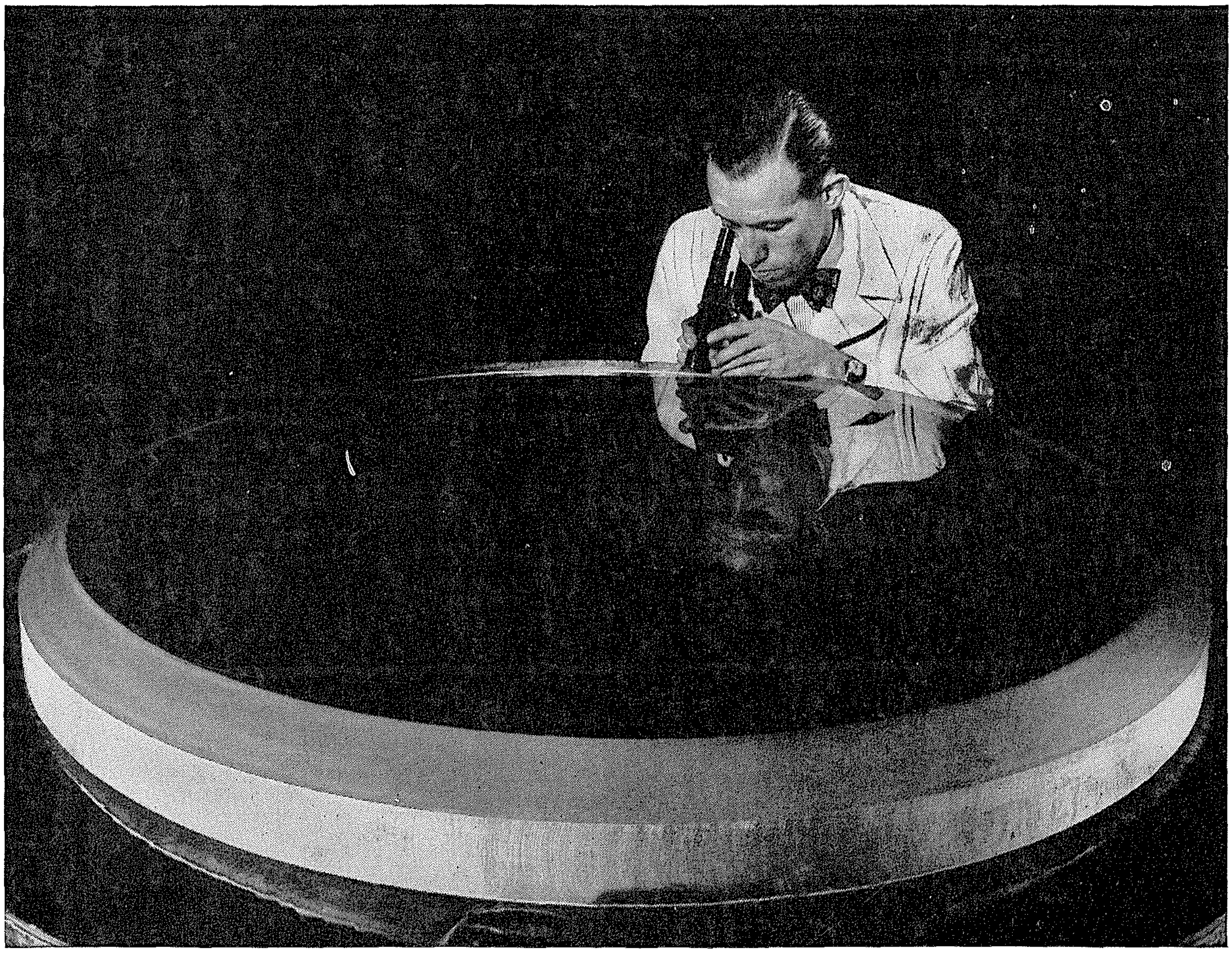
ENGINEERING AND SCIENCE

APRIL/1951

The Guided Missile . . . page 11

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY



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BOOKS

THE IMPACT OF SCIENCE ON SOCIETY

by Bertrand Russell

Columbia University Press,
New York, $2.00

Reviewed by Charles E. Bures
Assistant Professor of Philosophy and Psychology

THESE THREE LECTURES comprise the Matchette Foundation Lectures delivered at Columbia University in November, 1950. In his usual clear and incisive fashion Bertrand Russell discusses the effects of science on traditional views, the effects of scientific techniques on social problems, and finally science and human values. The meat of the matter is salted by the characteristically dry and satirical Russellian wit.

In the past three centuries science and technology have become a revolutionary force with tremendous social implications. The most influential scientific ideas, as Russell sees it, have been reliance on observation instead of unsupported authority, the doctrine of the mechanistic autonomy of the physical world, the dethronement of purpose from nature at large (but not from man), and the realization of man's relative insignificance from a cosmological point of view.

Functions of Science

Science has two functions: knowing about things and changing things through scientific techniques. Historically, scientific techniques set a limit on the size and stability of social organizations. Important discoveries like gunpowder, the compass, steam power (and transport), electrical communication, air-flight, and, lately, atomic energy, have increased the controllable size of nations and other social organizations. Speed of communication and accumulation of the means to enforce power have centralized power in fewer hands and increased the interdependence of individuals and groups. Scientific techniques have made possible the social control and stabilization of world-wide social organization and government.

Unfortunately, scientific techniques can also increase human misery. Increasingly powerful methods of making war have increased the general fear of war. Centralization of social power has brought new positions of power. The conflict of large groups within nations has become a serious threat to individual liberties. The irresponsibility of officials poses a source of danger for which controls must be found. Individual liberty tends to be lost in the shuffle.

Technology has led to rich nations with stabilizing populations, on the one hand, and poor nations with rapidly increasing populations, on the other. To Russell, this spells war inevitably, unless solutions are found. Communism is just a phase of this larger problem. Fear of war now brings to mankind the greatest misery.

Benefits of Science

Science also confers many benefits. Transport permits food distribution. Science can abolish poverty, reduce labor effort, increase living standards, decrease human suffering medically, reduce lawlessness, improve education, increase opportunity, diffuse happiness. Biology, physiology, and psychology are only beginning to show benefits of great promise. They may well outweigh the effects of physics and chemistry in the past.

What about prognosis? To Russell, the basic solution to human misery is the extension and widespread understanding of legal processes and their humane enforcement. Unrestrained national sovereignty must be abandoned. Democracy and traditional personal freedoms, birth control, and world government must be realized. Dogmatisms and fanaticism of all kinds must be faced with a rational intellectual temper.

Tension between East and West fosters great fear and great fear breeds fanaticism. The average level of happiness in the West is higher than in any previous community. The West possesses the highest level of science and technical skills. The best available brains must be mobilized to remove fear of war and other evils.

In philosophy, the effect of technology has been an emphasis on altering the world. By different routes this has led to dialectical materialism and pragmatism. Both doctrines, in their extreme, lead to force as a criterion. Truth and fact

CONTINUED ON PAGE 48

"That's right.... *church closed*"

"No, this didn't happen in a communist country.

"Happened right here in town. We'd just gotten home from a motor trip and, of course, hadn't heard what happened.

"Been going to that church about fifteen years, so what a shock it was when Officer Povey stopped us at the door. *'That's right,'* he told us, *'I said church closed!'*

"*Then* he explained. There'd been a fire in the church the day before and he was shooing folks over to the Guild Hall for services. Mary and I looked at each other . . . then grinned. We'd *both* had the same crazy idea that the State had taken over the churches.

"That night Bill and Edna Johnson dropped in for TV. We told them what happened at the church. And about the crazy idea we had. But Bill asked, *was* it so crazy? Then he pointed out that it *had* happened in other countries. So we all got talking real serious.

"All week I've had it on my mind . . . *suppose we had no Freedom here?* Suppose the State took over religion, the press and professions like music, medicine and art? Suppose they took over industry and made me work where I didn't want to? Suppose the State took over our house? And suppose, on election day, we had our choice of *one* candidate?

"Maybe I don't run my life perfectly but I sure wouldn't want the State to run it for me! Y'know, every Thanksgiving we give thanks for the good things we have . . . all of which add up to Freedom. *So why shouldn't we all be just as thankful the* other *364 days, too?*"

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ENGINEERING AND SCIENCE

APRIL 1951 VOLUME XIV NUMBER 7
PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

IN THIS ISSUE

This month's cover shows a Private A rocket in flight—one of the early rockets developed at Caltech's Jet Propulsion Laboratory, and one of the first to be developed in the laboratory's long-range guided missile program. On page 11 of this issue Clark Millikan tells all that can be told about guided missiles at this time. It's a subject on which he is particularly—even spectacularly—well informed; Dr. Millikan is Chairman of the Guided Missiles Committee of the Research and Development Board.

ECONOMY RUN

The story on the Mobilgas Economy Run on page 30 of this issue was written by Bill Wright '51, who tells some of the experiences of the Caltech student observers—of which he was one—on the Run. Next month we hope to have a follow-up article by Peter Kyropoulos, Professor of Mechanical Engineering at the Institute, and the AAA's Technical Advisor on the Run, in which he promises to evaluate some of the results of the Run.

NEO-THOMISM

This month's Letters column (page 46) carries some of the pro and con mail we've received on Alfred Stern's March article, "Neo-Thomism and Modern Science."

PICTURE CREDITS

Cover	Jet Propulsion Laboratory
pps. 22, 23	Robert Spencer
pps. 30, 32, 34	Art Streib Studio
p. 39	George Stranahan

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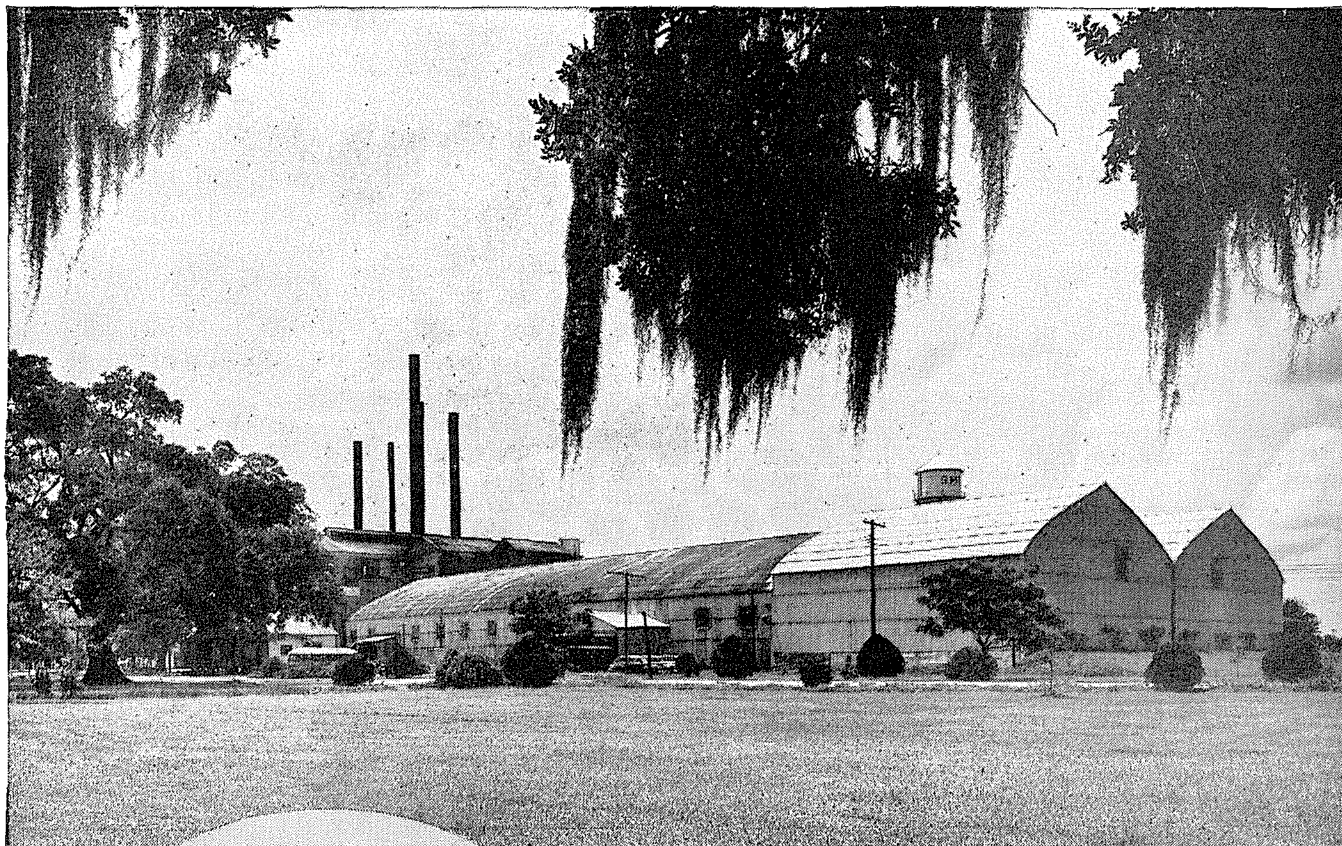
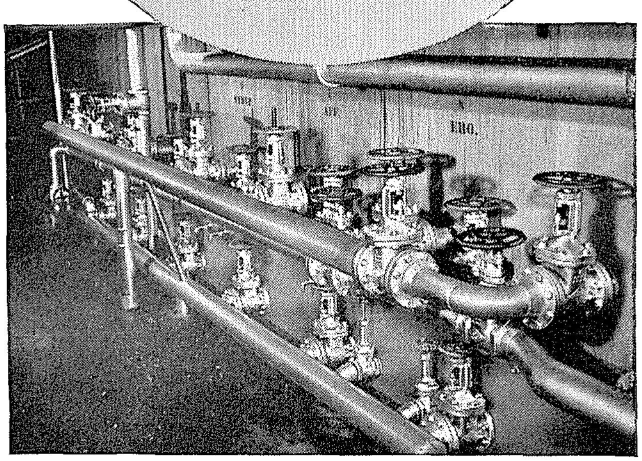
Published monthly, October through June, at the California Institute of Technology, 1201 East California St., Pasadena 4, Calif., for the undergraduates, graduate students and alumni of the Institute. Annual subscription $3.00, single copies 35 cents. Entered as second class matter at the Post Office at Pasadena, California, on September 6, 1939, under the act of March 3, 1879.





SCIENCE AND LIBERAL EDUCATION

Science can no longer be dismissed as "purely technical" or "merely vocational." It has an essential role to play in a liberal education—along with human liberalism and practical technology.

by L. A. DuBRIDGE

ABOUT A CENTURY AGO the introduction into the curricula of the American universities of courses in the field of science met with powerful and bitter opposition. It was revealing that the opposition was intensified when laboratory work by the student was inaugurated in these courses. It will be necessary to examine the reasons—as we see them today—for this opposition. For to some extent the opposition still exists.

For the American university to resent the intrusion of science was rather surprising in view of the fact that modern science was created largely in the halls of the universities of Europe. In the universities of Italy and later of France and still later of England the foundations of modern science were laid in the 17th, 18th and 19th centuries.

The early American universities, however, were not established as communities of scholars as had been many of the European predecessors. They were, in fact, often more of the nature of vocational schools, schools for the training of preachers and teachers in the pioneer communities. Later, as these communities developed, the lawyer, the public servant, and finally, the "gentleman and scholar" received their education in Greek, mathematics, philosophy, history and jurisprudence at these same colleges.

The seething intellectual ferment going on in Europe, represented by such names as Newton, Boyle, Pascal, Harvey, Lavoisier, Faraday, Maxwell, Pasteur, Darwin, hardly touched these colleges at all. Indeed, except for a few conspicuous exceptions like Benjamin Franklin and Joseph Henry (who were not in any college or university), this ferment hardly reached the shores of this continent at all.

The results of these new achievements in science, however, did eventually have their effects here. These new discoveries gave rise to new technologies and these new technologies found fertile ground in a nation whose people were developing a virgin continent. The steam engine ushered in a mechanical era and, stimulated by the needs of a frontier area, a host of brilliant American inventors were in the 19th century introducing devices and techniques which revolutionized agriculture and transportation and laid the basis of modern American industry.

But where was American industry to find the technologists (or engineers as we now call them) to carry on the task of building factories and railroads and canals and bridges and mines?

Not in the 19th century American colleges! Why? Here, indeed, is a curious paradox. The American college, though originally a vocational school, had now become the home of the gentleman and scholar and the college rejected science and technology (not distinguishing between the two) because they were too vocational! Noisy, dirty machines and smelly chemicals clearly had no place in a temple of classical learning! It was inevitable then that the first schools of technology had to grow up as separate institutions. Rensselaer Polytechnic, and later M.I.T. and others, came into being in response to this demand which the older colleges refused to meet. After the passage of the Morrill Act the state colleges of agriculture and applied arts were created. And as a direct result of all these new institutions, American technology grew by leaps and bounds and was soon in a position to lead the world.

Now possibly it was proper and desirable that centers

SCIENCE AND LIBERAL EDUCATION *is adapted from an address given at the spring meeting of the Western College Association, Whittier College, April 7, 1951* of technological training should have not found their first homes within the American college or university. At least it was probably a good thing for technology that these institutes were separately established.

However, the sad part of the story was that basic science, on which technology is based, became tarred with the brush of prejudice against technology, and so science, too, found few friends in university halls. And this was tragic for all concerned. While the most exciting intellectual adventures in human history were taking place in the universities of Europe, American intellectual centers were but vaguely aware of what was taking place. A strong stimulus to strengthening the dynamic, intellectual quality of American institutions of higher education was thus rejected.

Furthermore, technology could not long continue its advance without new advances in science. As long as these advances were coming from the universities of Europe only a few people were worried. But if the exclusion of science from the American University had lasted another dozen years or so American scientific centers would have been unprepared to carry on when World War II put European centers so completely out of action.

The dawn of the 20th century then found the American university a pretty pale reflection of the European centers where the revolutionary discoveries in basic science were being made that have transformed both science and technology in the past 50 years. Neither the American universities nor the technological institutes had yet entered this exciting new realm of intellectual endeavor.

Science without technology

On the other hand, during the 19th century in Europe, and particularly in England, a curiously reversed situation had arisen. There science *was* a respectable field of inquiry for the human mind. New discoveries in astronomy, theoretical mechanics, thermodynamics, molecular chemistry, the theory of evolution, and later in atomic physics, were shaking intellectual foundations, were creating a new philosophy, a new kind of civilization. It was all a part of an intellectual adventure of the highest order. But the British university apparently failed to realize that these new discoveries were resulting in practical applications—that they had initiated the industrial revolution. Hence, the British failed to establish schools of applied science and technology. And to this day, Britain suffers from the fact that she still has no really first-rate institutes of technology. One might say that England developed the world's best physicists and the world's worst mechanical engineers.

In other words, in England science was regarded as too pure to be dirtied by practical technological applications. And at the same time in America science was so thoroughly tarred with the brush of vocationalism that it never occurred to anyone that any part of it could be pure and respectable.

It was in Germany that a reasonable balance was finally found. Pure and applied science each had a place in the university system—and the two must be and could be closely tied together. The successes which resulted from developing both were astounding. Germany by 1914 was not only taking the lead in progress in basic science but was also leading the world technologically.

Sadly enough this success went to her head. Soon Germany was apparently asserting the inherent superiority of the German mind. Science and technology provided the answers to *all* human questions. Cold intellectualism was enthroned as a new god, and considerations of simple moral principles were forgotten.

Where then does reason lie? Is there any hope that warm human liberalism and cold intellectualism can come together and live side by side? Is there a way in which understanding the facts of nature and also of human nature can both be thought of as essential and respectable intellectual pursuits, and both be regarded as necessary not only in preparing men for living but also in preparing them to make a living?

The essential elements

The solution which the colleges and universities of America have reached has been achieved by combining three essential elements. The German universities seized upon science as a supremely challenging field of intellectual endeavor and recognized, too, the importance of its practical applications. But they forgot that a nation or a university which neglected human beings would inevitably ride to a fall. In Britain the human being was not forgotten—indeed, he reigned supreme. And when human beings sought to use their intellectual powers to understand their environment and their own physical bodies they were recognized as being embarked on a worth-while human endeavor. But the practical task of putting the new knowledge to use for the benefit of man was neglected. In America before 1900 practical technology was reaching heights undreamed of—in some places. And in other places the humanistic studies reigned supreme. But the gap between remained unfilled. The study of nature was regarded solely as a practical matter of building new devices and new machines—not as a bold human adventure in understanding.

But today the gap is at least partly bridged. For the first time in history an educational platform rests upon three legs instead of two. Human liberalism, scientific inquiry and practical technology have all found their places. Our educational system is shedding its narrow vocationalism on the one hand, its intellectual snobbery on the other. Furthermore, our universities have moved toward the goal of being not only centers for the dissemination of knowledge but also for its achievement. They are communities of scholars, not merely collections of teachers. As a community of scholars they will neither ignore nor suppress the advancement of knowledge in any field. But neither will they refuse to recognize that knowledge may be useful and that it is worth while to help young men and women learn how to use it.

It is now recognized that professional education, whether it be for law, the ministry, medicine, science or engineering, need not be "mere vocationalism," providing two conditions are met: first, the professional education must be built on a broad basis of a general liberal education; second, it should emphasize the essential intellectual content of the field rather than the routine skills, techniques and practices. I think you will agree that the history of professional education in this country during the past quarter century has been the story of striving toward these two objectives. The leading professional schools have, in fact, consciously or unconsciously, adopted the point of view outlined by Oliver Wendell Holmes when he said, ". . . . if a man is a specialist it is most desirable that he should also be civilized; that he should have laid in the outline of the other sciences, as well as the light and shade of his own; that he should be reasonable, and see things in their proportion. Nay, more, that he should be passionate as well as reasonable, that he should be able not only to explain, but to feel; that the ardors of intellectual pursuit should be relieved by the charm of art, should be succeeded by the joy of life and become an end in itself."

Thus the goals of professional education have now encompassed those of a liberal education and the conflict between them is being made to vanish.

But it is my thesis today that science (not technology) has a place in a liberal education, whether or not this is in preparation for a later or concurrent vocational education. After all, what is a "liberal education"—what is the liberal tradition in education? Everyone has his own definition, but the word liberal can hardly be dissociated from the concept of liberation—the act of freeing. Liberal education then should be education which frees men's minds; frees them from the chains of ignorance, superstition and fear; frees them from the atrophy which comes from lack of being used; frees them to be of use. A man with a free mind is simply a man prepared to act intelligently.

What then must one do to prepare a man to act intelligently in the world in which he finds himself? Aside from certain elementary skills which should be acquired in early years, a college graduate should have acquired a certain degree of knowledge and understanding of things—a type of knowledge and understanding which can be acquired only if at the same time he has learned to *think*.

Knowledge and understanding about *what* things? Very briefly, I suggest that the intelligent man should know about three things: (1) about himself, (2) about the physical world in which he lives, and (3) about his relations to the other human beings who inhabit that world. These, of course, are short titles for big subjects. In fact, I can't think of any recognized intellectual discipline that is not concerned with at least one piece of one or more of these three subjects.

If we accept these three subjects as essential goals of the educational process, the place of science is already clear. For the story of science is nothing but the story of man's attempts to understand himself as a physical being and to understand the physical world around him. The humanities and social sciences have to do with man as an intellectual and spiritual being and his relations to other men. To leave out the subject matter of science, therefore, is to leave out a substantial part of the picture.

But aside from the fact that the subject matter of science is a vast and important part of all knowledge, there is still a deeper reason for it to command our attention. That has to do with the method and spirit of science.

Science and common sense

It was a matter of great good fortune that during the period when I was preparing these remarks there appeared from the press the book, *Science and Common Sense*, by James B. Conant. For those interested in a straightforward discussion of the methods of science I can suggest no more profitable or enjoyable experience than reading this volume. And in what follows I shall borrow heavily from Dr. Conant's analysis.

To the nonscientific layman the field of science often appears as a cold and complex collection of slide rules and microscopes, elaborate glassware, machinery and mathematical equations, tables of data, cold uninteresting facts. Unfortunately, many scientists have themselves contributed to the spreading of this view of their field by emphasizing exclusively just these things—portraying the scientist as a cold fish, oblivious to all but his instruments and his notebooks.

Dr. Conant, however, presents a different view of the world of science. He introduces us to the very real and intensely human men and women whose efforts have built and are building the structure of science. He presents the human mind at work—complete with its flashes of genius as well as its stupidities and prejudices. He presents the story of science as the story of the struggle of the human mind to build a conceptual framework which helps to "make sense" of the many things which we observe in the physical world. The essential feature of any area of science is not the collection of observations, the tables of data, no matter how elaborate or elaborately systemized or classified the observations may be. The essential thing which converts a collection of observations into a science is a conceptual framework, a system of theories if you wish, which ties these observations all together, which interprets them and—most important of all—predicts the results of new observations.

The fact that such conceptual frameworks can be built at all is one of the great achievements of the human intellect. And it is one of the great hopes of the human race that such frameworks can encompass not only the field of the physical and a portion of the biological sciences, but also, eventually, all of natural science and what we now call social science. Clearly an understanding and appreciation of this intellectual process must be an essential feature of the equipment of every educated man. Surely a liberal education—an education that frees the mind—should impart some understanding of how the human mind has already freed itself in many areas from ignorance and superstition and fear.

Why is it that there has been too little acceptance of this attitude of regarding science as an expression of the free mind rather than as a mere "technical subject"? I fear that much of the blame must fall on the scientists and science teachers themselves. Too often have we emphasized the facts of science to the exclusion of its methods and its spirit. Too often have we treated science as the routine collection of data rather than as an imaginative adventure of the human spirit. The professional scientist, of course, takes this adventure for granted but too often fails to impart it to his students, or even tries to hide it behind a cloak of cold objectivity. But cold objectivity is not enough. It is not enough to advance science. Still more it is not enough to insure the preservation of the conditions which make science possible.

I do not say that cold objectivity has no place in science. Unbiased examination of facts has an important place in all fields of thought. But objectivity is a method, not a motive. What motivates a scientist? What causes him to spend days and nights in the laboratory, seeking new facts, puzzling over their meaning? Some scientists, of course, are motivated by the hope of practical applications of their work, some by ambitions for personal glory. But basically the motive of the great scientist has been aesthetic rather than practical. A successful theory or concept has a beauty and an elegance that appeals to the scientist in the same way that a great painting or poem appeals to those who love art or literature.

The beauty of science

The beauty of science is a subtle one and is fully revealed only to the men and women who have toiled long and lovingly in the pursuit of science. And rare is he who can convey a sense of this beauty to his students in elementary physics. But some teachers do, and more should try. For the student who has come to understand the method and spirit of science and who has come to recognize little of its beauty has had a rich experience—he will, indeed, have had a liberal education.

A liberal education—the education of free minds—is a subject which has unusual poignance for us in America in the year 1951. Clearly a free mind can exist only in a free human being. There would be little use in providing a liberal education to men who are not to be free to think and to act for themselves. Conversely, men will not long retain such freedom unless they learn to use it and to value it.

The world today is split into two hostile armed camps. What is the issue on which these two camps are divided? Essentially it is the moral issue of whether individual human beings are endowed with an inherent, that is a divine right, to life, to liberty and to the pursuit of happiness. The rulers of one portion of the world deny these rights—except in so far as they, the rulers, see fit to confer them. The peoples of the western world assert that these rights are God-given and hence inviolate. Essentially the contest we face today is the one our own nation faced in 1861; a contest to determine (to paraphrase Abraham Lincoln) whether the world can exist half slave and half free.

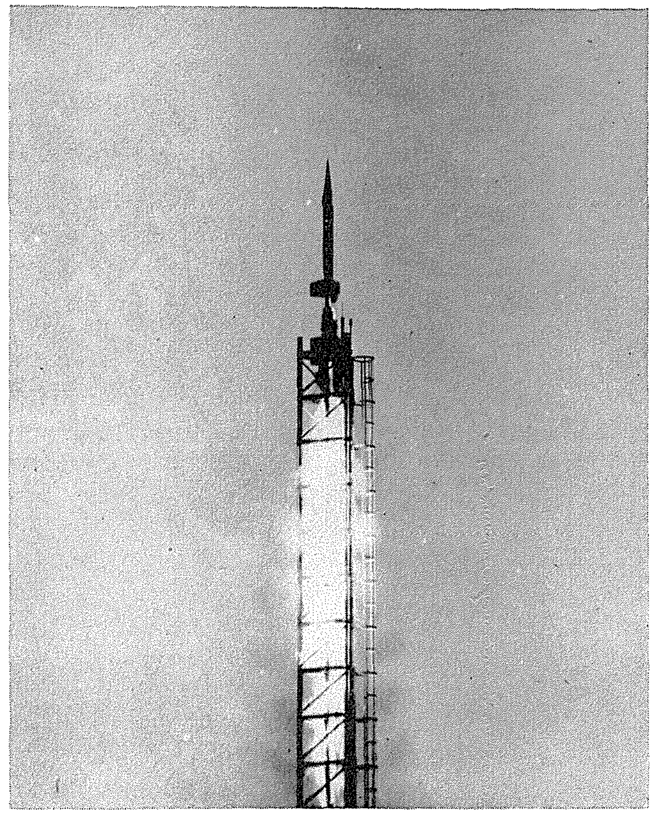
Some of the particular issues which divide the Communist world from the western world have been subjected to blurring by Communist propaganda and by frequent and sudden shifts of Communist policy. But on the issue of intellectual freedom there has never been any doubt. A Communist must believe what the Party tells him to believe. By almost daily edict and action this point is made abundantly clear. Deviationism is among the most heinous of crimes.

There were many who believed for some time that this requirement of intellectual conformity would actually be imposed by Communists only in the area of politics and economics. But within recent years it has become clear that it is to extend to every field—including the field of science. In the field of genetics the purge of those who held to the "reactionary" theories of Mendel and Thomas Hunt Morgan was apparently completed a year or two ago. During the past year the attack on "reactionary" physics has been mounting and one of the greatest of Russian physicists has recently ignominiously admitted his past errors, has recanted and promised in the future to espouse only the Physics consistent with Communism—whatever that is.

Now I am not one who would assert that anything the Communists don't like is something we should embrace —even though it seems to be a rule with but few exceptions. I do not base a justification of the study of science on the ground that it is something which the Communists think is dangerous. Nevertheless, the Communist attitude does illustrate a fact of deep importance—namely, that the spirit of science and the spirit of freedom are one and the same. Science has developed only in those areas and in those periods when and where men's minds were free. The development of science has at once been the highest expression of that freedom and a strong bulwark to support and extend it.

My thesis is thus a simple one: science has an essential role to play in a liberal education—or can have if science teachers will understand this role. Science can no longer be dismissed as being "purely technical" merely because some of its laws are reasonably exact, and hence can be stated in mathematical form. It cannot be dismissed as "merely vocational" simply because parts of it are useful. Science is the study of some of mankind's greatest intellectual achievements. The method of science is one important method by which the human mind may grapple with the problems that face it. Finally, the spirit of science, like the spirit of true liberalism, is the spirit of freedom.

THE GUIDED MISSILE



—PRECOCIOUS PROBLEM CHILD OF THE MILITARY ART

by CLARK B. MILLIKAN

THE COMPONENT WORDS of the title of this article actually represent some of the most crucial and striking aspects of the recent and spectacular development known as the Guided Missile. Accordingly, by taking up the various terms in the title one by one, and attempting to assign meaning and significance to each, it may be possible to get a picture of this Problem Child from several different points of view.

THE GUIDED MISSILE

The term "Guided Missile" is now generally considered to refer to an unmanned vehicle carrying a warhead or other payload, propelled by an internally carried power plant, and guided and controlled during its trajectory through the air or the space above the atmosphere, to a selected target. By military definition, torpedoes are excluded since they travel through the water, although this distinction has a historical rather than a logical basis.

The first crude precursors of the guided missile appeared during the last war primarily as a result of German developments. Guided glide bombs lacked only the propulsion element, but this omission so restricted their effectiveness that they played a relatively unimportant role. The V-1 Buzz Bomb and V-2 rocket were controlled by pre-set internal mechanisms but were not guided after leaving the launching area, in the sense that no subsequent information concerning the target or their deviation from the desired trajectory was furnished them. Thus their accuracy was poor and their effect primarily psychological rather than strictly military.

From these early and relatively ineffective ancestors has developed the large family of weapons which are now being actively worked on. These weapons may conveniently be grouped in categories corresponding to their principal military objectives. These categories,

This article has been excerpted from a speech delivered at the Sunset Club, Los Angeles, on February 28, 1951

German V-2 rocket—precursor of the guided missile. Its effect was more psychological than military.

together with their associated conventional weapons, are: air defense by anti-aircraft artillery and fighter planes carrying small-calibre guns; anti-ship by naval guns, torpedoes and bombing planes; tactical support by field artillery and strafing or bombing aircraft; strategic bombing by long-range bombers.

There are only two reasons for developing guided missiles to supplement or replace these "classical" weapons: inability of the older weapons to do their job under modern conditions, and higher effectiveness or efficiency of guided missiles compared with their more conventional competitors.

The first may be illustrated by the case of anti-aircraft artillery. Against modern aircraft flying at nearly the speed of sound and at altitudes of 40,000 feet and above, the conventional anti-aircraft gun is essentially useless and no foreseeable improvements in it can help matters appreciably. The guided missile seems the only possible replacement, but it, to be effective, must have tremendous speed (say twice that of sound) and extraordinary guidance accuracy. In the other three categories conventional weapons are still effective but have limitations of range, dependence on weather, vulnerability, etc. which high performance guided missiles could eliminate or greatly reduce. Thus both reasons furnish powerful incentives for developing high performance guided missiles.

The qualification "high performance" is what makes the problem so terribly difficult. To illustrate the difficulties I shall consider only the two most important aspects of "high performance," although there are many others which introduce problems almost as serious.

The first is speed. I have already indicated that anti-aircraft missiles must have speeds of the order of twice the velocity of sound, say 1200 to 1500 miles per hour. It is now generally conceded that, for reasonable effectiveness and invulnerability, guided missiles of all types should operate at velocities of this general magnitude or greater. There is probably a justification for slower, interim missiles in certain categories, but these should soon be replaced by true supersonic followers. This requirement of tremendous speed means that the missile size must be as small as possible, and even then the power of the motor must be enormous. Two types of power plant seem to be suitable: the ramjet and rocket. The former burns fuel utilizing the oxygen of the air and hence is limited to altitudes of the order of 80,000 feet. The rocket carries its own fuel and oxidizer and operates either in the atmosphere or in empty space. Both involve powers per cubic inch of engine which are enormously larger than that of any other known power plant. Their development accordingly requires the solution of a host of formidably difficult engineering problems.

The second aspect of "high performance" is that of accurate guidance and control. To illustrate this problem I shall consider only one of the types of guided missile as an example. The anti-aircraft missile must intercept a very high speed aircraft which may be at extreme altitude and which can engage in active evasive maneuvers. On the other hand, the range need not be more than a few tens of miles, and during the missile flight both target and missile will usually be on a "line of sight" from a ground control station located at or near the missile launching site.

Three types of guidance systems

To meet these conditions three major types of guidance systems have been developed. The simplest to describe is the beam-riding system in which a radar at the missile launcher tracks the incoming enemy plane and keeps the radar beam center on the plane. When the enemy is at the proper range the missile is launched into the radar beam and then, by elaborate electronic devices in the missile, follows the center of the moving beam out to the plane where its warhead is detonated. The name "beam-rider" is, as you see, a very descriptive one.

A second system is the so-called "command system" in which again the ground control station tracks the enemy plane with a radar. The position and speed data from this radar are fed into an elaborate electronic computer which practically instantaneously computes where the enemy should be at a later time if he continues his present course. At the proper time the missile is launched along a trajectory which should bring it to the computed collision point. During the missile flight the radar continues to track the enemy and the computer determines new collision points as well as the missile maneuvers required for it to reach the new collision point. By means of a second radar the missile is then continuously given the commands worked out by the computer and is finally detonated as it reaches the target.

The third or "homing" system involves a "seeker" in the missile itself which "looks at" the enemy by the reflection of radar signals originating on the ground or in the missile. The missile thus "sees" where the enemy is and its controls are manipulated so that it continuously flies toward its target, finally intercepting it and being detonated.

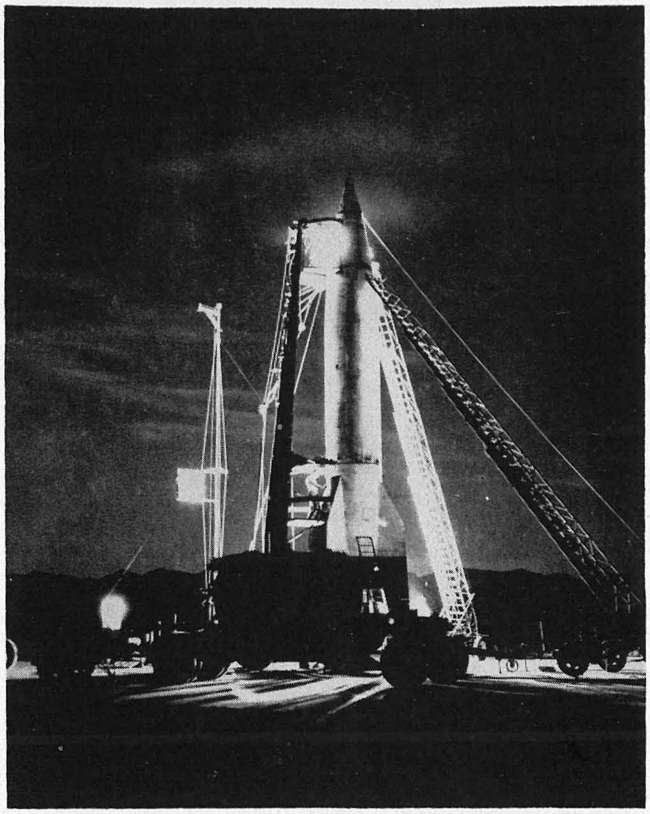
In all three of these guidance systems the function of sensing, which in the past has been done by the human eye, and that of interpreting observations, done by the brain, have been taken over by electronic apparatus. Further, the human operation of estimating the future behavior of target and missile is, in some systems, carried out by electronic computers. In addition, the manipulation of controls to produce the required missile maneuvers, which in aircraft is done by human muscles, is here accomplished by elaborate servo systems which usually turn out to be as sensitive and unstable as the most jittery of prima donna athletes.

I have sketched only the bare outlines of three of the simplest of the many types of guidance and control systems, but I hope this sketch is adequate to indicate the extraordinary complication and difficulty of the problems involved. For long-range missiles against fixed targets the maneuverability requirements are much less severe, but the impossibility of using line of sight methods, and the extraordinary accuracies required make the overall guidance problem even more difficult than is the case for the short-range anti-aircraft missiles.

THE MILITARY ART

It is almost impossible to conceive of a peacetime or commercial application for any guided missile of the short-range, surface-to-air, anti-aircraft type. It might seem that the long-range surface-to-surface missile could develop peacetime applications. However, even this seems unlikely to me, at least for the near future, for two primary reasons. The first is cost. Long-range (i.e., several thousand miles), supersonic missiles are necessarily very large, and the combination of size, tremendous speed, and enormously powerful engines, means that they will inevitably be very expensive both to build and to operate.

The second reason is even more fundamental. One of the tremendous advantages of presently conceived guided missiles over long-range bombers is that the missile need not be designed to land at its destination or to return to its launching site. It is hard to conceive of any economical commercial utilization of a one-shot, payload-carrying vehicle which is destroyed after its first trip. It would, of course, be possible to design a long-range missile which could land and be recovered



The V-2 was controlled by pre-set internal mechanisms, but was not guided after leaving the launching area.

at the end of the flight, but the performance penalty would be serious. Furthermore, it would probably be more efficient in such a vehicle to replace some of the elaborate guidance equipment by a human pilot, in which case the guided missile disappears and becomes a supersonic manned aircraft.

However, even though guided missiles appear doomed to a monogamous wedding with the Military for a pretty respectable number of years, there will undoubtedly develop peacetime applications for many of the elements of the various Guided Missiles projects. Ramjet and rocket motors, and enormously complicated guidance and control systems are examples of elements which are now being developed only through the military support of the Guided Missiles program, but which will certainly be incorporated in future commercial projects. Such eventual non-military applications for their work furnish a solace to many engineers and scientists working in the field, but most of them will have to admit, in many cases sadly, that for the near future their sponsors and deities will be the gods of war.

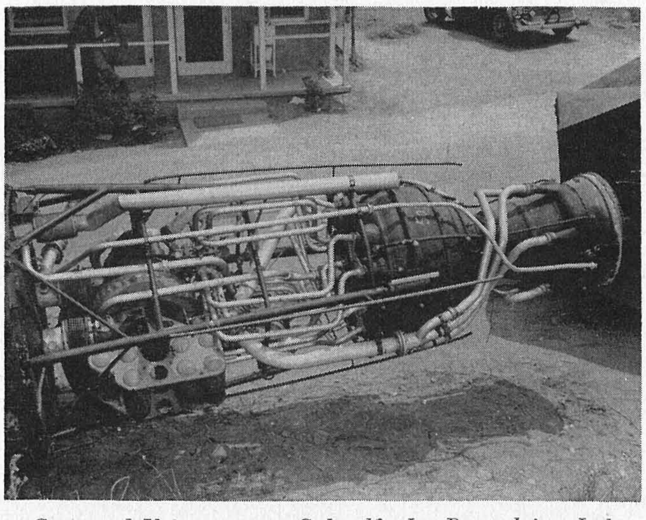
PRECOCIOUS

Dr. L. R. Hafstad, a very distinguished physcist who has been intimately connected with most of the striking recent applications of science to warfare—including radar, proximity fuses, atomic energy and rockets—admitted in a speech a few years ago: "I have no hesitation in saying that the guided missiles field is the most complex and difficult of the lot . . . . In neither my civilian nor my military experience have I seen a problem which includes so many branches of physical science." When one realizes that ten years ago the guided missile in its presently used sense had not even been conceived of, while today several different missiles and complete systems are being successfully operated, it becomes clear that "precocious" is certainly not too strong.

Two questions are naturally raised in this connection: Why was the development started so recently, and what are the driving forces which have required that the development, once started, be pushed so rapidly? The answers to both are, I think, very clear. That for the first is the fact that before about 1940 many of the essential component elements for a true guided missile simply did not exist. For example, in propulsion the ramjet had hardly been thought of and the rocket motor was in a primitive, small-scale laboratory stage. Even more important was the non-existence of radar and all of the other electronic devices which are required for guidance and control. Until these components came into existence a practical and useful guided missile was not even conceivable.

As to the driving force, it seems to me that the two most important factors (both military) have been the extraordinary increase in aircraft performance which has made existing anti-aircraft weapons essentially ineffective, and the post-war international tensions which have made it necessary to think very hard about intercontinental warfare and the possible methods of effectively delivering large warheads at very great distances. In any case the driving forces have been extremely powerful and guided missile development has been pushed very intensively.

The program has been subjected to much criticism by commentators impatient over the fact that there are as yet no operational type guided missiles in the hands of service troops—in other words, that "push-button warfare" is not "just around the corner." The following quotations from editorials which have appeared within the last few months are, if not typical, at least far from unique:



Captured V-2 motor at Caltech's Jet Propulsion Lab

"The United States does not now have in being any service-tested or service-accepted missiles of any type or range. What we do have are assorted and sundry test vehicles, or limited quantities of missiles that could, with time-consuming rework, become operational. But we do not have any missiles with warheads that are yet on a standby basis. Some missiles are in or about to go in production, but they are all test models. None is intended to do any serious combat work."

And again: "$100 Million Missile Program Under Fire. With no production in sight, Congress tells Defense Department to investigate."

Although there have inevitably been mistakes and confusion in the program, it seems to me that such comments are based only on wishful thinking as to what would be nice to have, rather than on any understanding of what is technically possible. I hope that I have already given some idea of the unparalleled magnitude of the technical task of developing a guided missile. When one realizes that serious work on any scale was initiated only a little over five years ago, it seems to me that the present state of development instead of being blameworthy is truly precocious.

PROBLEM CHILD

And now to squeeze the last juice out of my title, let me consider the remaining phrase, "Problem-Child." The underlying reason for its applicability, apart from the technical problems already mentioned, lies, I think, in the following circumstance: When, towards the end of the last war, it became apparent that guided missiles might now be technologically feasible, there was no existing niche in the military structure into which their development could naturally and uniquely be fitted. To ordnance officers the guided missile appeared as a device to extend the range and accuracy of guns, whether anti-aircraft or bombardment. To airmen it appealed as a natural development of the piloted aircraft—and in fact Guided Missiles were, for some years, always referred to as Pilotless Aircraft by the air branches of the Army and Navy. There was no single agency in the military service which could naturally take the new fledgling under its cognizance and alone sponsor its growth. Accordingly four more or less independent programs were started: one by the Air Force, one by the Army Ordnance Department, and two by the Navy, one under the Bureau of Ordnance and the other under the Bureau of Aeronautics. The latter two have been pretty effectively coordinated since the appointment a few years ago of a Deputy Chief of Naval Operations for Guided Missiles, but it is apparent that with such a number of different approaches the possibilities for confusion were great.

The difficulties were intensified by the fact that the program was inevitably a terribly expensive one, requiring the construction of very elaborate laboratory facilities and test ranges, and that it was undertaken during a period of retrenchment and "economy" in military budgets. Funds were appropriated by Congress to the three services individually, and this resulted in a competition, sometimes pretty bitter, between Army, Navy, and Air Force, for Congressional favor.

In such battles the "public relations" expert almost always becomes an important character and in this case, unfortunately, all three of the services used the publicity weapon extensively and often unwisely. Glowing and inflated accounts of "successful tests" frequently appeared, and the impression was given that guided missile developments were much further along than was actually the case. This conflicting and inflated publicity seemed to indicate a confusion, duplication, and lack of coordination in the over-all program far worse than was the case in actuality. And the over-optimistic press releases resulted inevitably in a sense of disillusionment on the part of the press and Congress when the claims of "tactical weapons available tomorrow or next week" failed to materialize. It was primarily these unwise publicity activities which were responsible for the criticisms of the program which have already been mentioned.

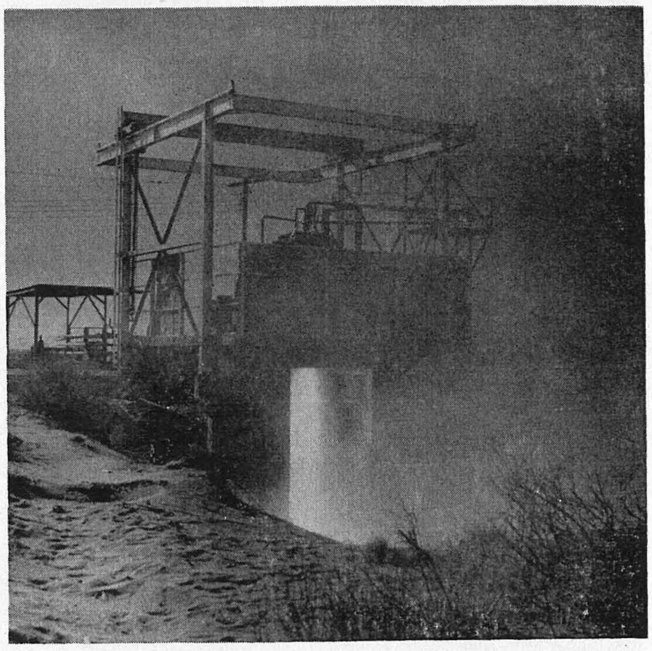
On looking back now on this period, which extended from the end of World War II until fairly recently, it is clear that there was some duplication, overlapping, and certainly competition between the various cognizant agencies. Many more projects were started than could effectively be carried to fruition, and in the subsequent pruning many were dropped. However, I cannot help feeling that this shotgun and somewhat haphazard approach was, in this case, not undesirable but was even essential.

Trial and Error

When work was started on the development of guided missiles there was no background of technical experience on which a judgment could be based as to which of the many possible lines of approach to any single objective would ultimately prove most effective. The only way in which answers could be found and the best path chosen was the expensive and inefficient one of trial and error. And, if the answer was to be found in the short time which international tensions made mandatory, then the various approaches had to be investigated simultaneously rather than in chronological sequence.

Furthermore, the interchange of technical information at the working level was remarkably good, so that each of the competing groups had very up-to-date information as to the technical approaches, successes, and failures of all the others. It is almost an axiom in science and engineering that the best way to avoid undesirable and fruitless duplication is the free interchange of ideas between workers engaged on similar problems. Such interchange existed in the guided missiles field to an unprecedented degree.

One more fortunate consequence should be mentioned of the setting up of many guided missile projects by



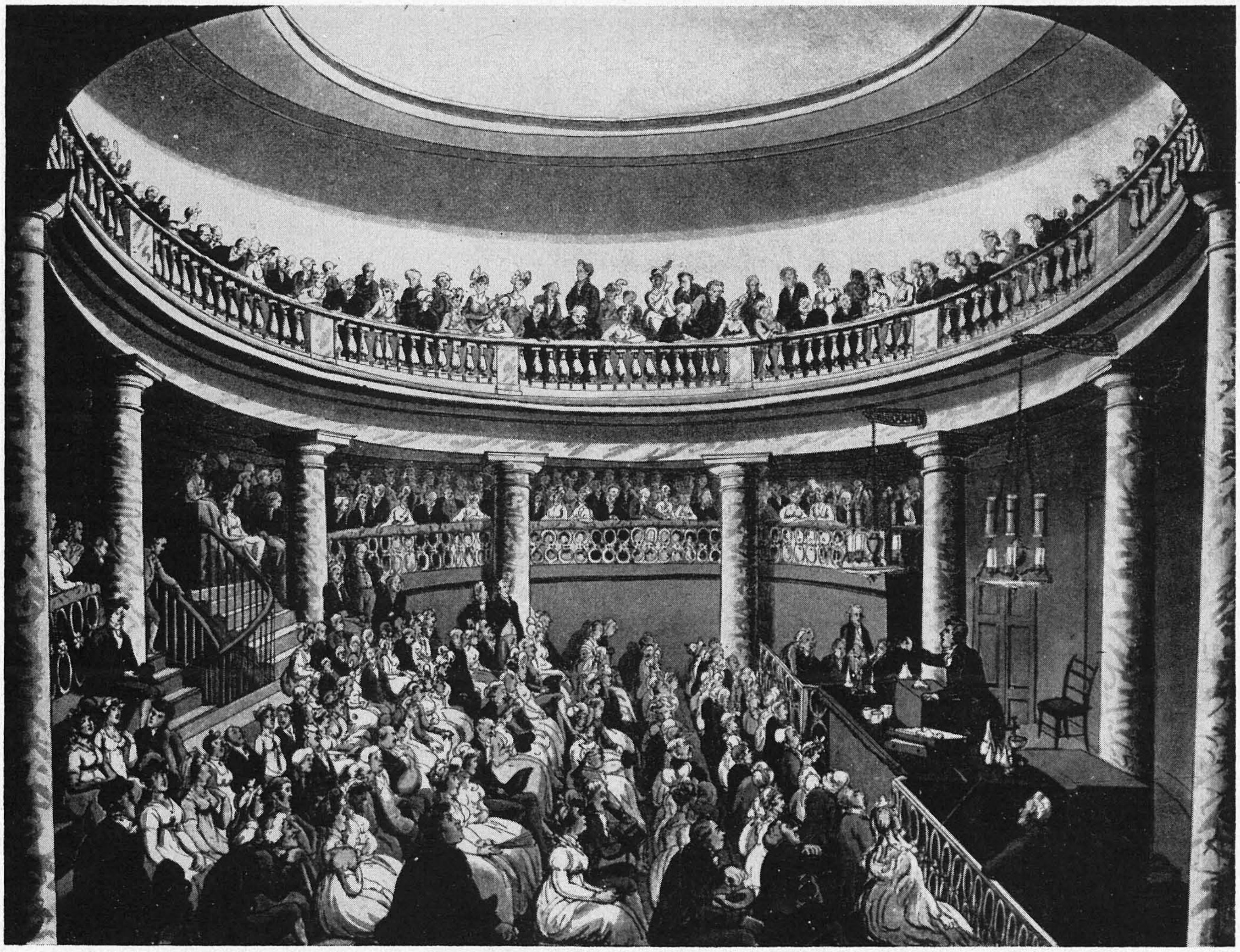
Static test-firing of a large-size rocket motor

four somewhat competing agencies. When work started five or six years ago there were practically no scientists or engineers with any experience or knowledge of the tremendous complexities of the guided missile. In particular there were no teams who had even considered the problem of integrating the enormous number of diverse components into a guided missile system. A large number of study projects made it possible to train a large number of such individuals and teams which could be used in other projects if their own were eliminated in the contractions dictated by the economy program. The most serious bottleneck in the entire field today is the lack of enough trained and experienced technical personnel. If it had not been for the earlier period of so-called duplicating projects our present expanded program would be utterly impossible for lack of trained manpower.

Growing Up

There have certainly been headaches and difficulties in the raising of our infant, resulting from the multiplicity of sponsoring agencies, and in this sense he can justly be called a Problem-Child. However, I am quite certain that the precociousness of the youngster now is directly associated with these headaches. If he had been brought up more deliberately, systematically, and efficiently he would today be many years less advanced than he actually is.

Since Korea certain of the most important and technically advanced Guided Missile programs have been greatly emphasized and accelerated. As a result it is apparent that it will now be only a short time before the Precocious Problem-Child is grown up and ready to play his part in the defense of our free world against the totalitarian tyranny which threatens it. That part will be a major, and may well be a crucial one.



Rowlandson's painting of Fredrick Accum lecturing at the Surrey Institution in London

Science in Art

LECTURES AT THE SURREY INSTITUTION - - -

AS PORTRAYED BY THOMAS ROWLANDSON

by E. C. WATSON

THE ROYAL INSTITUTION of Great Britain was founded in 1799 by Benjamin Thompson, Count Rumford, for the purpose of "diffusing the knowledge and facilitating the general introduction of useful mechanical inventions and improvements, and for teaching by courses of philosophical lectures and experiments the application of science to the common purposes of life."

"The application of science to the common purposes of life" gradually ceased to be a primary object of the Royal Institution, and its school for mechanics, workshops, models and journals gradually died away. The laboratories, lectures and library became the life of the Institution, and its purpose "the diffusion and extension of useful knowledge in general."

"Lectures on scientific subjects, to be given in a lecture room with the most up-to-date facilities for experiment and demonstration" were a part of the original scheme for the Royal Institution, and these lectures played an important part in the life of London during the whole of the nineteenth century.

The success of the Royal Institution, together with the rapid growth of London south of the Thames, led

Rowlandson's caricature of the scene he painted in the picture on the left

in 1808 to the establishment of a similar project on Blackfriars Road. The purpose of The Surrey Institution, as it was called, was the same as that of the Royal Institution and the building which housed it contained likewise a library and reading rooms, a chemical laboratory, conversation rooms and a spacious anteroom for the display of scientific apparatus, in addition to an elaborate lecture room. This theater, which seated approximately 500 people, was considered one of the finest rooms in London.

Accum's lectures

Friedrich Christian (Fredrick) Accum, best remembered as a pioneer in the field of gas lighting, but also known as a dealer in scientific supplies, a scientific investigator, a pure-food agitator and an industrial expert, was professor of chemistry and mineralogy; and his lectures, which were begun in November, 1808, were well attended. The project was not long successful, however, and by 1823 it was abandoned.

The picture on page 16 gives a very adequate idea of the lecture theater with its two galleries, the uppermost supported by eight Doric columns of Derbyshire marble. It is reproduced from one of the 104 magnificent aquatints, depicting every phase of the colorful life in London under the Regency, which appeared in that most distinguished of color-plate books, *The Microcosm of London; or London in Miniature,* published by Rudolph Ackermann in 1808-1810. The drawings themselves are the work of Augustus Charles Pugin, one of the best architectural draftsmen of the period, and Thomas Rowlandson, the caricaturist who portrayed "the high and low life of his time with incomparable gusto and charm."

The picture on this page is a caricature of the same scene, also by Rowlandson. A fair likeness of Accum is provided, but the other figures have not been identified, if indeed they were intended to represent actual persons. "Wonder and interest are expressd by the faces of the stylishly dressed audience" and "one old enthusiast, who watches the lecture with his head and hands resting upon a cane, has a book marked 'Accum's Lectures' thrust in his side-pocket." This is probably typical of the interest which London society took in such lectures. The original print, which is quite rare, is 13x9 in. in size and brightly colored.

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

THE EPSOM SALTS LINE

—Monorail to Nowhere

by RICHARD H. JAHNS

Some engineers dream of a modern monorail transportation system that would whisk thousands of Los Angeles commuters and shoppers back and forth in half the usual time, to say nothing of putting an end to present serious growth among the local populace of parking-lot palsy, freeway frenzy, and other forms of the traffic tremens. Suspended monorail lines of great carrying capacity, they argue, could be built along low-cost routes such as the bed of the Los Angeles River, and could connect key points to and from which some means of rapid transit is sorely needed. They point out that a monorail line of this type has been operated successfully for many years in Germany, and without a fatal accident. And then, perhaps in a shrewd appeal to civic pride, they add that Los Angeles could be a true pioneer in introducing monorail transportation to this country.

They might well be right in most of their arguments, but certainly not on the last point. The monorail, in one form or another, has been used in several parts of this country, and for a few months' time one line flourished within 150 miles of the present Los Angeles City Hall! This little-known railroad, long since defunct, was built to handle relatively light and infrequent traffic at rather low speeds. It never was a common carrier, nor did it otherwise closely resemble the lines envisioned by present transportation engineers. Indeed, there is some question as to whether it closely resembled any other line, and the story of its design, construction, and operation is among the most unusual in the history of transportation.

The story begins with the discovery, at least 40 years ago, of a deposit of magnesium salts in the multicolored badlands of the Crystal Hills, a jumbled mass of low ridges and tortuous ravines sprawled across a patch of desert country in northwestern San Bernadino County. To the north lay the broad floor of Wingate Valley and the bold slopes of the Panamint Range; to the south, the ragged cliffs and broken volcanic ridges of Brown Mountain and the Quail Mountains. And 20 miles to the northeast, just visible through a notch in lower Wingate Wash, lay the floor of Death Valley. Although the property was on the old Barstow-Ballarat road and not far from one of the routes followed by the famous 20-mule teams of that period, it would have been difficult to select a more desolate spot in the great expanse of virtually uninhabited country that lies between Death Valley and Randsburg.

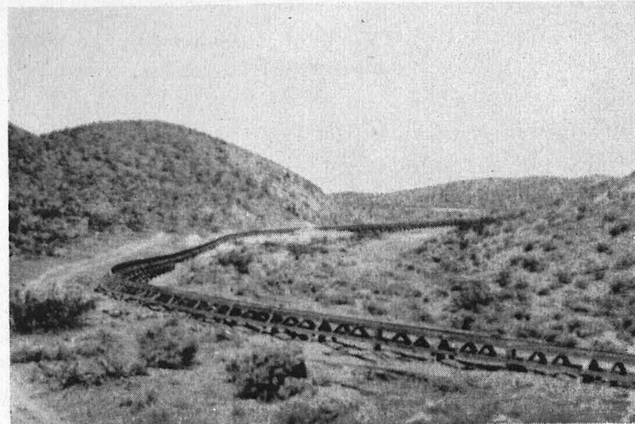
By the time of World War I, the deposit was being prospected and the ground prepared for mining by the American Magnesium Company of Los Angeles. A temporary camp had been set up in Crystal Hills Wash, and a crew of men was kept busy hauling in supplies from Randsburg, 37 miles distant as the crow flies but 63 miles by road. The roads, mere tracks across sandy valley bottoms and through rocky passes, were so rough, and in places so steep and sharply turning, that they were a sore trial to team and truck alike.

As one man feelingly wrote, a journey to the deposit by truck was, in those days, "an interminably long and punishing sentence of bumps and jolts, punctuated now and then by the brisk snap of breaking springs, truculent overtones in the clatter of the badly treated motor, and the sinister hissing of water frying in the radiator." Small wonder, then, that the management considered some other means of transportation essential to further development of the property.

All activities were suspended during the brief post-war depression, but in 1921 it was decided to build a railroad to the deposit. There was some talk of a route following Wingate Wash to Death Valley, and thence rising southeastward along the Amargosa River to a junction with the Tonopah and Tidewater Railroad at Sperry, but this was given up in favor of a shorter, though locally much steeper route westward to a connection with the Trona Railroad on the southwestern shore of Searles Lake.

From the junction point, which became known as Magnesium Siding, a right of way was surveyed eastward in two long tangents across the salt-encrusted lake bottom, and thence in a series of broad curves to a crossing of the Slate Range at Layton Pass. The winding, and in places sharply turning route down the precipitous Layton Canyon into Panamint Valley promised plenty of hard-rock blasting, as did the short but equally steep climb out of the valley onto the flats above Wingate Pass. From here the route angled eastward across the broad slopes of Wingate Valley, and thence was thrust for several miles up the steep bed of Crystal Hills Wash to the camp. The total distance between terminals was a little less than 30 miles.

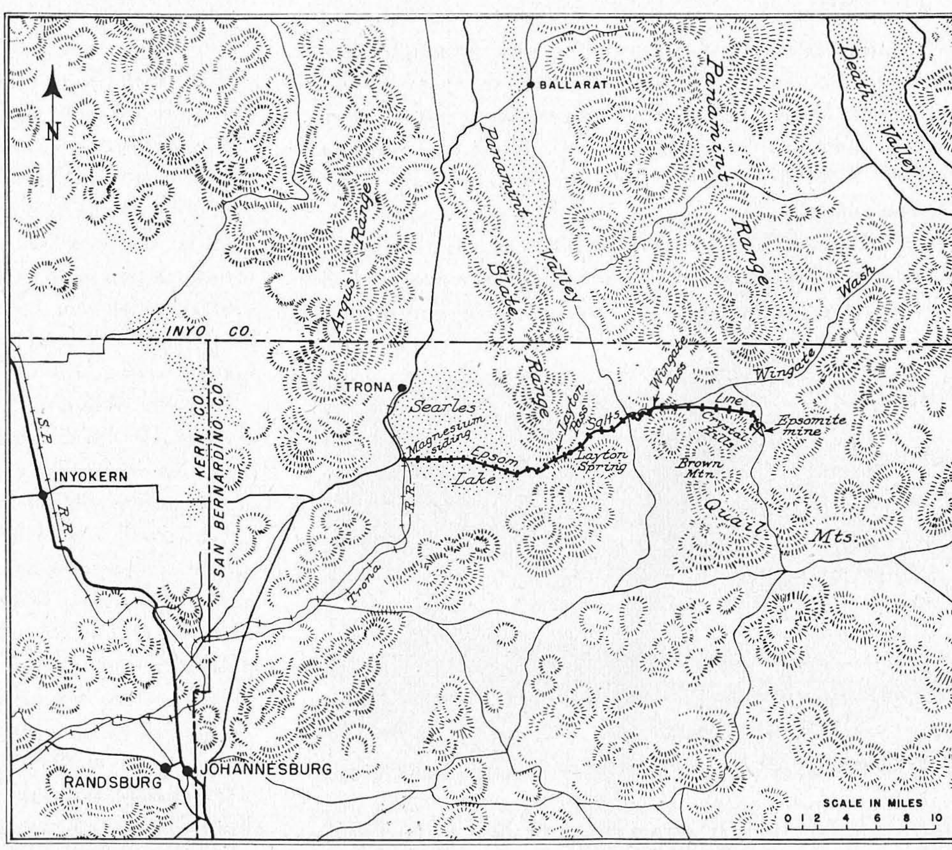
The records are not clear as to when the big decision was made—the decision to have the rolling stock operate on one rail instead of two. The reasons for the choice, though, seem easy to guess. A monorail line of low-trestle design, operated with straddle-type locomotives and cars, might be far less expensive to build over such rugged terrain than a railroad of more conventional design. Not only would there be a substantial saving in requirements for steel rails, but the need for grading would be eliminated in all but the most difficult canyon portions of the line. Moreover, the trestle would be easy to maintain, so far as drainage was concerned, although there is some question as to how long the structure itself



Like a huge caterpillar the monorail line bends to and fro in its tortuous climb to Layton Pass.

was expected to remain serviceable without periodic repairs or replacement of timbers.

Building of the line was begun late in 1922, and the job was finished in 1924. The trestle was of timber construction throughout, and the Douglas fir that was used had been shipped by boat to San Pedro and thence by rail via Mojave. The structure consisted of a 6 by 8 inch "riding beam" that was supported on A-frames, or bents, spaced 8 feet apart. Each A-frame comprised a 6 by 8 inch vertical member, which carried most of the load, two diagonal braces, and a horizontal crosspiece. The crosspiece extended several inches beyond the bar of the A, as shown in the photographs, and spiked to its ends were the two 2 by 6 inch timbers that served as side rails, or sway stabilizers. The timber bents were spiked to broad sills, many of which were sunk several inches



Map of a part of the Mojave region of California, showing the route of the Epsom Salts Line.

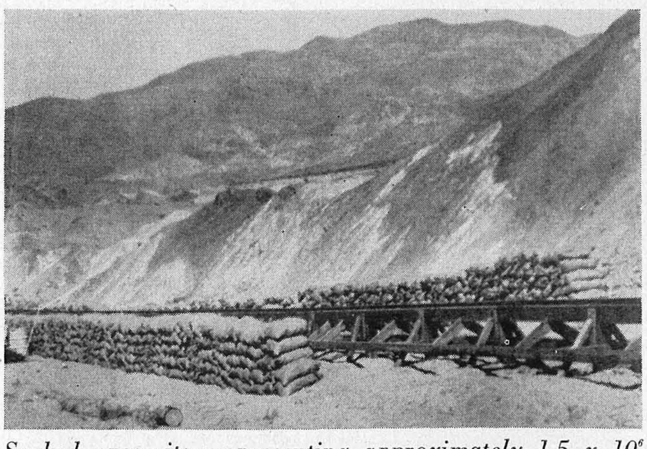
into the sand or gravel. Some of these sills were parts of old redwood telephone poles; others were the outermost parts of large fir trees, and fragments of dried bark still cling to many of them.

The side rails were stiffened by triangle-braces spaced between the A-frames, and the entire structure was stiffened where necessary with fore-and-aft diagonal bracing. The "riding beam" was held in place at the top of each bent by a cradle, or yoke, of short 2 by 4 inch pieces that were spiked to the sides of the main bearing member of the bent. Wherever the trestle crossed arroyos or other low areas too narrow for dips in the grade, the length of the A-frames was appropriately increased and additional bracing was used. All heavy members in the trestle were joined with bolts or drive screws, but most of the bracing was attached by means of heavy spikes. The running rail was of standard T-section design. Most of the rail was rather heavy, 80 pounds to the yard, but some 65- and 70-pound rail was used as well.

The rolling stock was the most unusual part of the railroad. Both locomotives and cars were built on rectangular steel frames, and each had a pair of double-flanged wheels. Extending downward from the main frames to points well below rail level were steel supports for two sets of plank "steps," on which the loads skimmed along only a few inches above the desert floor.

Eight chain-driven locomotives were used on the line. Seven of them were powered by Fordson tractor motors, and the other, a heavier model, mounted a Buda motor. Each locomotive could handle one or two trailers, and a few trains comprised two locomotives and three or four trailers. The couplers used on all rolling stock had been salvaged from scrapped Los Angeles streetcars.

When operating fully loaded, both locomotives and cars balanced nicely on the running rail, although there was some tendency to sway at speeds in excess of 15 miles per hour. To curb this tendency, and to give needed lateral support when the equipment was running "light," 8 by 8 inch steel rollers, mounted on short vertical shafts, were used to contact the two side rails of the trestle. These rollers were held against the wood rails by tension springs, and are said to have contributed substantially to the operating noise of the equipment.



Sacked epsomite, representing approximately 1.5×10^6 adult catharses, awaits shipment in Crystal Hills Wash.

A load of timber, bolts and spikes, during construction days on the line. This was the heaviest locomotive.

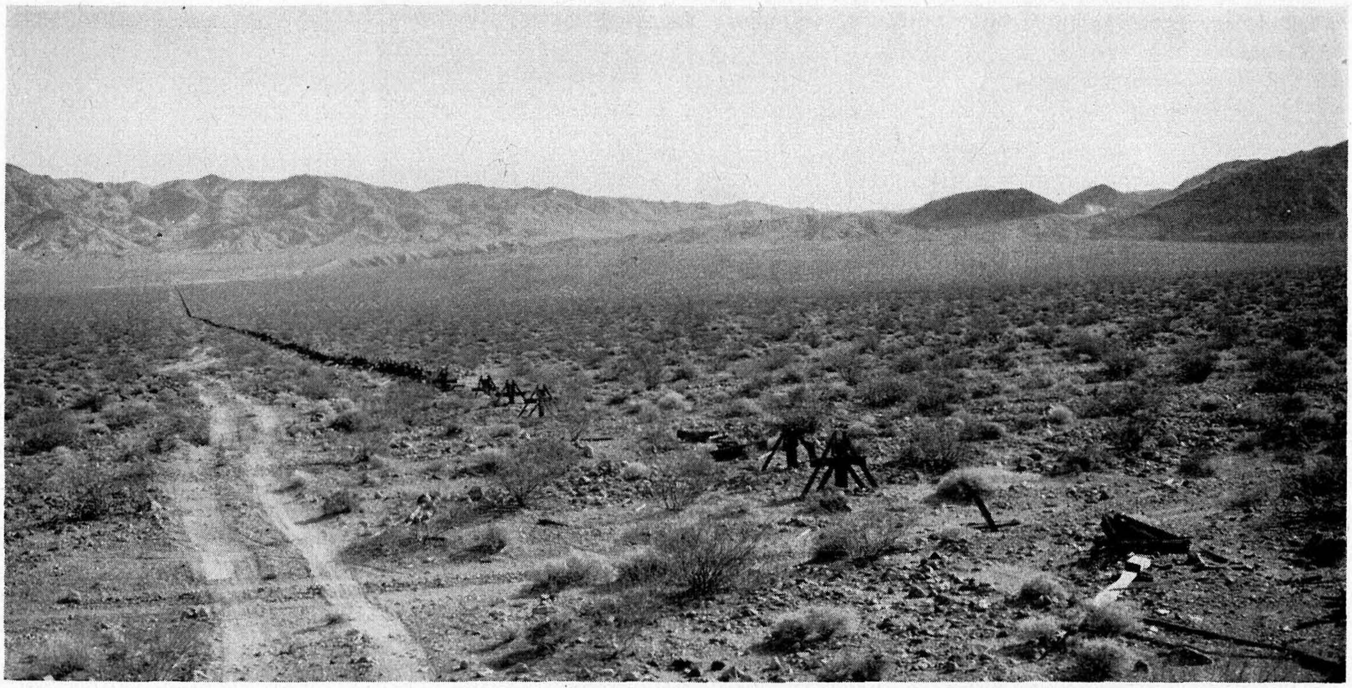
It must have been an experience to watch one of these little trains astraddle the framework of the trestle, sliding along bug-like and rolling gently from side to side as the trestle creaked and flanges and rollers squealed.

Each locomotive was assigned a maximum pay load of about 3400 pounds, and each car a top load of 8500 pounds. Loads were limited, of course, by the trestle over which the trains were run. Speeds varied with grades along the line, but 35 miles per hour was the maximum permitted. Most trains were operated at about 30 miles per hour on the flat, but were perforce slowed to a tortured crawl as motormen opened throttles wide and used plenty of sand on the 10- and 12-percent grades between Wingate Pass and Layton Pass.

One motorman, apparently trying for an all-time record, once made the 30-mile trip in one hour flat, and with a full load of sacked Epsom salts; instead of receiving praise or a raise for his feat, he was himself summarily sacked. Perhaps it was he who inspired the local designation of the railroad as "The Epsom Salts Line—Fastest Moving Monorail in the World!"

Between Wingate Pass and Layton Canyon was the floor of Panamint Valley—and the only crossing with a road. It was plainly impossible to negotiate this crossing at grade without installing a drawbridge-like device on the road, so Milus G. Robison, chief construction engineer, designed an overpass for the monorail trestle. According to Mr. Robison, who kindly supplied most of the photographs reproduced in this article, several of the motormen enjoyed the roller-coaster effect of hitting this "bump" in the line at speed.

The cost of this strange little railroad is reported to have been about $350,000, an especially impressive sum as compared with the total value of magnesium salts shipped over its twisting single rail. White crusts of



A long row of A-frames, all that remains of the monorail trestle, heads toward Crystal Hills Wash and Quail Mountains

nearly pure epsomite, a hydrated magnesium sulfate, were scraped from the surface of the ground at the mine, and mixtures of magnesium sulfate, magnesium carbonate, and clay were dug from shallow pits and short tunnels nearby.

This output was sacked and hauled via the monorail to Magnesium Siding, and from there was shipped to a small plant in Wilmington for refining. This plant was designed to yield Glauber salt, light magnesium carbonate, and pharmaceutical-grade Epsom salts, but apparently never attained full production. A few tons of material was processed in 1927, but no output is recorded for later years. Operations evidently were halted because of severe competition from other companies engaged in extracting magnesium compounds from natural and artificial brines.

The monorail trestle vibrated under train after train during 1924 and 1925, when 12 to 15 men were busy at the mine. Although most of the routine operations were smooth enough, the line crews fought many bitter battles with the country. It seems ironic that, in a region where only one source of fresh water lay even near the line, virtually all the troubles stemmed from overabundance of water. Several cloudbursts in the Slate Range washed out sections of trestle on both sides of Layton Pass, and much fill was required to put the line back in service. A stubborn campaign was waged on the 8-mile tangents across Searles Lake, the normally dry bed of which was covered with as much as 14 inches of water after heavy and general storms in the region. Again and again parts of the trestle settled unevenly into the softened lake-bottom sediments. Riprap that had been installed during building of the line was strengthened with additional timber and hundreds of tons of rock before the grade could be restored and normal operations resumed.

Activities at the mine and refining plant never reached anticipated levels, and trips on the monorail became fewer and less regular after the summer of 1925. Finally, in June 1926, the mine was shut down and the last load of salts was eased down the wash below the camp. For more than 10 years the rusting rails and gradually disintegrating trestle lay quiet beneath the desert sun, and the few travelers in that wild country wondered whether the trains might operate again some day. The official answer came in the late '30's, when the rail was taken up and sold for scrap. The longitudinal timbers also were removed as salvagable material, and only the A-frames were left to mark the route of the "Epsom Salts Line."

Today there is little in the Crystal Hills to mark the ambitious beginnings of mining 30 years ago. Only a few stone foundations and scattered metal, bottles, and other litter remain at the site of the old camp; even the trestle of the railroad has been swept away and scattered far down the wash by the tumultuous waters of flash floods. A part of the old loading platform is still visible, and on it are ragged bits of burlap and several small piles of salts that never will reach a bathroom shelf.

In some places, particularly along the few and infrequently used routes of travel, the timbers of the A-frames have been used for firewood, or even have been carried away for re-use in buildings and mines. Elsewhere, though, many of the stout little bents still stand in an upright position, and resemble squat scarecrows, marching one after another through the sagebrush and across the desert gullies toward a distant skyline.

THE MONTH AT CALTECH

Caltech Movie

LAST MONTH THE INSTITUTE started work on a movie about Caltech, to be used for recruiting new students. The finished film should be between 20 and 30 minutes long, and is being shot in full color and with sound—to the extent that there will be a narration accompanying the action.

The picture is being produced by the American Releasing Corporation, a Hollywood commercial film firm—with occasional assists from Frank Capra, Hollywood producer and noted Caltech alumnus.

The film is intended to give high school students some idea about student life and work at Caltech, and to tell them something about its facilities and faculty.

Shooting is well under way on the film now, and should be largely completed within the next month. The film should be finished and ready to be shown early in the fall.

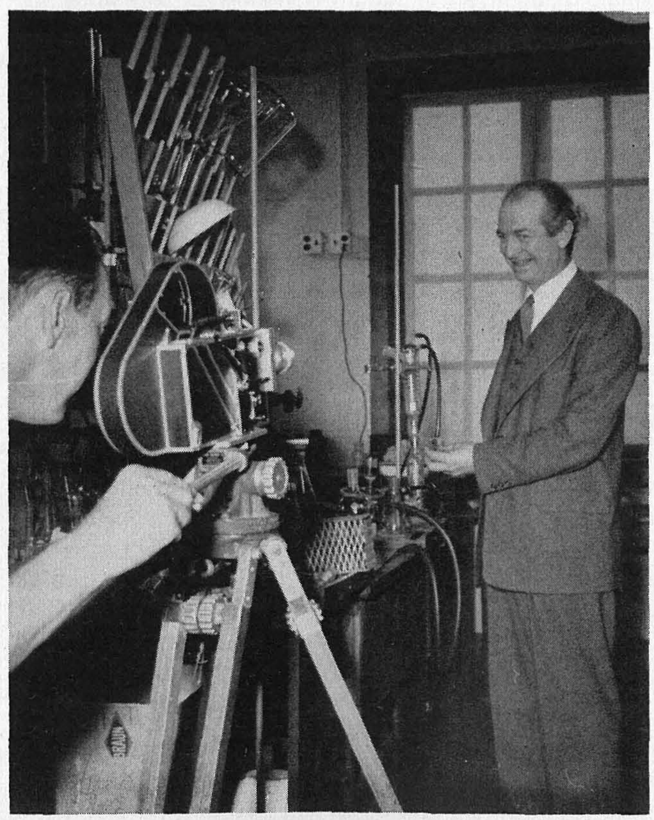
Visiting Lecturer

DR. ENRICO FERMI of the University of Chicago arrived at the Institute last month to deliver a series of special lectures in Physics on "Properties of Elementary Particles." Dr. Fermi's lecture series follows those of such other distinguished visiting physicists as Dr. I. I. Rabi, Executive Officer of the Department of Physics at Columbia University; Dr. J. Robert Oppenheimer of the Institute for Advanced Study at Princeton, N. J.; Dr. Robert Feynman (now a member of the Caltech faculty); and Dr. Hans A. Bethe, Director of the Laboratory of Nuclear Studies at Cornell University.

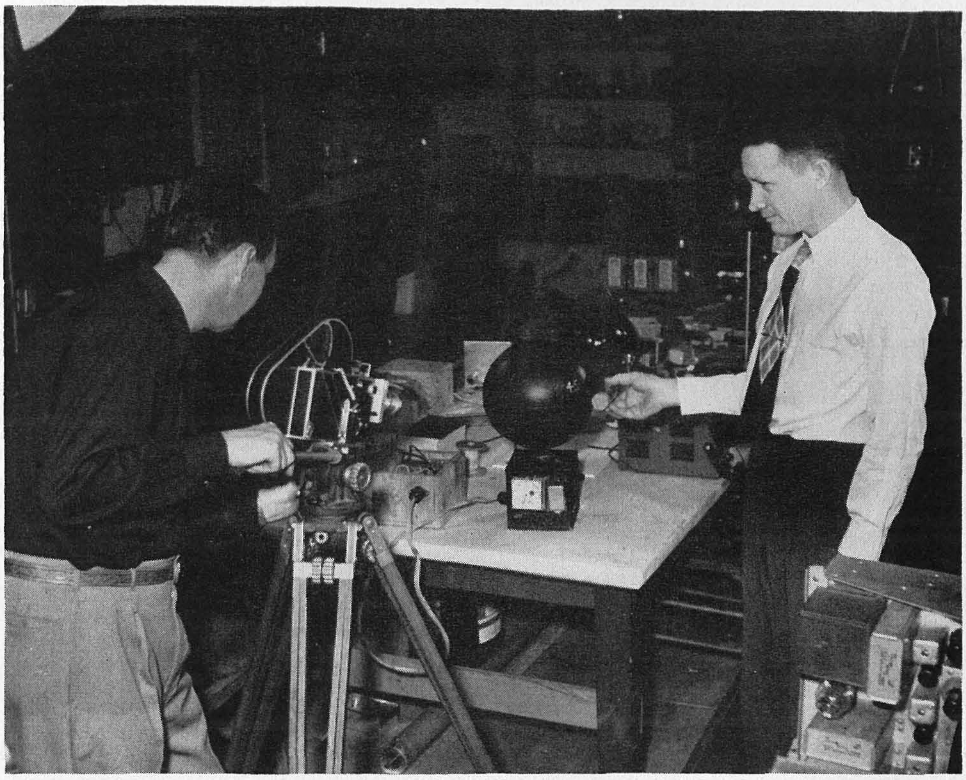
Dr. Fermi won the Nobel Prize in 1938, while he was at the University of Rome, for his discoveries of new radioactive substances which he found with the aid of neutrons.

Dr. Fermi later worked out the theory and design of the nuclear reactor, and helped supervise construction

Movie men move in on Dean Eaton's English class . . .



. . . and move on to Dr. Linus Pauling in the laboratory



Victor Neher demonstrates some of his cosmic ray research equipment for a scene in the Caltech movie

of the atomic pile at the University of Chicago, where the first controlled chain reaction took place in 1942.

"I have not the slightest feeling of guilt," Dr. Fermi remarked at a press conference held at the Institute last month, "concerning any part I may have played in creating the atomic bomb. Scientists can't help but make discoveries. You can't stop discoveries. Besides, any single individual can offer only so much of a contribution to the discovery."

Questioned about cosmic rays, Dr. Fermi, who is responsible for several cosmic ray theories, remarked that "although some cosmic ray energy definitely comes from the sun, it is probable that much of the radiation comes from the most distant stars, or even from remote space."

He maintains that the fastest cosmic particles must have been constantly accelerated for as long as 2,000,000,000 years to reach their present speeds.

"We can't control cosmic rays," he said, "or make better machines with them. But they constitute our sole hope of learning more about energies which are far

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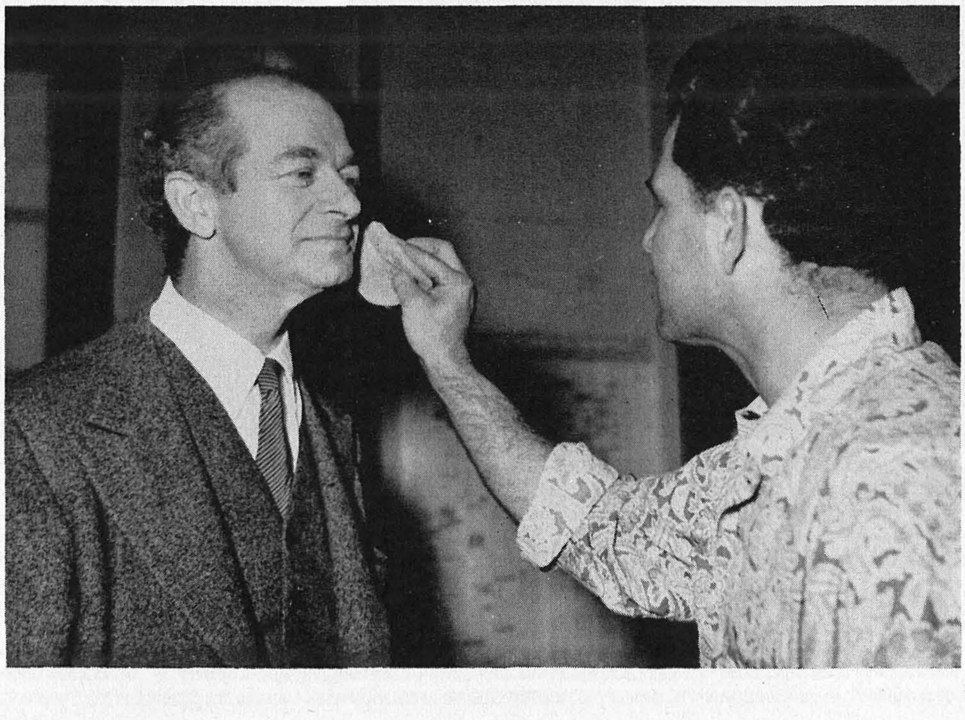
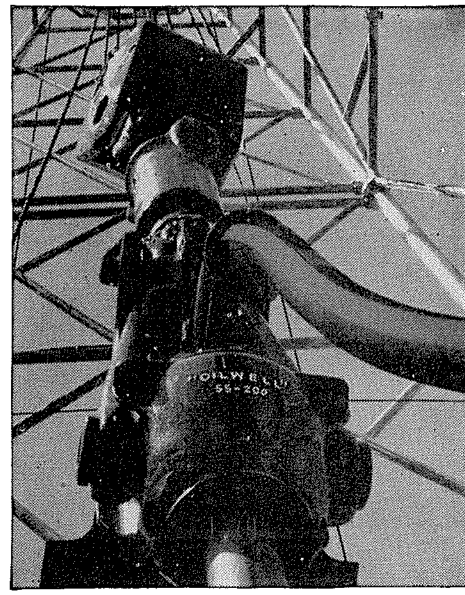


Linus Pauling gets the Hollywood treatment — an application of face powder before he faces the cameras

Only STEEL can do so many jobs

NINE TIMES THE DISTANCE TO THE MOON. Each year, it is estimated that America uses approximately 30 billion tin cans (in terms of an average-sized can) to protect food, oil, paint and hundreds of other products. Stack those 30 billion cans one on top of the other, and they'd stretch more than nine times the distance to the moon. A goodly percentage of these tin cans is made of U·S·S Tin Plate . . . steel with a very thin coating of tin.



MAN FROM MARS? No, it's an "Oilwell" Swivel and Rotary Hose . . . a common sight in the oil fields where they drill for the precious "black gold." Steel for oil-well drilling equipment like this is essential to building America's security. And U. S. Steel produces a great deal of it.

THESE PIPES CARRY COMFORT. You won't see them when the house is finished. They'll be buried in the plaster. But this National Steel Pipe for radiant heating will keep the rooms warm and uniformly comfortable, in the coldest weather.

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so well...

THE MRS. McGREGOR'S FAMILY NAIL BOX— a wide assortment of small size nails—is handy to have around the house for any kind of repair job from fixing Junior's fire engine to mending Dad's stepladder. Wire nails of all types are today making an important contribution toward helping to build a better America.

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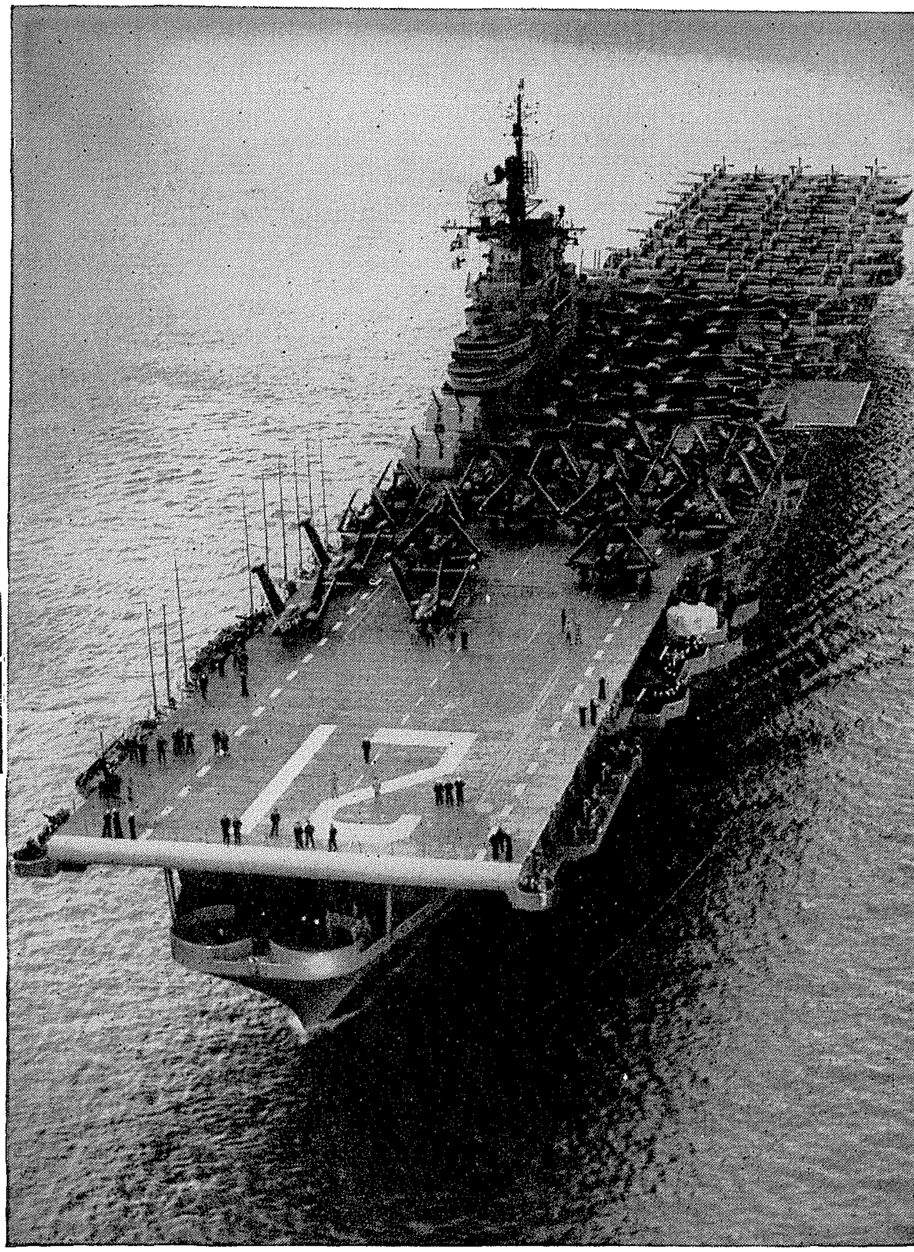
Every day, American steel mills produce enough steel to make all of the following:

1000 freight cars	2 cargo ships
2000 trucks	2 tankers
12,000 autos	500 tanks
2000 houses	500 airplanes
20,000 refrigerators	1000 anti-aircraft guns
20,000 stoves	1000 howitzers
1 aircraft carrier	2000 aerial bombs
2 heavy cruisers	500,000 3" shells

and have 23,000 tons of steel left over!

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★



SEA-GOING ROOST FOR WAR BIRDS. An aircraft carrier like this is an incredibly complex structure, made mostly of steel. The ship's plates, wiring, machinery, even the planes themselves, call for steel and more steel. Only steel can do so many jobs so well. And fortunately, United States Steel and the 200 other steel companies in America, can produce huge quantities of this vital metal . . . about 13 million tons more per year than the rest of the world combined.

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higher than we can hope to produce and study in laboratories. In the last 20 years cosmic rays have proved a limitless source of new discoveries about matter."

"The understanding of what goes on in the atom," Dr. Fermi said, "is a field we have barely scratched yet. It's rather amazing that we have been able to make this much progress toward harnessing the atomic nucleus with such a small amount of knowledge. There are so many new particles of energy and so many interrelationships between them that years of research are before us.

"We're only at the point earlier scientists were at when they were trying to understand the solar system without knowing much of anything about the nature of light and gravitation."

Atomic Energy Chairman

Dr. Robert F. Bacher, Chairman of the Division of Physics, Mathematics and Astronomy, has been appointed Chairman of the Committee on Atomic Energy in the Department of Defense Research and Development Board.

The Committee consists of four civilian and six military members who will assist the RDB in atomic energy aspects of the military research and development program. They will also coordinate the research and development activities of the Department of Defense with those of the Atomic Energy Commission—of which Dr. Bacher was the sole scientist member for two and a half years, before coming to Caltech in 1949.

JPL

Major General Elbert L. Ford, chief of Ordnance, arrived in Pasadena last month from Washington, D. C., accompanied by Brig. Gen. Merle H. Davis, chief of the Ammunition Branch, on an inspection tour of the country's 14 ordnance procurement districts. Major Ford took occasion to praise the Jet Propulsion Laboratory for the part it has played in the development of the guided missile program of the armed forces (see page 11)—and to remark that Caltech scientists, under the direction of Dr. Louis G. Dunn, director of the Jet Propulsion Laboratory, had "made an outstanding contribution to defense preparations."

Also last month residents of Pasadena, Altadena and La Cañada—in the areas adjoining the Jet Propulsion Laboratory—were aroused to the point of preparing petitions, demanding removal of the installation, because of the "unbearable noise" which comes from it.

Moving the lab—if such were possible—would cost between $30,000,000 and $40,000,000. If it were moved to an isolated area, it would lose approximately 50 to 75% of its technical personnel. Right now it has 699 people on its payroll—which amounts to something under $3,000,000 annually.

As a result of citizens' complaints, the Pasadena city board of directors last month toured the laboratory to see what caused the noise, how bad it was, and what was being done to cut down on it.

Unfortunately, the citizens themselves couldn't be shown around the facilities, because all work being done is for the military, and thus most of it is classified.

Dr. Dunn explained that he thought complaints had arisen because people don't know what's being done at the lab, pointing out that people tolerate bus, truck and plane noises because they know the source of the noise.

"But people don't know what we're doing here," he said. "They become suspicious and they object. Actually the noise from here, measured in decibels, is not nearly so loud as a passing car."

To deaden noise, the lab has already muffled all but two of its nine rocket motor test cells, and the wind tunnel is being soundproofed now. About $65,000 has been spent to date on noise studies and soundproofing. and the current $7,000,000 annual budget of the lab provides funds for a continuing sound-suppression program.

"I don't know what we could do to stop (the lab)," said Pasadena's Mayor A. Ray Benedict, after the tour, "—and I don't think we should try to. They're doing a good job, not only for America but for all the free people in the world. It's one of the most outstanding institutions of its kind in the United States."

Guggenheims

Four members of the Institute faculty received Guggenheim Fellowships this month, when the John Simon Guggenheim Memorial Foundation announced its annual fellowship awards.

Dr. Robert B. Corey, Professor of Chemistry, received a two-year fellowship to continue his investigations of the structure of proteins "by means of a complete X-ray diffraction study of wet crystals of lysozyme halides."

Dr. Albert Tyler, Professor of Embryology, was also granted a two-year fellowship for his studies of prolongation of the functional life span of spermatozoa and of the physiology of fertilization.

Dr. Sterling Emerson, Professor of Genetics, was granted a 12-month fellowship for his studies of interrelated gene-controlled reactions on the fungus Neurospora.

Dr. Arthur Galston, Senior Research Fellow in Biology, who has been on leave from the Institute since last summer to study in Europe on a Guggenheim, was granted a three-month renewal of his fellowship to continue investigations into the biochemistry of floral initiation.

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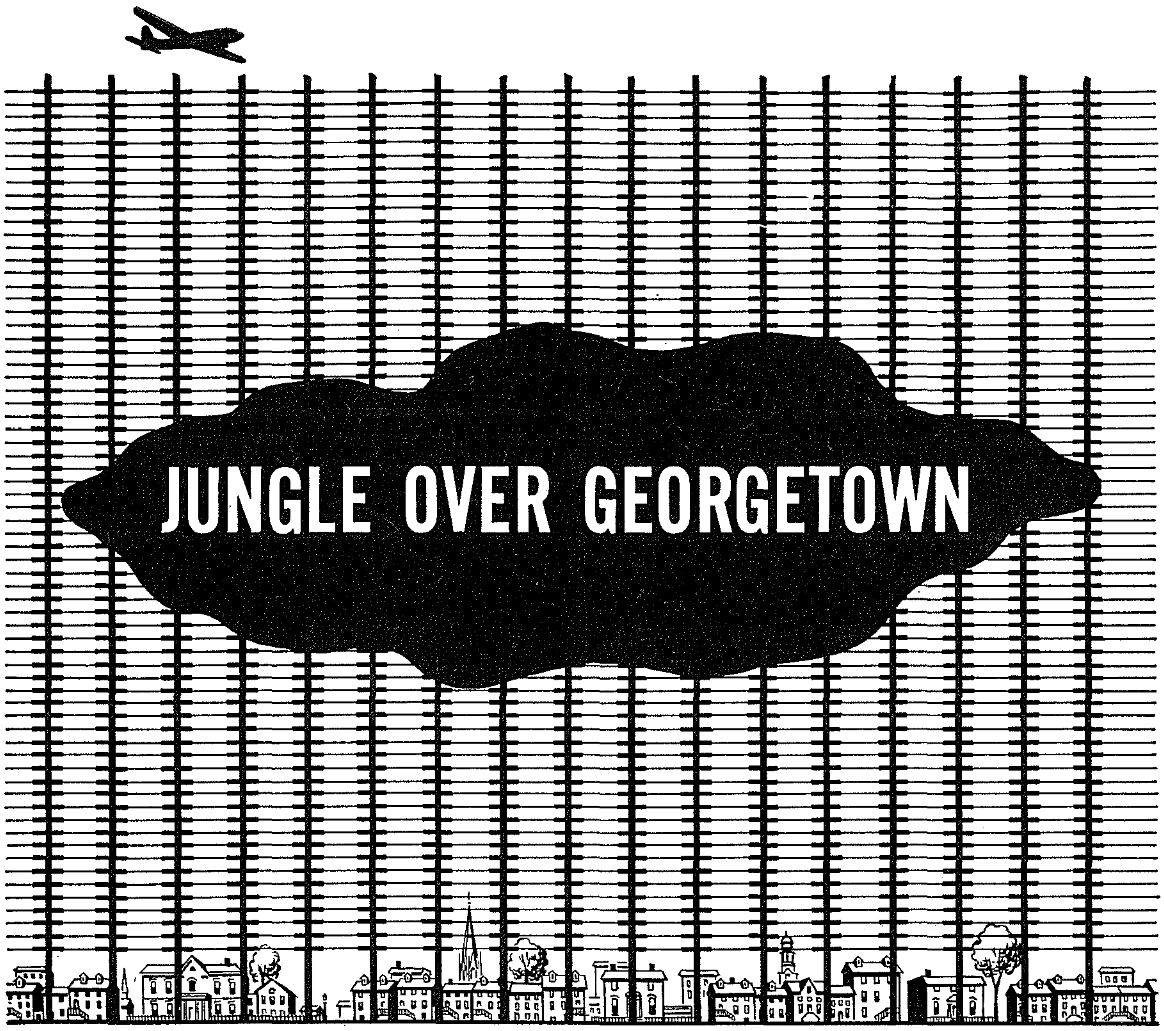


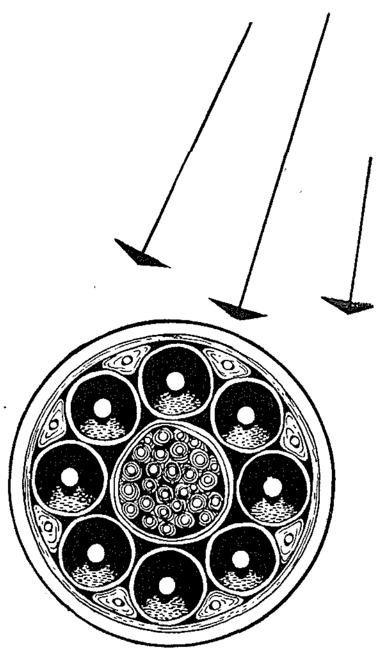
IF all the telephone voices
That ride together in one coaxial cable
Traveled as they once did
Over pairs of open wire,
The sky above Georgetown University,
In Washington, D. C.,
And over all the other points
Along our extensive coaxial network,
Would be a jungle of poles and wires.

• • •

Coaxial cable—no thicker than a man's wrist—
Can carry 1800 telephone conversations
Or six television programs
At the same time.

• • •

This cable is the product of
Years of continuous research and development—
And another example of the way we work,
Day in and day out, to make the telephone
An important and useful part of your life.



In the old days, it would have taken a pole line over 700 feet high to carry all the conversations that can go through a 2½-inch coaxial cable.

BELL TELEPHONE SYSTEM

Cancer Grants

GRANTS-IN-AID totalling $21,750 were awarded to three Institute scientists by the American Cancer Society this month.

DR. HENRY BORSOOK, Professor of Biochemistry, was given $10,000 to be used in his work on biological synthesis of proteins using radioactive istopes.

DR. JAMES BONNER, Professor of Biology, received $7,000 to further his research on the biochemistry of plant tumors.

And DR. SEYMOUR BENZER, American Cancer Society Research Fellow in Biology, received a $4,750 fellowship to study under Dr. Andre Lwoff at the Institut Pasteur in Paris.

Smog and Health

THREE INSTITUTE FACULTY members have been named to a new 16-man Los Angeles County Medical Commission to study the effects of smog on health: Dr. George W. Beadle, Chairman of the Biology Division; Dr. Frits Went, Professor of Plant Physiology; and Dr. C. A. G. Wiersma, Professor of Physiology.

Appointment of the commission followed a recommendation for such a study by the Los Angeles Medical Association, after a survey of its members recently revealed that 2,651 out of 2,803 doctors found reason to believe that air contamination was responsible for creating, or aggravating, ill health in this area.

Honors and Awards

DR. ROYAL W. SORENSEN, Professor Emeritus of Electrical Engineering, has been elected an honorary member of the Institute of Electrical Engineers of Japan. He was recommended for the honor by the American Institute of Electrical Engineers when the Japanese society asked for the name of "a noted American scientist or engineer closely connected with AIEE . . . who had an interest in Japan."

Dr. Sorensen, who organized Caltech's electrical engineering department in 1910 and headed it until his retirement last July, was president of the AIEE in 1940-41. He visited Japan in 1947 as the engineering member of a six-man scientific advisory group appointed by the National Academy of Sciences at the request of the federal government.

Others who have received this honor from the Japanese society are Thomas A. Edison, Frank B. Jewett, Irving Langmuir, Elmer A. Sperry and A. E. Kennelly.

DR. EDWIN P. HUBBLE, staff member of the Mt. Wilson and Palomar Observatories, will deliver the R. A. F. Penrose Memorial Lecture at the general meeting of the American Philosophical Society in Philadelphia, April 19-21. He will speak on "Explorations in Space: The Cosmological Program for the Palomar Telescopes."

Wanted: *More Green Thumbs*

IN A WORLD faced with constant food shortages in so many countries, more "green thumbs" are needed!

Here in America, modern agricultural methods have increased farm production 60% in the past generation—even though today there are 20% fewer workers on the farms. This increased yield means plenty of food for every one here—and more besides. And the same methods, applied in other countries, would help answer world food needs.

Better seed, fertilizer, and new scientific methods play their part. Equally important are the various chemicals that now fight off blight, disease, and destructive insects. Starting before planting and continuing until the food is ready for our tables, hundreds of new materials increase and protect our food supply.

Even after harvest, man-made agents speed the ripening process. Others guard our food against rodents and insects.

The people of Union Carbide help make possible the high productivity of America's food producers by supplying chemicals for fungicides and insecticides, gases for ripening and preserving, and the stainless steel so important in the preparation and distribution of food. If you have a materials problem, in this field or other fields, it is quite likely they can help you also.

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THE ECONOMY RUN

A report from one of Caltech's student observers

by WILLIAM V. WRIGHT

EARLY LAST JANUARY Caltech senior Mechanical Engineering students trooped into Peter Kyropoulos' Hy II lab expecting to begin the usual grind of lab tests and reports for the next ten weeks. To their surprise they found an opportunity to become AAA (American Automobile Association) official observers for the Mobilgas Grand Canyon Economy Run, and the door was opened for an exciting and interesting experience to give these boys a lift from the usual routine.

After last year's Economy Run, A. C. Pillsbury, Regional Director of the Contest Board of the AAA, decided that a new system of appointing impartial observers for the event was in order. Mr. Pillsbury, a graduate of MIT, has a high regard for the honor system and its operation. He reasoned that CIT students would be the most impartial, objective, and honest men for the job.

The Institute approved the idea, but it was not made an official function. Students had to take their own time off for the job and make up all work missed.

The purpose of the Mobilgas Grand Canyon Economy Run is to measure the gasoline mileage for stock 1951 model automobiles of American manufacture on an 840-mile indirect trip from Los Angeles to the south rim of the Grand Canyon, through Death Valley and Las Vegas.

The trip duplicates, in two days, all the conditions the average motorist will encounter in a full year's driving. Altitudes vary from 280 feet below sea level to 7,005 feet above. Temperatures may range from below zero to the high eighties. There are 70 miles of city driving, 345 miles of mountain driving, and 425 miles of level driving.

To insure that the cars are stock, they are picked at random from manufacturers' assembly lines and impounded by the AAA Contest Board. From that time on the car is driven only while an AAA observer is along—and this is where the Caltech students come in.

One observer rides with each car during the break-in period (4500-miles maximum), and during the final run. He must see that the car is not tampered with in violation of AAA regulations, that it is not driven in a "trick" manner, and he must record everything that happens in connection with the car while it is under his observation. For this he receives 10 dollars a day and his expenses.

During the break-in period (January 20 to February 23) about 60 students took one or more trips, from one to five days long, to the far corners of California, Arizona, and Nevada.

This was quite an experience for the fellows. They rode usually with two or three other people, including the driver and representatives of the manufacturer or dealer entering the car. These people know all the ways to get extra economy from an automobile, including illegal ones like putting additives in the gas tank or crankcase or tampering with the carburetor or manifold.

For many of these men, winning the event meant promotion and bonuses, while losing it meant demotion or losing their jobs. It was the responsibility of the CIT students to see that no illegal work was done on the cars at any time. They had lead wire seals which were applied to all engine openings, gas tank openings, the hood and the doors. They had to make sure that none of these seals were broken or tampered with. They had to record where the cars went, where they were fueled, and everything that was done to them enroute.

Considering that some of the cars covered 2,500 miles in five days at a stretch, the boys had quite a time. Some of them felt like WCTU members in a brewery.

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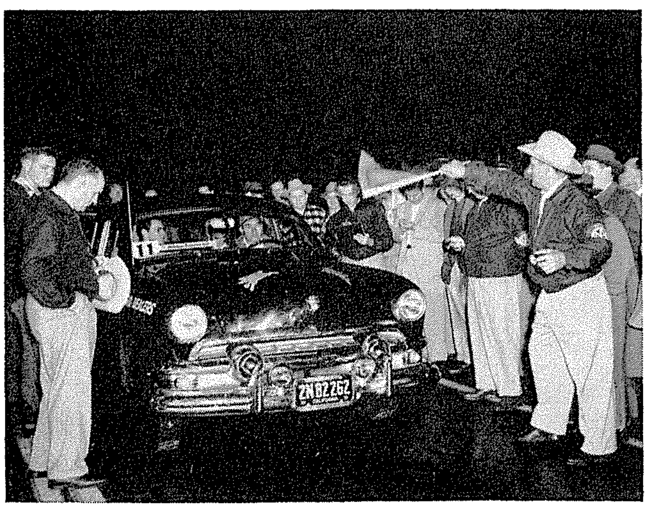

Start of the run—3 a.m. March 6, downtown Los Angeles

ECONOMY RUN . . . CONTINUED

But they travelled through some of the most scenic country of the west, stayed at the finest hotels, and occasionally sampled some of the more virtuous diversions of Las Vegas. This, after all, was a pleasant sojourn from the rigors of campus life, even though nerve-racking and tedious at times.

As the time rolled around for the final run the fellows burned plenty of midnight oil making up work they had missed. The run came on the week before finals and lasted from Tuesday, March 6 to Friday, March 9.

At 7 o'clock Monday evening, March 5, 19 CIT students went to the General Petroleum garage—the starting point—in L. A. to observe the fueling and preparation of the cars for the run. At 1 o'clock Tuesday morning 32 more students arrived. They were the riding observers for the run. They were furnished with official armbands, windbreaker jackets, and kits containing special instructions and information. They were then assigned to their cars—the assignments being secret until then.

The first of the 32 cars entered in the run started at 3:00 A.M. on March 6, with the others following at two-minute intervals. Each car follows exactly the same route, and must arrive at Las Vegas (at the end of the first day's travel) in 13 hours 30 minutes elapsed time. At no time during these 13 hours 30 minutes may the observer leave the car. Actually he is with the car about 15 hours without relief, and during this time he must be constantly watching for any trick driving or unusual occurrences which might give one contestant an unfair advantage. He must see that all speed limits and other traffic laws are strictly obeyed. Above all he must not go to sleep—and this is pretty hard not to do on a continuous 15 hour journey at moderate speed.

The first refueling stop came at Lone Pine, Calif., about five and a half hours from Los Angeles. Here the observers had to watch the refueling operation and resealing of the gas tank by AAA officials, and record the amount of gas taken on.

From here the cars proceeded across the Argus and Panamint ranges to Death Valley. On the long downgrades from Argus Pass and Townes Pass the drivers in over-drive equipped cars are permitted to use the free wheeling available with these units. Speed limits are enforced to keep the drivers from ignoring all safe and sane driving judgement, but even so, many observers grew a little grey going around sharp mountain turns on screeching, smoking tires. The situation got a little more tense when brakes began to get hot and fade out, but fortunately the only casualties were a few brake linings.

The cars wound through Death Valley for several hot uncomfortable hours, passing the lowest elevation in this hemisphere (—279.6 ft.). 13 hours and 30 minutes out of L. A. the cars reached the quiet, peaceful health resort of Las Vegas, Nevada. Here the cars were parked in a special impound area, and guarded all night by AAA officials, and the 19 non-riding observers mentioned earlier. Meanwhile the 32 riding observers were relieved (at last!).

That night while the 19 non-riding observers were guarding the cars, the other men were busily visiting the museums, art galleries, concert halls, and other cultural spots for which Las Vegas is so well known.

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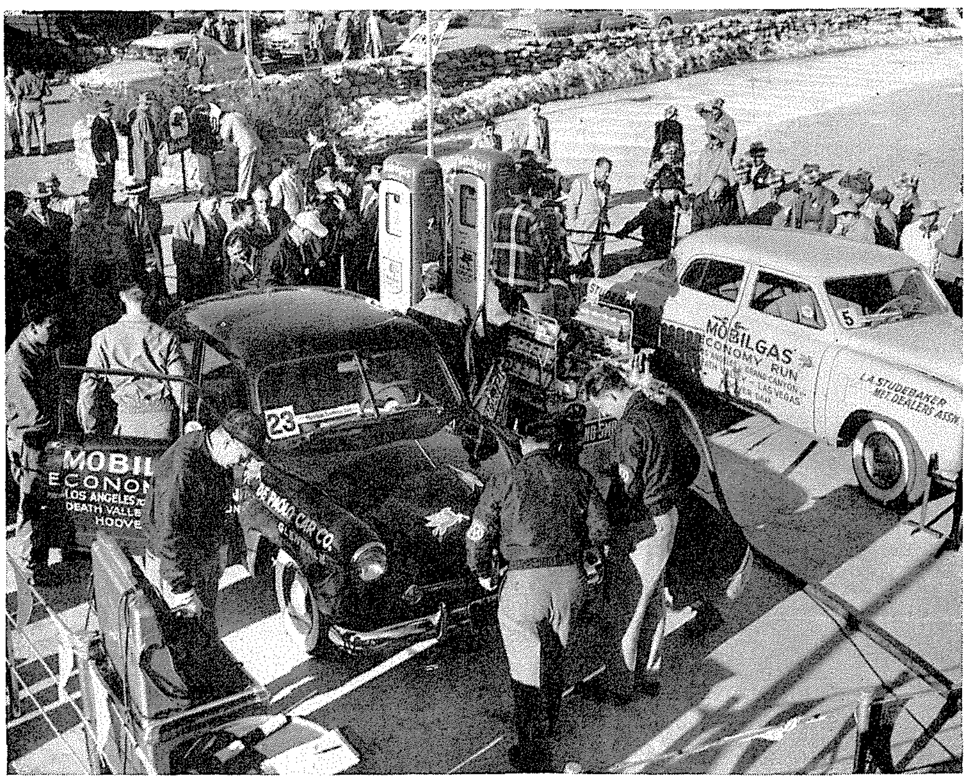
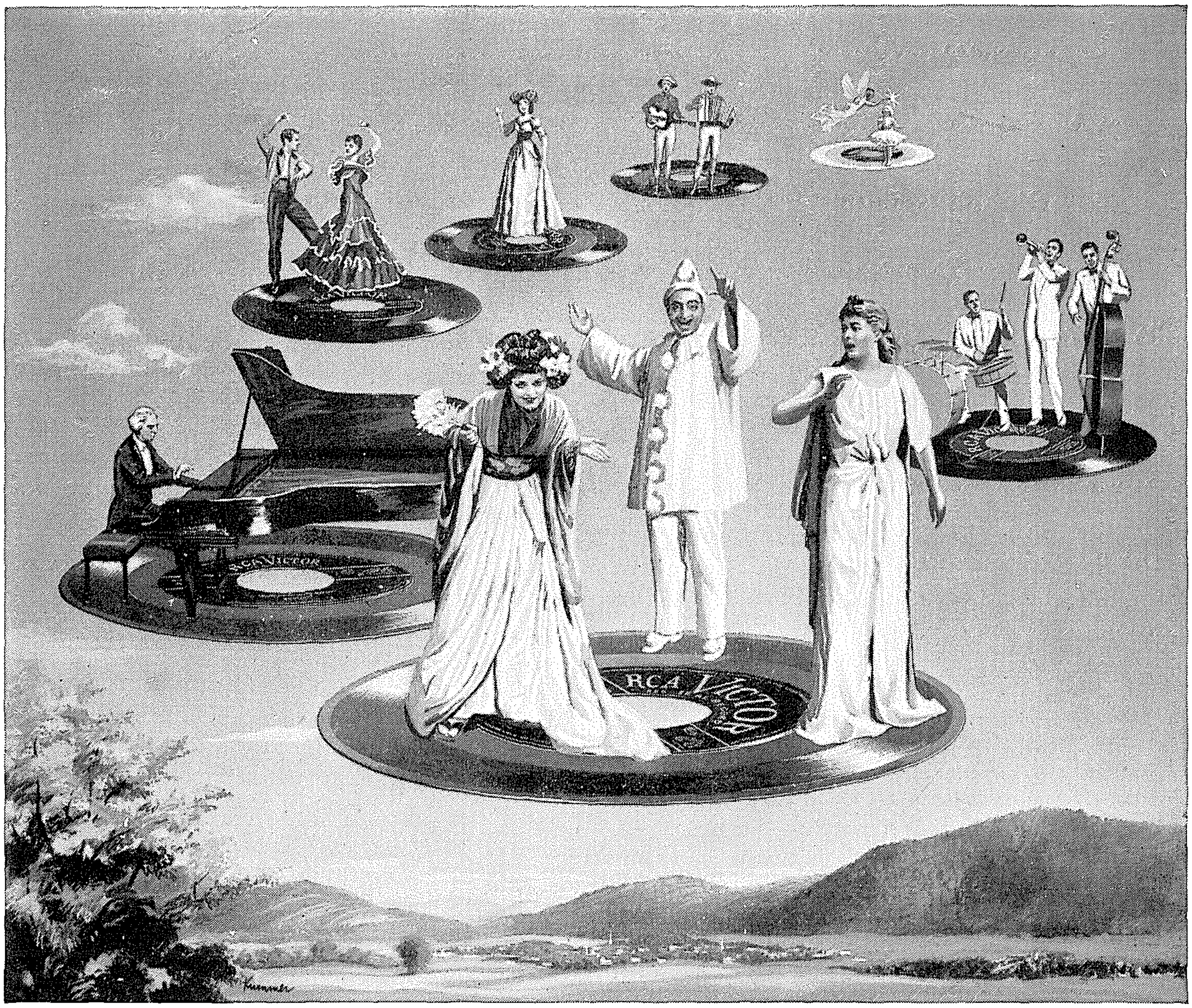


End of the run — 4 p.m. March 7, the final refueling station at the southern rim of the Grand Canyon



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A treasury of Music's Immortals

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ECONOMY RUN . . . CONTINUED

This intellectual activity was so engrossing that some earnest students did not retire until early morning.

Arising at the happy hour of 5:30 on Wednesday morning the fellows ate breakfast, showed up at the impound area at 6:30 A.M., and were reassigned to different cars. After refueling, the first car left at 7 A.M. and the others followed at two minute intervals. An hour's drive brought the cars to Hoover Dam, which is still called Boulder Dam by the residents of Boulder (Hoover) City (Democrats). Crossing the massive structure the boys reverently bowed and kissed their slide-rule cases.

The caravan proceeded through Arizona toward the Grand Canyon via Kingman, Seligman, and Williams, Arizona. It is interesting to note that one of the highest tributes of faith, trust, and confidence was paid us by the State of Arizona. They allowed the cars to pass through the Arizona Agricultural Inspection Station on the strength of a mere certificate stating "This car does not carry any fruits, honey, plants, shrubs, or bulbs in violation of Arizona State Law." This was signed by the driver, riding observer, and Contest Board AAA official in charge of state affairs. Fortunately, the President's signature was not necessary—an amazing example of trust in these troubled times.

The drive through Arizona was relatively pleasant and short. The cars arrived at the south rim of the Grand Canyon 7 hours and 25 minutes after leaving Las Vegas. The total elapsed driving time allowed for the 840 mile trip from Los Angeles was 20 hours and 55 minutes, or an average speed of 40.16 mph. The payload for the trip was accurately set at 750 pounds, made up of the observer's, driver's, and passengers' weights, plus lead to make up the difference. The cars were accurately weighed before the run started, so that final results could be computed on the basis of ton-miles per gallon.

At the Grand Canyon the cars were carefully topped off. This consists of painstakingly filling the gas tank to a predetermined level in the filler tube neck. This was also done at Los Angeles before the start. The cars are carefully leveled by jacks during this operation so that refueling conditions will be identical. By adding the exact amount of gasoline taken on at the Grand Canyon to the amount taken on en route, the total gasoline consumption can be computed to within a thousandth of a gallon.

After refueling, the cars were impounded and carefully checked by AAA mechanics to see that no seals had been broken, and that the car had not been tampered with during the run. The observers' written reports were carefully read to see there had been no infraction of the rules.

Caltech Observer Jens Stavnes, records gas consumption of the Nash Rambler at the end of the run

The wind-up

While the final checking of cars and data was keeping some of the officials busy most of the night, the canyon was bursting with activity. Several hundred people, including top executives of General Petroleum and the nation's auto industry, had arrived by plane, bus, and special train. There were dinners, speeches, and private parties testifying to the importance of this event—which is considered second only to the classic Indianapolis Memorial Day race in the automotive industry.

Above this atmosphere ran a hum of speculation. Rumors went around about the performance of the entrants, and several contestants were considered favorites during the evening. Most of the observers, thoroughly worn out, retired from the scene for a good night's rest.

At ten o'clock Thursday morning, March 8, the official results were read. To Caltech's credit the observing job was well done; not a single protest was lodged by one contestant against any other contestant for the first time in several years.

Dr. Kyropoulos, the AAA technical advisor for the trip, returned to Las Vegas with the Sweepstakes-winning car for a thorough check of its parts. The observers boarded a train at the Grand Canyon, Thursday night, for the return trip to Pasadena. They had spent the day sightseeing in the Canyon.

The 51 Beavers rolled home that night with mixed emotions. They were tired, both glad and sorry it was all over, and faced the dirge of finals the very next week. But they were unanimous in feeling it was one of the most interesting experiences of their CIT careers.

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HOW COULD THE UNITED STATES BEST UTILIZE ITS COLLEGE-LEVEL ENGINEERS AND SCIENTISTS DURING A NATIONAL EMERGENCY?

by BOYD ISRAELSEN

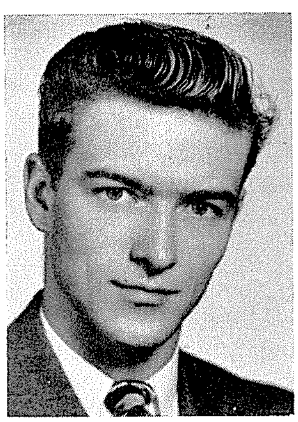
In any attempt to formulate a plan for the effective use of this country's scientific and engineering manpower during a national emergency, a logical first step would be to determine the nature of that emergency. In essence, it appears to be this: we stand opposed by a concept of economic and social organization that is diametrically opposed to our own. An eventual conflict between the two appears inevitable, but at present the nature and time of that conflict are indeterminate. It may consist of a long period of preparedness with varying degrees of open hostility, or it may take the shape of a full-scale war in the relatively near future. Our plans must be such as to meet any eventuality.

In terms of sheer manpower we cannot hope to outweigh the enemy. Our course, rather, should be that of using the individual in the most effective manner possible. Inasmuch as scientific and technological skills are our most critical, and in view of the inseparable link between technological advance and military success, the need for a carefully worked-out plan for using these skills is obvious.

The operation of any such plan depends on a continuing flow of men through our scientific and technical institutions and naturally must include provisions for maintaining that flow. In this connection it might be well to consider some figures recently compiled by the manpower committee of the American Society for Engineering Education. In 1948 (the peak year) enrollment in the engineering schools of the country reached 226,000. Last fall it was 130,000, and within two years it is expected to drop to 30,000. Barring intervention by Selective Service, it is expected that 32,500 engineers will graduate in 1951, 21,900 in 1952, 17,000 in 1953, and 12,400 in 1954. This against an estimated minimum need of 30,000 per year. Clearly the situation has grave implications, especially when coupled with the shortage of highly trained manpower resulting from World War II.

The problem, then, is not only one of maintaining the flow of men in scientific and engineering training but of increasing that flow when necessary. And here it must be viewed in its relation to the mobilization effort as a whole. The universities and the proposed 3-million-man army both depend primarily on the same source of manpower—the high school graduates. Hence some means must be devised for determining who will go on to school and who will serve in uniform. A qualifying examination would offer the simplest and fairest solution. The Army General Classification Test might be used. College Entrance Board examinations and pre-engineering and pre-science inventories offer other possibilities. Those achieving scores above a certain standard to be determined would then be at liberty to enter the institution of their choice and continue on to graduation, subject, of course, to their maintaining satisfactory grades. Those men who are qualified and who desire to

CONTINUED ON PAGE 38



Boyd Israelsen '52 is winner of this year's Tau Beta Pi essay contest at Caltech. His entry appears on these pages. The contest is an annual event in Tau Beta Pi, national honorary engineering society. All new pledges to the society are required to enter the essay contest, writing on an assigned topic. Winning essays from local chapters go on to Tau Beta Pi national headquarters to compete for nationwide honors.

UTILIZE SCIENTISTS? . . . CONTINUED

pursue graduate work should certainly be permitted to do so.

Unquestionably many of those passing the qualifying examination would be unable to enter college for financial reasons. It is recommended that in such cases some form of assistance be made available, similar to that afforded veterans under the GI Bill. From the standpoint of national well-being, money thus spent would be an excellent investment.

An essential part of this plan is that fundamental research, as well as those phases of technology bearing directly on contemporary military needs, be not only continued but strengthened. This applies to fundamental research in all fields of scientific endeavor. A program which would sacrifice long-range scientific development to current expediency or attempt to predict from which facet of fundamental research the next "super weapon" would devolve, with consequent neglect of other facets, would be not only foolish but highly dangerous. Again, on an individual level, the aim must be not to produce highly specialized technicians but engineers and scientists with a broad, solid foundation of knowledge. A restricted range of training would inevitably result in the crippling of adaptability and insight.

With a steady flow of trained manpower thus assured, the other aspect of the problem is that of proper utilization of this training. To effect this, some type of advisory board, consisting of representatives of industry, government, and education should be set up. The board would keep the educational institutions informed as to the current scientific and engineering manpower needs of industry, at both the B.S. and the advanced degree levels. The needs of government research and development laboratories as well as those of research projects of the universities themselves would be taken into account. This arrangement would bring about a proper distribution of talent between essential civilian and military production since the board, knowing both the supply and the demand in each field, could work out the most favorable balance.

In so far as possible, the scientist or engineer should be allowed to choose his own position. Should this arrangement prove unsatisfactory, however, the board should be given authority to place men where needed. This restriction on free choice of a position, should it be necessary, is still a minor sacrifice compared with those demanded of men put in uniform. It follows as a necessary consequence of the principle of most effective utilization of every individual's particular talents, a principle adopted in the interest of national survival.

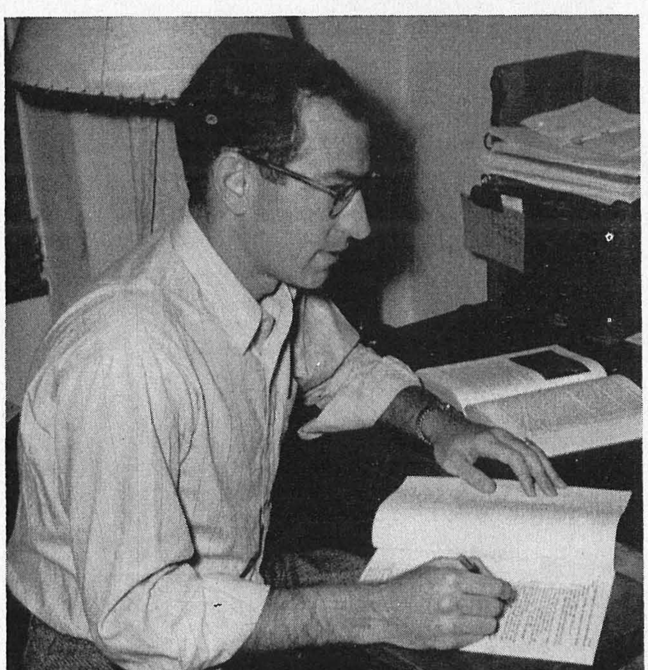
THE BEAVER

Some Notes on Student Life

TECHMEN SLAMMED SHUT the books, forgot the formulas, and washed the glassware that had occupied them during the second term, to be greeted by what first seemed like a warm and welcome spring. As their hearts warmed up and their brains thawed out, they realized that this Easter vacation did not herald an ordinary spring. The seniors were faced with vague question marks hanging at the end of their one remaining term of college life: grad school? . . . the draft? . . . essential industry? . . . The undergrads found that other students their age and sex were far more worried about military service than they were—perhaps because life at Tech leaves little time for pessimism. But Tech leaves little time for optimism, too, and many were shocked to realize that the possibilities of conscription and war they had considered in Current History were grim reality at least in the worries of the people outside.

Private Enterprise and History

Every year freshmen and sophomores at the Institute have been reading, outlining, and carefully memorizing from eighty to one hundred pages of history per week. While in the throes of this tedious process last year, some enterprising freshmen conceived the idea of pooling their resources of time and energy: some of them would read and outline the required material carefully and concisely, while others would be responsible for the printing and distribution of the outlines.



Sophomore George Moore, one of the originators of the history outlines, studies American history with his outline for the week. He got a B in history last term.

The simple economic laws of monopolistic expansion and supply and demand could not long remain inoperative in such a situation, and soon other freshmen expressed an interest in the outlines and a willingness to join the group. The efficient division of labor into reading and outlining, printing, and distribution became a weekly practice for the group, as the popularity of the outlines steadily grew. The system flowered into a big business, and the original group pronounced itself a pseudo-corporation.

Now that the originators of the idea are sophomores (none of them failed freshman history), they are extending their system to cover the sophomore history course. These sophomore outlines, which are distributed at the beginning of each week, and copies of last year's freshman outlines are currently being sold at a price of $1.25 for a one-term subscription. Optimistic rumors suggest that about one hundred members of each of the two classes now subscribe to the series.

The general attitude of the history instructors is that the important thing is to learn history—with or without these or any other kind of outlines. But the instructors fear that the students may come to rely upon the outlines to the extent of neglecting their assigned reading. The entrepreneurs counter that the outlines, which generally run about six pages of concisely mimeographed sheets per week, are intended only for the purpose of reference and review, and that their main purpose is merely to save the students the time spent in writing up their own notes. And besides, they add, continuous reading of the texts without the disturbance of stopping to jot down points every few minutes will allow the student to appreciate the smooth continuity that the texts are purported to have.

Perhaps some of the memory courses will provide a fertile field for expansion. It is rumored that the combine may extend its activities into engineering courses. Although it is unlikely that we have here the beginnings of a major crisis in education, the main protagonists are maintaining a tight-lipped secrecy. The instructors have no comment concerning the possibility of changing textbooks, or the choice of examination questions; and the advocates of the outlines offer no data correlating subscriptions with grades.

A Chemist and an Engineer

Six hundred forty delegates from 35 states and 133 college chapters of Pi Kappa Delta, National Forensic Fraternity, converged upon Oklahoma A. & M., Stillwater, Oklahoma, for the 17th national convention of Pi Kappa Delta, one of the two top-ranking national debate tournaments. Among these were 110 men's debate teams, composed almost entirely of political science, pre-law, and other liberal arts students who had come to debate . . . "Resolved: That the non-Communist nations should form a new international organization." But with them were a junior mechanical engineering student, a senior chemist, and their debate coach from Caltech—Stan Groner, Ulrich Merten, and Dr. Lester L. McCrery, respectively.

After eight debates, the team of Groner and Merten had won seven and lost one, thereby gaining a rating of superior, the highest rating awarded at the tournament. They returned with appropriate medals and the interesting report that some people on the Oklahoma A. & M. campus were seen with slide rules affixed to their belts.

Biologists Arise!

Small classes and intimate contact with instructors are not guaranteed assets in pursuing an education, but an illustration of how the unique opportunities at Tech can be most effectively exercised was recently provided by the undergraduates and faculty members in the biology division. The faculty and many of the students sensed that the sequence of courses in the undergraduate biology curriculum could be revised and reintegrated to form a more unified whole in relation to themselves and the surrounding context of chemistry courses. On their own initiative, the undergraduates polled each other, juggled units and requirements in the Institute catalogue, and proposed a new system to the faculty.

The new system, with minor changes, was accepted and endorsed by a special committee of the biology faculty. The changes have enabled the biology curriculum to achieve three main goals: courses in plant biochemistry can make the most effective use of the background furnished by chemistry courses; pre-medical students can satisfy the requirements for medical schools in only three years of undergraduate work at Tech without having cramped or overloaded schedules; and biology undergraduates will enjoy a wider choice of courses and more electives. Less important than the nature of these specific changes, however, is the way in which they were initiated.

—*Al Haber '52*

ALUMNI NEWS

Family Day

SUNDAY, MAY 20, has been set aside as the date for the Alumni Association's annual Family Picnic. Last year and the year before the Association ran inspection trips to Inyokern and Palomar, respectively. Also, for the past two years the Association has held an annual stag Field Day. This year's Family Picnic combines the best features of these other functions.

Family Day will be held at the Munz Lake Resort, just west of Palmdale, where there are facilities for swimming, fishing, boating, softball, and barbecuing. Full directions for reaching the picnic grounds will be sent out shortly to all alumni.

Directory

THE 1951 ALUMNI DIRECTORY is now due to be mailed out early next month. It's the first directory to be issued since 1948, has been under the supervision of John Sherbourne, Alumni Association Director in charge of the project.

Help Wanted

MEMBERS OF the Civil Engineering staff at the Institute are receiving a number of requests to recommend men for positions. Several of these requests have been in connection with positions requiring substantial experience, and involving corresponding responsibility.

Such requests are always referred to the Placement Office at the Institute—but the number of men listed with Placement is pretty limited. This note is being run, therefore, to urge any men who may be willing to consider changing positions to make such willingness known to the Placement Office. Both the Institute Staff and the Placement Office take satisfaction in helping prospective employers engage well-qualified Tech alumni.

Chapter Note

THE CALTECH CLUB of New York held a dinner meeting on April 2 at Whyte's Restaurant to hear Dr. Bruce Sage, Professor of Chemical Engineering at the Institute, talk on "Current Activities at Tech."

PERSONALS

1900

Leonard E. Davidson, retired school teacher and resident of Oakland, Calif., passed away May, 1950.

1919

Fred A. Marshall writes from Los Angeles that he is sales representative for the Western Division of the Axe Securities Corporation, one of the largest and oldest investment management and counsel organizations operating on a national scale in the United States.

1921

Edward L. Champion, vice president of Gibbs & Hill, Inc., Consulting Engineers, New York City, since 1940, assumed charge of the company's West Coast activities on December 18 in Los Angeles. Ed returns to California after 25 years of engineering service in the utility and industrial fields in the U. S. and foreign countries.

1922

William D. Potter writes from Washington, D.C., to report his first grandchild, John Martin Whalen, born March 18. Bill thinks he's going to enjoy being a grandfather, and doesn't feel a day older yet.

1924

Carl F. Eyring, professor of physics and mathematics and Dean of the College of Arts and Sciences at Brigham Young University in Provo, Utah, died January 3rd of a cerebral hemorrhage. He had served on the faculty of Brigham Young University since 1912, and was a Fellow and former President of the Utah Academy in 1923. He was the vice-president of the Accoustical Society of America at the time of his death, and was a member of the American Physical Society.

1925

Cdr. Clarence A. Burmister writes from Washington, D. C., that he was recently presented with the Department of Commerce Award for Meritorious Service, for outstanding improvements in hydrographic surveys by the use of electronic control systems. At present, Clarence is with the Chief Radio-Sonic Laboratory, U. S. Coast and Geodetic Survey.

1926

Allen L. Laws has been with the Southern California Edison Company since 1923. In 1933 he was named assistant to the new business manager at the general office. He was advanced to power sales engineer in 1938, and was appointed district manager at Vernon in 1941. Since 1946, he has been assistant commercial manager, and has just recently been made district manager in Alhambra.

Joseph Matson, Jr., living in Waialua, Hawaii, writes that he has the same job—that of Civil Engineer for Waialua Agricultural Co., and his outside activities include holding the offices of Vice-Commander (Post 5) Dept. of Hawaii, American Legion, and Chairman of the local district disaster relief agency.

1927

Charles L. Gazin, M.S. '28, Ph.D. '30, curator of the Division of Vertebrate Paleontology of the Smithsonian Institution, was speaker at the March 28 meeting of the Panama Canal Natural History Society —the subject, Fossil Bones from Ocu and Pese, Panama.

Edward M. Browder, Jr., writes from the Panama Canal Zone that he is now Assistant Engineering and Construction Director of the Panama Canal. Ed has two sons, Edward, Jr., 17, (who hopes to get into Tech next fall) and William, 7.

Layton Stanton, Ph.D. '31, now in Sacramento, California, writes that he is still a geologist for the Union Oil Company in charge of exploration work in northern California. His two daughters, Sandra and Kay, are in senior and sophomore classes in high school, respectively.

Thomas S. Southwick, M.S. '29, has been with the U.S. Weather Bureau since 1931, except for four years spent with the Corps of Engineers at Ft. Belvoir and New Guinea. Tom is currently in charge of the Station Facilities Section of the Weather Bureau in Washington, D. C., and is living in Falls Church, Va., with his family.

1929

Charles Bosserman, of Seattle, along with his family—wife, two sons and a daughter—toured the U.S., on an 8,000 mile trip, last summer, on the extended vacation plan for employees of Boeing Aircraft who have been with the company for ten years or more.

William H. Mohr, M.S. '30, is on active duty at Fort MacArthur as a colonel with the Boat and Shore Regiment of the 370th Engineers. Bill's father, known to many of his classmates, passed away last month. He had served with the Santa Monica Fire Department for thirty-nine years, and was chief for sixteen years until his retirement.

1932

Paul G. Burman writes from Springfield, Mass., that after ten years as Engineer in Charge of the Fuel Injection Laboratory of the American Bosch Corporation, he has been appointed Section Engineer on special assignments. In this capacity he is engaged in development and consultation with various engine companies and power plants in the U.S. and Mexico. In his spare time, Paul is busy as president of the local camp of Gideons International.

Clifford C. Cawley, from Sharon, Mass., tells us that his book of short stories, *No Trip Like This* was published in March by House of Edinboro, Boston.

1933

Andrew Ashton, writes that he thoroughly enjoys the *clear* air and scenery of the Pacific Northwest, where he has been owner of the Madison Park Hardware in Seattle for the past two years.

Edgar Bright Wilson, Jr. has recently been appointed the first Wallace Hume Carothers Research Professor of Chemistry at Harvard University. As a Carothers Professor, he will continue his studies of the structure of molecules by the use of micro-wave spectroscopy. Besides this new appointment, Ed will continue to be a Theodore W. Richards Professor of Chemistry, which is his permanent rank on the Harvard faculty.

1934

John F. Pearne writes from Cleveland where he has been engaged in the private practice of patent law since leaving the legal department of the Sherwin Williams Co. a little over two years ago. He says the profits of such activity go to the support of his wife, daughter, 8; son, 6; and son, 1 month.

William Bollay, M.S., Ph.D. '36, of Seattle, Washington, has been with North American Aviation Inc. since he left the Navy in 1945, where he helped to develop turbojets and gas turbines for the Navy Bureau of Aeronautics.

1937

Arthur E. Harrison, M.S. '37, Ph.D. '40, will be chairman of the 1951 IRE Seventh Region Conference on the University of Washington campus in Seattle on June 20, 21, and 22. As a hobby, Art has been investigating glaciers in Washington and California, and proposes his own hypothesis that a new glacial advance may have started. Anyone interested in joining Art on a trip to Mt. Lyell this summer? Let him know.

Dean Nichols, M.D., has just started a new job—Resident in Radiology in the Scott and White Clinic in Temple, Texas. Dean says it's an excellent appointment with much to see, and he will pinch hit for their dermatologist when he is away or ill—he's glad of this aspect; it will keep him from getting too rusty in dermatology, and he plans to practice both specialties when he returns to Helena. Dean's wife and son, Peter Dean, will arrive sometime in June.

1938

Wallace B. Mechling, M.S., has been Commanding Officer of the Navy's Combat Information Center School at Glenview, Ill., for the past twenty months. Wally says, "We teach young Naval Officers how to run CIC's on board ship, and one of the main jobs is direct control of aircraft by use of radar information in order to defend friendly forces from enemy air attacks." Wally expects to go on sea duty in June.

Henry S. Hopkins has been Field Service Engineer for the Boeing Airplane Company in Seattle, Wash., since July, 1950. The Hopkins' (she was Eleanore Hamlin, Captain, U.S. Army Medical Corps.) have two children, Robert Alan, 2; and Edward Brian, 1.

Newman A. Hall, Ph.D., Professor of Mechanical Engineering and Head of the Heat Power Division at University of Minnesota, recently completed a new text—*Thermodynamics of Fluid Flow.* The purpose of the book, published by Prentice-Hall, Inc., is to serve as a basic text for courses in the flow of compressible fluids, advanced fluid mechanics, advanced thermodynamics or gas dynamics on the senior or graduate level. It is also intended to be of special interest to mechanical engineers.

1939

Leo Silvio Lavatelli received his Ph.D. degree from Harvard University this spring.

Keats A. Pullen, Jr., reports from Baltimore, Maryland, the birth of a son, Keats A. III, on January 7, 1951—just too late for the 1950 income tax.

Robert Hoy, M.S. was recently made Chief Geologist for the Northeastern U. S. Bob also works for the New Jersey Zinc Exploration Co., and lives with his wife and three children, Mary Ellen, 7; Patricia Anne, 5; and Robert, 3, in Bethlehem, Pa.

1940

Howard J. White is now in his fourth year with the General Electric Co. at the Hanford Works (atomic energy) in Washington State, where he is in charge of a test and development section handling tests of reactor components. Howard's still a bachelor, and according to him, in no immediate danger of changing this status.

1941

Bruce Lawrence is now at the U.S. Naval Ordnance Test Station at China Lake, Calif., where he is Head of the Management Division engaged in administrative engineering and management analysis work. His family include Shelley Diane 5, and David Bruce 3.

1942

Arden H. Fredrick recently joined the General Precision Laboratory, Pleasantville, New York, as Staff Member in the Production Department. Arden's children are Jane, 2 years, and Hugh, 8 months.

Robert Franklin Hall received his L.L.B. from the Rutgers University School of Law in June, 1950. He was president of his Law School class during 1948 and 1950, and has accepted a position with Link Aviation Devices Inc. in Binghamton, N. Y. Bob's family includes wife, Martha Davies, Robert Davies 4½ years, and Richard Maxwell 2½.

1943

Edward Paul Fleischer was married to Sally Ann Foote on March 25 in Piedmont, Calif.

Ken Johnson writes from Palo Alto, Calif., where he is still working as engineer for Johnson-Williams, Ltd., manufacturers of combustible gas indicators, that the arrival of a 3rd child, Lawrence, has forced the Johnsons to move to larger quarters in the city.

1944

Maurice Rattray, Jr., M.S. '47, and Mary Louise Wolsey of Winnetka, Illinois, will be married June 9 in Seattle, Washington.

John Jepson Garland of Menlo Park, Calif., has become engaged to Roberta May Hutchinson. The couple plan to marry in June.

1945

William S. Tatlock received his Ph.D. degree from Harvard University this spring.

Howard Booth, Jr., works for the Illinois Commercial Telephone Co. in Belvidere, Ill. as Plant Engineer. The latest addition to his family, Paul Edward, brings the total number of children to two boys and one girl.

1946

John C. Nickerson, Jr., stationed at Sandia Base, Albuquerque, New Mexico on the Armed Forces Special Weapons Project, is currently completing a brief course in nuclear physics at Los Alamos.

Warren W. Berning, M.S., writes from Aberdeen, Maryland to announce the arrival of a son, David Warren, born February 28 at Cincinnati, Ohio.

Lt. Howard W. Morgan, USN., was recalled to active duty last November. His present assignment is that of Assistant Plans and Intelligence Officer on the staff of Commander, Fleet Air, in Guam.

1947

John J. Deniston was transferred to New York from Los Angeles about 3 years ago by American Tel & Tel. He's now in the Department of Operation and Engineering, as an engineer in the group handling equipment for nationwide toll dialing. John lives in Ridgewood, New Jersey, claims he enjoys living in the East—but qualifies that statement by admitting he thinks the West is better in the long run —and qualifies *that statement* by adding, "except for L.A. and the smog."

Lt. Q. R. Whitmore, USN, M.S., writes from Kansas City, Mo., that he expects to leave the Bureau of Aeronautics office there this summer. It looks right now as if he'd move on to the Bureau of Aeronautics in Washington, D. C. Quent has two children now—a boy 5, and a girl 2.

PERSONALS . . . CONTINUED

Bob Belyea left his job with General Electric late in 1949, now works as an engineer with a family concern, the Belyea Company, in Jersey City, N. J. He's living in Pompton Plains, N. J., is the father of two daughters. The Belyeas are due to vacation in southern California this month.

Arnold H. Nevis writes that he expects to graduate from Harvard Medical School this June, and in July he begins a surgical internship at Stanford University Hospitals in San Francisco. Last summer Arnold worked as an intern at a 150-bed hospital in Newfoundland—a grand experience, he says.

Arnold also reports that *Hank Wheeler* has been appointed an intern in medicine at Presbyterian Hospital in New York, and that *Dave Sheldon*, '46, is interning at the Mass. General Hospital in Boston.

Harold E. Rice, from New London, Conn., has taken command of the U.S.S. Diablo, a submarine operating out of Norfolk, Va. Hal says that since leaving Tech, his third child, Mike, was born in the Panama Canal Zone in 1948.

John Raymond Scull was married to Judith Atkinson of Winnetka, Illinois, on March 31, in San Gabriel, California. The couple spent two weeks motoring along the California coast on their honeymoon.

1948

Byron L. Youtz and Bernice Livingston were married on March 17, are now living in El Cerrito. Miss Livingston was Oxy '46, and, as Byron remarks, "the Tech-Oxy attraction is strong even when removed from its natural habitat." He's still hoping for a Ph.D. in Physics one of these years, and is doing research toward that end at the Radiation Laboratory of the University of California, in the field of meson investigations.

James A. Harder, after having worked for two years with the Soil Conservation Service as a civil engineer, is now doing graduate work in hydraulics at the University of California in Berkeley.

Richard A. Ferrell, M.S. '49, is one of 12 winners of General-Electric science research fellowships, announced this month. A total of $17,200 will be granted the 12 men (selected from applications from 56 colleges, universities and technical schools) for research during the coming school year. Dick plans to use his $1,000 fellowship to study at the Max Planck Institute in Goettingen, Germany.

Hamad Kamal Eldin, M.S., from Cairo, Egypt, received his Ph.D. in Mechanical Engineering from the State University of Iowa in February.

J. K. Wimpress, M.S., is an aerodynamicist at the Boeing Airplane Co. in Seattle. He was married in March, 1948, to a Pasadena girl.

1949

Don Hibbard writes that he and his wife have been "touring" the country, courtesy of the U.S. Army, ever since he was drafted last November. Don had basic training with 28th Division—the "Bloody Buckets" of the Battle of the Bulge. Until last month he was instructing a few classes in Map Making and Reading; now he's been transferred to Fort Myer, Virginia, for reassignment as a geologist.

Don recently met up with both *Doug Brown*, '49, and *Manuel Bass* '48—Brown being in the Army, Bass working for the U.S. Geological Survey in Washington.

Samuel N. Domenico, M.S., is now in the exploration department of the Tulsa, Okla., general offices of the Stanolind Oil and Gas Company.

Carl Arthur Price received his M.A. from Harvard this Spring.

1950

Myron Arcand and *Floyd Humphrey*, now doing graduate work in chemistry at the University of Minnesota, will be returning to Tech next fall on graduate assistantships.

Frederick Duny, Jr., writes from U.S. Naval Indoctrination School at Monterey, Calif., that he embarked on a Naval Reserve cruise to Ecuador, aboard a destroyer, immediately after graduation last June—only to return in July to find us embroiled in Korea. Though his recall to active duty seemed certain, he nevertheless took a job with the hydrographic division of Southern California Edison. He worked for exactly one week, then got a week's leave to fly to Hawaii and marry Stephany Carole Gerrard. The Dunys returned to California at the end of the week, and three days later Fred was recalled to active duty. His wife is now living in Artesia, where she is expecting a baby in May.

Weldon R. Donsbach, M.S., is now at the Baltimore, Md., works of the Westinghouse Electric Corp., as design engineer on commercial radar and on a transponder unit for aircraft use. Weldon's been married since 1946, has a daughter, Ruth, 3½, and a son, Leonard, 1½.

John Whittlesey, M.S., served on the faculty of the University of Nevada from February to June, 1950, then returned to the coast for the summer, as a Guest Investigator at Mt. Wilson and Palomar Observatories under Dr. Fritz Zwicky. From August to October, 1950, John took professional training in dianetics at the Hubbard Dianetics Research Foundation in Los Angeles. Since last November he has been practicing and teaching dianetics in Reno, Nevada, where he is also legal representative of the Hubbard Foundation, and doing research at the Nevada State Mental Hospital.

LETTERS

Neo-Thomism

Sirs:

Dr. Alfred Stern's article on Neo-Thomism in the March issue of *Engineering and Science* is a provocative one—especially to one like the undersigned, who started out in Engineering and finished up in Theology.

Dr. Stern rightly recognizes that Neo-Thomism is a powerful movement in contemporary philosophy. On the campus of one of our great State's Universities "Should Auld Aquinas be forgot . . ." has become a popular song—so I am told. Be that as it may, is it any wonder that vigorous young minds should turn away from the intellectual pessimism which tells them there is no such thing as objective knowledge or certain truth, that the intellect is only an adjusting mechanism, and that since there is no will, freedom is an illusion?

Neo-Thomism is unique today as a harmonious system of philosophy whose theory of knowledge is Critical Realism. It provides extensive proof from pure reason to uphold objective reality of knowledge to support the scientist in the validity of his observations and to defend the data of common sense. It gives a rational foundation for the ideals of democracy as well as the freedom and dignity of the human person, and leads our reason from observations of the world about us to intellectual certainty that the first cause of it all is one infinite and perfect God.

Dr. Stern did not dwell on any of these things in his article. He appeared chiefly concerned with only one department of Philosophy, namely Cosmology or Natural Philosophy. His opinion of Neo-Thomism seems to be dominated by two ideas: First, he thinks this philosophy must be outmoded simply because Aquinas and Aristotle lived so very long ago, and he believes evidently that their disciples today are not permitted to bring them up to date. Second, he thinks Neo-Thomistic philosophy must conform to "dogma" and therefore cannot be based on the free power of thought. These are two prejudices on which I would like to comment.

Dr. Stern asserts, "Almost all of Aristotle's system has been superseded by modern science." Since neither Aristotle nor St. Thomas had a microscope or telescope—not even a cyclotron—no one would be foolish enough to hold that their knowledge of science would be valid today. They, themselves, would be the first now, as they were in their own age, to accept the latest scientific discoveries. Aristotle indeed, was the principal founder of the scientific method in his "Analytica Posteriora."

Although the application of the scientific method in our times has changed many things, it has not altered human nature nor the parts of philosophy based on human nature, like Ethics. It has made no change in Logic, which is taught today in all the schools as it was first developed by Aristotle in his "Organon." One wonders what scientific discovery could be made to change the mathematical fact that $2 + 2 = 4$.

Dr. Stern believes that "Aristotle has been declared sacrosanct" and "to criticise Aristotle has become to be thought almost impious." Apparently he is not aware that many modern Neo-Thomists do criticise Aristotle, and have turned away from his "Hylomorphic" theory to "Hylosystemism," which visualizes matter as an "atomary energy system"—and dispute his politics, which uphold Monarchy as the ideal form of government.

Mr. Stern thinks St. Thomas regarded Aristotle as the "precursor of Christ in the scientific sphere." The fact is that Aquinas warned his pupils that Aristotle was "human and fallible," and he rejected many of Aristotle's ideas; for example, the eternity of time and motion.

Modern Neo-Thomists are likewise free to criticize and disagree with him, and indeed with St. Thomas himself, as the Scotists and the Molinists do. As Eberhardt says, "St. Thomas should be our beacon, not our boundary."

In choosing an example to support his assertions that Neo-Thomism is out of date, Dr. Stern seems to have stumbled. He says: "According to Aristotle, movement is already in the movable body but in a state of potentiality, and fire is potential in the combustible object. These primitive conceptions of Aristotle's physics have been wiped out by modern science." If the Doctor will have the kindness to step over to the Physics Department he will find that potential and kinetic energy are still very much a part of modern physics, and that budding engineers are still busy computing the efficiency of engines

CONTINUED ON PAGE 46

on the basis of how well they transfer the potential energy of the fuel into kinetic or actual power. What discovery of modern science has "wiped out" these concepts Dr. Stern does not reveal.

In criticizing Neo-Thomism Dr. Stern seems to confuse philosophy with natural science, and to overlook the fact that they have different points of view and different objectives. A physicist may look at a man and say that he is a prodigious swarm of atoms; a biologist will discern a great system of cells; a philosopher will see a rational animal; and a politician, a vote. They are not contradicting each other, and one does not have to give up his impression in deference to the others. They simply have different objectives and different points of view.

Thus, the scientist may split the atom to get at its physical parts and the philosopher may analyze matter to discern its rational divisions—*matter* that gives it extension and *form* that makes it specific and individual. In this way he can explain how a block of marble is a statue of Apollo and not of a horse, which the physicist can never do on the basis of electrons and protons. So, let Dr. Stern be liberal and leave to philosophy its own autonomy.

Like the savants who wrote before the Twelfth Century, Dr. Stern merges philosophy with physics on the one hand, and with Thomistic theology on the other. He tells his readers that Neo-Thomistic philosophy adopts "dogma," fears "the sin of heresy," builds "on Faith" and "takes revelation for its starting point."

This is obviously the language of Theology and is not to be found in Neo-Thomistic philosophical works. St. Thomas did indeed apply philosophy both to science and to theology to unfold the significance of their teachings, but he drew a clear and definite line of demarcation between them, basing his philosophy on pure reason and his theology on Divine revelation.

His distinguished disciple, Maritain, writes in *An Introduction to Philosophy*: "It is therefore plain that philosophy and theology are entirely distinct, and that it would be absurd for the philosopher to invoke the authority of revelation . . . the premises of philosophy are self supported and are not derived from those of theology. . . . it is not from its agreement with Faith, but from its own rational evidence that it derives its authority as a philosophy . . . in our arguments and in the very structure of our expositions of philosophy it is not Faith but reason and reason alone which occupies the entire ground and holds undivided sway."

Dr. Stern, however, without giving any references, alleges "Thomas and Neo-Thomists *state* that no philosophy is legitimate that does not take revelation for its starting point . . . that the declaration of autonomy of philosophy which Thomas had proclaimed was again denied." This he tries to exemplify by claiming that the basis on which St. Thomas founded his contention that the truth of science cannot contradict the truth of Faith is itself an article of Faith; namely, the veracity of God.

Dr. Stern surely cannot be unaware of the fact that Aquinas had provided cogent arguments from principles of pure reason without any appeal to Faith to establish "the veracity of God"—arguments, by the way, which have never been successfully attacked.

If this letter were not already too long I would enjoy commenting on Dr. Stern's remarks about Galileo, who tried to use the Bible as a textbook of science and prove the Copernican theory by revelation (for which Dr. Stern would also condemn him), and on his attempt to get Maritain into a dispute with Einstein, who never included God and the angels in his theories or tried to claim that this chain of relativity which we call Creation can hang from nothing—like the Fakir's rope, or even compete with the "Strong Man of Ireland" who could lift himself up by the seat of his pants.

Perhaps some day we may pull the loose ends together over our pipes and coffee.

Joseph T. McGucken
AUXILIARY BISHOP OF LOS ANGELES
VICAR GENERAL
ARCHDIOCESE OF LOS ANGELES

Dr. Stern Replies:

I AM VERY GRATEFUL to the Most Rev. Bishop McGucken for his comments on my article "Neo-Thomism and Modern Science." He certainly knows Neo-Thomism very well, and this is only natural. For me Neo-Thomism is only *one* philosophy among many others, among which I may choose. For him it is *the* philosophy, the only one he is allowed to adopt, because it had been chosen for him in 1819 by Pope Leo XIII.

I fully agree with Bishop McGucken's supposition that, if alive, Aristotle and St. Thomas would be the first today to accept the latest scientific discoveries. I am also perfectly aware of the fact that the concepts of potential and kinetic energy are widely used in modern physics. Nevertheless, this does not mean that modern physics still thinks that fire is potential in the combustible object nor that "the light is developed out of the heavy . . for it is only potentially light, but then becomes effectively light," as Aristotle says in his *Physics* (VIII,IV). And there is no doubt that his teleological conception of nature has been "wiped out" by modern science.

I am glad to learn that Neo-Thomists are allowed to criticize Aristotle. I believe that this is especially true in those respects in which St. Thomas' philosophy disagrees with Aristotle's.

I fully agree with the Most Rev. Bishop McGucken in that reality offers different aspects to the representatives of different sciences. In an essay published years ago in the "Revue de l' Université de Bruxelles" (No. 1, 2, 1939-40) I insisted on this "partitive" character of science and gave as example a piece of marble, defined by the chemist as calcium carbonate and by the archeologist as the Venus of Milo. These two aspects, however, are coordinated, while, according to Maritain, the scientific aspect is subordinated to that of Aristotelian-Thomist philosophy of nature.

This becomes obvious when Maritain writes "The configuration of a body may be a compound of electrons and atoms, but the *essence* is a substantial compound of potency and act," or when he states that "the *authentic* conception of the organism is the animist hylomorphist conception" (*The Degrees of Knowledge*, p. 220, 244). Thus, my contention that Neo-Thomism tries to superimpose upon modern science the concepts of medieval Aristotelian-Thomist science as a pretended higher degree of knowledge has not been refuted by Bishop McGucken's arguments.

The Most Rev. Bishop thinks I should condemn Galileo for having tried to prove the Copernican theory by revelation. I certainly do not, for had Galileo acted in a different way, he would have shared the fate of the philosophers Giordano Bruno and Lucilio Vanini who, a few years before Galileo's process, had been burnt at the stake by the Inquisition, because of the disagreement of their teaching with that of the Church.

I am surprised by Bishop McGucken's statement that no change has been made in logic and that "in all schools" it is still taught as it was developed by Aristotle.

The last century has brought about the development of dialectical logic, semantics, mathematical or symbolic logic. Aristotelian logic is hopelessly inadequate for the analysis of mathematical and scientific knowledge. At Caltech symbolic logic is predominantly taught.

In conformity with its title, my article had only to deal with "Neo-Thomism and Modern Science" and had therefore to disregard the other tenets of this philosophy, especially ethics and politics. To meet the reproach of this omission I shall quote two statements of Maritain's, illustrating Neo-Thomist politics and ethics. They read as follows: *"Rome* is not the *capital* of the Latin world, but *of the world. Urbs caput orbis"* (*Ibid.* p. 21) and "if a Saint abandons her children to receive holy orders . . . if another allows her brother to be murdered at the door of her convent so as not to violate the cloister . . . those acts are *good*, they are the *best* of all *moral* acts" (Maritain, *Courte Traité de l Existence et de l Existant*, p. 92-93). I have to confess that I am not very favorably impressed by these political and moral theses.

The Most Rev. Bishop quotes a very liberal sounding passage from Maritain's *An Introduction to Philosophy* in order to refute my contention that Neo-Thomist philosophy must conform with "dogma" and therefore cannot be based on free power of thought. However, Bishop McGucken omits to say that in the same chapter Maritain restricts the freedom of philosophy and science he had granted to such an extent that it is tantamount to its complete denial and total subjection to the rule of theology. This passage from Maritain's reads as follows:

"As the superior science *theology judges philosophy* in the same sense that philosophy judges the sciences. It therefore exercises in respect of the latter a function of *guidance or government* . . . which consists in *rejecting as false any philosophic affirmation which contradicts theological truth.* In this sense *theology controls* and exercises jurisdiction over *the conclusions maintained by philosophers.*" (Maritain, *An Introduction to Philosophy*, p. 126)

This is exactly what I said in my article. If Maritain adds that philosophy is subjected to theology "neither in its premises nor in its methods *but in its conclusions*, over which theology exercises its control" (*An Introduction to Philosophy*, p. 132) this is pure casuistry; for how can you arrive at certain conclusions without starting from appropriate premises and still remain logical? This is impossible. Thus, my contention that before they begin to philosophize, the Neo-Thomists already know the conclusions at which they have to arrive, is fully substantiated by the statements of the leading Neo-Thomist Maritain.

The unprejudiced reader will certainly recognize that the contentions of my article have been reinforced rather than shaken by Bishop McGucken's attack.

Alfred Stern

BOOKS CONTINUED FROM PAGE 2

are reduced to the test of workability or success. Russell refers to such doctrine as "this engineer's philosophy." Such absurd consequences can be overcome by distinguishing between knowing and applying.

Our age needs compassion for all mankind, desire for knowledge, eschewing of pleasant myths, courageous hope and creativeness. Only in genuine compassion are found the desire to understand human misery and the urge to combat it.

While the contents of this small book may strike the literate reader as old stuff, Russell's diagnosis and prognosis hammer home the essentials and the urgency of the directions we must take if science is to aid mankind and not increase human misery.

PRINCIPLES OF PHASE EQUILIBRIA

by F. E. W. Wetmore and D. J. Leroy
McGraw-Hill, N. Y., $3.50

Reviewed by Norman Davidson, Asst. Prof. of Chemistry

PHASE EQUILIBRIA is a part of physical chemistry that is of vital interest in a variety of other fields—geology and metallurgy being notable examples. The interpretation of phase diagrams is presented here in a series of examples, starting with one and two component systems and progressing to four components. The discussions are based on the phase rule and on common sense; they are clear and can be understood by a reader who does not have an extensive training in physical chemistry. The text is therefore suitable for the practising technical man who wishes to extend or refresh his knowledge of the subject.

STEAM TURBINES

3rd Edition
by Edwin F. Church, Jr.
McGraw-Hill, New York $6

Reviewed by R. L. Daugherty Professor of Mechanical Engineering

THIS IS A REVISED and expanded edition of a book that has been a standard text in this field for 23 years. It contains an excellent description of the various types of steam turbines now in use, and a clear presentation of the fundamental thermodynamic theory.

There is an unusually comprehensive treatment of the theory and practice of steam nozzles, and the treatment of blade theory is adequate and understandable. An interesting feature is the application of aerodynamic theory to design of turbine parts. The scope has been extended also to sonic velocities in flow through the turbine.

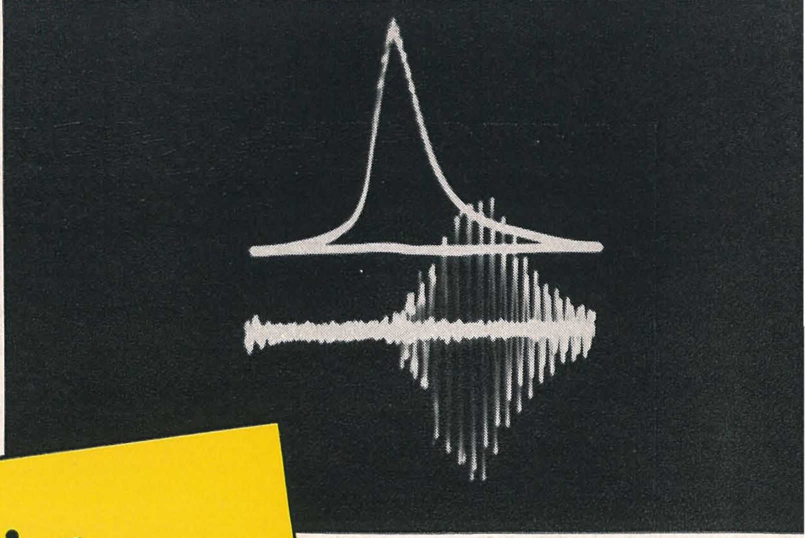
Altogether this is a well-rounded treatment of the entire field.

STRATIGRAPHY AND SEDIMENTATION

by W. C. Krumbein and L. L. Sloss
W. H. Freeman and Co.,
San Francisco, $5.00

THIS COMPREHENSIVE textbook treatment of stratigraphy and sedimentation is an integration of facts, principles, and hypotheses bearing on the general field of study. The first part of the text deals with certain basic concepts, including a useful chapter on stratigraphic procedures. Discussion of sedimentary environments and of the tectonic frameworks of sedimentation in some of the later chapters is especially interesting.

The application of principles is stressed rather than coverage of a great deal of purely descriptive stratigraphy, and an attempt is made to present recent contributions as well as the standard literature of stratigraphy and sedimentation.



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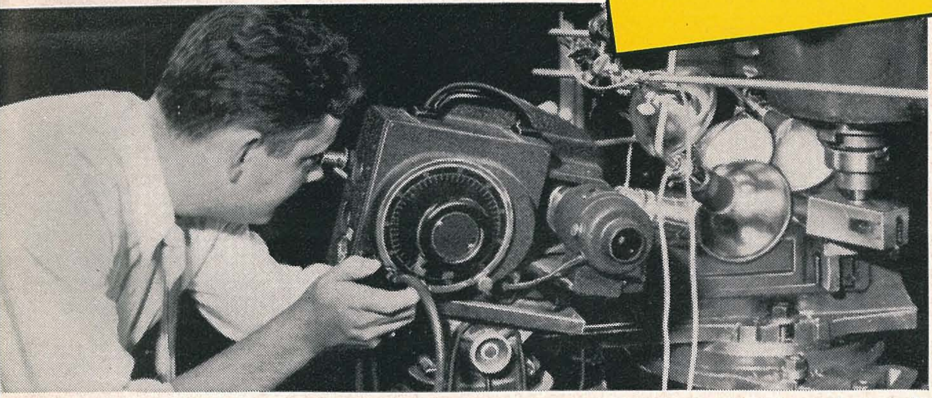

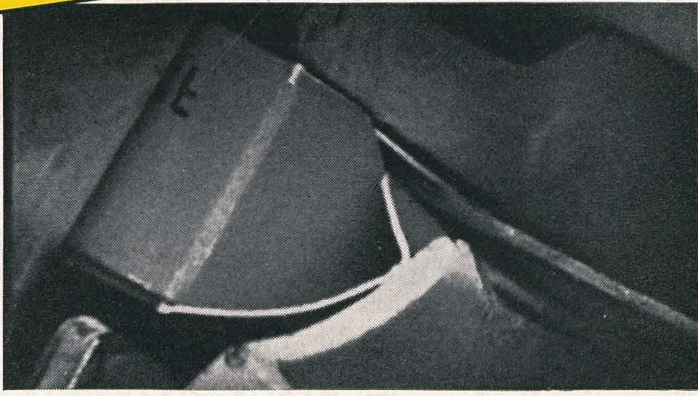

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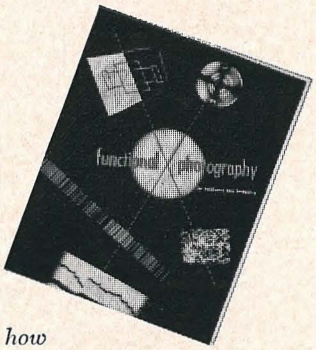

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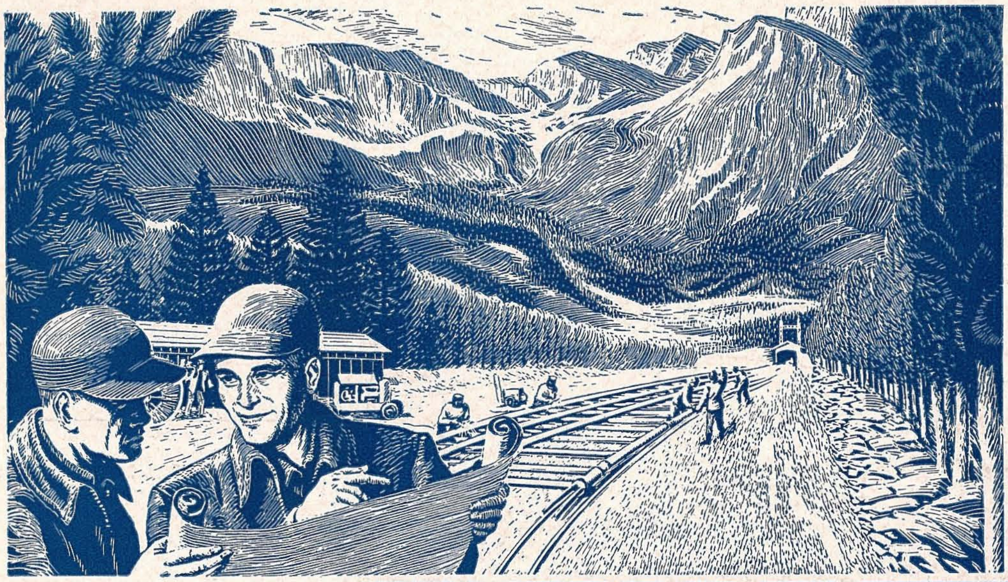

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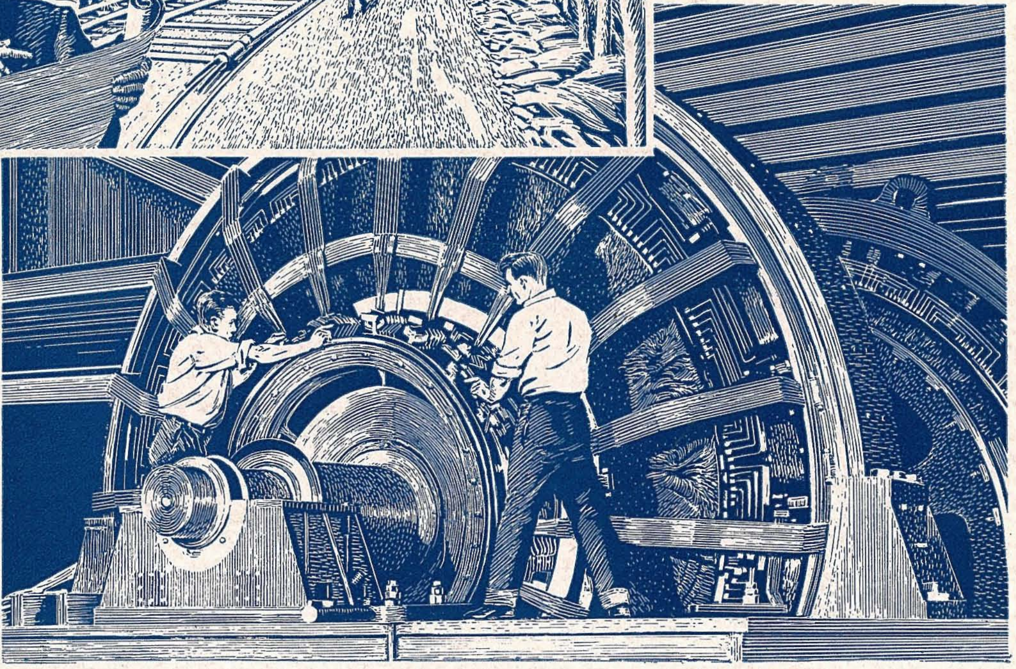

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