religious view about the metaphysical aspect and, nevertheless, the older moral views did not collapse, did not change.

Second, there are good men who practice Christian ethics and who do not believe in the divinity of Christ. They find themselves in no inconsistency here.

Thirdly, although I believe that from time to time scientific evidence is found which may be partially interpreted as giving some evidence of some particular aspect of the life of Christ, for example, or of other religious metaphysical ideas, it seems to me that there is no scientific evidence bearing on the golden rule. It seems to me that that is somehow different.

Now, let's see if I can make a little philosophical explanation as to why it is different—how science cannot affect the fundamental basis of morals.

The typical human problem, and one whose answer religion aims to supply, is always of the following form: Should I do this? Should we do this? Should the government do this? To answer this question we can resolve it into two parts: First—If I do this, what will happen?—and second—Do I want that to happen? What would come of it of value—of good?

Now a question of the form: If I do this, what will happen? is strictly scientific. As a matter of fact, science can be defined as a method for, and a body of information obtained by, trying to answer only questions which can be put into the form: If I do this, what will happen? The technique of it, fundamentally, is: Try it and see. Then you put together a large amount of information from such experiences. All scientists will agree that a question—any question, philosophical or other—which cannot be put into the form that can be tested by experiment (or, in simple terms, that cannot be put into the form: If I do this, what will happen?) is not a scientific question; it is outside the realm of science.

I claim that whether you want something to happen or not—what value there is in the result, and how you judge the value of the result (which is the other end of the question: Should I do this?)—must lie outside of science because it is not a question that you can answer only by knowing what happens; you still have to *judge* what happens—in a moral way. So, for this theoretical reason I think that there is a complete consistency between the moral view—or the ethical aspect of religion—and scientific information.

Turning to the third aspect of religion—the inspirational aspect—brings me to the central question that I would like to present to this imaginary panel. The source of inspiration today—for strength and for comfort—in any religion is very closely knit with the metaphysical aspect; that is, the inspiration comes from working for God, for obeying his will, feeling one with God. Emotional ties to the moral code—based in this manner—begin to be severely weakened when doubt, even a small amount of doubt, is expressed as to the existence of God; so when the belief in God becomes uncertain, this particular method of obtaining inspiration fails.

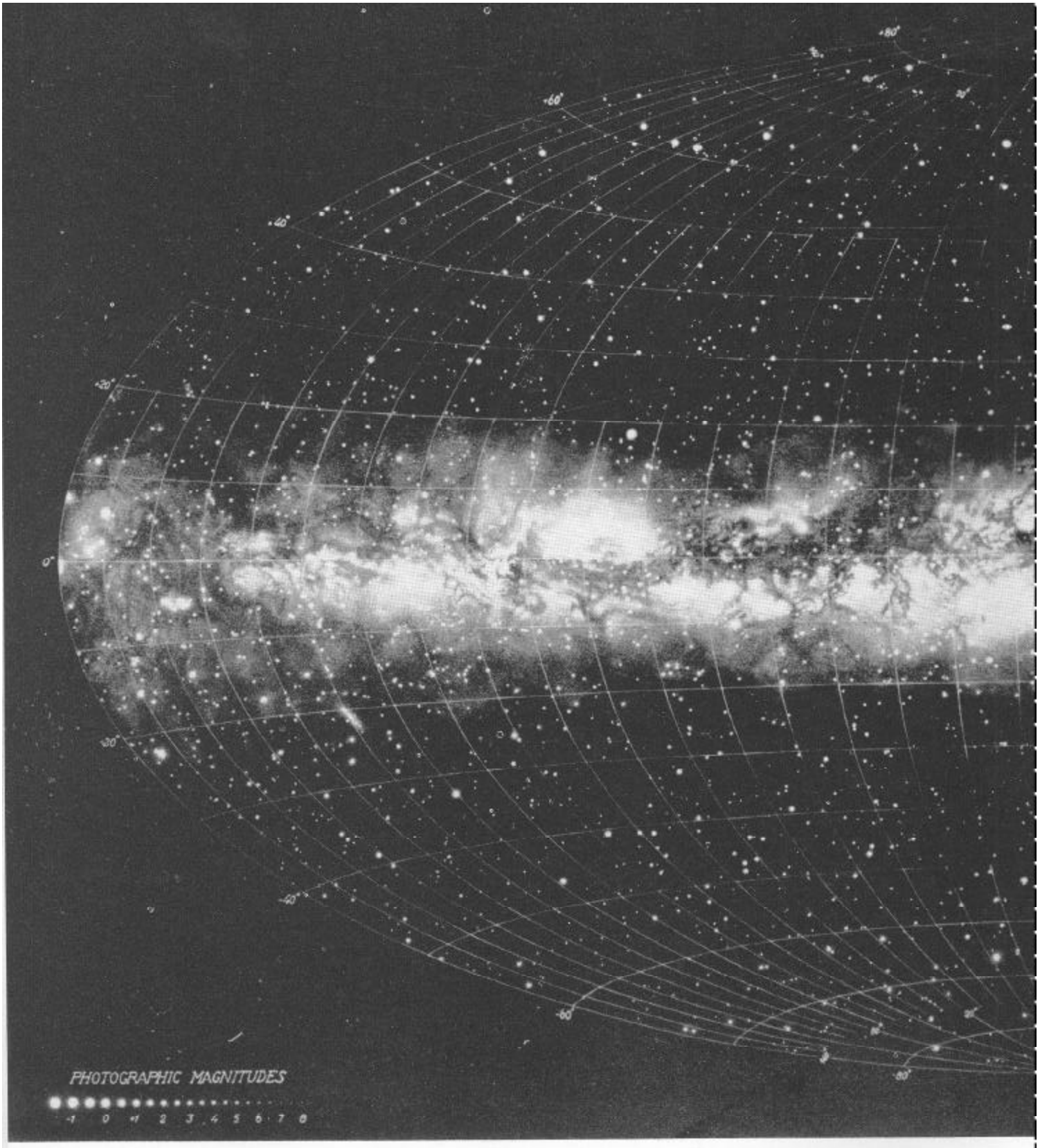
I don't know the answer to this central problem—the problem of maintaining the real value of religion, as a source of strength and of courage to most men, while, at the same time, not requiring an absolute faith in the metaphysical aspects.

The heritages of Western civilization

Western civilization, it seems to me, stands by two great heritages. One is the scientific spirit of adventure—the adventure into the unknown, an unknown which must be recognized as being unknown in order to be explored; the demand that the unanswerable mysteries of the universe remain unanswered; the attitude that all is uncertain; to summarize it—the humility of the intellect. The other great heritage is Christian ethics—the basis of action on love, the brotherhood of all men, the value of the individual—the humility of the spirit.

These two heritages are logically, thoroughly consistent. But logic is not all; one needs one's heart to follow an idea. If people are going back to religion, what are they going back to? Is the modern church a place to give comfort to a man who doubts God—more, one who disbelieves in God? Is the modern church a place to give comfort and encouragement to the value of such doubts? So far, have we not drawn strength and comfort to maintain the one or the other of these consistent heritages in a way which attacks the values of the other? Is this unavoidable? How can we draw inspiration to support these two pillars of western civilization so that they may stand together in full vigor, mutually unafraid? Is this not the central problem of our time?

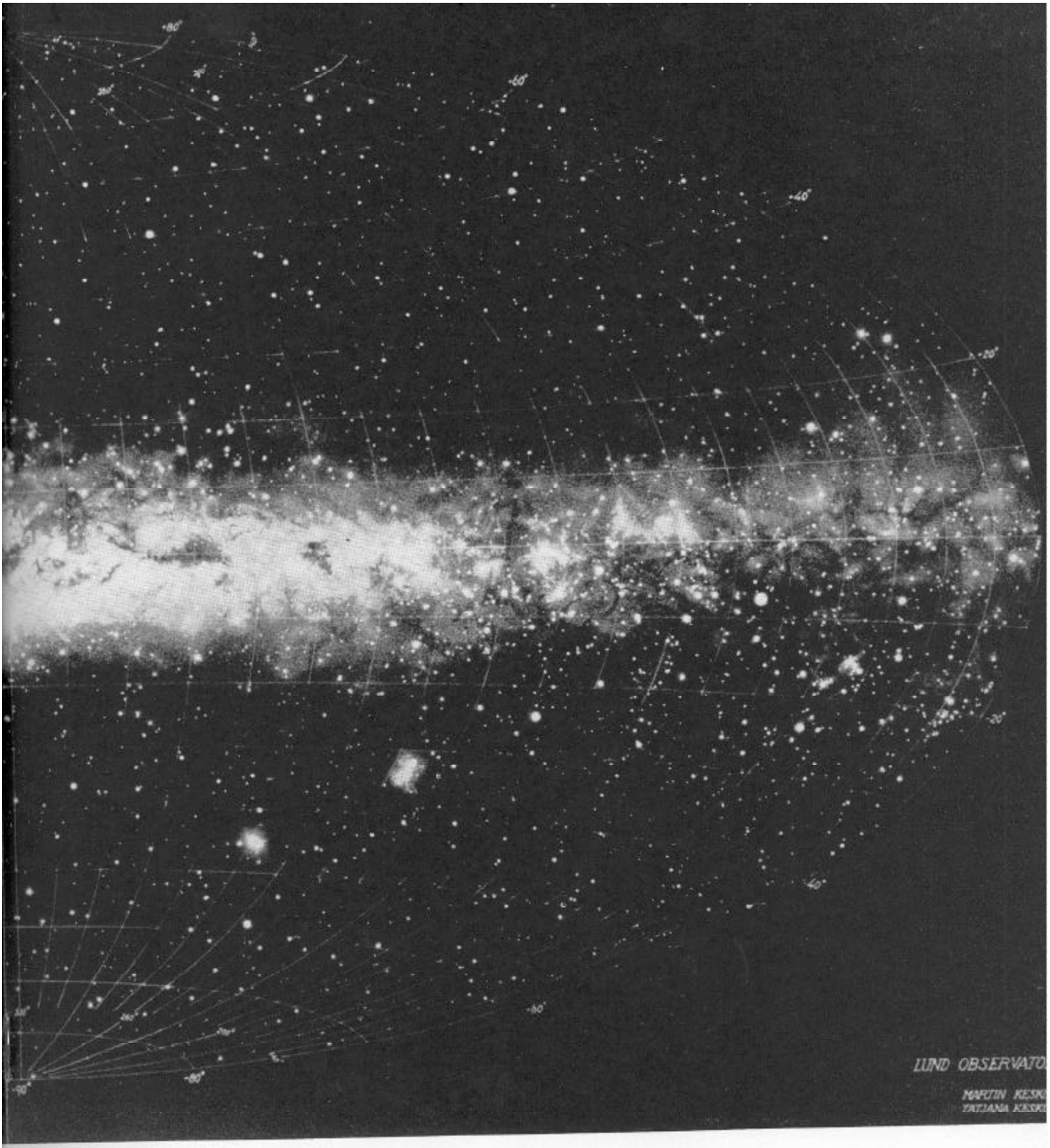
I put it up to the panel for discussion.



THE MILKY WAY

THIS PICTURE, published here for the first time, is one of the finest known reproductions of our Galaxy, the Milky Way. It is not a photograph.

Though astronomers have photographed over a thousand million galaxies, the Milky Way Galaxy cannot be seen or photographed in its entirety because a great



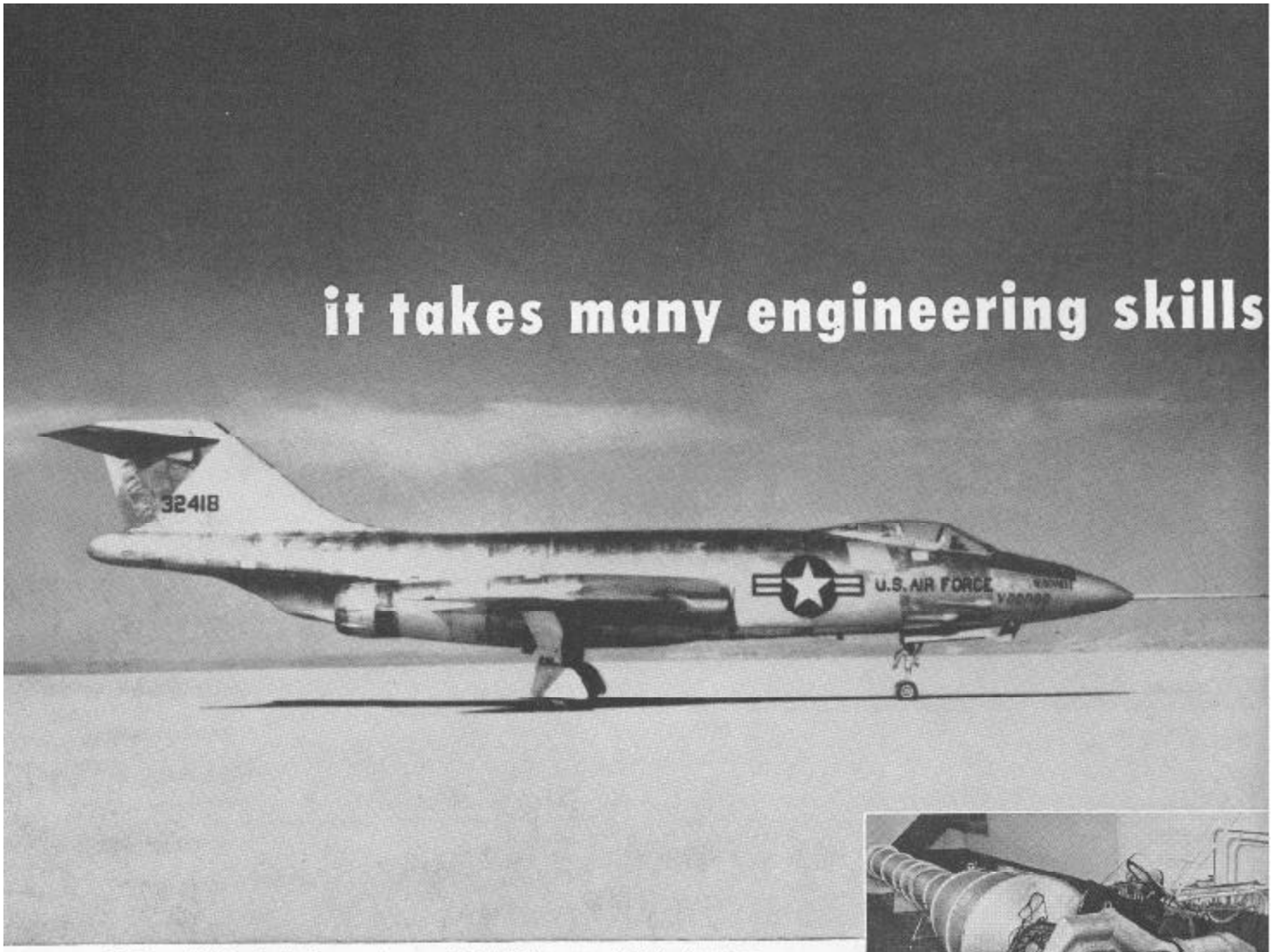
deal of it lies hidden from us by gases, dust and stars.

This picture is a painting, made under the direction of Dr. Knute Lundmark, former director of the Lund Observatory in Sweden, who presented a reproduction to the Mount Wilson and Palomar Observatories.

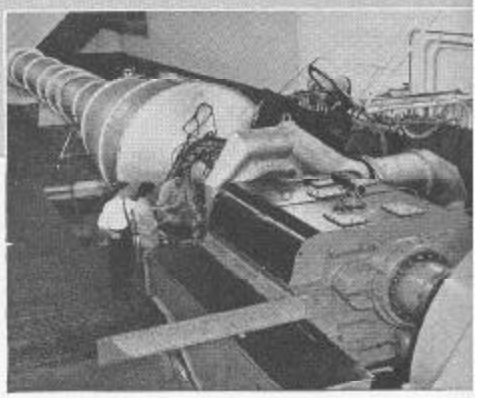
Working on an eight-foot screen, the artists painted tiny white dots on a black surface—grouping the dots so carefully that the actual luminosity of each is correct according to current magnitudes.

The Milky Way measures about 100,000 light years in diameter; our whole solar system is a tiny dot about two-thirds of the way from the center of the Galaxy.

it takes many engineering skills



McDonnell "Voodoo", *the most powerful jet fighter ever built in America.*



MECHANICAL ENGINEERS are concerned with many phases including experimental testing and development, mechanical design, stress and vibration analysis, combustion research, heat transfer and nuclear reactor development.

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F-101	A3D
F-102	B-52
F4D	KC-135

COMMERCIAL

Boeing 707

Douglas DC-8

AERONAUTICAL ENGINEERS work on innumerable internal and external airflow problems concerned with design, development and testing of aircraft powerplants. Some who specialize in analytical engineering forecast engine-airplane combinations a decade in advance of design.

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The best planes are always designed around the best engines. Eight of the most important new military planes are powered by Pratt & Whitney Aircraft J-57 turbojets. The first two jet transports in the United States will use J-57s. Further, no less than 76 percent of the world's commercial air transports are powered by other Pratt & Whitney Aircraft powerplants.

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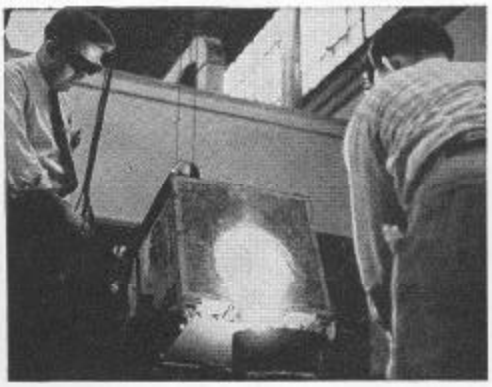
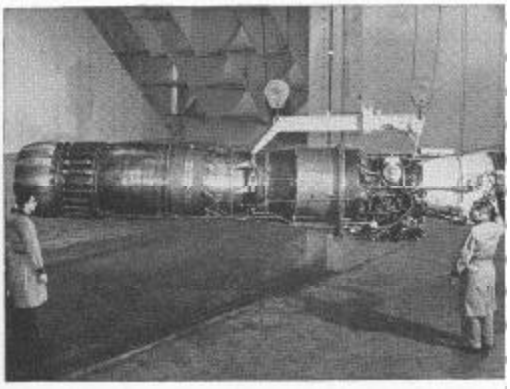
CHEMICAL ENGINEERS, too, play an important role. They investigate the chemical aspects of heat-producing and heat-transferring materials. This includes the determination of phase and equilibrium diagrams and extensive analytical studies.



METALLURGISTS investigate and develop high temperature materials to provide greater strength at elevated temperatures and higher strength-weight ratios. Development of superior materials with greater corrosion resistance is of major importance, especially in nuclear reactors.



WORLD'S MOST POWERFUL production aircraft engine. This J-57 turbojet is in the 10,000-pound thrust class with considerably more power with afterburner.

D. S. CLARK: Triple-threat man

DONALD S. (for Sherman) Clark is probably one of the few men in these parts who can wear three hats at the same time, not only efficiently—but even comfortably. One job is enough for most men; it takes three to occupy Don Clark. At Caltech he serves three masters; the faculty, as professor of mechanical engineering; the administration, as director of placements; and the alumni, as secretary of the alumni association.

It takes efficiency and organization to keep three jobs like this going full tilt, and efficiency and organization are two of Don Clark's strongest points. He operates from a central location on the first floor of Throop Hall, with the assistance of seven female office-workers, who are more generally referred to as his harem. Four of these ladies are concerned with placement activities, two work on alumni affairs, and one serves as Clark's personal secretary. All of them know their boss as a man who can handle a staggering amount of work himself, and so expects at least as much of everyone else—as a man who never forgets anything, never loses anything, and never throws anything away.

Don Clark became director of placements in 1936, shortly after the office was established at Caltech. In this position he now fills about 400 jobs a year, including part-time jobs and summer work for students, permanent employment for seniors and graduate students and new positions for alumni. Each year more and more organizations send interviewers to the campus to recruit students, and it is Clark's responsibility to see that the two groups make contact. As a matter of record (to give you an idea of the thorough records the placement office keeps), in the past academic year D. S. Clark ate lunch with a total of 394 company representatives on the campus, sitting down with the first on October 14, getting up with the last on April 27, sometimes taking on as many as 16 at a throw, and rarely missing a single workday.

Don Clark once served a two-year term as a director of the alumni association, and for four years he functioned as editor of *Engineering and Science*, but his main contribution to the alumni has been as secretary of the alumni association. He took the job for a year, in 1946—and has been the strong right arm of the alumni organization ever since. Each succeeding slate of alumni officers usually makes certain that Don will still be on the ticket before it chooses to run itself. In this position, Don runs the alumni office at the Institute, helps plan all alumni events each year, helps committeemen and the alumni board of directors carry out details of their work, attends the monthly meetings of the alumni board (and keeps a spectacularly detailed set of minutes), handles all correspondence dealing with alumni matters and with membership in the alumni association, and keeps in touch with all alumni association chapters.

None of this considerable activity, however, seems to detract from Don Clark's main interest and chief job —which consists of teaching and research in the field of physical metallurgy. Of his many jobs, the most stimulating and satisfying to him is teaching. He began teaching engineering materials and processes to undergraduates in 1930-31 — which was the first time the course was given here—and he's still at it today. He also handles graduate courses in metallography laboratory and in physical metallurgy.

His research in the dynamic behavior of metals and alloys has already (1) earned him membership on the board of trustees of the American Society for Metals in 1939-40; (2) won him the Richard H. Templin Award of the American Society for Testing Materials in 1949; (3) won him the Charles B. Dudley Medal of the ASTM in 1951; (4) made him the Edward DeMille Campbell Lecturer of the American Society for Metals in 1953.

The most recent of his professional honors is the most important of all, though. As national vice-president of the American Society for Metals he is currently the nominee for the office of president of the ASM, and is heading for election at the society's annual meeting this fall.

Don Clark was born in Springfield, Mass., on December 27, 1906. He grew up in Burlington, Vt., and was scheduled to study engineering at Cornell when his father decided to go into business in California. Don hastily applied at Caltech, which agreed to let him take his entrance exams under rather special circumstances. Since, on the day of the exams, Don, his mother, and the family car had got only as far as Albuquerque, New Mexico, Don was sealed up in a storeroom at the University of New Mexico for two days to work on the long series of exams.

As it turned out, he didn't do very well on one of these exams; in fact, there was some doubt about admitting him to Caltech at all, but he put on such a fiery display of confidence in his own ability to do the

Donald S. Clark, professor of mechanical engineering, director of placements, and secretary of the Caltech Alumni Association.

work that he was promptly taken in—and has been proving ever since how right he was.

After he received his BS from Caltech in 1929, Don went on to get his MS here in 1930 and his PhD in 1934. He began teaching here as a graduate student, and he's been at it ever since—attracting additional duties like a magnet.

Along with everything else, he has functioned for many years as secretary of the faculty in mechanical engineering. He has written two textbooks—*Engineering Materials and Processes*, with William Howard Clapp; and *Physical Metallurgy for Engineers*, with W. R. Varney. During the war he added three or four more jobs to his normal quota by working on the Caltech rocket project, supervising development projects for the War Production Board and the OSRD, and teaching night training courses in metallurgy.

From his active life Don Clark manages to eke out a certain amount of spare time. Some of it goes into growing camellias and roses, but his real hobby is bookbinding. Like the good Yankee he is, he manages to turn this hobby to a good practical purpose by binding—not rare old quartos and folios—but all the publications of the half-dozen technical societies to which he belongs. These impressive volumes line the walls of his office at the Institute, and provide an invaluable reference library for his colleagues and students (who sign out the carefully indexed books, just as in any professional library).

From 1935 to 1942 Don was Resident Associate of Dabney House on the campus. Since then he has lived, with his mother, in San Marino. (As evidence that being a bachelor has its advantages—he's the only member of the faculty who comes to work every morning in an air-conditioned Cadillac). He is still a demanding teacher, though nothing like as demanding as he was in his early days. Even before the first term was up, in his first year of teaching at Caltech, his punch-drunk pupils had given him the nickname "Butch." Today his students are more inclined to call him "Doc," which can only mean one of two things—Clark is getting mellower or students are getting tougher.

His office staff supplies a clue. As an indication of the affection and regard in which they hold their boss, the harem presented him with a nameplate for his desk a couple of Christmases ago. It says: "Simon Legree."

William W. Michael

Robert L. Daugherty

Stuart J. Bates

THE MONTH AT CALTECH

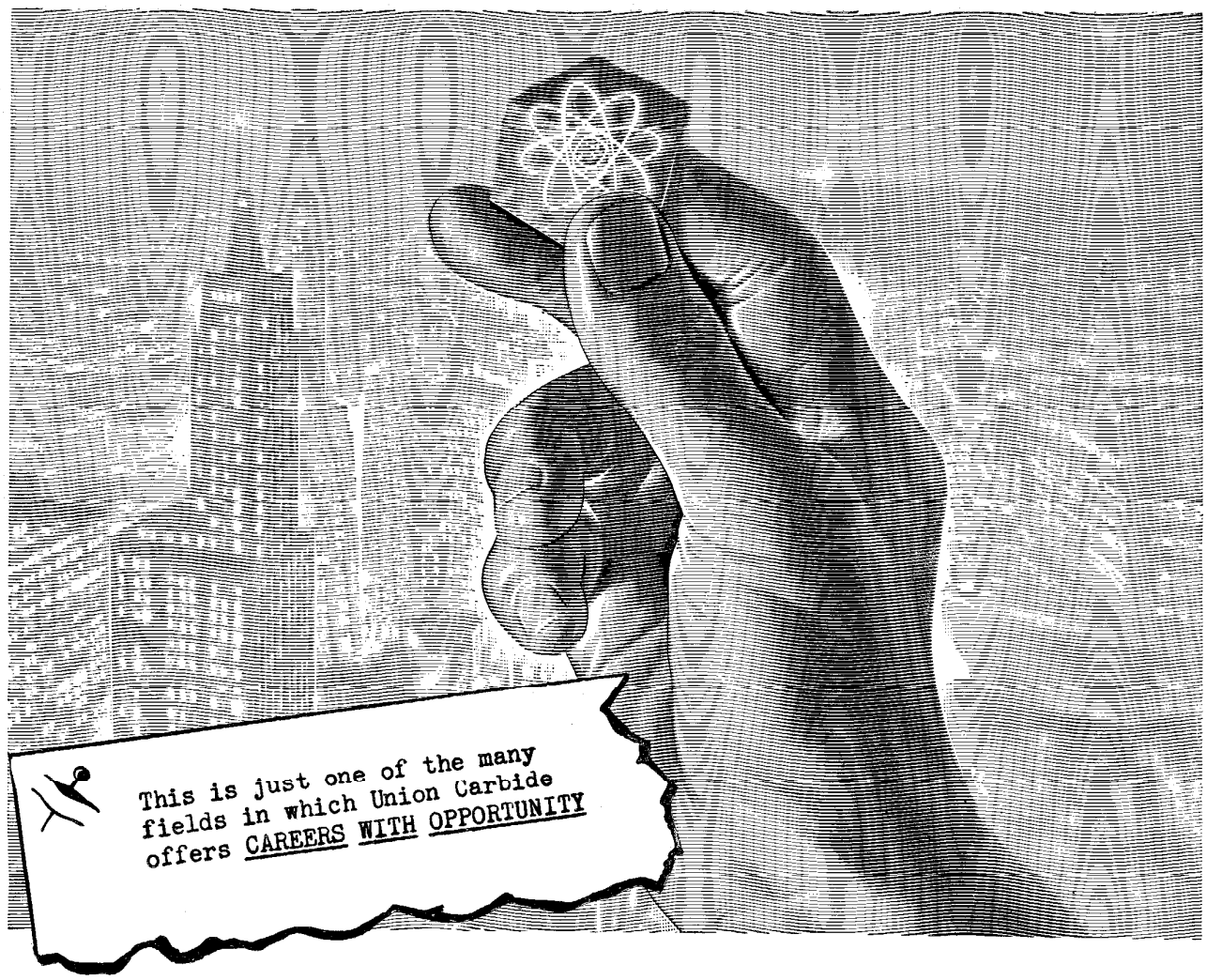
Retirements

THREE MEN retire from the Caltech faculty this month: Stuart J. Bates, professor of physical chemistry; Robert L. Daugherty, professor of mechanical and hydraulic engineering; and William W. Michael, associate professor of civil engineering.

STUART J. BATES, professor of physical chemistry, came to Caltech in 1914, when the school was known as Throop College of Technology. Except for a year on leave (1922-23) at the Massachusetts Institute of Technology he has been here ever since. Born in Toronto, Canada, on May 9, 1887, he received his AB (in 1907) and AM (in 1909) from McMaster University there. In 1912 he got his PhD from the University of Illinois, and served as a research associate and instructor in physical chemistry there until he came to Caltech in 1914. One of the oldest members of the Caltech faculty in point of service, Dr. Bates is also the author of paper No. 1 in the numbered series (which now runs well over 2,000) of papers published by workers in Caltech's Gates and Crellin Laboratories of Chemistry. It is worth noting, too, that in something over 40 years of teaching at Caltech Dr. Bates managed never to miss a single class.

ROBERT L. DAUGHERTY, professor of mechanical and hydraulic engineering, was born on Sept. 14, 1885, in Irvington, Indiana. A graduate of Pasadena High School, he spent his college freshman year at Throop Polytechnic Institute in 1904-05. He received his AB in mechanical engineering at Stanford University in 1909 and served as an instructor there during the next year. In 1910 he went to Cornell University as assistant professor of hydraulics, and in 1916 he became professor of hydraulic engineering at Rensselaer Polytechnic Institute. He has been at Caltech since 1919. Professor Daugherty has had an active career as a consultant to industry, having worked with Union Oil, General Petroleum, Riverside Cement, and the Metropolitan Water District, among others. He has served as a city director and (from 1929 to 1931) as chairman of the board of city directors of Pasadena. From 1948 to 1953 he was chairman of the advisory committee of the Air Pollution Control District, and since 1954 he has been a member of the Air Pollution Control Hearing Board. He has written a number of textbooks in his field, the most recent being *Fluid Mechanics*—in collaboration with Alfred C. Ingersoll, assistant professor of civil engineering at Caltech—which was published in 1953.

WILLIAM W. MICHAEL, associate professor of civil



A pound of fuel to light Chicago

THAT'S ALL THE URANIUM needed to produce atomic power equal to the energy in 3 million pounds of coal. It could light Chicago for a full day!

ATOMIC RESEARCH is focused on developing an economical way to produce electricity from atomic energy. Scientists at Oak Ridge National Laboratory, which Union Carbide Nuclear Company operates for the Atomic Energy Commission, have already built experimental power producing reactors that are serving as a guide to commercial atom power plants.

PEACEFUL USES for the atom have also been found in the diagnosis and treatment of disease. Radioactivity is uncovering important facts about plant and animal growth. Industry uses the atom's radiation to control production processes, to test product quality, and for research.

THE CHALLENGING FIELD of atomic energy is not new to the people of Union Carbide. They have been pioneering in every phase of this exciting business—from the mining of uranium ore to harnessing the atom for our future comfort and well-being.

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engineering, was born on July 13, 1888, in Palatine Bridge, N.Y. He received his BS from Tufts College in 1909 and worked for several years as an office engineer, development engineer, and construction engineer before going into private practice in Kingston, N.Y., in 1915. He came to Caltech in 1918, and he has been in charge of the courses in surveying and highway and airport design since that time; in the early years of the Institute he taught geology as well. Professor Michael's hobby—trout-fishing—has brought him as much fame as his teaching. He is the author of a book, *Dry Fly Trout Fishing*, published in 1953, as well as countless magazine articles on this subject, and he has been in steady demand for speeches and broadcasts.

Military research

CALTECH IS ONE of five major educational institutions chosen this month to form a new agency—the Institute for Defense Analyses—to conduct scientific research on military problems. The other institutions are the Case Institute of Technology, Massachusetts Institute of Technology, Stanford University, and Tulane University.

The new non-profit agency will make scientific analyses of present and future weapons systems, and will study the cost and effectiveness of various systems in the changing technology of future war. These analyses will then go to the Weapons Systems Evaluation Group, established in 1949 by the Department of Defense, for further study.

Caltech's President L. A. DuBridge and Comptroller George W. Green are members of the board of trustees of the new organization.

Increase in tuition

STUDENT TUITION fees at Caltech will be raised from $750 to $900 a year, beginning in September, 1957. The need for additional funds to meet steadily rising costs has prompted the increase, which is actually in line with similar increases and tuition levels now in effect at other private colleges and universities.

Additional scholarship funds will still be provided for students who need assistance with their tuition.

Honors for Pauling

LINUS PAULING, professor of chemistry and chairman of the division of chemistry and chemical engineering, left early this month for Italy, where he will give a series of lectures (in Italian) under the auspices of the Italian Chemical Society. Dr. Pauling was recently elected an honorary fellow of the society—a distinction conferred on a small number of foreign chemists.

While he is in Italy, Dr. Pauling will also be awarded the Avogadro Medal of the Italian National Academy of Sciences. This is a newly-instituted award, to be given to distinguished chemists, and Dr. Pauling will be the first to receive it, along with Sir Cyril Hinshelwood, professor of physical chemistry at Oxford and president of the Royal Society of London. The award is to be presented at a special ceremony commemorating the death 100 years ago of the great Italian scientist, Amadeo Avogadro, whose work forms the basis of modern theoretical chemistry, and especially of the structural theory of chemistry.

Departures

CALEB W. MCCORMICK, JR., assistant professor of civil engineering, leaves Caltech on July 1 to work for Pereira and Luckman, Los Angeles architects.

FRANCIS G. STEHLI, assistant professor of invertebrate paleontology, has resigned to do paleontological research for the Stanolind Oil Company in Tulsa, Oklahoma.

LLOYD C. PRAY, assistant professor of geology, has accepted a position as senior research geologist with the Ohio Oil Company in Littleton, Colorado.

SAMUEL KARLIN, associate professor of mathematics, leaves next month for Stanford University, where he will be professor of mathematics and statistics.

Walter Sydney Adams

WALTER SYDNEY ADAMS, noted astronomer and for 22 years director of the Mount Wilson Observatory, died at his home in Pasadena on May 11.

Dr. Adams first came to California in 1904 and played an important part in the planning and building of the Mount Wilson Observatory with Dr. George Ellery Hale. In 1923 Dr. Adams succeeded Dr. Hale as director of the Observatory and held this post until his retirement in 1946.

In his 50 years of astronomical work, Dr. Adams made many valuable contributions to the field of astrophysics, among the most important being his use of the spectroscope to determine the distances of stars and his research on solar phenomena and rotation.

Samuel Jackson Barnett

SAMUEL JACKSON BARNETT, research associate at Caltech since 1924, died at his home in Pasadena on May 23.

Known for his original theories on magnetization by rotation, called the "Barnett effect," Dr. Barnett continued his research work at Caltech until last year, even though he had retired in 1944 as professor of physics at UCLA, after teaching there since 1926.

Meet Dick Foster

Western Electric development engineer

Dick Foster joined Western Electric, *the manufacturing and supply unit of the Bell System, in February 1952, shortly after earning his B. S. in mechanical engineering at the University of Illinois. As a development engineer on a new automation process Dick first worked at the Hawthorne Works in Chicago. Later, he moved to the Montgomery plant at Aurora, Illinois where he is pictured above driving into the parking area.*

Dick's day may begin *in one of several ways: an informal office chat with his boss, a department "brain session" to tackle a particularly tough engineering problem (above); working with skilled machine builders in the mechanical development laboratory; or "on the line" (below) where he checks performance and quality and looks for new ways to do things.*

Here Dick and a set-up man check over *the automatic production line used to manufacture a wire spring relay part for complex telephone switching equipment. This automatic line carries a component of the relay on a reciprocating conveyor through as many as nine different and very precise operations—such as percussive welding in which small block contacts of palladium are attached to the tips of wires to within a tolerance of ± .002".*

Examining the plastic molded "comb" *components of the wire spring relay Dick recalls his early work when he was involved in working-up forming and coining tools for the pilot model of the automation line for fabrication of wire spring sub-assemblies for relays. At present he is associated with the expansion of these automation lines at the Montgomery Plant.*

Dick finds time *for many Western Electric employee activities. Here he is scoring up a spare while tuning up for the engineers' bowling league. He is active also in the golf club, camera club, and a professional engineering society. Dick, an Army veteran, keeps bachelor quarters in suburban Chicago where he is able to enjoy the outdoor life as well as the advantages of the city.*

Western Electric offers a variety of interesting and important career opportunities for engineers in all fields of specialization in both our day-to-day job as the manufacturing and supply unit of the Bell System and in our Armed Forces job.

If you'd like to know more about us, we'll be glad to send you a copy of "Your Opportunity at Western Electric" which outlines the Company operations and specific job opportunities in detail. Write: College Relations Department, Room 1030, Western Electric Co., 195 Broadway, New York 7, N. Y.

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ALUMNI NEWS

Annual Meeting

A TOTAL OF 327 ALUMNI met at the Elks Club in Pasadena for the annual banquet and meeting of the Alumni Association on June 6.

In his report to the alumni on developments at the Institute during the past year, President DuBridge announced that the Alumni Association had raised more than $26,000 to add to the Alumni Scholarship Endowment Fund—making a total of $68,000 which will be used to provide four-year scholarships for worthy undergraduates at Caltech.

The featured speaker of the evening was Virgil Pinkley, editor and publisher of the Los Angeles *Mirror-News*, whose subject was "Asia and the World."

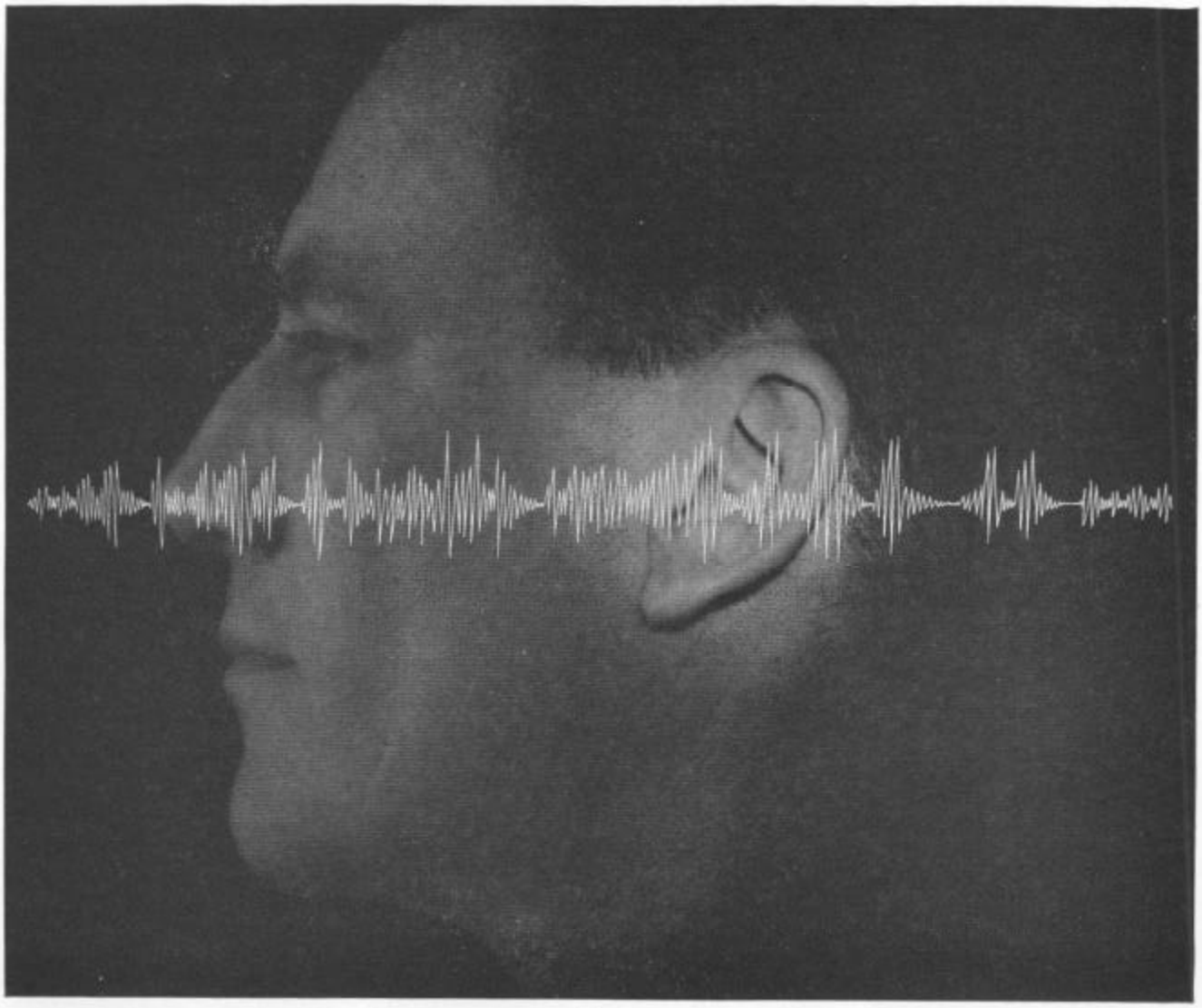
William F. Nash, Jr. '38 of Pasadena, took over as president of the Alumni Association. The new vice president is Willis R. Donahue '34 of San Gabriel. Donald S. Clark '29 and George B. Holmes '38 were re-elected as secretary and treasurer, respectively.

Newly-elected members of the Alumni Association Board of Directors for two-year terms are John R. Fee '51 of Pasadena, Chester Lindsay '35 of Ontario, John Osborn '39 and E. P. Fleischer '45 of Pasadena.

Reunion classes this year included 1911, 1916, 1921, 1926, 1931, 1936, 1941, 1946 and 1951. Out of the 327 alumni who attended the banquet, 215 were members of reunion classes. Two of the class of 1911, Royal D. Ward from Upland, California, and Harold C. Hill from Covina, celebrated their 45th anniversary at the banquet.

Out-of-state alumni who attended the banquet and meeting included Charles H. Bidwell '26 of Albuquerque, New Mexico; Rear Admiral Clarence A. Burmister '25 of Bethesda, Maryland; W. F. Chapin '41 from Houston, Texas; Carl Hirsch '51 from St. Louis, Missouri; Byron B. Johnson '31 from Waukegan, Illinois; A. W. Thiele '51 from Richland, Washington and E. G. Trostel '31 from Dallas, Texas.

The Class of 1956 attended its first alumni banquet and meeting, with 67 members present. Three of the graduates are sons of alumni; Kenneth L. Laws, son of Allen L. Laws '26, Byron Johnson, Jr., son of Byron B. Johnson '31, and Stuart W. Bowen, son of William H. Bowen '32.



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These instruments have been made possible by RCA's experience, skill—and the tremendous facilities of the David Sarnoff Research Center at Princeton, N. J. There, constant improvement has been sought—and found—on every phase of musical reproduction, from the microphone over the conductor's head to the "Victrola" phonograph at your elbow.

The same leadership that brings you New Orthophonic High Fidelity instruments is behind all RCA products—all conceived through "Electronics for Living" that make life easier, happier, safer.

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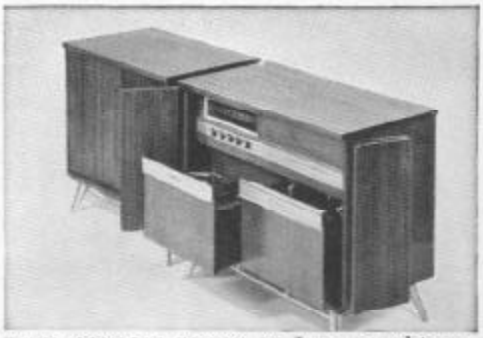

TWIN CONSOLE "MARK I." In one cabinet: "Victrola" 3-speed phonograph, tape recorder, AM-FM radio. In the other: four matched high fidelity speakers. Model 6HF1. $1600.

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How the world's first atomic sub was welded

Welding the hull of the USS Nautilus, world's first atomic submarine, presented a tough problem.

Submerged-arc automatic welding seemed to be ideal for the job. Question was—could you rotate the hull sections of the Nautilus to take advantage of this fast, high-quality welding method?

Worthington's answer to General Dynamics Corporation's Electric Boat Division, builder of the Nautilus, was the largest turning roll ever built.

The result? Welding of the Nautilus hull was accomplished in record-breaking time — and cost less than originally estimated. Unchanged, the Worthington roll set-up is also being used in the construction of the nation's second atomic sub, the USS Sea Wolf.

Turning rolls for submarines aren't all that Worthington makes. The long list of Worthington-designed, Worthington-built equipment includes air conditioning units, construction machinery, compressors, Diesel engines, steam power equipment and, of course, pumps of all kinds. For the complete story of how you can fit into the Worthington picture, write F. F. Thompson, Manager, Personnel and Training, Worthington Corporation, Harrison, New Jersey. You may be glad you did.

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PERSONALS

1912

John D. Merrifield writes from Rocky Ford, Colorado, that his business is doing well and that he himself is "going strong." He's a partner in J. D. Merrifield & Son, manufacturers of automatic weighing machines.

1925

Captain Clarence A. Burmister retired in April from his position as chief of the radiosonic laboratory of the Coast and Geodetic Survey in Washington, D.C. This rounds out 30 years of service, with time out for Army combat duty in World War I—which won him the Silver Star Medal. He retires with the rank of rear admiral.

Since October, 1946, when Captain Burmister became chief of the laboratory, he was concerned with the development of electronics, particularly aids to navigation and the execution of precise surveys. Because of his inventions and scientific research in these fields, the position of a surveying ship is now determined with a high degree of accuracy while carrying on hydrographic surveys—even when operating at night or under severe weather conditions.

1926

James M. Carter who has operated the Carter Laboratories in Pasadena since 1951, writes that they were incorporated in September 1955 and that he is now president of the company. Also in the company are: *Nathan F. Scudder* '26, who serves as secretary-treasurer; *Paul W. Webster* '42, MS '43; and Frank A. Ludwig '53. Jim reports that his son, James S., got his BS in 1955 at the University of California in Berkeley and is now a lieutenant in the Army — currently in training for the U. S. Olympic Shooting Team. Another son, Robert, will graduate this June from Dartmouth. Daughter Mary is a shoe designer and foreign correspondent for Sbicca of California, and 10-year-old Kathy is in school in Pasadena.

Sterling B. Hendricks, PhD, visited Caltech in April as a Sigma Xi Lecturer, speaking on the "Control of Growth by Light." As head chemist of the Soil and Water Conservation Research Branch of the U.S. Department of Agriculture in Beltsville, Maryland, his current work concerns the photoperiodic phenomena of plant growth. He has been affiliated with the Department of Agriculture since 1928.

1927

Frederick T. Schell was recently appointed division manager for the Southern California Edison Company in Fullerton. He was formerly district manager.

1929

Kenneth E. Kingman was elected in April to the board of directors of the Union Oil Company. Now vice-president, he's worked for the company since 1929 and has been, in turn, manager of the Los Angeles refinery and manager of manufacturing in charge of all refining activities.

George F. Wiesmann is now assistant to the southwest division manager of the marketing department of the General Petroleum Corporation. Except for time out with the Navy in World War II, George has been with the company since 1929.

Thomas H. Evans, MS '30, dean of engineering at Colorado A & M College, writes that "the school of engineering on this campus has finally come into its own. We expect to start construction this summer on a complete new engineering center which will house all of our four departments. We hope to move in by the fall of 1957." Tom also writes that he is now a grandfather: his oldest daughter, married to a CE graduate of A & M, had a daughter on Valentine's Day this year.

1930

Rollin Eckis, MS, has been named executive vice-president of the Richfield Oil Corporation in Los Angeles. Since 1954 he has been manager of exploration and vice-president of the company. He first began working for Richfield in 1937 as a district geologist, eventually assuming direction of geological work on many new oil reserves for the company in the United States as well as in foreign areas such as Canada, Alaska, Peru, South Arabia and Egypt.

Galen B. Schubauer, MS, was recently awarded the Department of Commerce Gold Medal for Exceptional Service for his outstanding contributions to basic aerodynamics over the past 20 years. He is chief of the fluid mechanics section of the mechanics division of the National Bureau of Standards where he has worked since 1929.

1931

Carl F. J. Overhage, MS '34, PhD '37, is now head of the aircraft control and warning division of the Lincoln Laboratories in Lexington, Massachusetts. He was formerly assistant director of the color technical division of the Eastman Kodak Company in Rochester, New York.

1933

Wendal A. Morgan, planning engineer for the Washington Water Power Company in Spokane, writes that "there has been no lack of interesting work here. In addition to the technical work such as planning the location of about 1,000 miles of 230 kv and 345 kv transmission lines for our proposed Mountain Sheep-Pleasant Valley project on the Snake River, there is a running battle between the public power proponents and we private enterprise enthusiasts which may well be a life or death struggle as time goes on."

Wendal's son, Donald, is a sophomore at Stanford and his daughter, Lois, will enter either Berkeley or Stanford next fall.

John Meskell has been elected president of the new commercial-industrial chapter of the Building Contractors Association of California. He is immediate past president of the BCA. John is a partner in the firm of Theisen Company, which specializes in commercial construction.

1934

Colonel Paul H. Dane paid a brief visit to Caltech last month on his way to an assignment as professor of thermodynamics at the new U.S. Air Force Academy in Denver. Paul has just returned from overseas duty.

1936

Robert H. Marsh writes that for the past two years he has been with the Hughes Aircraft Company in Tucson as assistant manager of engineering. He was formerly assistant chief engineer at the Raytheon Manufacturing Company in Lexington, Massachusetts.

Karl Unholtz, MS '39, is chief engineer at the MB Manufacturing Company which is a division of Textron American, Inc., in New Haven, Connecticut. Karl lives in Woodbridge, Conn., and has one daughter, 13.

1937

Stanford W. Briggs is now associate professor of chemical engineering at Purdue University. He was formerly with the Cutter Laboratories in Walnut Creek, California.

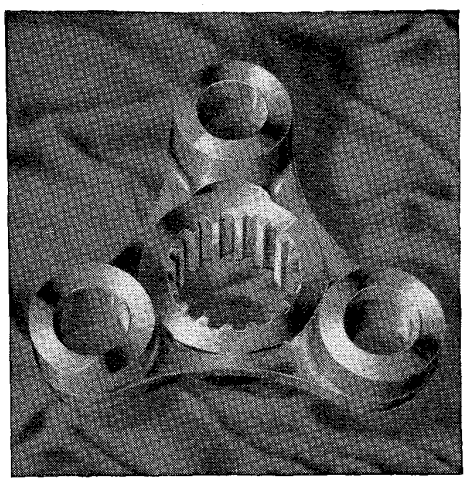
Owen C. Johnson is vice-president of Water Chemists, Inc., in Los Angeles—a firm which treats water for use in cooling towers, evaporative condensers, boilers, etc. He writes that "the company is building a new office one block from Sears Olympic. We're living in San Marino (my wife and two children and I) and have just returned from a two-week trip to Hawaii."

1938

John G. McLean is now a vice-president of the Continental Oil Company and is in charge of coordinating and planning ac-

Another page for **YOUR STEEL NOTEBOOK**

Spiders that spin savings



This steel part is called a spider. You'll find it spinning away inside a big farm implement. It's part of a planetary gear used to reduce the speed of the final wheel shaft. Because it is subjected to terrific operating pressures, the spider's steel must be tough. But the manufacturer had trouble machining the forgings from which these spiders were made. The job was slow and costly. Drills needed constant resharpening. Drive pins sheared off in the drilling machines.

The manufacturer called in metallurgists from the Timken Company. They studied the problem, then recommended a special resulphurized Timken® forging steel. The manufacturer tried it. As a result, these spiders have been spinning savings at a great rate. Drilling time per piece has been halved. Drilling tool life has been increased 500%. And the easier machinability of this Timken fine alloy steel means the manufacturer can use his drills considerably longer before resharpening.

Want to learn more about steel or job opportunities?

Some of the engineering problems you'll face after graduation will involve steel. "The Story of Timken Alloy Steel Quality" will help you learn more about steel. And you might be interested, too, in the excellent job opportunities described in "This Is Timken." Drop us a card, ask for one or both booklets. The Timken Roller Bearing Company, Canton 6, Ohio.

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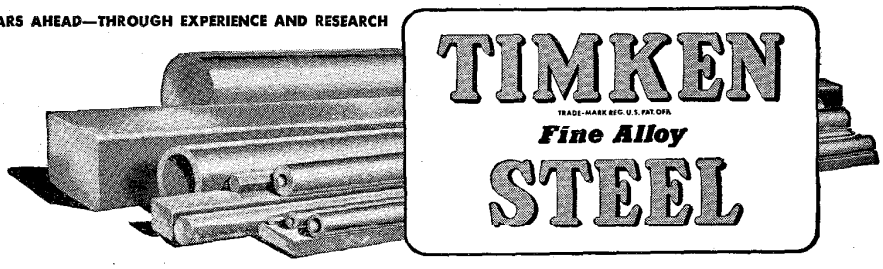


SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

Personals . . . CONTINUED

tivities for the company in Houston. For the past 15 years, John has been at Harvard as professor of business administration. He became a part-time consultant with Continental in 1948 and, since 1954 had been on leave of absence from Harvard to serve as assistant to the president at Continental.

1939

Charles F. B. Carstarphen, MS '40, has been made superintendent of the Kansas City factory of Procter & Gamble. He had been superintendent of the company's Baltimore branch since 1952.

1940

Robert S. Ray, MS '41, has been appointed vice-president and manager of manufacturing at Brea Chemicals, Inc., in Brea, California. Bob is living in nearby Fullerton.

1941

John J. Rupnik, MS, is a partner in the newly-created firm of Rupnik and Ballou in Tulsa, Oklahoma, which will specialize in review analysis, crew supervision and exploration program management. Both John and his new partner were formerly with the firm of Manhart, Millison & Beebe in Tulsa.

1942

V. Cadambe, MS, writes from New Delhi, India, that he has taken over the post of director of research and development in the Indian Government's Ministry of Defense. He had been assistant director and head of the division of applied mechanics of the National Physical Laboratory of India since 1948.

Robert E. Densmore Jr. is now a chemical process engineer for the Filtrol Corporation in Vernon, California.

1943

Jack L. Mataya, MS, has been named district geophysicist at the Stanolind Oil and Gas Company's office at Tyler, Texas. Jack has worked for Stanolind since 1941 in the Central, Rocky Mountain and North Texas-New Mexico divisions. The Matayas have two daughters—Janice, 7, and Judy, 2.

1945

John D. McKenney, MS '48, has a six-month-old daughter, Kathryn Glen. The McKenneys' elder daughter is now 3. Jack is at JPL, working in the Mechanical Ground Equipment Engineering Department.

Wayne A. Roberts, MS '48, is now working as a geologist in the acquisition and exploration department of the Climax Uranium Company in Grand Junction, Colorado.

Hugh S. West, who is in the agency department of the Connecticut General Life Insurance Company, was recently transferred from San Francisco to Hartford, Connecticut. The Wests now have a third child, Kathryn, born in April.

1946

Elmore G. Brolin has left Standard Oil of California in San Francisco, where he worked as analyst in organization and planning, to take a new job as chief engineer in the switchgear division of Zinsco Electrical Products in Los Angeles.

Julian David Cole, MS, PhD '49, was given a Guggenheim fellowship award last month to continue his work in theoretical aerodynamics. Julian is assistant professor of aeronautics at Caltech and his current work has been theoretical research in transonic flow and viscous compressible flow.

1947

Commander Harold E. Rice, MS, writes that he has "just reported to the staff of the Commander Submarines, U.S. Atlantic Fleet, as Staff Gunnery Officer. The headquarters are located in New London, Conn., at the U. S. Naval Submarine Base. I am now in the process of building a home on an acre of land in Gales Ferry, one mile north of the base."

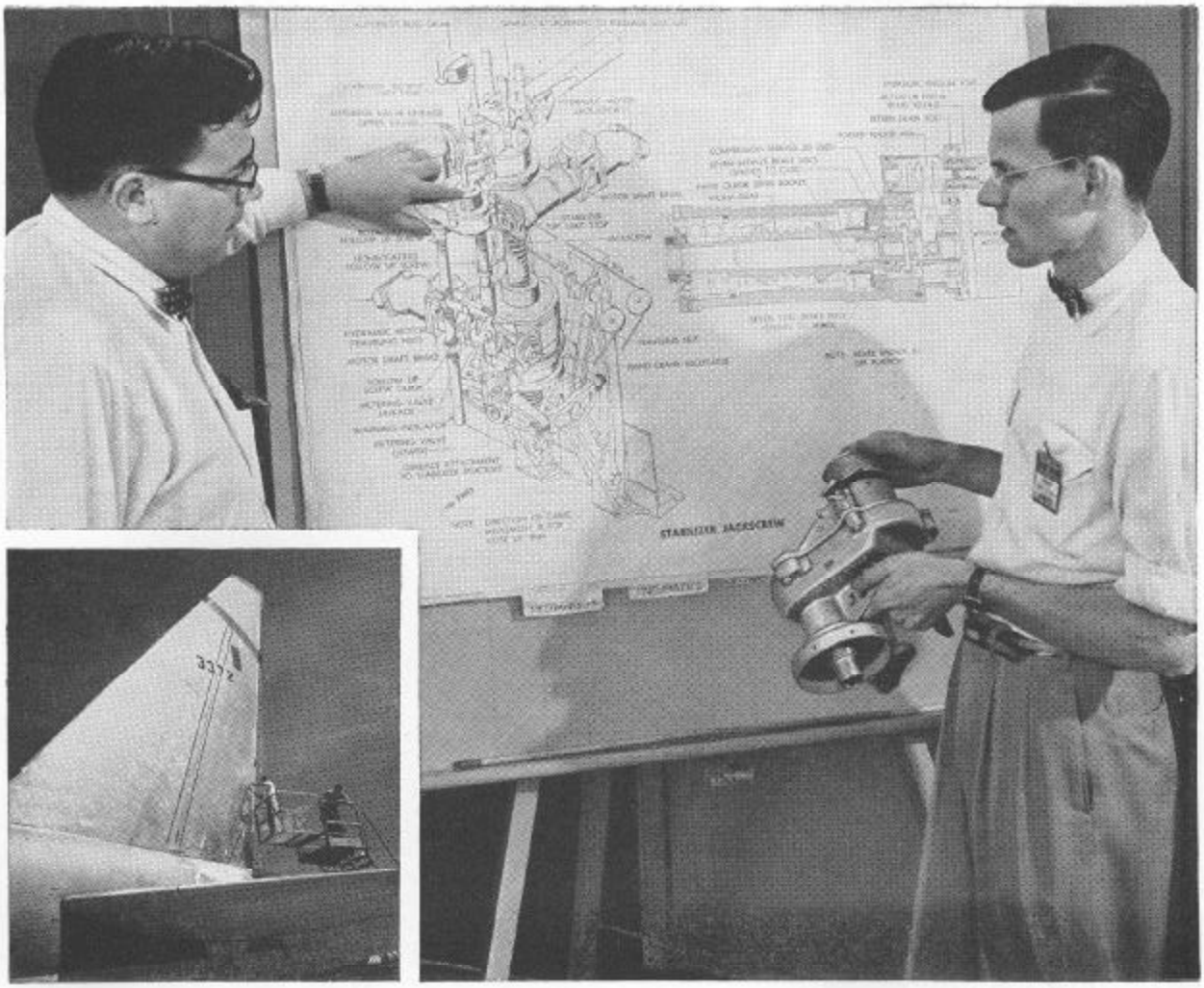
Harry P. Brueggemann has been in charge of engineering for the West Coast Division of the Pathe Laboratories since 1954. He has four children—Linda, Bruce, Mark and David—ages 3 to 11 years.

Kurt Mislow, PhD, last month received a Guggenheim fellowship which will enable him to do chemical research in Switzerland. He's now an assistant professor of chemistry at New York University. The Mislows have a son, Christopher.

1948

Glen Mitchell, Jr., who for the past four years has been working in the contracting department of the consolidated Western Steel and American Bridge Divisions of the United States Steel Corporation, is now a partner in a new firm, Steiny and Mitchel, Inc. Located in Los Angeles, the firm deals in industrial and commercial electrical contracting.

William J. Dixon, MS '49, PhD '52, has been vice-president of Computer Engineering Associates since its formation in 1952. He writes that he's still single, and that he got his pilot's license this year. Bill also reports that other Caltech alumni working with the firm include *Michael A. Basin* '51, MS '52; *Bart N. Locanthi* '47; *Howell Tyson* '20; *Vincenzo Cestari*, BS, MS '55; and *James Ross Jr.* '52, MS '53.



B-52 jack screw—a typical Boeing design challenge

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The device that performs this function is a jack screw, which, though it weighs only 255 pounds, can exert a force of approximately 225 *tons!*

Many kinds of engineering skills went into designing and developing a jack screw so precise that it automatically compensates for stretch and compression under load. Civil, electrical, mechanical and aeronautical engineers, and mathematicians and physicists — all find challenging work on Boeing design projects for the B-52 global jet bomber, and for the 707 jet tanker-transport, the BOMARC IM-99 pilotless interceptor, and aircraft of the future.

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Personals . . . CONTINUED

1949

Jesse C. Denton, MS '49, a senior thermodynamics engineer at Convair in San Diego, was selected in April to attend a 10-month course in nuclear energy at the Argonne National Laboratory of Chicago.

Robert P. Crago, MS, has been made general manager of the Military Products Center (a self-governing branch of IBM) in Kingston, New York. Bob has been with IBM since 1949.

1950

Reverend Dale F. Stewart writes: "I have been a Baptist minister ever since receiving my degree. I am now pastor of a new Baptist church in a new housing area in Pueblo, Colorado. Starting from scratch, our 16 months here have resulted in a new building with 3800 square feet, an average attendance in Sunday School of over 100 and a membership of 66."

Frederick W. Drury, Jr., is vice-president and chief engineer of the Airox Company in Los Angeles, manufacturers of lightweight aggregate and pozzolan for concrete. Fred is also member of the American Concrete Institute Advisory Committee on admixtures for concrete. The Drurys have three sons—Stephen, 5, Frederick, 4, and Douglas, 2½.

Robert H. Korkego, MS, PhD '54, has been on the staff of the engineering center of the University of Southern California as a research associate for the past two years. "This summer," he writes, "I'll be on leave from USC to work in Paris as consultant to AGARD (Advisory Group for Aeronautical Research & Development) for NATO. In this capacity I will be engaged in hypersonic work and will present one or two lectures at the Sorbonne, ONERA, etc."

William H. McLellan who was formerly project engineer with William Miller Instruments, Inc. in Pasadena, is now with the transducer division at Consolidated Electrodynamics Corporation, also in Pasadena. He's been with the company since January. Bill has two daughters—Jill, 3½, and Judy, 9 months, who are going to England for the summer with their mother.

1951

Erdem I. Ergin, MS, and Leita Harmon were married on May 11 in Istanbul, Turkey. Leita was manager of Caltech's Athenaeum until September 1954, when she left the U. S. to work at the Istanbul Hilton.

Herbert M. Hull, PhD, writes that he is still a plant physiologist with the Agriculture Research Service of the U. S. Department of Agriculture in Tucson. The Hulls have a daughter, Laurinda Lee, born on Valentine's Day, 1955.

Dean M. Blanchard writes that his travels in the past several years have done a lot to abate his wanderlust. After graduating from Caltech he went to work in the New York engineering office of the California Texas Oil Company, and a few months later he was sent to the Far East where he spent three years—first on the construction of crude oil shipping facilities for the Minas field in Central Sumatra and Indonesia, then to southern Luzon, to work on the first oil refinery to be constructed in the Phillippines. In 1954 he was drafted into the Army (he expects his discharge in August) and the last 18 months have been spent on a mapping project with the Interamerican Geodetic Survey in the Republic of Panama.

Barrie H. Bieler, MS '52, reports that he received his PhD from the Mineralogy Department of Pennsylvania State University in 1955 and is now working for the U. S. Geological Survey in Denver. While at Penn State, he married Althea Rector (BS '54 from Penn) and now they have a son, Thomas, who was born on April 18.

George H. Trilling, PhD '55, research fellow at Caltech, has received a Fulbright grant to do research in physics at the Polytechnic School in Paris.

1952

Gilbert E. Kitching gets his MD degree from USC Medical School this month and will interne at the Tripler Army Hospital in Hawaii for a year as an Air Force lieutenant. He'll have two more years of Air Force service after this—in parts unknown. Gil is married and has one son, Alfred.

Bruno Herscovici is now Bruno Harris; he changed his name in 1953. He was married to Janet Bloch last March in Brooklyn. He is due to receive his PhD in mathematics from Yale, this month, and he will spend the next year there on a National Science Foundation Fellowship.

Harry E. Williams, MS, who received his PhD at Caltech this month, has received a Fulbright grant to study aerodynamics at the University of Manchester, England, for the 1956-7 academic year.

1953

Walter J. Eager, who has been an ensign in the Navy since December, 1954, writes from Raleigh, North Carolina, that he is "presently assigned to duty with the Nuclear Power Branch of the engineering research and development lab at Fort Belvoir, Va., as the Navy representative of the joint reactor project. "I am attending North Carolina State College under the AEC reactor physics and engineering

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course program, along with seven American industrial people and 25 foreign scientists and engineers. Upon completion of this course and one at Oak Ridge or ALCO in Schenectady, I will instruct crews in reactor fundamentals and the operation and maintenance of the Army package power reactor at Fort Belvoir which is to start in 1957.

"My previous very enjoyable assignment was at Treasure Island where I was shops engineer and assistant officer in charge of the Public Works Transportation Center. Skiing in the Sierras and sailing the Admiral's 26-foot knockabout sailboat in San Francisco Bay was not the hardest way to fight a war.

"I strongly recommend the U. S. Navy Civil Engineer Corps to those classmates who have service looming over their heads."

Gordon P. Eaton, MS, is teaching and doing research at Wesleyan University in Middletown, Connecticut. Under a National Science Foundation grant, Gordon's research involves structural and petrologic problems in central Connecticut; he's teaching general geology and structural geology.

Frederick C. Harshbarger, MS, has received a Fulbright grant which will enable him to study molecular physics at the Norwegian Institute of Technology in Oslo during the next academic year. He has completed assignments for his PhD in mechanical engineering at Caltech.

1954

Thomas K. Caughey, PhD, has been at Caltech since September as assistant professor of applied mechanics. "After graduation in 1954," he says, "my family and I returned to Scotland to spend a year with my mother. While in Scotland we had two additions to the family—twin daughters, Kit and Kriss. They took up most of our spare time, so we didn't have very much time for sightseeing, though my job as consulting engineer to a large mechanical engineering company took me about the country quite a bit."

1955

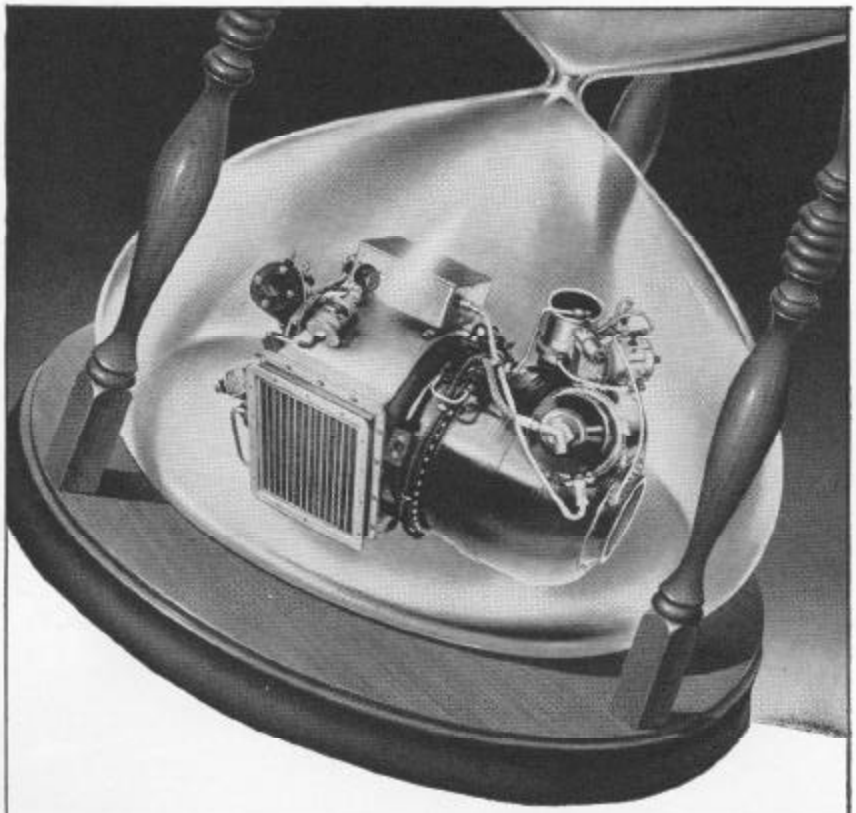
Captain Howard L. Strohecker, MS, is stationed at the U. S. Army base in Fort Belvoir, Virginia. His wife, Jean, is with him.

Stanley L. Grotch, who this month received his MS in chemical engineering at Caltech, has been awarded a Fulbright grant to study at the Municipal University of Amsterdam, Holland, for the 1956-57 academic year.

Richard M. Okada, MS, is now a second lieutenant in the Army and is stationed at the Army Electronics Proving Ground at Fort Huachuca in Arizona. He's project officer in the VT Fuze Countermeasures division of the Electronic Warfare Department.

Charles St. Clair, who is a graduate student at the University of Arizona, writes that he "will be working for the United States Geological Survey this summer in connection with my MS thesis. The thesis will be a reconnaissance from Camp Verde to Rock Springs, Arizona, to determine the relationship of sedimentary rocks, erosion surfaces, lavas and structures—in an attempt to clarify some of the Tertiary and/or recent geology of Arizona."

To the engineer with a bent for research...



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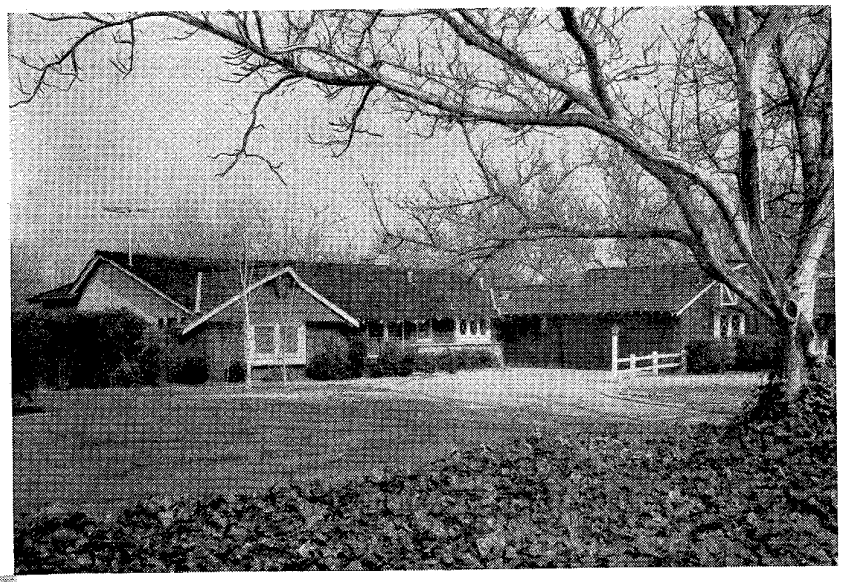

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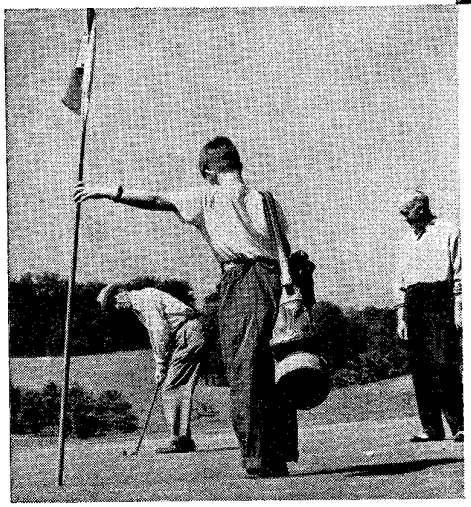

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Saturday, June 23
Corriganville Movie Ranch

To create in steel the flowing lines of today's cars, calls for metal of particular forming qualities.

Sleek styling starts with special steel:

Photography turns chemist—helps produce it.

Fenders, hoods, roofs and side panels call for best quality steel—and the watchful eye of photography guards specifications and controls that quality.

Car designers' dreams come true only if steel forms well under the pressure of deep drawing operations. That takes a particularly high quality steel.

Great Lakes Steel Corporation, Detroit, Mich., unit of National Steel Corporation, makes this steel for the automobile industry. And to make sure of its high quality they use photography. For example, during production, spectrograms show chemical make-up—insure the proper minute quantities of alloying elements, and photomicrographs reveal crystalline structure.

Controlling quality is but one of the many ways photography works for modern industry. In small businesses and large it is aiding product design, simplifying production, creating sales and expediting office routine.

At Great Lakes Steel a spectrogram is readied for reading in the densitometer—one of the tests that assure quality steel.

Behind the many photographic products becoming increasingly valuable today and those being planned for tomorrow lie intriguing and challenging opportunities at Kodak in research, design and production.

If you are interested in these opportunities in science and engineering—whether you are a recent graduate or a qualified returning serviceman, write to the Business and Technical Personnel Dept.

Eastman Kodak Company, Rochester 4, N. Y.

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Apparatus Sales Training Program
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