ENGINEERING AND SCIENCE

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Homemade Organ . . . page 17

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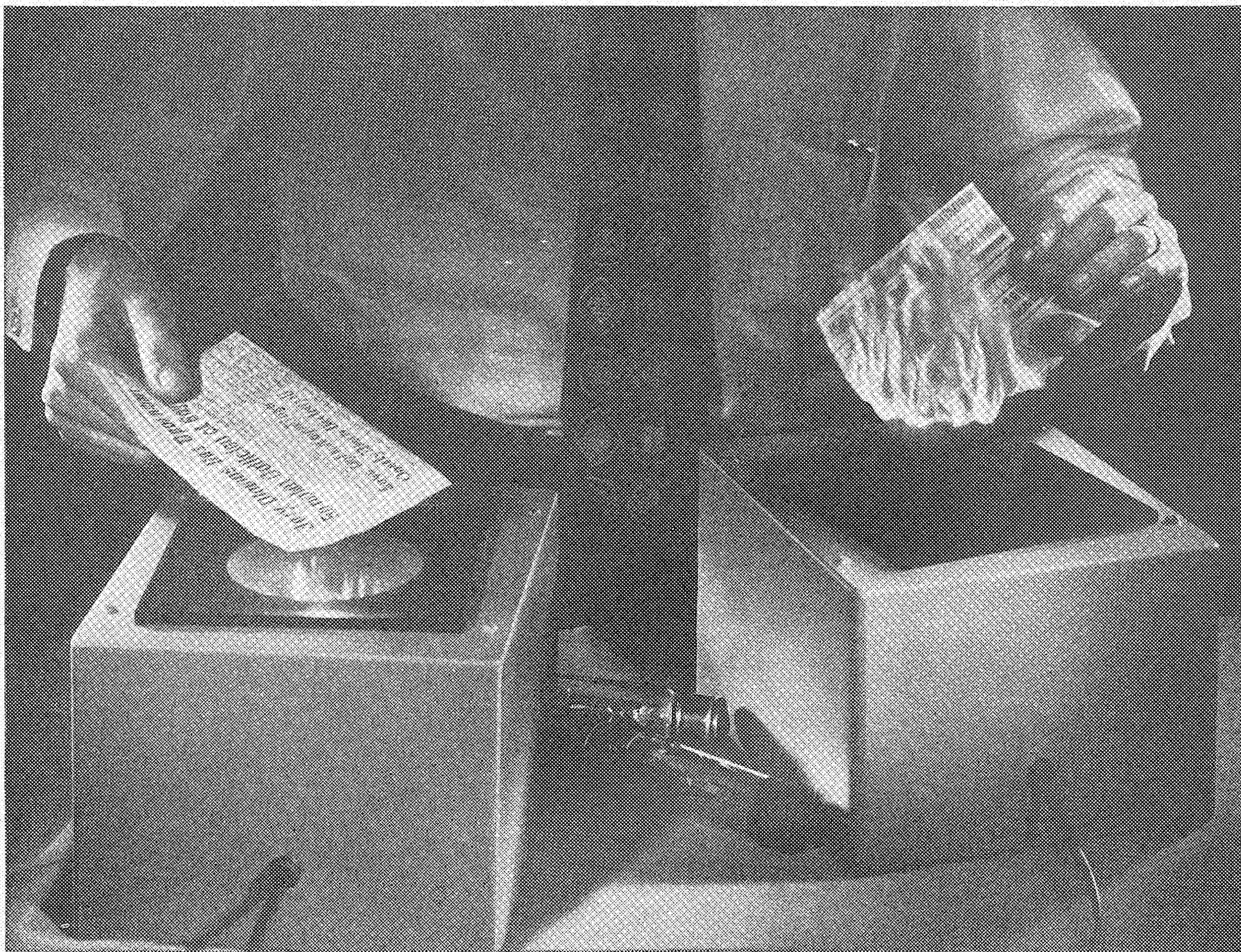

Glass that picks fire out of a light beam

The electric lamps you see between the boxes on the table are exactly alike—they generate both powerful light *and* intense heat.

If you should concentrate the beam of one of them with a reflector and plug it into an ordinary socket, you'd be practically blinded by its glare and your clothes scorched by the heat—unless you turned away fast!

But look what happens when you put them into the fixtures in the foreground, so their beams are covered by two different kinds of Corning glass.

The beam from the bulb on the left is cooled down so sharply that you can hold a wisp of newspaper in it for hours without its catching fire. Yet the light is almost as dazzling as ever.

Notice now that no light apparently shines from the bulb in the fixture on the right. But if you hold a piece of newspaper over it—in a matter of seconds you have fire in your hands!

The explanation is: One of the glass plates transmits the comparatively cool, visible rays generated by the bulb, blocking off most of the invisible heat rays. The other allows only the invisible heat rays to pass.

These pieces of glass are only two of the dozens of ray-transmitting or ray-blocking glasses that Corning makes—glasses that can pick out any segment of the light spectrum and put it where it's needed.

For example, a lamp shielded with a Corning glass which transmits *only* near ultraviolet rays lights automobile instrument panels without glare. Another kind of Corning glass transmits only invisible infrared rays and is used in electronically controlled burglar alarm systems.

Throughout industry, *Corning means research in glass*—and these ray-blocking, ray-transmitting glasses represent only one of a multitude of outstanding developments that have earned Corning this reputation.

We hope you'll keep in mind that Corning research and technical skill have made glass one of the most versatile engineering materials there is.

For when you're out of school and are concerned with product and process planning, you'll find it to your advantage to call on Corning before your plans reach the blueprint stage. *Corning Glass Works, Corning, New York.*

CORNING
means research in glass

BOOKS

JAMES WATT AND THE HISTORY OF STEAM POWER

by Ivor B. Hart

Henry Schuman, N.Y., 250 pp., $4

Reviewed by Peter Kyropoulos
Assistant Professor of
Mechanical Engineering

IVOR B. HART is a familiar name to those who are interested in the history of science and engineering: he has written *The Mechanical Investigations of Leonardo da Vinci; The Great Physicist; The Great Engineers*, etc. It is not surprising then that the emphasis here is on the history of steam power rather than on James Watt.

The book starts with a review of the development of civilization and points out how the need for mechanical power sources gradually became the key problem of industrialization. It becomes clear that the steam engine is really not an invention but a development to which many people contributed.

Then follows a chapter on "The England and Europe of James Watt," in which the development of science and engineering in the 18th century is traced, in order to furnish the philosophical background for the biography. After a short passage on Watt's early life, some of the principles of physics are reviewed in the sequence of their discovery (nature of air pressure, latent heat of steam). Much of this reminds one of the treatment of Lancelot Hogben in *Science for the Citizen* and is equally well done, if perhaps somewhat tedious to a reader who has never heard of it before.

It is then shown how the problem of removing water from mines furnished a powerful incentive to develop some sort of prime mover to do the pumping job which kept men and horses busy day and night. We hear about Savery and Newcomen and their engines, as well as their predecessors. All these earlier engines employed condensation of steam to produce a vacuum in the cylinder against which the atmosphere then would move the piston.

Watt recognized the limitation which this imposed on the useful pressure ratio. The maximum working pressure was 14.7 psia and no more. Watt's contributions are thermodynamic and mechanical improvements:

(1) Addition of a condenser, separate from the engine cylinder.

(2) Use of pressure steam in the cylinder.

(3) Use of expansion of the steam in the cylinder.

(4) Use of crank and connecting rod to translate reciprocating into rotating motion.

(5) Introduction of the slide valve.

(6) Use of the governor to control the speed of the engine.

With the exception, perhaps, of the slide valve and the pressure volume indicator, none of the items listed were new inventions in the strict sense; only their use and combination was new. It is this combination which constitutes Watt's contribution and which made his engine the prime mover that was needed for the growing industry.

The usual troubles of financing and marketing a development program mark the struggle of Watt and his partners and backers. The book ends with the death of Watt and a brief look at steam power since then.

The author has produced a book which is both readable and correct, which is more than can be said for the usual attempt of biographers, who write without knowledge of the victim's specialty.

APPLIED HYDROLOGY

by Ray K. Linsley, Jr., Max A. Kohler, and Joseph L. K. Paulhus

McGraw-Hill, N.Y., 689 pp., $8.50

Reviewed by Jack E. McKee
Associate Professor of
Sanitary Engineering

FOR TWO DECADES or more the standard text and reference books in the relatively unexplored field of hydrology have been Mead's *Hydrology* and Meyer's *Elements of Hydrology*. Since 1945, however, there has been a rash of new books on the general subject of hydrology and on its specialized branches. This is attributable in part to the fact that Mead's and Meyer's books, while now classics, are decidedly out of date; in part to the fact that since the early days of the New Deal there has been a great expansion in applied hydrology as manifested in flood-control works, water supply, pollution abatement, and reclamation projects; and in part to the fact that though the technical jour-

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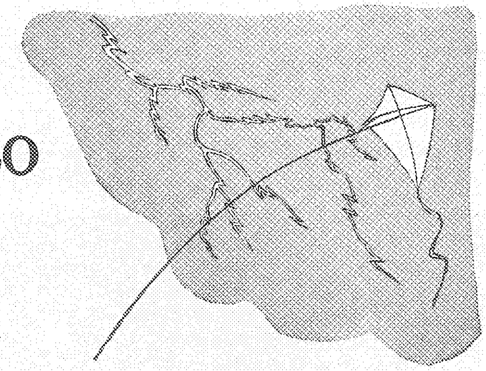
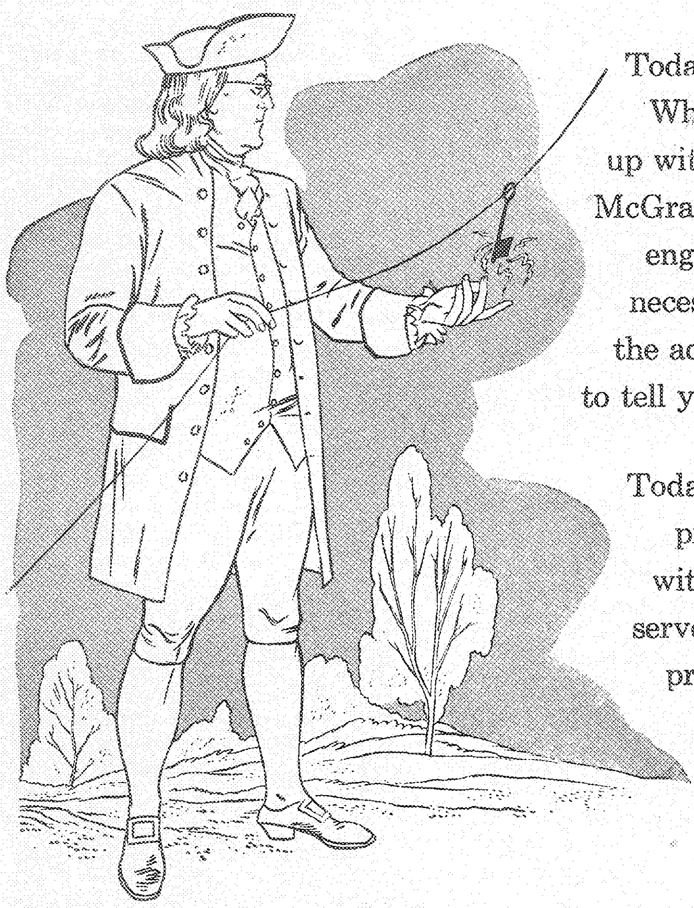
What was the key to Ben Franklin's success?



It wasn't the one on the end of this kite string, you can be sure. The key to Franklin's basic contributions to the progress of science and engineering in America was his solid grounding in technical fundamentals. In America, the finest textbooks are available to everyone. They provide the indispensable background in technology that has made and keeps America great.

Many of the books in which you are now studying the fundamentals of your specialty bear the McGraw-Hill imprint. McGraw-Hill is the world's largest publisher of books for technical reference and instruction. as well as advanced research and study.



Today's discoveries are tomorrow's fundamentals. When you finish college, you will want to keep up with the latest advances in your field. Then, McGraw-Hill magazines and books for the practicing engineer will report to you on all that is new, necessary and important. And you'll depend on the advertising pages of McGraw-Hill publications to tell you where the latest equipment is available.

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Books CONTINUED FROM PAGE 2

nals have been replete with papers on various phases of hydrology, most of the significant material has just recently begun to be condensed in book form.

Of several excellent new books, *Applied Hydrology* is the most general and the most complete. While not exhaustive in its treatment—no standard-sized volume could hope to be—it is a thorough presentation of all of the normal phases of hydrology and even delves into related phenomena such as sedimentation, silting, bedload movement, and wave action. That the chapters on climatology, atmospheric temperatures, humidity, and winds are especially thorough is not surprising in view of the fact that all three authors are employees of the Weather Bureau.

This book was intended to be a convenient text reference for general data, basic theory, and methods of application. In their first and third purposes the authors have succeeded admirably, including a wealth of data, empirical formulae, references to recent literature, and descriptions of current practice. Their so-called "basic theory," however, is often far from basic. In presenting the detailed results of many empirical formulations the authors have frequently by-passed elementary concepts and mathematical development. If it is used as a student textbook, *Applied Hydrology* should be supplemented by more fundamental treatment of the probability analysis and other mathematical tools.

Geographically, this book overcomes the tendency of older texts to rely on the longer hydrologic records of the eastern states by including frequent references to western conditions and practice. In this respect it should be welcomed by reclamationists and other engineers west of the 100th Meridian. The chapter on snow, ice, and frost is especially thorough and the presentation of flood routing and unit hydrograph analysis is excellent. The coverage of ground water, however, is weak, comprising less than five percent of the pages in the book, but the authors acknowledge this deficiency and refer the reader to other texts specializing in this phase of hydrology.

Applied Hydrology will be a worthwhile addition to the library of every practicing civil engineer and will make an excellent textbook for a graduate course in advanced hydrology when properly augmented with mathematical analyses and more detail on ground water.

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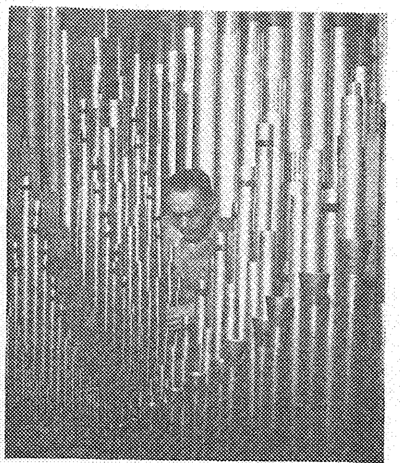

In This Issue

On the cover this month is Hunter Mead, Professor of Philosophy and Psychology at the Institute, surrounded by just a few of the thousand organ pipes which currently occupy the spare bedroom of his house on North Chester Ave. in Pasadena.

Prof. Mead is probably one of the few poor people in the — well, let's say world — who has a functioning pipe-organ in his parlor. If you're curious — as we certainly were — as to how, and more particularly, *why* it got there, you'll find Dr. Mead's True Confession on page 17 of this issue.

Challenge to Management

President DuBridge's article on page 7 is adapted from a speech he made before the American Management Association in San Francisco on January 18. Originally titled, "The Challenge of Science and Technology to Management," the speech has already been abstracted in *Time*, and is to be reprinted by the American Management Association. We think it's one of the best Dr. DuBridge has made in some time.

Millikan Autobiography

Last month *E & S* ran an extract from "The Autobiography of Robert

CONTINUED ON PAGE 6

Mead

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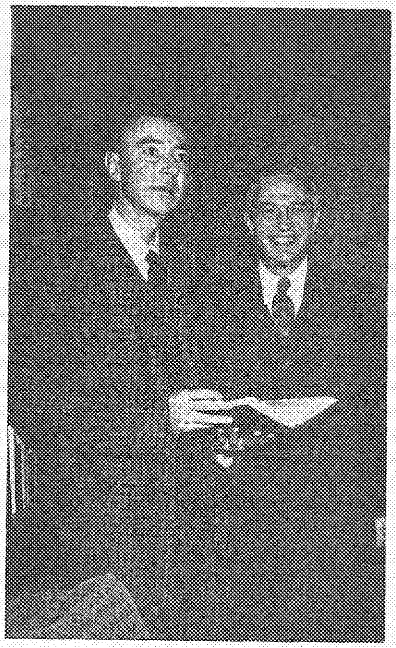

Distinguished Visitor

A. Millikan"—which is to be published on March 22—dealing with Millikan's early days at the Institute. This month (page 14) we have another excerpt from the book—"The Two Supreme Elements in Human Progress." In the original draft of the book Dr. Millikan had this section labeled "My Philosophy." It's a rewarding and inspiring piece of writing.

And What's More

C. M. Stearns, who wrote the article on bacteriophage on page 11, is a member of the Institute staff attached to the Office of the President . . . Please note—the test tubes which all the members of the Phage Group are clutching in their fists in the picture on page 13 are merely drinking glasses filled with port. It's part of the routine whenever the group holds a seminar. Dr. Delbrück pours—and passes out cigars . . . J. R. Oppenheimer, the distinguished visitor shown above with Dr. DuBridge was just one of several d.v.'s who came to Caltech last month. You'll find notes on them on page 22.

PICTURE CREDITS

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THE CHALLENGE OF SCIENCE AND TECHNOLOGY

by L. A. DuBRIDGE

Here are some of the changes the science and technology of tomorrow may bring — and what we can do today to encourage these changes and insure that they will be for the best

SCIENCE AND TECHNOLOGY have become so intertwined during the past few years that today we face the rather curious situation that many people—far from thinking of science and technology as two separate and distinct disciplines—are now inclined to regard the two as different forms of the same thing. Before we can understand the challenge of science and technology we must understand something of what science is and what technology is and in what respects they are alike and in what essential respects they differ.

First, what is science? It is easier to recite first some of the things that science is not. Science is not the development of new weapons of war. It is not the development of new or improved industrial products or processes. It is not even the discovery of new cures for human disease. Science is not the development of any device or technique. Science is simply knowledge. The goal of scientific research is to discover new facts and principles concerning the behavior of the physical world. The eventual goal of science is to build a conceptual framework of the physical world, a system of well established theories, if you wish, on the basis of which one can understand and interpret natural phenomena and can also predict what future events will occur under specified conditions.

This ability to understand and predict has during the past two centuries reached a high stage of perfection in certain areas of science. The laws of celestial mechanics are so exactly known that, for example, eclipses of the sun can be predicted with a high degree of precision for centuries to come. Quite adequate precision of prediction is also possible in great areas in the fields of mechanics, optics, electricity, and in certain fields of chemistry. However, as we enter the areas of more complex phenomena of organic chemistry and the biological sciences we find that we are only at the threshold of an understanding of the phenomena which take place here. The investigations of the past few years have shown pretty clearly that the first problem in these fields is the understanding of the nature and behavior of complex molecules. It is exciting to visualize what important progress can be made in this area in the coming years if suitable efforts are devoted to it. The basic techniques are now at hand so that an adequately extensive research effort may cause our knowledge to grow in snowball fashion.

But the point to be emphasized is that in all fields of basic science the goal of research is further understanding. The object is not to invent but to comprehend.

Now, of course, the goal of technology is very different. Each individual technological research project has as its aim the development of a specific device or technique which will be of practical use. In the days before the development of the scientific method technology proceeded largely by the trial-and-error method. The sum total of the achievements in the practical arts which were attained by human beings by this method over thousands of years of technological efforts is impressive indeed and culminated in the magnificent achievements of Edison. But the rate of progress during the past hundred years has been fantastically higher than that of any previous era, to the extent that in such fields as the development and use of power and in the fields of transportation and communication more progress has been made in the past fifty years than in all the previous thousands of years of human experience.

It is the interaction of science with technology which has made possible this accelerated rate of development. This interaction is of two forms. In the first place, the discovery of new phenomena and new laws in the field of science has given rise to new practical applications. The abstruse theoretical studies of James Clerk Maxwell on the nature of light and of electricity led to Hertz' experiments which uncovered the existence of electromagnetic waves. These discoveries stimulated the brilliant Marconi to establish a whole new area of technology which has given us among other things modern radio and television and radar.

The discovery of the laws of electromagnetic induction by Faraday eventually gave rise to the modern electric power industry and all of its ramifications. The discovery of the basic laws of thermodynamics by Carnot, Joule, Kelvin, Helmholtz and others made possible the many modern forms of heat engine, including the steam engine, the internal combustion engine, and now the jet engine and the gas turbine. Pioneering work of a whole host of physicists and chemists who studied the nature of atoms and molecules made possible the creation of modern chemistry and the chemical industry. Dozens of other examples from other fields could, of course, be mentioned, in which the discovery of a new law or new phenomena in science has made possible the creation of whole new areas of technology.

But technology has also grown by adopting in technological research the *methods* of science. Though the systematic trial-and-error method is still the mainstay of many areas of technology where the fundamental principles are still not fully understood, there are many other areas of technology where the method of the controlled experiment is not only possible but highly fruitful. The controlled experiment leads to an advance in understanding which, in turn, leads to the prediction of the results of new experiments. Practically the whole of the technology of the electrical and radio industries, for example, proceeds in this fashion—the method of science which came out of the science laboratories of the nineteenth century.

Contributions of science to technology

In other words, science has contributed to technology not only new discoveries and a new understanding of nature upon which new practical devices and techniques can be based, but has also contributed a new method of research which has multiplied the rate of technological advance by fantastic proportions.

Now the very fact that the research methods used in a laboratory of technology or of applied science are essentially identical with the methods used in a laboratory of pure science has led many people, including some very well-known writers, to the conclusion that there is no real distinction between science and technology—between pure and applied science. This, it seems to me, is not only a very superficial view, but a very dangerous one.

This view is dangerous because it implies that the burden of scientific research, which was largely carried by the universities during the nineteenth century and the first quarter of the twentieth century, has now been largely assumed by the industrial laboratories, and more recently by government laboratories. All three kinds of laboratories, it is said, are working toward the same goal, and the great expansion in industrial and government laboratories will result in a great acceleration in the rate of growth of science. Even if the university laboratories should go out of business, some would conclude that science will continue to thrive in the laboratories of industry and government. There are even a few industrial leaders who have apparently subscribed to the thesis that what goes on in the university laboratories is of relatively small importance, in any case, for the only things of practical import will come from the industrial laboratories.

Basic science vs. industrial research

I think what I have already said is sufficient to suggest the fallacy of this point of view. The laboratories of basic science in universities and the laboratories of applied science in industry do have much in common. But like the east- and west-bound sections of the streamliner, however identical they appear to be in their physical form, they are simply not headed in the same direction. The aim of science is to discover new knowledge and new principles. The aim of technology or applied science is to invent new devices, new machines, new processes, new techniques. Furthermore in the long run the new developments in technology will be based only upon the new knowledge uncovered by science. Only when totally new knowledge is discovered can a totally new technology arise.

I emphasize this situation because I believe that we in this country are approaching a real crisis in regard to the future development of basic science. The American people seem to be so imbued with the idea that the chief products of science are such things as jet-propelled planes, atomic bombs and television sets, that they have forgotten that all of these things rest upon basic scientific discoveries which were uncovered in research work which was not at all aimed at such practical results. The American people take such great pride in the fact that hundreds of millions of dollars of government and industrial money is going into research in applied science that they are unconcerned and even uninformed about the fact that but a tiny fraction of this amount is being fed into the laboratories of basic science, wherein will be made the discoveries on which future technology will be based.

The dangers of spending all our funds and effort on applied science to the neglect of basic science can, I think, well be illustrated by a consideration of the field of medicine. Many people, I am sure, believe that the one and only way to find a cure for cancer is to build many large medical research centers where hundreds of doctors try out hundreds of thousands of chemical compounds on thousands of animals and human patients until some day the miraculous compound is discovered which will remove the scourge of cancer from the human race.

Finding a cure for cancer

Now I admit that there is a possibility that a cure for cancer will be found in this way. The trial-and-error method in applied science has led to many spectacular practical achievements. Nevertheless, it would surely seem to be good sense not to place all our bets in this direction. Rather we should give some support to those scientists who are trying to understand the basic processes that go on in the biological systems, the basic processes which give rise to the normal growth of cells and tissues, as well as to the abnormal growth which we call cancer. It is quite possible, in fact it is almost inevitable, that if we really understood the basic nature of cell growth, the conditions which give rise to abnormal growth would become evident and the methods of preventing such conditions might be immediately obvious.

It is not impossible, for example, that the cause of cancer may lie in the fact that molecules of the wrong shape somehow get synthesized under certain conditions in the human body. Recent research by Dr. Pauling and his associates at the California Institute of Technology has shown conclusively that one human disease, known as sickle-cell anemia, is in fact a molecular disease. These workers have found that the hemoglobin molecules, which are present in the red blood cells of patients suffering from sickle-cell anemia, differ in structure from normal hemoglobin molecules. Because of this difference in structure, the molecules tend to clump into small crystals, producing a condition which, in turn, causes a change in shape in the red blood cells themselves in such a way that the blood no longer flows freely through the blood capillaries and lack of proper circulation results.

It appears likely that this abnormal formation of abnormal hemoglobin molecules can be made normal again by some method of increasing the oxygen supply to the blood. At least the development of a cure for this disease is now a straightforward development program, and the cure which eventually comes about would possibly not have been reached in a hundred years of trial-and-error experimentation.

Basic research — a practical investment

What I am driving at is simply this. Great centers of medical research are fine, just as are great centers of research in other areas of applied science, such as the great industrial laboratories working on industrial technology and the great government laboratories working on military technology. But the fuel which will eventually keep all of these laboratories going is the scientific knowledge which will come out of the laboratories of basic science. At the very least, for every hundred million dollars spent on medical technology, I wish that at least ten million dollars could be spent for basic research in biology, biochemistry, chemical biology and medical chemistry. I believe that one can say with confidence that out of the studies in this broad field of what is often called molecular biology will come the basic knowledge on which better health for the human race can be built.

The same remarks might be made about many other fields of applied science. The most impractical thing we can do as a nation is to devote all our efforts and funds to so-called practical research to the neglect of more basic investigations.

Let us now turn to the question of what we may expect the science and technology of tomorrow to bring. What kinds of things dare we predict?

Looking to things which might come to pass in the next fifty years we find that these fall into two classes. First, those which, while not impossible, have no basis for achievement in presently available scientific knowledge. When the scientific discoveries which might render them attainable will be made, if ever, it is of course impossible to forecast. For example, it is not impossible that we may some day be able to observe directly whether there is animal life on Mars. But the realization of this goal will require some wholly new discovery in the technique of observation—a discovery not yet in sight.

Similarly, the control of certain diseases, the extension of man's life span to, say, 150 years, the control of the weather, and the many other things which we like to think about can come about only when and if totally new scientific discoveries are made. No one can say such discoveries will not be made—but no one can predict when they will come.

The second type of new developments which might be anticipated are those based on presently known scientific facts but requiring practical inventive development to bring them into being or to render them practical and economical. The practical utilization of nuclear energy for the generation of electric power lies in this class. The basic scientific knowledge necessary for this use is at hand. But how long it will be before a reliable and practical power plant will be designed and built is still uncertain. Surely experimental units will be operating within five years, assuming of course that the work of the AEC is not stalled by political interference. Within another five or ten years the engineering problems standing in the way of building a large-scale practical unit will have been solved.

Changes we can count on

It is still uncertain, however, just how practical and how *cheap* atomic energy may be. I think it will be highly expensive for a long time. And I also think the serious dangers of the intense radiations from radioactive products will confine atomic furnaces to use only in remote locations. I will even go so far as to predict that in the year 2000 atomic energy will still be only in limited use for special purposes—and in any case will not in the least have reduced the market for coal or oil or water power. But the special purposes for which atomic energy will be useful may be of the very greatest importance—and the very expensive engineering developments required will eventually pay off.

If, however, present American industry does not need to fear the danger of a complete revolution based on atomic power, there are plenty of other possible technological developments which will result in very great changes. We can be perfectly sure that the art of communication will continue to advance at a dizzy pace. We have only begun to exploit the possibilities of rapid transmission of information by radio. Not only a news story or a picture or a television image can be transmitted, but in principle one could transmit the contents of an entire book or newspaper in a few seconds. Long-distance telephone cables may well go out of existence, and radio waves of wave lengths down to a few inches will come into use in hundreds of ways.

Transportation will not stand still either. We could have passenger air transport from coast to coast in five hours now if we were willing to pay the cost. Two hours or less is certainly coming—maybe at rather high cost.

Industrial processes will also change rapidly. Automatic-control techniques can even now eliminate great areas of routine tiring labor. The assembly line operated by a thousand men will give way to one operated by a hundred or ten or one. Maybe President Truman is right in predicting that by the year 2000 the national production will reach a value of a thousand billion dollars a year. In fact this figure *would* be realized if only the present rate of growth continued. Technologically speaking, this is certainly not impossible. Whether the political and economic problems which stand in the way can be solved or not is a subject on which I shall offer no predictions whatever.

I could, of course, go on indefinitely offering guesses about new possibilities. But you are as able to do this at your leisure as I am. As long as you refrain from predicting things that violate basic laws of physics or chemistry, *some* of your predictions are bound to come true, provided only you make lots of them.

The challenge — and how we can meet it

And so what? What is the challenge? What shall we do about it?

There are, of course, those who fear the future—who fear the further progress of science and technology. There have always been such people. A school board in Ohio a hundred years ago passed a rule that its school rooms should not be used for discussion of such wicked and impossible things as steam engines and railroads. Still earlier in England, a member of Parliament heatedly denounced the dangers of our growing knowledge and teaching of geography. It will be the ruination of the common people, he said. Another denounced research in anatomy, holding that the Lord had purposely covered up our insides and we would only get into trouble by penetrating His curtain of modesty.

We laugh at people who could be so blind—at people who feared knowledge rather than welcomed it. We scorn those who 50 years ago lacked the vision to forsee how science and technology would change the world—and who feared and fought the changes as they came.

But are we entitled to laugh? Can anyone of us today foresee the world of 2000 A.D. or even the world of 1951? Or do any two of us agree as to what we see? We are all short-sighted. And we will never know which of us sees or guesses the future the best until events have proved his words. The important thing is not that we foresee the future but that we do not fear it. We know there will be change. The challenge is to welcome it—to encourage it—to make it a change for the better.

The first challenge is this: science and technology will bring changes—so we must be ready to make the most of them.

But waiting for new developments to come along and hoping to use them—or not be destroyed by them—is not enough. And this brings us to challenge number two: the challenge to encourage and stimulate new developments by means of applied research. Inventive ingenuity, using the techniques of modern science and technology, has not even begun to exploit the possibilities of applying present scientific knowledge for the benefit of men. Increased productivity in industry and agriculture, new products and techniques in every industrial area, new advances in medicine making immense forward strides in the conquest of disease—all of these will come—some slowly, some quickly. But they do not come automatically, or without effort or cost. But come they will, because forward-looking men in industry will put forth the effort required.

Industry bears the burden

I wonder if you realize that, aside from developments in military technology and in some phases of agriculture and public health which will be supported by government funds, practically the whole burden of applying scientific techniques for the improvement of the material well-being of men and women in this country lies on the shoulders of industry. It is from the industrial laboratories that new and better products and techniques will come. Someone else is not going to do that job. If it is done, the management of industry and of business will do it.

It is a grave responsibility but an exciting challenge. It is precisely the kind of challenge that American industry under the free enterprise system has always met. In fact, it is a challenge that can be fully met *only* in a system of private free enterprise. New and creative ideas in technology—ideas which must originate in the minds of men—do not come from men who are not free to think—and to think for themselves. No dictator can force men to have ideas. No system of regimentation of thought will nourish creative thinking. And regimentation is equally fatal, whether it be imposed by a national dictator, by a police state or even by a government bureau. By the same token, of course, it must not be imposed by industrial management either! If there is any area of human activity which flourishes only in an atmosphere of freedom, it is the area of creative science and technology. You will never find a real scientist advocating a dictatorship. You may find scientists with all sorts of other silly ideas (for they are just like other men) but not *that* one!

Freedom—private initiative—that is the first prerequisite for a virile technology. But there are other things that industry must provide or acquire in order to maintain technological progress. There are, in fact, four things: management, money, men and knowledge.

Management, money, men, knowledge

The intelligent management of research and an intelligent management policy toward research and toward the utilization of the products of research are a prime requisite.

Adequate funds for research are also necessary. But if the desirability and the necessity for industrial research are appreciated money will somehow be found.

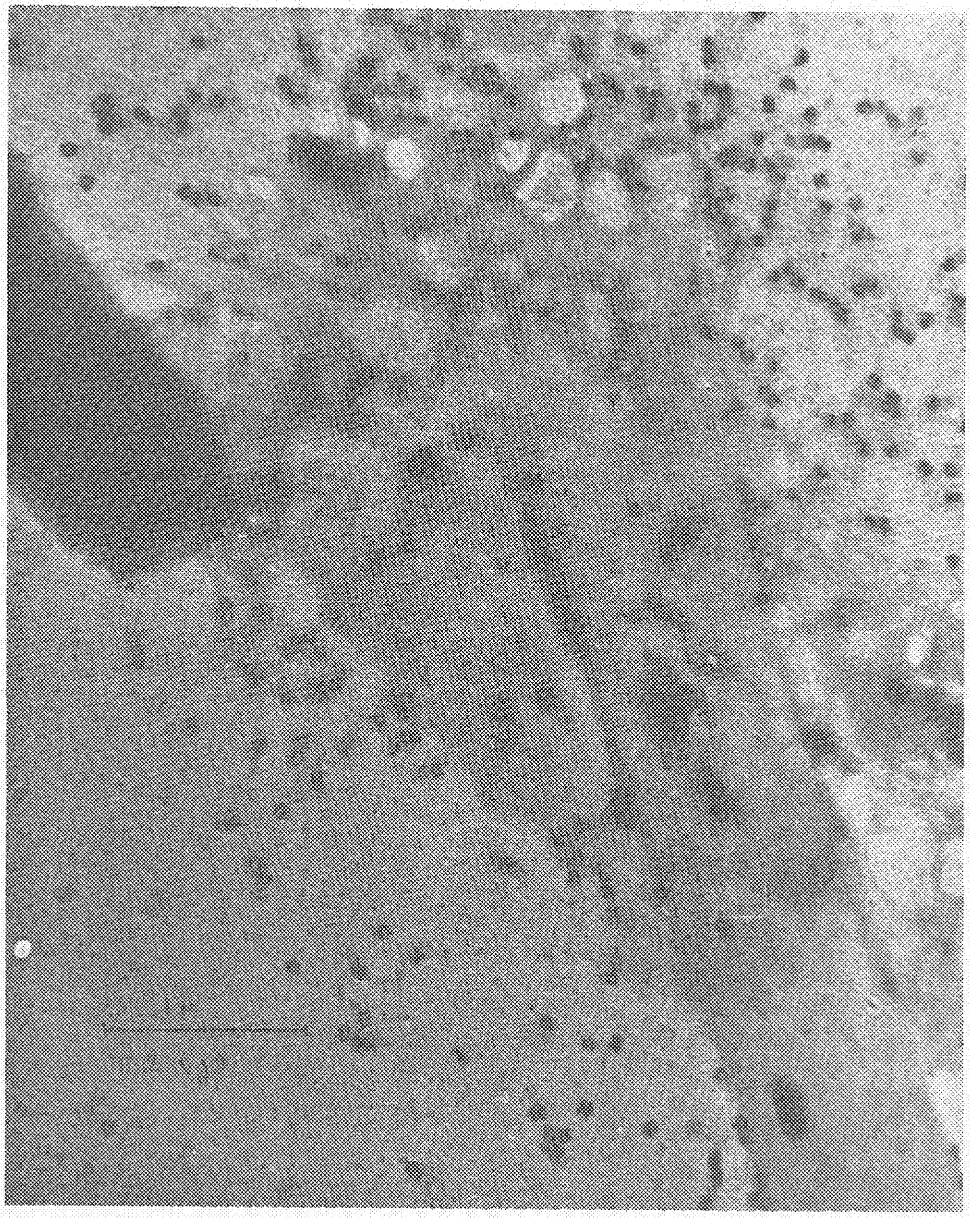
The last two ingredients of industrial research—men and knowledge—may not be so easy. We sometimes tend to take them for granted. But unless industry can draw on a supply of men carefully selected and adequately and soundly trained in creative research, no million-dollar laboratories will be worth a cent in advancing technology. Research men are, of course, the products of the universities. The universities do the selecting and the training. It will be well for industry from time to time to take a look at our colleges and universities to make sure they are thriving—to make sure they are kept free. For without their products in trained minds, not only technology but all of industry would soon wither and die.

And finally, knowledge. What knowledge is needed and whence does it come? The knowledge I am talking about is knowledge about the physical world—the knowledge of science. I refer not only to the knowledge we now possess, which must flow continually into every industrial laboratory, but also new knowledge which is yet to come—new knowledge which is essential to a new technology. In other words, a strong technology—as I have already frequently said—depends upon a strong science.

And this brings me to the third challenge—a challenge which has not previously existed or one of which industry has been unconscious. This is the challenge to insure the future of science. Industry has always in the past taken basic science for granted. It has always assumed that somehow, somewhere, the new scientific discoveries on which the new technology of tomorrow would be built would be made. And where have they been made? With a few important exceptions they have come from the laboratories of the world's universities. And until a few years ago the most active university laboratories were in Europe.

And what of the science of the future? The responsibility clearly rests heavily on the universities of America. Can they meet this responsibility? Under the American system this depends upon the people of America. If the people, through taxes paid for the support of state universities and gifts to the private ones, continue to support the universities they will continue to thrive. But since industry, as we have seen, is a great benefactor of the products of the universities, namely, men and knowledge, industry too faces the challenge to insure their continued virility. Just how this will be done is not yet clear. It is a new situation—a new problem—and an adequate solution has not been found.

But we can be sure of one thing, that if the challenges I have presented are met—the challenges to support science, to encourage technology, and to make use of their products—then no prediction about the future material welfare of this country is rosy enough to live up to the actual facts as they are certain to develop.



Bacteriophage (black dots), escaping from the corpse of an E. coli bacterium that they have destroyed, ready to attack the next E. coli (upper left). This scene was captured with an electron microscope.

Caltech biologists are using the viruses that attack bacteria to learn more about heredity, reproduction, and the chemistry of life.

by C. M. STEARNS

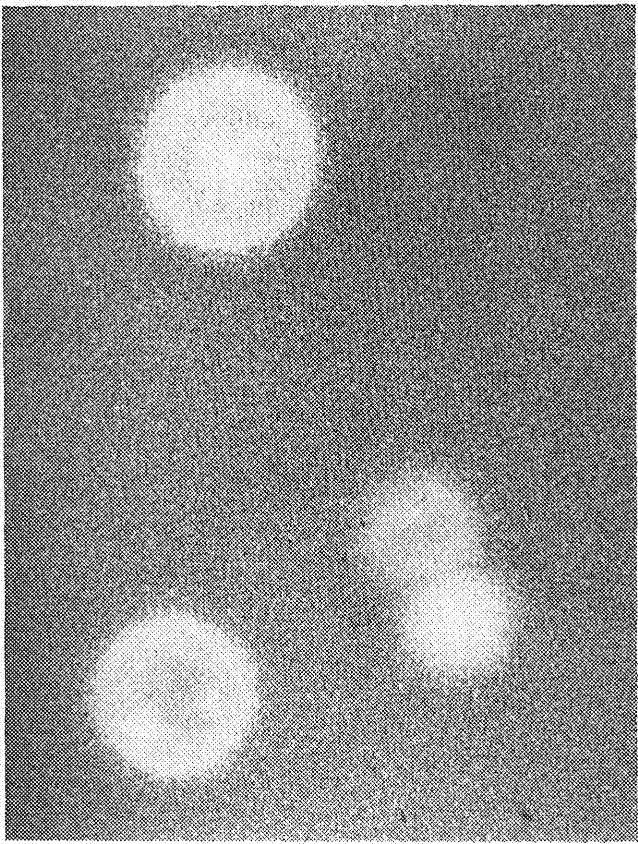
Bacteriophage: A New Test Animal

FROM THE TIME of its discovery during the First World War to the beginning of the Second, the group of viruses called bacteriophage remained little more than a scientific curiosity. In the last few years, however, men like Luria, of Indiana University, and Delbrück and Dulbecco, of Caltech, have lifted the "phage" out of obscurity. It has now reached a prominent position, in laboratories devoted to the biological sciences, as a remarkably useful "test animal" for the study of reproduction, heredity, and the chemistry of life itself.

The virus seems a promising crack in the wall of mystery that surrounds the fundamental process of reproduction principally because it is the simplest system in which reproduction takes place. Small enough to pass through a filter of solid porcelain, without any metabolic system of its own, at times a seemingly lifeless crystalline material, the virus still, once it gets into a living cell, can bring forth copies of itself. In fact, the virus is little more than a pure self-reproducing principle.

But even so, virus reproduction is not easy to study. For one thing, a virus will not reproduce outside of a living cell. The study of its reproductive mechanism is therefore obscured by the chemistry of the cells within which the virus multiplies, and frequently by the chemistry of the whole organism (for instance, a man) of which those cells are a part.

This difficulty was partly overcome when, a number of years ago, biologists began working with a group of viruses that attack, not the cells of complex animals, but the relatively simple single-celled bacteria. This group of viruses has been given the collective name of bacteriophage.



Four holes made in bacterial colony by phage. Size and clearness of "plaques" identify phage strain at work.

Because the bacteriophage virus attacks bacteria, its discovery raised great hopes that it might offer a cure for bacteria-caused diseases. It would be a simple matter, doctors thought, to dose a patient with bacteriophage and let the "phage" kill the guilty bacteria. For a number of reasons, the scheme failed. But bacteriophage, because it operates at such an elementary level of life, has made up for its early failure by becoming an ideal tool for studies of reproduction, in laboratories at the Institute and elsewhere.

For the sake of obtaining uniform results, one group of scientists who work with bacteriophage have limited themselves to seven closely related strains, all of which attack one kind of bacterium. The bacterium involved is Escherichia coli (bacteriologists habitually shorten the first word to "E"). E. coli's natural habitat is the intestinal tract of man and other animals; it is almost always there and almost always harmless. But E. coli thrives also in the test tube, or on the rimmed glass discs known as Petri dishes.

In ordinary studies of the phage's reproductive processes, the phage's attack on E. coli is not observed directly. It is possible, however, to watch the process. Under a microscope with "dark field illumination," E. coli look like miniature capsules, and the phage particles are no more than minute flashes of light a little like minnows in a sunlit pond. Focus on one individual E. coli bacterium, and after a few minutes you will notice that it seems to be boiling, inside. It is not possible to see the phage entering the bacterium (how it enters is, in fact, one of the still-unsolved problems of phage research); but the boiling is proof that a phage has entered the bacterial cell and begun to reproduce.

Then, suddenly, after perhaps twenty minutes, the E. coli cell bursts wide open, and a watchful eye may see a whole cloud of new phage particles moving away from the broken corpse—each new phage ready to find another E. coli and repeat the process. One phage, hidden inside a bacterial cell for fifteen or twenty minutes, has somehow multiplied itself to 300 or more.

But, as in most similar studies in current biological research, bacteriophage experiments rely not so much on individual viruses attacking individual bacteria as on the statistical results of thousands of attacks. For example: to discover the effect of some chemical agent on the reproductive power of a phage, it is not necessary (and would in fact be impossible) to inject the agent into one phage and then persuade that phage to enter a single bacterium. Instead, the agent can be mixed with fluid containing thousands or millions of phage, and the mixture applied to E. coli growing on Petri dishes. Thereafter, a simple count of the clear spots, or plaques, on the Petri dishes gives the answer. Each plaque represents an area where E. coli has succumbed to phage, and the number of plaques is therefore a key to what effect the agent being tested had on the phage's ability to multiply. The whole test procedure is characterized by biologists, respectfully, as an "elegant one," meaning that they admire its ingenuity, its simplicity, and the lack of ambiguity in its results.

The Chemical Approach

Another way of approaching the problem of reproduction as it occurs in bacteriophage is the chemical way. Chemical analysis of the nature of phage shows that it is made up largely of phosphorus-containing proteins. So chemists have added radioactive ("tagged") phosphorus to a medium containing E. coli infected with phage, and at suitable intervals have measured (with Geiger counters) the relative amounts of "hot" phosphorus that remain in the medium, that have been taken up by the bacteria, and that have been taken up by phage. By this technique chemists have begun to separate the steps that the phage takes, during reproduction, to build up the phosphorus-containing proteins needed to make up the new phage particles.

The experiment has recently revealed that what a phage actually does is to take over the metabolic system of the E. coli it has penetrated and put it to work making, instead of more E. coli material, more phage material. And this, by the way, is getting quite close to the kind of thing that may go on when the gene of the human cell uses the material surrounding it to make a second gene like itself to be transmitted to the cell's offspring. It is getting even closer, of course, to what must happen when a virus, say that of polio, penetrates the nerve cell of a victim.

Inseparably bound with the problems of reproduction are those of heredity, for heredity is in the final analysis simply something that results from the process of reproduction. And in understanding heredity, too, the bacteriophage is therefore useful. The seven strains of phage that scientists use invariably breed true to form in certain ways—in shape, for example, and in the length of time that it takes for a phage to multiply and burst the bacterium that it has invaded. For any given one of the seven strains of bacteriophage, these particular traits remain unchanged through generation after generation.

But there are a few traits that change. One controls the size of plaque that each strain of phage can produce in a Petri dish of E. coli; a strain that normally (in the "wild" state, a biologist would say) limits itself to small plaques may begin to make larger ones. Another change-

CALTECH BACTERIOPHAGE GROUP, 1950

Gunther Stent H. M. Kalckar Max Delbruck Leora Duberg
Egon Bittner G. H. Bowen William Hudson Renato Dulbecco
Wolfhard Weidel Seymour Benzer J. J. Weigle

able trait is defined by the range of E. coli types that a strain of phage attacks; a phage strain may suddenly increase in its ability to overwhelm differing kinds of bacterium. The fact that there are a few, but only a very few, ways in which bacteriophage are known to mutate makes them seem as promising to the investigation of the fundamental machinery of heredity and mutation as, say, the fruit fly, which is the old and valued stand-by of geneticists—but which exhibits instead of a few, more than five hundred genetic variations.

There is one further way in which bacteriophage may prove useful in the study of reproduction and heredity, and in fact in the study of a process so basic that it applies to several other aspects of cell behavior as well. This process is the one by which substances outside a cell manage to pass through the cell's membrane and get inside, and is obviously a fundamental part of the chemistry of life.

In the case of the phage, the problem centers around the question of how a phage gets into a bacterium. The reason why it may be possible to answer this question is this: while most phage have no trouble getting through E. coli's protective sheath, there is an occasional mutant form of phage that requires outside help. This helpless variety cannot break into E. coli unless there are added to the medium surrounding E. coli certain specific chemicals, such as tryptophane. If it is possible to discover why tryptophane is able to assist a phage to pass the bacterial wall, the answer may throw helpful light on the whole problem of cell penetration.

Such is the scientific position of the bacteriophage, and such is its promise. What has it proved, so far?

First of all, the phage has proved that something quite like sexual reproduction goes on in the interior of an E. coli that it has attacked. It was once supposed that, at this simple level of life, reproduction followed the familiar nonsexual system of division—one unit dividing to give two, the two dividing to give four, and so on. In such a pattern of reproduction, each cell (barring mutation) has of necessity only those characteristics that were possessed by its one "parent."

In the sexual pattern of reproduction, however, *two* parents contribute traits to the offspring. And it has been found that when E. coli is infected with two types of phage, the cloud of new phage particles that later bursts from the destroyed bacterium contains many phage that combine the traits of both of the two parent types. This indicates, then, that there must be at least some similarity between the hereditary machinery of the phage and that of infinitely more complex systems such as the human being.

Another surprising field of investigation has been opened to view through the study of the effect on bacteriophage of ultraviolet light. Ultraviolet light of a certain wavelength can "kill" bacteriophage, so that it is no longer capable of reproducing and destroying E. coli. That is not surprising, since ultraviolet light has the power to damage a wide range of microscopic germs and spores, and even the living cells of the human eye (as many people have found by looking too long at the sun). What *is* surprising is the recent discovery that ultraviolet light of a slightly different wavelength can bring the killed phage back to life.

This discovery has raised many questions and answered none, which is just what a great many important scientific discoveries have done in the past. But it may open a new way to the understanding of what makes a phage active and thereby help to disclose a new link in the chain of events that constitute life.

Practical results from the phage research now in progress at the Institute (and elsewhere) are far, perhaps years, off. But, as the foregoing discussion of the procedure and promise of phage research has attempted to show, the phage may someday assume a scientific importance out of all proportion to its size—which is such that it would take between two and four hundred thousand phage, side by side, to make a line one inch long.

The Two Supreme Elements in Human Progress

by ROBERT A. MILLIKAN

An extract from the forthcoming "Autobiography of Robert A. Millikan" *

NEVER IN HISTORY has mankind faced a situation which forced every person on earth to ask himself so insistently the question, "How can I help to make a better world?" for we know, as never before, that unless by our joint efforts we do find a way specifically to put an end to world wars the human race has the possibility, and indeed the likelihood, of destroying itself; so that the choice is now between a better world or no world.

The key to my own answer to the question I have raised is found in the following statement: Human well-being and all human progress rest at bottom upon two pillars, the collapse of either one of which will bring down the whole structure. These pillars are the cultivation and the dissemination throughout mankind of (1) the *spirit* of religion, (2) the *spirit* of science (or knowledge).

In the long sweep of evolutionary history from amoeba up to man, what we call spirit or soul—the latest and the most important element in the evolutionary process of creation—first began to appear in and evolve from the animal world when a being developed who began to bury with the bodies of his dead the implements that he thought might be needed in a world beyond the grave. That was a supreme moment. For can one imagine a mere animal thinking about a future life?

Breasted calls the time at which this kind of an idea first came into a brain "the dawn of conscience." I shall call it also "the dawn of religion," for with all the evolution that religion has undergone since its crude beginnings at that far distant date, our word *conscience*, which implies a sense of personal responsibility is today very closely identified with what I mean by the spirit of religion.

* By permission of the publishers. "The Autobiography of Robert A. Millikan" will be published on March 22, at $4.50, by Prentice-Hall, 70 Fifth Ave., New York 11, N.Y.

But in this long evolution of religion since that time, the word religion has, in fact, had all kinds of extraneous ideas associated with it or grafted upon it, some good, some very bad. It has meant, and still means in some minds, crude superstition; it has meant all kinds of man-made theologies; it has meant bigotry and intolerance and wars and inquisitions. But none of these things has, or should have, anything to do with what I call the essence of religion in the United States today.

We have in this country dozens of different religious sects and just as many different theologies, all necessarily wrong in some particulars since there obviously can be but one *correct* theology and certainly no one knows what that is; but there is just one element which I find common to all these religions. That common element is found, I think, simply in the life and the teachings of Jesus—in the attitude of altruistic idealism (the psychologist may want to call it extrovertness, the common man simply unselfishness) which was the sum and substance of his message.

He states it in the Golden Rule, "Whatsoever ye would that men should do to you do ye even so to them." *You* are the sole judge of what you *ought* to do. For to man alone of all creation has been given the power of choice between good and evil, and it is in the exercise of that choice that man fulfills his great mission on earth. Further, he obviously cannot choose the good without having the possibility of choosing the evil way, and with that choice open, if history teaches us anything then it is to be expected that here and there a John Dillinger or an Adolf Hitler will be found who will choose the evil way.

But this raises another very important question; namely, what guide has man to enable him to determine what is the good and what the evil way? Listen to how the great French political philosopher Montesquieu in

1747 answered that question for himself: "If I knew something beneficial to myself but harmful to my family, I would drive it out of my mind. If I knew something advantageous to my family but injurious to my country, I would try to forget it. If I knew something profitable to my country but detrimental to Europe or profitable to Europe and detrimental to the human race, I would consider it a crime."

From my point of view, the supreme personal and individual opportunity and responsibility of every one of us, without exception, in the present world crisis is substantially as Montesquieu stated it two hundred years ago. So far as I myself am concerned, that responsibility can be rephrased thus:

It is so to shape my own conduct at all times as, in my own carefully considered judgment, to promote best the well-being of mankind as a whole; in other words, to start building on my own account that better world for which I pray. The sum of all such efforts will constitute at least a first big step toward the attainment of that better world.

This means that my personal job is to develop an attitude of willingness—better of determination—to subordinate my own immediate personal impulses, appetites, desires and short-range interests to the larger good of my fellow man, *as I see it*, in cases in which there seems to me upon careful consideration to be conflict between the two. Otherwise I am free to follow my inclinations.

The essence of religion

Further, that kind of altruistic idealism is certainly the very essence of the teachings of Jesus. From my point of view, this attitude is the essence of religion. And not from my point of view alone, for Alfred N. Whitehead defines religion in these four words: "Religion is world loyalty." It necessarily involves faith in the existence of an ultimate Good (Einstein calls it "The Intelligence manifested in nature") which is worth living or dying for—a Good which justifies one in sacrificing his life, if need be, to promote it, as our boys did in the terrible war just past. If there is a better definition of a belief in God than that, I, at least, do not know what it is.

But this attitude of world loyalty, which is the measure of one's personal moral character—and for this there is no substitute whatever—is clearly an attribute of the emotions and the will, where lie, in fact, the springs of all our conduct. That attitude has nothing to do with *knowledge*. I may be as ignorant as a Hottentot, but if I am *living up to my light*, doing what, in all seriousness, I think I ought to do, that is obviously all that can be asked of me. That, I think, is what makes the difference between a religious and a nonreligious man today. The main activity, I think, of the churches should, and does consist in the effort to spread as widely as possible this attitude of world loyalty.

The scientist is inclined to underrate the importance of this effort to spread the spirit or attitude of world loyalty. I think he is fundamentally wrong! And to convince himself of his error he has only to ask himself: How many of us live up to what we ourselves know we ought to do? That should make him realize the magnitude of his mistake. Or, if he shrinks from or discounts such self-analysis, then let him take the easier task of counting up in his community the number of men whom he regards as essentially self-centered, devoid of any sense of social responsibility though they may be recognized as very able and well-informed. I suspect he will find his list a fairly long one. Either of these two procedures should bring home to the scientist the greatness of his error in discounting the importance of spreading the religious *attitude*—the attitude of world loyalty.

The religious leader, on the other hand, is prone to say that the world would be a perfect world if the hearts of men were right. But he is wrong, too. He has only to look at the horrors of inquisitions or of religious wars, which have been carried on in the main by sincere men who thought they were doing the will of God. Or again, he has only to acquaint himself with the history of infectious diseases like malaria, yellow fever, typhoid, syphilis, etc.; for these have been spread and great populations infected, sometimes wiped out, through practices not only tolerated but inculcated, often enforced, by well-meaning but unenlightened religious leaders.

I shall give two concrete illustrations. I am told by reliable observers that the sanitary conditions in some of the countries between the Mediterranean and India are so bad that of all the babies born only a minor fraction survive through infancy, the reason being that the Koran teaches that running water is sacred and is to be used for both drinking and bathing purposes, wholly without reference to the fact that it may be mixed with sewage and loaded with typhoid and other noxious germs, for Mohammed lived before sanitary knowledge came into existence.

Another conspicuous and a very live illustration of the point here at issue is found in religious opposition to population control measures in countries already so overpopulated that the only hope of escape from the Malthusian hell is to let them remain so disease-ridden that the oncoming population dies off as fast as it is produced.

Take another illustration from the social field. Look at the worldwide disasters, probably involving more deaths even than World War II, which have followed from the preaching by sincere and well-meaning but misguided and bad-thinking fanatics of the Marx-Lenin class war, for example, perhaps the most horrible type of war ever started, in order to see clearly that good hearts coupled with bad heads are quite as destructive of social well-being as are good heads coupled with bad hearts.

"The good of the whole"

Clearly, then, individual, personal morality, of which each one of us must be his own judge, has little to do with social morality, for this latter depends as I am using it, indeed as I define it, not at all upon what I in my ignorance may think is right, but rather upon what sort of procedures do actually best promote social well-being, or "the good of the whole." That is a question of science or knowledge, pure and simple. That is what the university and all of our research institutes are here primarily to discover and to teach. It is a question to which we shall of course never have the complete answer because we shall never possess all knowledge; and yet it is a question to which we have been able each year to give better and better answers as our knowledge of physics and chemistry and biology in all their subdivisions, and geology and psychology and economics and history and government grows, and the applications of these sciences to our group life increase. For in each one of these fields there is, with all our ignorance, a core of definite, established, noncontroversial knowledge already attained that can be taken, insofar as it goes, as a dependable guide to correct thinking and correct acting.

A recent picture of R. A. Millikan, in his office at the Institute, with his long-time secretary Inga Howard.

It is these continuously growing cores of knowledge, coupled with the attitude of world loyalty, i.e., the combination of science and religion, that provides today the sole basis for rational intelligent living; and in spite of man's frailties this attitude and these cores are slowly guiding us forward, so that we have actually in the United States attained within a hundred years, and primarily because of science and its applications, a higher standard of living for the common man than has existed in any time or place in history.

Religion and science, then, in my analysis are the two great sister forces which have pulled, and are still pulling, mankind onward and upward. And the two are necessarily intimately related, for the primary idea in religion lies in the single word "ought"—the sense of duty being underneath all religion, while what is duty, that is, what particular line of conduct is actually best for society as a whole, must be determined by science; in other words, this is a question of knowledge or intelligence, rather than of conscience. I am thus using, as at the very beginning, the two words *conscience* and *knowledge* as at least very closely related to the words *religion* and *science*.

But I wish to go a step farther, for someone asks, "Where does the idea of God come in? Isn't it a part of religion?" Yes, I think it is, and I should like to reply in three different ways to the question here raised.

My first answer is taken directly from Holy Writ and reads: "No man hath seen God at any time . . . If a man says I love God and hateth his brother he is a liar: for he that loveth not his brother whom he hath seen, how can he love God whom he hath not seen?" In other words, one's attitude toward God is revealed by and reflected in his attitude toward his brother men.

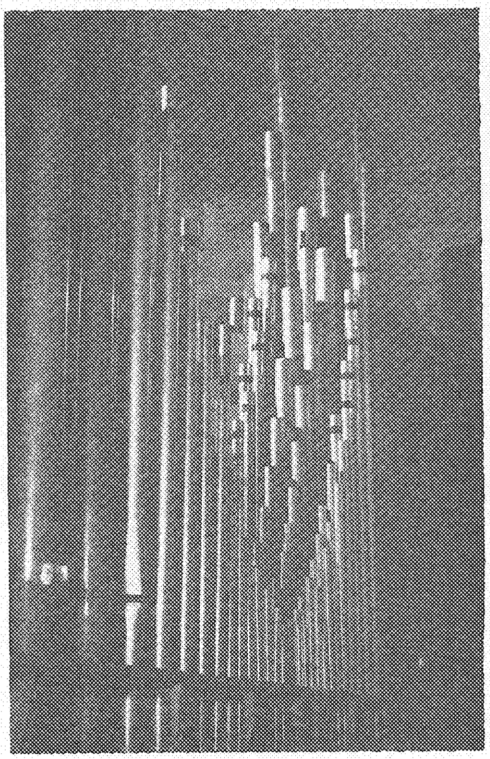
My second answer is taken from Dean Shailer Mathews, head of the Baptist Divinity School of the University of Chicago. To the inquiry, "Do you believe in God?," he replied "That, my friend, is a question which requires an education rather than an answer."

My third form of reply is my own and reads: I do not see how there can be any sense of duty, or any reason for altruistic conduct which is entirely divorced from the conviction that moral conduct, or what we call goodness, is somehow or other worthwhile, that there is Something in the universe which gives significance and meaning, call it *value* if you will, to existence; and no such sense of value can possibly inhere in mere lumps of dead matter interacting according to purely mechanical laws. Thousands of years ago Job saw the futility of finite man's attempting to *define* God when he cried, "Can man with searching find out God?" Similarly, wise men ever since have always looked in amazement at the wonderful orderliness of nature and then recognized their own ignorance and finiteness and have been content to stand in silence and in reverence before the Being who is *immanent in Nature*, repeating with the psalmist, "The fool hath said in his heart, there is no God." Einstein, one of the wisest of modern men, has written:

"It is enough for me to contemplate the mystery of conscious life perpetuating itself through all eternity, to reflect upon the marvelous structure of the Universe which we can dimly perceive, and to try humbly to comprehend even an infinitesimal part of the *intelligence* manifested in nature."

I myself need no better definition of God than that, and some such idea is in all religion as a basis for the idea of duty.

The Philosophy of Organ-Building



Why should anybody want to build an organ? Ask the man who built one.

by HUNTER MEAD

ANY MAN WHO FOLLOWS some hobby enthusiastically is likely to be considered eccentric by everyone except other persons who pursue the same hobby.

Among hobbyists, those who become absorbed in a creative avocation are likely to seem doubly eccentric, since there is apparently no limit to the amounts of time, money, energy and space they will sacrifice to their activity.

Among creative hobbyists, amateur pipe-organ builders constitute an elite of eccentricity. They are indeed a strange brotherhood. Some are mere dreamers, who get no further toward their dream than piling up reams of specifications and stop lists. Others may acquire a rank or two of pipes which gather dust and clutter up the garage for years on end. A few bolder ones may acquire parts of chests, perhaps a discarded blower or console—but these too gather layer after layer of dust and take up even more space in the garage or cellar. Only the most glassy-eyed and monomaniacal begin putting the assorted parts together, while only those whom the gods love to the point of insanity manage to get the thing working.

The objective observer might notice that the intensity of the organ-building infatuation appears to vary directly with the number of previous financial commitments, and inversely with the square feet of floor space the hobbyist may possess to house his dream organ. Psychological compensation, no doubt, but nearly invariable: If a man owns a five-room house and has an income of two hundred a month, he plans an organ that will require three of his five rooms and will cost ten years' income; if he has eight rooms, he plans to sacrifice only two of them to the organ and spend only five years' income, and so on. The rich, with acres of grounds and a thirty-room mansion, are usually content with an instrument that tucks nicely into one corner of their oversize living room. But, rich or poor, dreamer or doer, the true organ fans and would-be organ owners are a solid fraternity of lonely individualists who have at least their hobby to keep life worth-while.

After twenty-eight years as an organ dreamer, with endless lists of specifications and paper plans piling up in the desk drawer, I managed to get over into the active builder class. This is my story. It can be read either as a warning or as an encouragement, depending on your school of thought.

Three years ago when I bought a house, I selected one with organ potentialities. On a limited income the only potentialities I could afford were an extra bedroom adjacent to the living room and a living room just slightly larger than average, measuring 15 by 30 feet. The other very desirable feature would have been a high ceiling, but that was impossible, so it has been necessary to work within the limitations of the standard 8-foot 3-inch ceiling. It would also have been advantageous to purchase a house located on at least one acre of ground, but finances made it inevitable that I settle for the standard 50-foot lot. Fortunately the adjacent house on the future organ-chamber side was on a double lot, some 35 feet away from my dwelling.

My original plan was to wait several more years, save my money and build a new instrument. Last June, however, an unusually attractive bargain in an excellent old organ turned up, and at that moment I switched

The console is extremely compact. Waist-high, it occupies about the same floor area as an upright piano.

from the dreamer to the doer class—with less than one hundred dollars in the bank to start the doing on. First, it was necessary to dismantle the organ, and do it promptly. With the aid of a loyal crew of fellow organ-addicts and curious friends, the thousand pipes and several thousand pounds of chests and blowing equipment were moved in three days by trailer and rumble seat. Almost overnight the back yard and garage took on the appearance of vast salvage operations—an appearance which, alas, they still have after seven months of work.

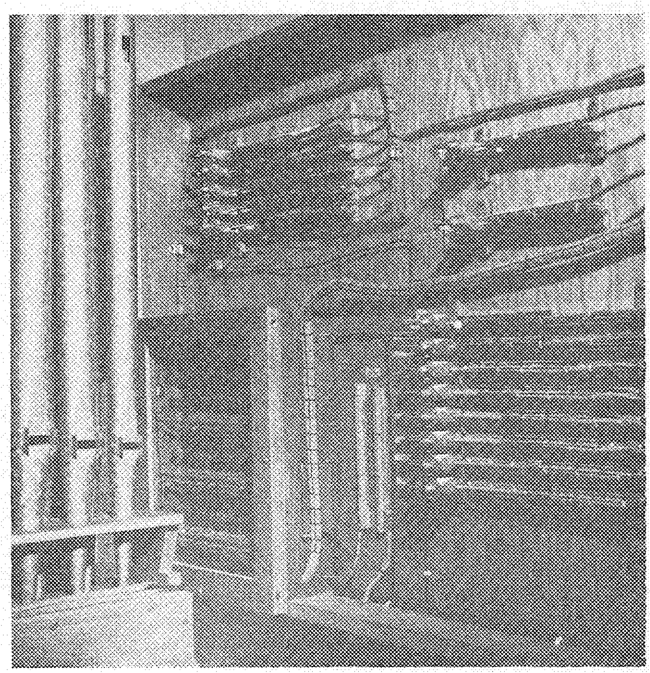
By this time I realized my need for some professional help and advice. I had read most of the available books on pipe organs and had played an organ for years in modest fashion, but the sudden realization that the several tons of stuff in my back yard had to be re-assembled and modernized became terrifying. Fortunately, among my organ acquaintances there was one who had gone on to become something of a professional; he had worked under the best local men and acquired enough experience to assume general supervision of the whole project. It was also fortunate that he was willing to work part-time, as money became available, and most fortunate of all that he was willing to wait months for part of his pay.

I must emphasize that without such aid and advice we would have been doomed to early and permanent failure. As every craftsman knows, there is a vast gap between book knowledge and the real thing, and it was Marvin Blake (who presently combines organ-building with attendance at Occidental College) that supplied us eager amateurs with that practical knowledge. Often his most important function has been to restrain our grandiose dreams by pointing out the difficulties and expenses we would incur if we tried to realize them.

Besides Blake's professional aid, much manpower has been supplied by a group of simon-pure amateurs. One or two are organists, several others mere organ addicts, still others merely tolerant and loyal friends. Combined, they have contributed several thousand hours of free labor, and saved me a corresponding number of dollars. The would-be home builder who lacks such free labor and enthusiastic support has a doubly hard job, a job which I personally would never have undertaken.

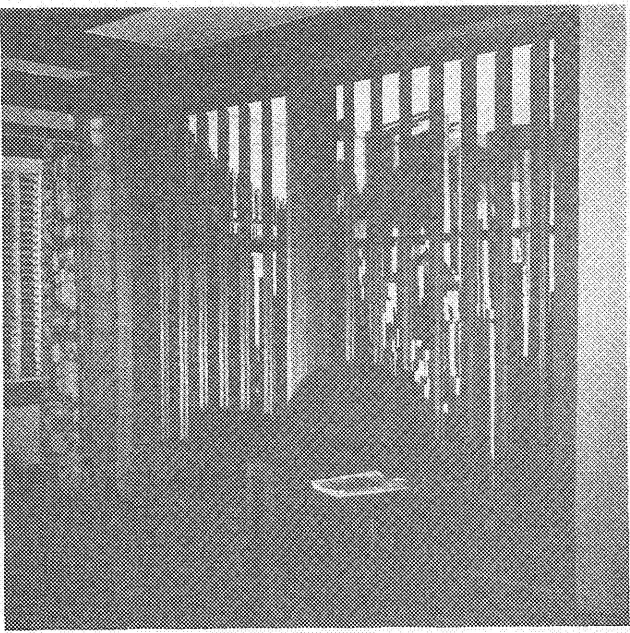
Installation of an organ in an ordinary residence usually creates two great practical problems: There must be adequate foundation, and there must be adequate height. It is of course possible to go upwards by tearing out a ceiling to utilize the attic, but this leaves the foundation problem unsolved. It is also likely to produce problems of thermal insulation, and perhaps increase the problems of sound insulation. In most cases it is better to go underground. By removing a floor and excavating, both height and foundation are provided. This we did, so the first major problem was to tear out the flooring and joists of our erstwhile bedroom, together with the wall which separated livingroom and bedrooms. Then the *real* work began.

It did not require a graduate civil engineer to determine that, since we needed some thirteen feet of headroom and our ceiling was approximately eight feet high, we would have to dig plenty. Happily the floor was two feet above ground, so a pit three feet deep was indicated. For a steam shovel, an area eleven by fourteen feet to be excavated three feet is nothing; for three manual workers armed with wheelbarrow, hoe, pick and shovel it is decidedly something—particularly when you are working inside a building and the dirt has to go out through a window whose sill is two feet above the old floor level. As you dig deeper you begin to have the impression of digging a cesspool through a keyhole.



Wiring system, though only half-completed, nearly fills space that once was a clothes closet. Pedal relays (lower left) are under glass to keep them quiet. Stop-action switches are at upper left and lower right.

The organ chamber, which used to be a bedroom, is screened from the living room by vertical louvres.



Faced with a choice of using buckets or wheelbarrows up a steep ramp, we chose the latter. (One wonders if Galileo ever realized what an instrument of torture an inclined plane can be!) Twelve tons of good earth went out the window, to be hauled away by dump trailer and deposited miles to the east.

Days went by—aching, filthy, discouraging days. Then more backbreaking work shoveling sand and cement into a mixer for our slab and sidewalls. Here again we wisely called in some professional help to supervise the cement work and install the forms properly, but the gritty slave labor still required the by-this-time somewhat sobered amateurs. More than eight tons of sand and cement went in by the same window out of which the dirt had so recently gone—with costs going up by the hour.

Constant use of electric fans for a week finally dried the cement sufficiently for us to work in what now began to look like an organ chamber, so we moved in to do the carpentering. All the windows were boarded up and covered with felt for insulation. Then the whole chamber was lined with pine planks backed with felt. This was a lot of work, but the results have been excellent as concerns both thermal and sound insulation.

And thus after a month of preparation, we were ready to begin installation of the actual organ. We decided that only part of the old action could be retained; much of it was hopelessly outdated, and even had it been modern there was too much wear for efficient operation. Even a relatively ageless pipe organ cannot stand 42 years of constant use (and considerable neglect) without beginning to show it. Consequently we decided to modernize most of the action, using electricity where the original builder employed pneumatic tubes and pouches.

While this decision was an inevitable one, we soon discovered that our most difficult problems would arise when we attempted to combine old action with new. Such parts of the old action as we retained were sound in themselves, and our new electric work was the best available; unfortunately there are critical points at which new and old had to be integrated, and it is at these points that most of the headaches have come. We saved money by doing what we did, but we lost weeks, not to mention much sleep and patience. In many ways it is more difficult to rebuild an old organ than to construct a new one, so we make the unqualified claim that we have built an organ. We had several large units to start with, but it has been far more of a test of skill (and character!) to utilize these second-hand units than it would have been to make our own.

All of the original pipework was retained, but we have so rearranged this that the present tonal effect has little relation to the way the organ sounded from 1907 to 1949. There are tides of taste in these matters as in all things human, and we have attempted to make our instrument conform to the best current tonal thinking. This has not been fully possible, at least for the present, but another year or two will bring us nearer this goal.

At the present time the instrument is substantially complete in terms of the 1950 edition. It will never be fully "complete" in the sense that organs are usually completed, since there will undoubtedly be changes and experiments going on during the rest of my lifetime. At the moment it is a two manual organ of just over one thousand pipes. There are seventeen "stops" or ranks of pipes. Preparation has been made in the console and relays for adding another five hundred pipes. Since most of these will be small, they can be squeezed into the present chamber. We hope they can be added by next fall.

The next *major* expansion will necessitate remodeling the front of the house so that part of the present front porch can be utilized. This will provide space for an additional six to eight hundred pipes, but will require a new console with a third manual (keyboard). Money being what it is, we estimate 1953 for this next big push, providing neighbors, building codes and the Institute's payroll office continue to cooperate.

Since buying the original organ I have secured a second much larger instrument (the dismantling and moving of this one is a whole saga in itself) whose two thousand pipes presently clutter up basement and garage and cause the attic to sag ominously. Thus we have an inexhaustible mine for experimenting with tonal effects and enlarging the resources of the instrument as time, money and space become available.

Obviously a 50-foot lot has a limit; and we will doubtless reach that limit long before 1960. But then we can start rebuilding the present instrument with a view to improving it and utilizing our limited space more efficiently. So we are not worried about running out of work and leaving the associated organ amateurs restless and unemployed.

The question might well be raised whether this is a musical instrument or a technological curiosity we are fabricating. It is, I assure the sceptical reader, a very musical instrument. Already, competent organists have pronounced it "the most impressive and useful instrument of its size in Pasadena."

But what of the future? Well, we are all relatively young, we've (barely) got our health, the attic is full of non-functioning pipes, and there are still six rooms in the house with no organ in them. What more can man ask for in this life? The world is ours! Amateur organ builders of the world, unite! You have nothing to lose but your sanity.

Science in art

Caricatures of Men of Science

by E. C. WATSON

Herbert Spencer (1820-1903), philosopher of science

A PHILOSOPHER may seem out of place in this series devoted to men of science, but Herbert Spencer's appearance here can be justified on at least two counts. First, he exerted a tremendous influence during his lifetime (1820-1903) upon English thought—and thus upon science. Secondly, the contrast between Spencer's caricature (and the written account which accompanies it) and those of the contemporary scientists which have already been reproduced in this series only serves to emphasize the respect accorded to science and scientists during the Victorian period.

As the philosopher of the great scientific movement of the second half of the nineteenth century, Spencer's doctrines were attacked from both sides—by the philosophers and by the scientists. His work coincided in time with the great development of biology under the stimulus of Darwin's theory, and it was Spencer who contributed to that theory the phrase "survival of the fittest."

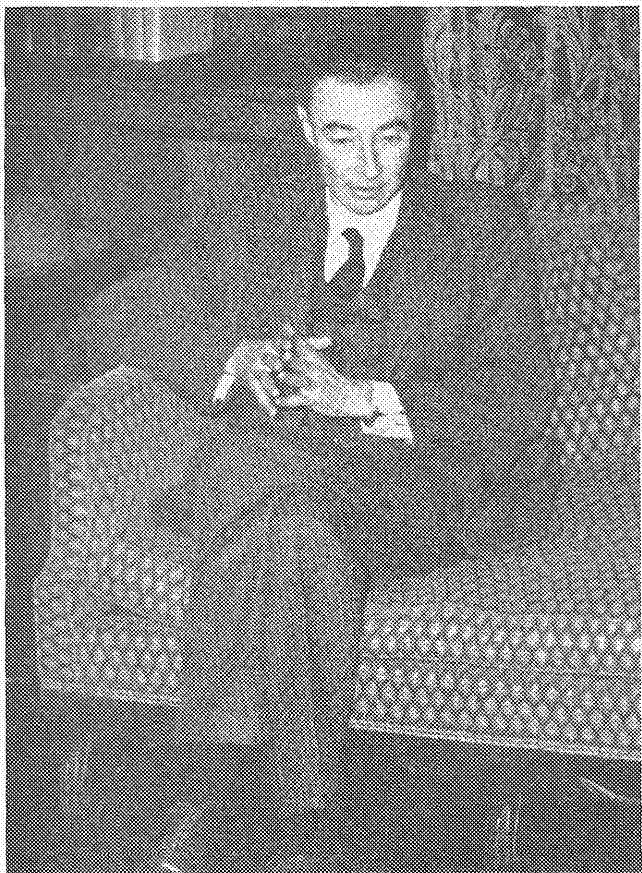
In 1860 he published a prospectus of a new system of philosophy which would embrace the general principles of all existing knowledge. Though he gave most of the rest of his life to the development of this philosophy, his attempt to synthesize all scientific knowledge could hardly help but fail. Because he lived at the beginning of a period of unparalled scientific activity, he could not possibly sum up and estimate its total production.

The caricature at the right and the acid appraisal of Spencer below appeared in *Vanity Fair* for April 26, 1879.

"Herbert Spencer holds the present greatest name among the philosophers. He is scarcely known in his own country outside the circles of fogies, but abroad he enjoys a wonderful reputation as the leader of all modern thought. He was born nine-and-fifty years ago, the son of a schoolmaster, who strove to culture him with the classics, and to make of him a civil engineer. But young Spencer resisted Greek and Latin, and soon renounced engineering. He was, and knew himself to be, powerful with the pen; so he became a writer. He learnt to handle a good plain English of the frigid sort. In a casual way he published articles on Government, Education, and other dull subjects, from the time he was one-and-twenty. But when Darwin invented Evolution, Evolution invented Herbert Spencer, who saw how the notion might be applied to psychologic problems. So he now addressed himself to pure philosophy, and began to publish distressing tomes. He fell foul of Comte and of Mill, and plunged about with atoms and monads in such fashion as made all men see that he must have a philosophy of his own. As nobody could well understand him his reputation waxed mightily. He is now the one recognised authority on 'Sociology'; he has discovered that 'ultimate scientific ideas are all representatives of realities that cannot be comprehended,' and that man of science 'knows that in its ultimate essence nothing can be known.' Yet he goes on writing.

"Mr. Herbert Spencer is believed by many to be a companionable, cheerful man. He has been more than once to a shareholders' meeting to war with railway directors; he delights also in children; and he holds that suicides should rather be encouraged. Yet he goes on living."

THE MONTH AT CALTECH



Oppenheimer

Distinguished Visitor I

■ As the first of a series of distinguished physicists to visit the Institute this year, Dr. I. I. Rabi, Executive Officer of the Department of Physics at Columbia University, came to Caltech last month chiefly to conduct a series of six seminars on nuclear physics. On at least two occasions, however—in an evening talk for members of the Athenaeum on "The Atomic Armaments Race," and in a subsequent conference with the press—Dr. Rabi addressed himself to the subject which most laymen are most interested in hearing most physicists discuss: the bomb.

If nothing else, said Dr. Rabi, the fact that Russia now has the atomic bomb should encourage us to re-evaluate our foreign policy. Ever since the Russian rejection of the Acheson-Lilienthal Report proposals, it has been our *declared* policy to continue to attempt to abolish the use of the bomb. But our *actual* policy has been to attempt to contain Russia within its present boundaries—counting on our possession of the bomb to enforce that policy.

Now that Russia has the bomb too, what do we do? Build bombs faster? Russia would be sure to do the same thing. The effect would only be an increase in our insecurity.

Thus far we have proceeded along only one line of policy in dealing with Russia. Now we must consider other possibilities. Considering the similarities between this country and Russia—including the fact that both are large countries, containing every natural resource; and that neither one can attack the other without devastating itself at the same time—we *must* attempt to find some basis for agreement.

But there didn't seem to be any way to reach any agreement, said one of Dr. Rabi's listeners.

"It is like living in the same house with a difficult neighbor during a housing shortage," said Dr. Rabi. "You still don't want to burn the house down."

Could Russia, in one surprise attack, bomb enough United States cities to paralyze us and prevent our retaliating?

"I'm not interested in whether we are *paralyzed*," said Dr. Rabi. "I want a policy that prevents this situation entirely—that isn't reconciled to this viewpoint, to be able merely to defend after ten million Americans are dead."

Distinguished Visitor II

■ Dr. J. Robert Oppenheimer, Director of the Institute for Advanced Study at Princeton, N. J., and a former member of the Caltech faculty, returned to the campus last month to deliver a series of lectures on the elementary particles of physics. Like Dr. Rabi, he had his day with the press too.

Elementary particles were the last things the newspapermen wanted to discuss with Dr. Oppenheimer at his press conference. And the atomic energy program and the hydrogen bomb were the last things Oppenheimer wanted to discuss with them.

"If I can't talk about these things," he explained, after dodging half a dozen questions, "it doesn't mean that I don't think I should. For my part, I think our

Rabi

situation would be a lot healthier if a large chunk of the lid could be taken off secrecy."

The press decided to play it safe and ask about new developments at the Institute for Advanced Study. Dr. Oppenheimer told them about the Institute's new electronic calculator, which is more marvelously complicated and faster than any other yet built, and is familiarly known as the Maniac. It can multiply two sets of figures, each containing 40 digits, in one hundred-thousandth of a second.

And what was the value of that?

"Well," said Dr. Oppenheimer, "it provides the basis for wider intuition. By giving a fast answer to a problem that would ordinarily take days or weeks to solve, it provides physicists and mathematicians with relative experience—which is pretty much what intuition is."

Was Dr. Einstein busy these days at the Institute?

He was. In fact, he was "wearing out one assistant after another."

What about atomic power?

"I'm afraid there is an uninformed expectation of atomic power," said Dr. Oppenheimer. "It's still an open question, but I don't think it's an urgent one. There's no great incentive in developing power from the atom in a hurry. We don't know yet how much atomic material is available, or to what extent thorium can be used as a supplement to uranium."

And Russia — what did the scientists think about Russia anyway; didn't they worry about Russia like ordinary people do?

Dr. Oppenheimer answered that one with a parable—about a woman who awoke one night to find a mean-looking, desperate character standing at the foot of her bed, glaring at her with bloodshot eyes.

"My God!" said the terrified woman. "What are you going to do?"

"Madam," the man replied, "this is *your* dream."

Y Drive

For more than two years the Caltech YMCA has been trying to find a larger residence house, closer to the campus. The present residence is not only too small; it's a mile from the Institute.

Early last December, the Board of Directors of the Y, after a house-to-house survey of residences and vacant lots near the Institute arranged to buy a piece of property at 391 S. Holliston Ave., just 400 feet from the campus. Here, the Y planned to build a new residence—the kind it needed, with space concentrated in the living room and dining rooms rather than in numerous bedrooms. The Board decided to take a 30-day option on the property, then try to raise $15,000 for construction of a residence and $15,000 more to endow its upkeep.

It looked like a long-term project until a young alumnus of the Institute, who had been active in the Y as an undergraduate and closely associated with the organization ever since his graduation, offered to contribute the $15,000 for the residence, as a memorial to his parents, if other friends of the Y would come up with the additional $15,000—*within 30 days.*

That was on December 10, and what happened after that deserves the careful attention of the most experienced professional fund-raisers.

Largely through the efforts of Prof. Royal W. Sorensen, Mrs. Margaret Fleming, Executive Secretary Wes Hershey, and Chairman J. Stanley Johnston, of the Y's Board of Directors the additional $15,000 was pledged by December 30. And by the time the January 10 deadline was reached checks had come in for $5,000 more, making an available endowment of $20,000.

Right now a local architect is drawing up plans for the projected residence—gratis, as his contribution to the project. Construction may get under way as early as March, and the residence should be ready by fall.

Eminent Member

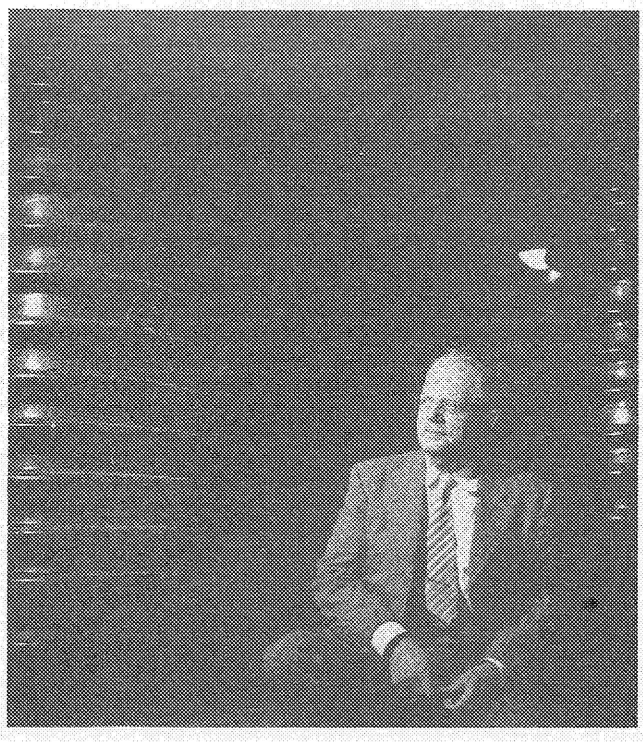
On January 30, Royal W. Sorensen, Professor of Electrical Engineering, was elected an Eminent Member of Eta Kappa Nu, national honorary organization of electrical engineers.

At the same meeting in New York City two other outstanding scientists were similarly honored—Dr. Vannevar Bush, President of the Carnegie Institution of Washington, who headed the Office of Scientific Research and Development during the war; and Dr. V. K. Zworykin, Director of Research for the Radio Corporation of America.

This is the first time that Etta Kappa Nu has awarded this honor, though it has been provided for in the organization's constitution for many years. For the past 13 years, however, Eta Kappa Nu has annually honored the Outstanding Young Electrical Engineer of the Year. Three of Dr. Sorensen's former students have received this award. In 1948 the honor went to Dr. A. M. Zarem (M.S. '40, Ph.D. '44), head of the Stanford Research Institute's Los Angeles office. In 1942 it went to Dr. John R. Pierce (B.S. '33, M.S. '34, Ph.D. '36), now with the Bell Telephone Laboratories. And in 1940 it went to Dr. Jesse E. Hobson (Ph.D. '35), at that time with Westinghouse, now director of the Stanford Research Institute.

NACA Advisors

Six members of the Institute staff were appointed members of technical subcommittees of the National



Sorensen

Advisory Committee for Aeronautics last month. Professor Ernest E. Sechler was appointed to the Subcommittee on Aircraft Structures and Frank E. Marble to the Subcommittee on Compressors. Reappointments: Dr. Clark B. Millikan (Chairman) and Dr. Hans W. Liepmann, Subcommittee on Fluid Mechanics; Dr. Beno Gutenberg and Dr. Oliver R. Wulf, Special Subcommittee on the Upper Atmosphere.

Members of the NACA's 27 technical committees and subcommittees are selected for their technical ability, experience, and recognized leadership in their special field of competence. They serve in a personal and professional capacity without compensation in contributing their knowledge toward formulation of the research programs required for the country's air leadership.

Responsibilities of subcommittee members include advising on problems related to the assigned technological field of the technical committee or subcommittee; reviewing research in progress both at NACA laboratories and at other organizations throughout the country; recommending research projects; and assisting in coordination of research programs.

McCallum Fellowship

■ PRESIDENT DUBRIDGE last month announced the establishment of a graduate fellowship for work in the field of biochemical genetics, to be awarded on a competitive basis to a student interested in working toward a Ph.D. degree in this field in Caltech's Biology Division. The $2,500 fellowship, which is established by the McCallum Foundation in cooperation with the Nutrition Foundation, will go to a student interested in "investigating the basic ways in which living cells build up and utilize foodstuffs."

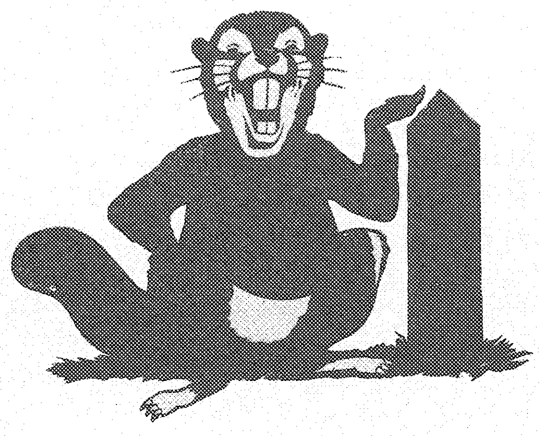
New Arrivals

■ PROFESSOR BENGT STRÖMGREN, Director of the Copenhagen University Observatory in Denmark, has joined the Institute faculty as Visiting Professor of Astrophysics for the second term. A graduate of Copenhagen University, Professor Strömgren served as a lecturer there from 1932 to 1936, when he came to the United States as Assistant Professor of Astrophysics at the University of Chicago. In 1938 he returned to Copenhagen University as Professor of Astronomy, and in 1940 he became director of the University's observatory. His last trip to the United States was made in 1947, when he served as Visiting Professor of Astronomy at the University of Chicago. At the end of the current term at Caltech, Professor Strömgren will go to Princeton as a visiting professor for the remainder of the academic year.

Professor Strömgren is General Secretary of the International Astronomical Union, and a member of the executive committee of the International Council of Scientific Unions.

■ WILLIAM H. GEIS has joined the Geology Division as Lecturer in Petroleum Geology. A graduate of the University of California, Mr. Geis has been specializing in oil-field engineering and petroleum geology since 1916. Formerly assistant to the vice president of the Union Oil Company, he is now a consulting geologist, living in Pasadena.

THE BEAVER



Some Notes on Student Life

THE SECOND TERM was quite obviously the worst term, the Beaver decided, laying his pencil sadly on the desk. He had been working diligently through the derivation of an equation and had suddenly realized that the next step would reduce it irrevocably to $1 = 1$, a fact which he felt hardly needed all this mathematics to prove. In the first or third terms he would have gone back over it at once. Now he only sat back and lit a cigarette. The second term was too far from September to be new and interesting, and too far from June to be almost over. Pajamarinos and callow Frosh and the Interhouse were past. Spring beach parties and graduation were in the future. But nothing seemed to be happening right now.

Electioneering

OF COURSE, elections were coming up shortly. Campus stump-statesmen were assuming busy, cigar-chewing airs and potential candidates were dark and secretive, giving back blank looks or cagey shrugs when asked if they were running for office. But very soon there would be the nominations assembly and they would look a little surprised when nominated, as though Popular Demand had walked into their rooms one night and twisted their arms. Then posters would spring up like dragon seed along the olive walk and a brief excitement would hang over the campus.

But, while the average Techman found all the electioneering interesting or amusing to some degree, he seldom did more than listen and vote. The Beaver felt it was a poor situation to leave the whole field of student government to a small group of a more energetic or exhibitionist nature, but he perennially wondered what could be done about it. That strangely universal malady, I-Haven't-Got-The-Time, was probably no idle excuse.

The Beaver himself knew *he* wouldn't want to step into Ralph Lovberg's shoes, or keep John Fee's rather recondite finance books, or even chew his already negligible fingernails promoting Bill Freed's ASCIT dances or Bert Snider's rallies and assemblies. Still he realized that he wasn't doing much just sitting here and filling paper with $1 = 1$. Maybe there was a job . . . He fumbled for his *Little T* and opened it to the Honor Point list, while his roommate eyed him suspiciously. His roommate was a very pure scientist and looked askance at political ambitions.

New Criteria

SOMETHING SEEMS on the verge of happening to the eternal campus problem of good instruction. In January, a seven-student committee headed by Prexy Lovberg was asked to present to the faculty the student complaints on graduate instruction and to withhold no fangs.

An amosphere of lethargy had long enshrouded discussion of teaching-improvement schemes. The students felt the existence of an attitude among some of the faculty that all such schemes had long ago been considered and rejected as impracticable. But the students also felt strongly that any working program—even experimental—was better than empty discussion without action.

The thesis the committee presented was that teaching was not accomplished by placing an outstanding research mind in close contact with an undergraduate mind and expecting ideas to flow between them by osmosis; teaching should rather be an active communication, requiring three essential qualities in the teacher—knowledge of his subject, interest in teaching, and ability to present material to a class lucidly and with maximum efficiency.

Armed with this threefold watchword the students appeared before an excellently-attended faculty meeting in the Athenaeum with a concrete program mapped out, chiefly for the improvement of instruction by graduate students. They asked first that graduate grants be divided into two sections—teaching fellowships for those responsible for actual instruction, and graduate assistantships for all others on grants, with a higher stipend and prestige value for the former. Then they asked for an effective screening process—to consist of interviews, questionaires, letters of recommendation, and psychological aptitude tests, all concerned with a man's teaching interest and potential ability—with the purpose of giving teaching fellowships in each case to the most qualified.

To improve existing instruction the committee reconmended finding a man who could give an effective course in class mechanics, speech, class psychology, and the practical aspects of teaching—a course which it would be required that all teaching fellows attend and pass successfully in order to hold their fellowships. Finally, to evaluate a man's teaching, the committee drew upon its Army experience of the Inspector General system and recommended that each department head spend about half an hour each team with every class in his department, in the absence of the instructor, to learn from his students an instructor's teaching qualities.

Here was no ordinary airing of undergraduate gripes but a practical, constructive program, and Lovberg's committee was invited to return to work it out further. The Beaver on campus was perhaps a little surprised at the sympathetic faculty reaction but was highly pleased with the ideas presented. Although many of his friends were skeptical, he ardently hoped that *this* time action would be taken and the program put into effect, even if only to try it out. He felt that, as a customer in this knowledge emporium where he paid out $600 yearly from a thin purse, he was entitled to this consideration.

—*Jim Hendrickson '50*

ALUMNI NEWS

Fund Donation

■ THE CLASS OF 1950 announced last month that it would donate $500 to the Alumni Fund, to go toward construction of the new gymnasium. Last year's graduating class contributed a similar amount to the fund.

Hawkshaw Jeffreys

■ FOR NEWS OF C. E. P. Jeffreys, Ph.D. '31, we refer you to the current (February) issue of *Westways*, the official publication of the Automobile Club of Southern California. In an article called "Hawkshaw in White" Ed Ainsworth describes some of the livelier activities of the Truesdail Laboratories in Los Angeles, where Jeffreys is Director of Research.

As a testing laboratory Truesdail tackles a fair share of knotty research problems for business and industry. But, according to Mr. Ainsworth, it takes on, and solves, a good many offbeat assignments besides. For example, Dr. Jeffreys works on smog, water purification, the problem of developing an effective but harmless synthetic smoke for movie fires, how to take the smell out of the air in and around an onion-dehydrating factory, and how to test a horse to determine whether he has been "hopped up" for a race.

Chapter Notes

■ THE CALTECH CLUB of New York met on January 10 at the Hotel Holley to hear a fellow-member, William

R. Hainsworth '18, tell the story of his successful climb up Mt. Vancouver last summer. Vancouver, which is in the St. Elias Range in Alaska, was the highest (15,850 feet) unclimbed peak in North America until Bill Hainsworth and his party negotiated it. Incidentally, it was just the latest in a long line of "first ascents" for Hainsworth.

The New York Club is getting set right now for one of its biggest meetings of the year on February 2, when President DuBridge is to speak on "The Year at Caltech." In addition to club members and their guests, parents of students now attending the Institute have been invited to, and will be particularly welcome at, this meeting.

■ The Washington Chapter met at the Roger Smith Hotel on January 30 to hear President DuBridge speak on "Caltech Today." There were about 35 present, including the wives of twelve of the members. On hand were: Caltech Professors C. C. Lauritsen, F. C. Lindvall, and H. P. Robertson along with J. Boyd, J. M. Buchanan, C. A. Burmister, D. C. Campbell, R. D. Fletcher, J. W. Follin, E. C. Fitch, J. B. Friauf, A. V. Haeff, B. C. Haynes, R. M. Langer, A. E. Lombard, D. H. Loughridge, A. Lovoff, P. G. Nutting, R. B. Pastoriza, R. A. Saplis, C. W. Stirling, G. F. Taylor, and K. Watanabe.

Management Club Speakers

■ Two prominent alumni will be guest speakers at the February 14 meeting of the Caltech Management Club—Alumni President Joe Lewis '41 will tell what the Alumni Association is doing; Howard G. Vesper '22, President of the California Research Corporation, will talk on industrial research.

PERSONALS

1915

Earl A. Burt writes that he started working for the County of Los Angeles Road Department a few days after graduation and is still with the same organization. He does mention, though, that he has advanced some since 1915—in fact, he's now Chief Deputy Road Commissioner.

1920

R. Carson Smith resigned on September 1 as Mayor of the City of Santa Ana in order to concentrate on his private realty business.

1921

Al Stamm has been busy completing a new book on "The Chemical Processing of Wood"—and building a new home for which he was his own architect. This in addition to being Chief of the Division of Derived Products at the U. S. Forest Products Laboratory in Madison, Wisconsin. He invites any alumni who get near Madison to call on him and tour the interesting lab.

1922

Ray W. Preston writes that since leaving Seattle and his war-time electrical engineering work for the Naval Air Stations in the Aleutian Islands and the Pacific Northwest, he has enjoyed four years of consulting practice with headquarters at Oswego, Oregon. Utility appraisals and engineering for architectural firms are his principal projects in industrial structures, elementary and high schools, and state work. He and his wife are living on the North Shore of Lake Oswego, a short distance from Portland.

William D. Potter is still head of the Section of Hydrology, Soil Conservation Service, Research, Washington, D. C.

1924

Fred Groat has been employed for the past year by the State of California, in Sacramento, as Senior Electric Utilities Engineer, Division of Water Resources. He and his wife have two children—Virginia, 11, and Jerry, 8.

Ed Wilson has been with the Union Oil Co. of California since graduation. His son, Stephen, is studying Mechanical Engineering at the University of Wisconsin. His daughter is still in high school in Berkeley, where the Wilsons make their home.

1925

Neal Smith, City Manager of Santa Cruz, was recently appointed by Governor Warren as a member of the Central Coastal Region Water Pollution Control Board, and was selected by the members of the board as its chairman.

1926

Manley Edwards has been transferred from the Electric Division to the Gas Division of the Public Utilities Commission, State of California, as Senior Utilities Engineer. He has been active in rezoning gas rates in Southern California in connection with recent rate increase applications.

Royal E. Fowle, ex-'26, has been appointed City Engineer and Manager of Water Works for the city of Watsonville, Calif. He has four daughters—one at the University of California, one at San Jose State, one at the Childrens Hospital School of Nursing in San Francisco, and one in 5th grade in Watsonville.

1927

Marshall Baldwin reports the birth of his second granddaughter on August 28!

Thurman S. Peterson, Associate Professor of Mathematics at the University of Oregon, has just had his third math textbook published. This one is titled *Elements of Calculus*, and is published by Harper & Brothers.

1929

Richard G. Rofelty, project engineer for the Guy F. Atkinson Company, has been transferred from Washington to California where he is now project engineer on the Pine Flat Dam Project at Sanger.

James Dunham has just received an official commendation from the Chief of Engineers, Los Angeles District, which says, "for meritorious service as a civil engineer, Los Angeles District, Corps of Engineers, from 1 June 1946 to 15 Sept. 1949. His accomplishments in the preparation of beach erosion and navigation reports; his initiative in devising new and improved procedures; and his success in instructing trainees and others in planning and design redounded to the credit of the Department." This certainly gives us a good idea what he's been doing for the past three years.

Bolivar Roberts has been appointed Assistant to the Vice-President and General Manager of the Southern California Area of the Pacific Telephone and Telegraph Co. This position carries responsibility for coordination of the development of revenue and expense estimates and for the analysis of operating results.

1930

Ernest Hillman has been elected president of the Structural Engineers Association of Southern California for 1950. He is a partner in the firm of Hillman and Norwell, Los Angeles, consulting structural engineers.

1931

Lawrence Ferguson, assistant executive engineer at G.E.'s Knolls Atomic Power Laboratory, has been put in charge of the West Milton Area Project, where an experimental atomic power plant is under construction by the AEC, as part of the laboratory facilities. He will be responsible for coordinating all phases of design and construction for this project, which is located at West Milton, New York, about 18 miles from Schenectady.

1933

Ferdinand Strauss is working for the General Electric Co. in Oakland, Calif., as Engineer and Superintendent of the Control Division of the Oakland Works. The Strauss's have one daughter, age 9.

Wilson Barlow, ex '33, has been working for the Hancock Oil Company of California for the past 15 years—13 as personnel manager.

William Pickles, M.S., is living in Houston, Texas, where he is chief engineer for the Schlumberger Well Surveying Corp., an oil industry service company.

1934

Frank and Aline McClain announce the birth of a daughter, Nancy Aline, on December 15. They are living in Alto, outside San Francisco—where Frank is chief engineer for the Factory Insurance Association.

Jack Desmond is a supervisor with the Western Geophysical Company. At present he is working in Montana.

Jack Cortelyou is a building maintenance engineer for the Southern California Gas Company in Los Angeles.

1935

Charles Patrick started as Director of Vocational Education in the San Diego City Schools last October. Before that he had spent twelve years in the northern part of the state in education and government.

George Tooby has been living in Wisconsin since 1940 where his firm, George Tooby and Associates, does consulting engineering work for food processing organizations and manufacturers of dairy equipment. He was married in 1944 to Grace Ferrier of Pasadena and Scripps. They have three sons, who are 4½, 3, and 1 year old.

Fred Allardt, M.S. '36 & '37, is a structural designer working on guided missiles for the Douglas Aircraft Co. in Santa Monica. He and his wife have two daughters.

Lind Davenport left the Air Conditioning Co. of Southern California in 1947 to purchase an interest in, and become president of, the Air Conditioning Supply Company. This company is a wholesaler of air conditioning equipment, located in Los Angeles. Lind lives in Monrovia and has four children—Roy, 8; Doreen, 6; Karen, 5; and Edwin, 3.

1936

A. M. O. Smith, M.S. '37 & '38 has been with Douglas Aircraft since 1938, except for two years on leave to help start Aerojet Engineering Corp. as Chief Engineer. He is now back at Douglas, as Supervisor of Design Research in the El Segundo Plant. He is a member of the Internal Flow Subcommittee of the National Advisory Committee for Aeronautics. He and his wife live in San Marino with their two children—Tove Anne, 3; and Gerard Nicholas, 1.

1937

John Selberg and his wife announce the arrival of a son, Steven Warren, on November 18. The Selbergs are living in Los Angeles.

1938

Elbert Osborn, Ph.D., is Professor of Geochemistry and Head of the Department of Earth Sciences, School of Mineral Industries, Pennsylvania State College. He has two sons—one 7 and one 3.

Armand DuFresne is still with Consolidated Engineering Corporation as Chief Test Engineer. He is also doing some extra management work as Executive Vice-President of the San Gabriel Valley Management Club. Two children—Loma, 7; and Peter, 3.

1939

J. Eugene Stones is supervising seismograph operations for the Superior Oil Co. in Oklahoma, Kansas, and Nebraska. He is living in Oklahoma City with his wife and four children (two girls and two boys).

Duane Beck is Production Engineering Manager for the Mission Appliance Corp. in Hawthorne, Calif., manufacturers of gas water heaters, room heaters and electric water heaters. He is in charge of engineering for all products in production and responsible for the administration of wage incentives. He and his family (which includes three sons, 8, 6 and 3) are living in a new house in Pacific Palisades.

Delos Flint's engagement to Frances McCormick of Delmar, New York was announced last month. They plan to be married early in the summer. Delos is a geologist with the U. S. Geological Survey in Washington, D. C.

There are three members of the class of '39 working for the Texas Company in the New York offices. *Bert Roudebush* is a senior engineer doing designing in the chemical process end of oil refineries. *Ray Gerhart* does work of a chemical engineering nature on plant operations, and *Bob Carter* deals with the technical aspects of operations. The last two are still bachelors and share living quarters in Pelham, New York.

Richard Pond is with the Elevator Division of Westinghouse Electric located in Jersey City, New Jersey. As Supervisor of Methods Engineering he directs the functions of planning for manufacturing and administration of wage incentives. He, his wife, and two daughters live in East Orange, New Jersey.

James Rainwater is an Associate Professor of Physics at Columbia University. He and his wife have two small sons, 4 and 1.

1940

Robert Brumfield is Head of the Propulsion Division, Underwater Ordnance Dept., at the Pasadena Annex of the Naval Ordnance Test Station. Working there with him are *Robert Glassco, G. J. Todd* and *Gerald Foster* of the class of '40.

Miller Quarles writes from Dallas, Texas that their second daughter, Penny Dee, was born September 5.

1941

Carl Carlson is working as a Field Coordinator-Engineer for C. F. Braun Co. of Canada. They are building a Light Ends Unit for Imperial Oil Ltd. in Devon, Alberta—about 28 miles from Edmonton.

Roger Wallace is a graduate student at the University of California, Berkeley, working for a Ph.D. in physics. He is doing research at the Radiation Lab.

1942

Hugh Baird, M.S. '46, has been working since graduation for C. F. Braun & Co. in Alhambra, in the Process Engineering Department. He and his wife have two children—Suzanne, 4½, and Mark, 21 months. They're living in Pasadena.

1943

Robert McLean, Prof. '48, is a senior designer in the body development studio of General Motors Styling Section. He and his wife live in a suburb of Detroit with daughter Constance Alice, born last March.

Mitchell Dazey and his wife had a son, Charles Mitchell, arrive last November. Mitchell is still with the Radiation Lab at the University of California, Berkeley.

David Arnold is married and living in Los Angeles. He received his M.B.A. from Stanford Graduate School of Business in December, 1947, and since January, 1948, has been a gas engineer with the Superior Oil Company.

1944

Douglas G. Dethlefsen is attending the Stanford Law School and working part-time in the patent department of the Hewlett-Packard Co.

Frederick Kruse received a degree of Engineer (in EE) in October, 1948, from Stanford, then worked at Stanford as research assistant doing low frequency ionosphere research until December, 1949. Now he is an "Aeronautical Research Scientist" in the instrument development section, NACA Moffet Field, Calif. He was married last August to Miss Mabel Hanson and they are living in Palo Alto.

Robert T. Nahas writes from Berkeley: "After several profitable years with corporations (Kaiser Inc., and Shell Oil) I decided I liked free enterprise better. My wife is a U.C. graduate. We have three sons and a dog. In addition I am a director of four corporations (president of two) engaged in real estate developments, general construction and investments respectively."

Henry Judd's engagement to Miss Sally Clark of Palo Alto was announced in December. Henry is now in business in Santa Cruz.

Neville Long and his wife became the parents of a son, Donald Stewart, in Walla Walla, Washington, last month.

Richard Seed attended law school at the University of Washington for two years (1946-48) and then went east to Washington, D. C. (after marrying Alice Mae Wilson of Seattle in April, 1948). In Washington he worked a year as a Patent Examiner in the U. S. Patent Office while continuing law school at George Washington University, from which he received a law degree last June. He and his wife then returned to Seattle where he is now a practicing patent lawyer.

1945

Stanley Clark has left the Standard Oil Co. and is attending law school at Loyola in Los Angeles. He and his wife and 15 month-old son are living in San Gabriel.

Robert Bennett, M.S. '47, Ph.D. '49, is with the Hughes Aircraft Co. in Culver City, doing guided missiles work.

Richard Reed received an Sc.D. in Meteorology from M.I.T. in June and is presently employed in the Meterology Department there as a member of the research staff. He is engaged to Miss Joan Murray of Quincy, Mass.—formerly of Newcastle on Tyne, England.

1946

Jim Lewis is employed as a reporter for the Chico *Enterprise-Record*, Chico, Calif. "My job is covering police, crime, and municipal government," he writes. "The latter means frequent drawing on CE background. I've thought seriously of getting into the technical magazine field but newspaper work is proving almost too interesting. Still single. M.A. (Journalism) from Stanford—less writing the thesis."

Herbert Strong was married in 1947 to Miss Marion Peck and they have one son, who is now 1½. Herb is working as Assistant to the Vice-President in Charge of Manufacturing at the Harshaw Chemical Co. main office in Cleveland.

Dansy Williams, M.S., is employed as an Airways Forecaster with the U. S. Weather Bureau at Wold-Chamberlain Airport, Minneapolis, Minn. Before being transferred there last summer, he was engaged in cloud seeding experiments for the Weather Bureau at Colfax, Calif., and Wilmington, Ohio.

1947

Donald Stewart, Jr., has been appointed Assistant Electrical Engineer at Kaiser Steel Corporation in Fontana, Calif.

Elmer Hall, Jr., M.S., is working as a field engineer for the Pacific Gas and Electric Co. He is married and has a son.

Herman Heidt, Prof., has obtained a California Professional Engineer license as a Mechanical Engineer and has a position as Chief Engineer of the S & M Lamp Co. in Los Angeles.

1948

John Thomas received an A.M. from Stanford in taxanomic botany last June. Currently he's working for a Ph.D. and is a teaching assistant in the Biology Department at Stanford.

William E. Smyth is engaged in television engineering (operations) for the National Broadcasting Co. in New York City.

Jim Thorpe became engaged in November to Miss Barbara Anderson of Minneapolis. They plan to be married in June. *S. M. Butler* is also engaged and will be married in April.

Byron Youtz, Bill Jarmie, Bob Kenney '47, *Kent Terwilligen* '49 and *John Rasmussen* are all living in International House at the University of California, Berkeley, and are all in various stages of graduate work—The first four in physics, John Rasmussen in chemistry.

Science in the News

Artificial Stars

■ ASTRONOMERS AT THE University of California's Lick Observatory have designed an ingenious new system for increasing the accuracy of star measurements. Dr. Joel Stebbins and his associate, Dr. Gerald Kron, now make telescopic observations of artificial stars perched on adjacent peaks from 1,000 to 3,000 feet away. The artificial stars consist of lamps with tungsten filaments which have temperatures of about 2,500 degrees absolute centigrade. Each lamp is placed in a box which has a small hole permitting observers to see just a part of the light from the filament. When a telescope is trained on it, observers see an artificial star with a magnitude approximating that of the brightest stars such as Arcturus and Betelgeuse.

In astronomy the magnitude, or brightness, of stars (and therefore their distance from the earth) is determined by their colors. Color is in turn determined by temperature. The brightest and hottest stars are blue; the next brightest are white, the faintest are red. Therefore, if the University of California astronomers know the temperature of their artificial stars, when the spectrum of a real star matches that of an artificial one they will be able to say it has the same temperature. Knowing how hot the star is, they will know how much light it is giving off. When they determine how much light is being received they will be able to tell how much has been lost on the way, and how far the star is from the earth.

Recovered Rocket

■ SCIENTISTS LAST MONTH recovered a fragment of the two-stage rocket which set a 250-mile altitude record last February at the White Sands (N.M.) proving ground. It had been generally agreed that the rocket had completely disintegrated when it re-entered the earth's atmosphere, but a civilian technician at White Sands stumbled over the wreckage recently near the north end of the 116-mile firing range. It was a badly-smashed and charred portion of the tail section of the WAC Corporal which was fired from the V-2 rocket at an altitude of 20 miles.

The fragment has now been turned over to the Jet Propulsion Laboratory—by the Army Ordnance Department and General Electric, which were responsible for firing the rocket—in the hope that it will provide information about the stresses encountered by supersonic missiles.

Water Shortage

■ IN A LECTURE to the Royal Institution of Great Britain Dr. Hans Pettersson, Swedish professor of oceanography, had some depressing things to say about water shortages. In a few thousand million years, he noted, there won't be any water left at all. The earth, according to Pettersson, is suffering from progressive desiccation, an ailment common to all aging planets. It is drinking all the water in the oceans, converting the water into components of its solid crust. "It will then have reached the present tragic state of its neighbor Mars, with its oceans gone," said Dr. Pettersson," and with them, inevitably also, its oceanographers."

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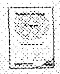
this  small

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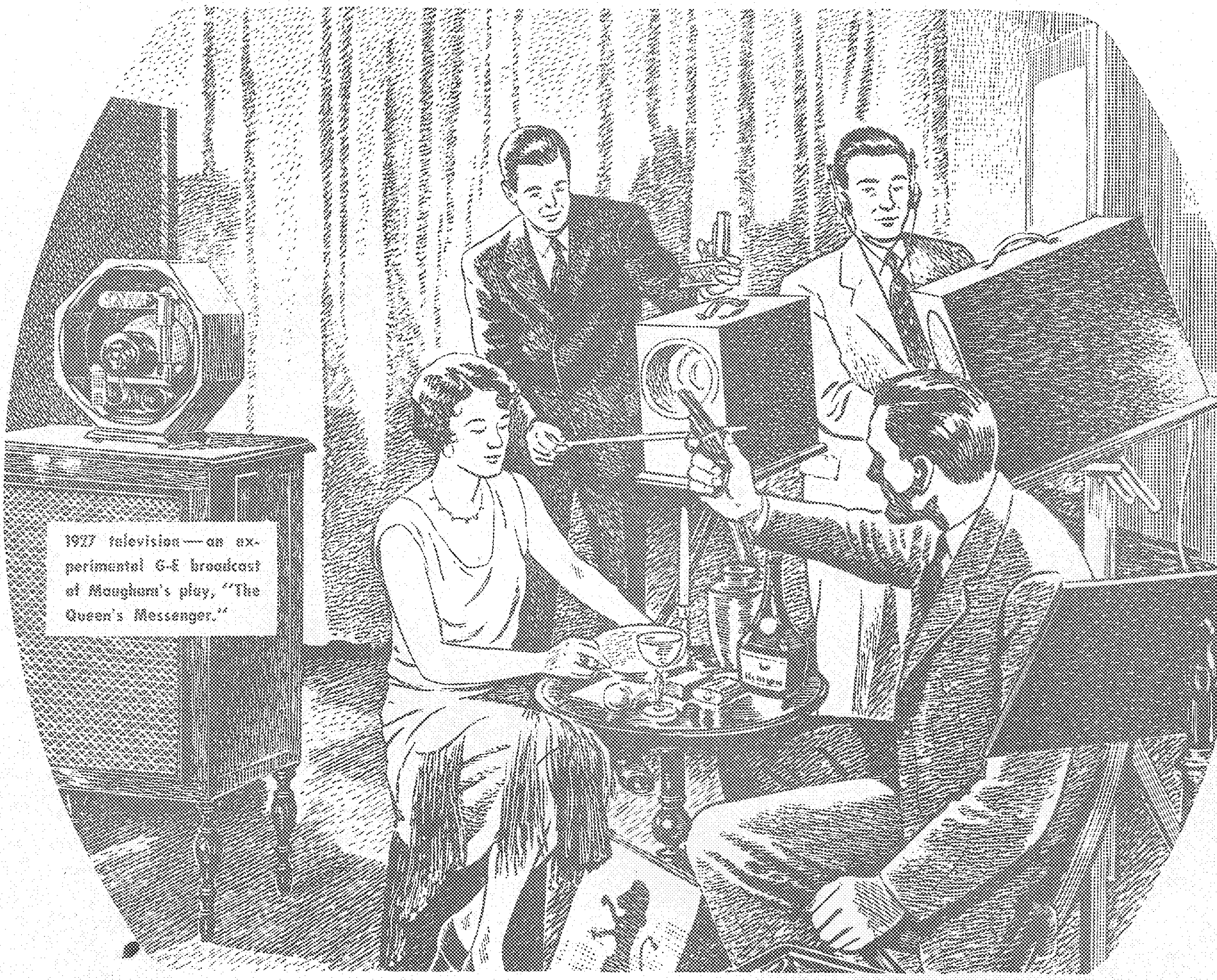

1927 television—an experimental G-E broadcast of Maugham's play, "The Queen's Messenger."

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asadena, Calif.

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