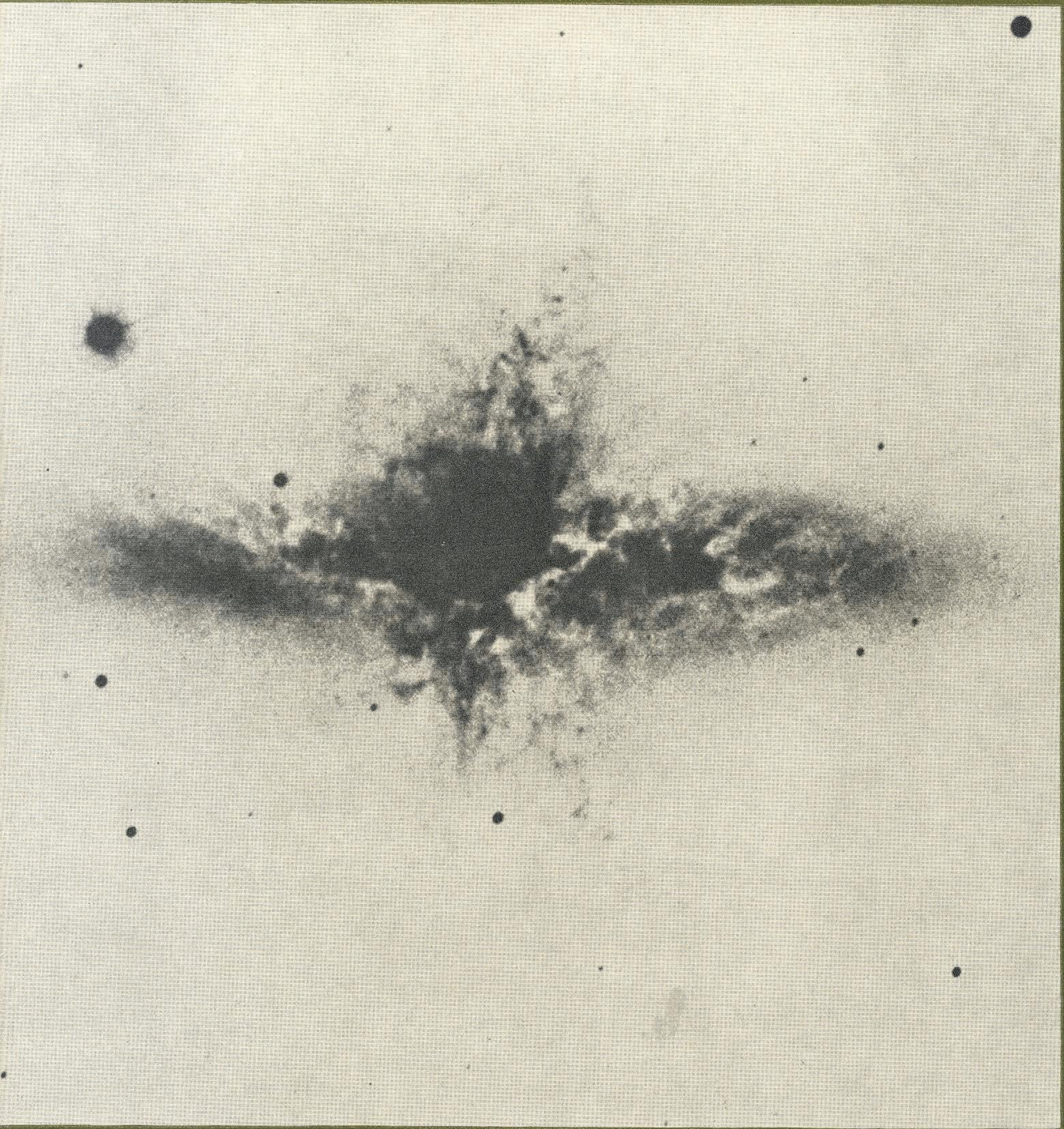
ENGINEERING | AND | SCIENCE

October 1963



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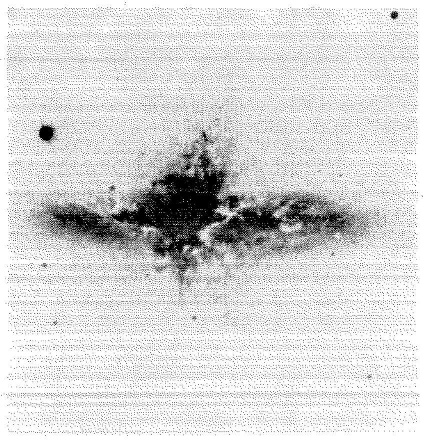

On Our Cover
is a photograph of the galaxy M 82 which has been exploding for 1,500,000 years and is still hurling material out from its nucleus at velocities ranging up to 20,000,000 miles an hour. The photograph was taken with the 200-inch telescope at Palomar Observatory, through a filter which screened out all light except that of excited hydrogen (H alpha, the brightest of the hydrogen lines).

Astronomers prefer to study negative photographs like that on our cover, with the object appearing black against a light background, because details show up more clearly. On page 15, the same picture in the more familiar positive—showing the gigantic explosion against a black sky.

William H. Pickering,
director of Caltech's Jet Propulsion Laboratory, is the author of "Man at the Threshold of Space" on page 7. The article was adapted from a talk given last spring in a UCLA lecture series on "Vital Centers of Human Decision Making."

Dr. Pickering has just returned from Paris, where he headed the American delegation of the 14th Congress of the International Astronautical Federation. At the meeting, more than a thousand scientists from 34 nations conferred on President Kennedy's proposal for a joint U.S.-Russian moon shot and on methods of preventing the cold war from spreading to the stars.

Illustrations:

Cover, 15—Mount Wilson and Palomar Observatories
16—James McClanahan
20—Harvey
24—Sarah Hunt

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Books

THE MACHINERY OF THE BRAIN

by Dean E. Wooldridge
McGraw-Hill Paperbacks $2.95

Reviewed by G. D. McCann, professor of electrical engineering

A review of this book should start with its author. Dean Wooldridge received his PhD in physics from Caltech in 1936 and is now serving as a research associate in engineering. With an eminent career both as a physicist and administrator at the Bell Telephone Laboratories, the Hughes Aircraft Company and the Thompson Ramo Wooldridge Company, he has recently directed a major portion of his attention to the nervous system.

He has reviewed the literature and research from the various fields and points of view that seek an understanding of nature's methods of intelligent information processing. In this book he presents a remarkably comprehensive summary, together with some of the interesting analogies that can be drawn with engineering principles employed for computers and automatic control systems.

The principal emphasis of the book is the central brain and higher-order thought processes of man. However, it also contains a comprehensive treatment of the sensory organs, the transducer properties of light, touch, smell, and taste receptors, and the information processing characteristics of the interneurons. Following this is a description of some of the more interesting simple reflexes, tropisms, and feedback control systems found in both the lower-order animals and the higher-order vertebrates. With these as illustrations of basic concepts used in the organization of nervous systems he then develops the principal subject of the book, the higher-order mental processes in the central cortex of man. Established concepts of complete sensory perception, conscious mental processes, and memory are presented, together with information on the control centers and seats of emotion, speech, and personality.

Written in a very readable form for the nonspecialist it nevertheless makes a valuable reference book for any research library that seeks to serve the interests of engineers, biologists, psychologists, or other related fields of the behavioral sciences.

MARINER: MISSION TO VENUS

by the Jet Propulsion Laboratory Staff
McGraw-Hill....Paper $1.45, Cloth $3.50

A straightforward account of the Mariner Project which sent a spacecraft to Venus in 1962, written by the men at JPL who carried out the mission which is probably the greatest feat to date in the exploration of space.

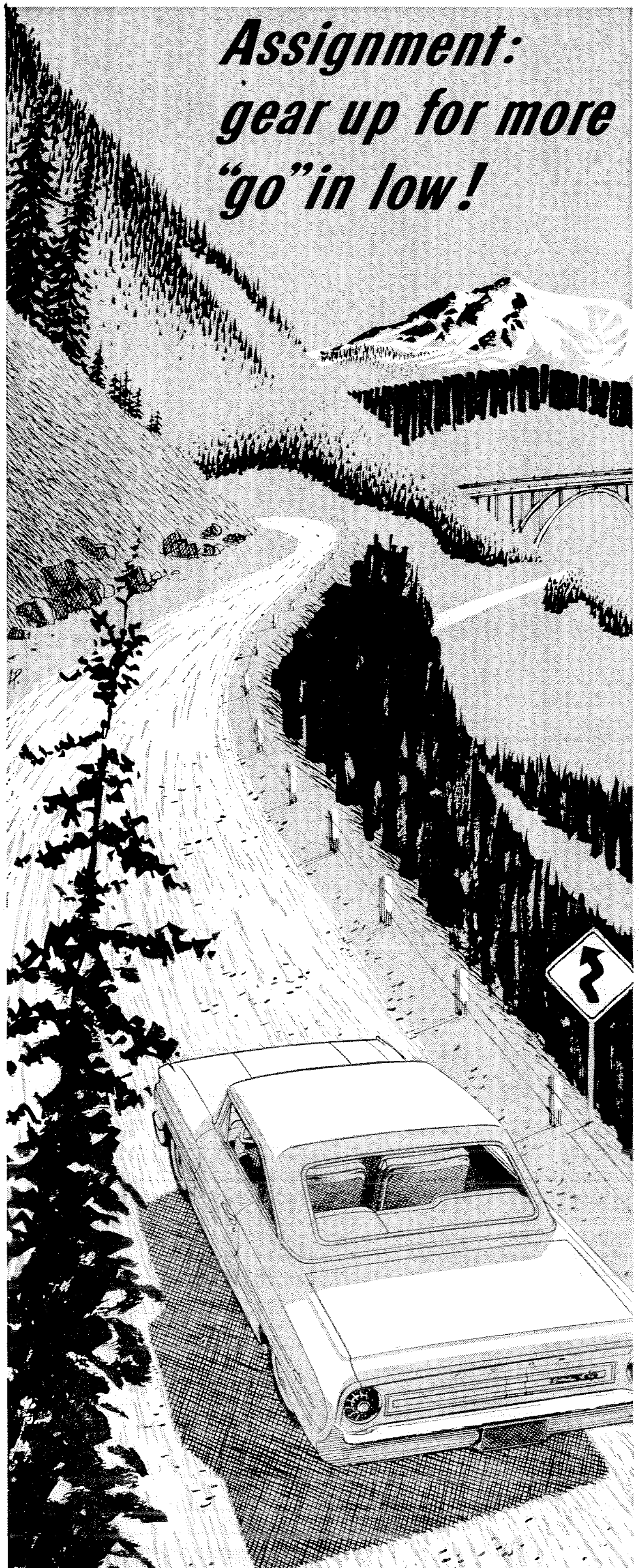
Alumni Books

RELIABILITY: MANAGEMENT, METHODS, AND MATHEMATICS

By D. K. Lloyd and Myron Lipow '49
Prentice-Hall, Inc. $11.25

ENZYME AND METABOLIC INHIBITORS (Vol. 1)

by John L. Webb '36, PhD '40
Academic Press $26.00



Result: All 3-speed manual transmissions in Ford-built cars with V-8's now are fully synchronized in each forward gear

To get more "go" in low, Ford engineers were asked to upgrade the conventional 3-speed transmission to give drivers more control in all three forward gears—to make "low" a driving gear—and they tackled the problem imaginatively.

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Another assignment completed and another example of how engineering leadership at Ford provides fresh ideas for the American Road.

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WHERE ENGINEERING LEADERSHIP BRINGS YOU BETTER-BUILT CARS

Shown: 1964 Ford Galaxie 500/XL two-door hardtop

Engineering And Science
October 1963, Volume XXVII, No. 1

MAN AT THE THRESHOLD OF SPACE

Are we at the beginning of a golden era — or can we expect the submergence of all human values?

by W. H. Pickering

For more than 50 years some writers and thinkers have been concerned about the consequences to humanity of allowing science to run roughshod over all facets of life. From Jules Verne to George Orwell they have painted a grim picture of life under a scientific dictatorship. As one reads these books it is surprising to realize how many of their prophecies have already come to pass and, consequently, to wonder if we are inevitably heading for one of these dreary, negative "utopias."

Today we are on the threshold of space. Science and engineering together have solved the problem of permitting man to step off his little planet into the emptiness of the solar system. Does this dramatic event presage the beginning of a golden era, or the submergence of all human values?

First, let us consider exactly what is meant by saying that we are at the "threshold of space."

It is now about six years since the Soviets startled the world by announcing that they had a satellite in orbit. I am sure that many of you remember the excitement produced by the first Sputnik on October 4, 1957. The Soviets had arranged to have a short-wave transmitter on the Sputnik so that people all over the world, with reasonably good short-wave receivers, could listen to the satellite and assure themselves that it was indeed in orbit. Furthermore, the radio signals reported instrument readings from space, so scientific data were being collected for the first time from far above the surface of the earth.

I will not concern myself here with the political repercussions of this event, but I do want to note two important thought processes which I think this first Sputnik generated. First, it showed conclusively that the earth is round and, secondly, that the earth is not very big.

As we all know, at the end of January 1958 the United States launched its first satellite – very much smaller than the Soviet satellite to be sure, but nevertheless a good scientific satellite – and with this launching the "space race" was on.

How much the space program has grown can be illustrated by the budget of the National Aeronautics and Space Administration. Starting from almost zero in 1958, it has grown to $3¾ billion in the current fiscal year, and NASA has asked for $5½ billion in the next fiscal year.

The space program has spent a tremendous amount of money with the support and approval of the Congress and I suspect the Soviets have spent comparable amounts of money. What has come about as a result of these expenditures? First, the close-in earth satellites: During these six years, the size of earth satellites has grown from a few pounds to a few tons. Satellites have carried scientific instruments of a wide variety; they have carried biological specimens; they have carried a man into orbit.

As a result of these satellite firings, a great deal of scientific information has been gathered. We have a wealth of knowledge now about the extreme upper reaches of the earth's atmosphere, of the environment in space in the near vicinity of the earth, of the appearance of the earth from a satellite looking down on the earth – and, indeed, even of such things as the exact shape of the earth, because it turns out that the path of a satellite in orbit can give us a very precise measure of the exact gravitational configuration of the earth. The first U. S. satellites discovered the Van Allen radiation belts which surround the earth and which are of considerable interest in a practical sense because of the radiation hazard which they portend for space travelers and explorers who may tarry too long in those regions.

The satellites have also produced practical results. For example, we have such things as the Echo satellite, the Telstar satellite, the Tiros satellite. These first two demonstrated the capability of satellites to be used for communications purposes. There is no doubt whatever that in the future there will be a growing interest in satellite communications. In fact, satellites will probably be the only economically feasible answer to the growing load of transoceanic telephone communications.

Tiros first showed what could be done by looking down at the earth from a satellite. It gave the meteorologists a great deal of new information about weather and cloud formations over the earth. Undoubtedly, Tiros is only the first in a series of meteorological satellite developments which should lead not only to a better understanding of weather phenomena, but also to more accurate weather forecasting. The next satellite in this series is called Nimbus, and will be flown next year.

Deep space exploration

A second area of space exploration has been the area of deep space exploration, to the moon and to the planets. Both the Soviets and the U.S. have conducted experiments in deep space; the Soviets have successfully launched four space probes towards the moon (Luniks I, II, III and IV), with varying success. Lunik III is probably the most interesting because this succeeded in taking some photographs of the back side of the moon; poor photographs to be sure, but nevertheless showing a portion of the moon never before seen by human eye. The U. S. has launched three spacecrafts towards the moon – Rangers III, IV and V, of which Ranger IV actually landed on the moon – but none of the three accomplished their scientific missions.

In the planetary area, the United States successfully launched Mariner II towards the planet Venus in August 1962. Data were received during the entire journey to Venus and also scientific observations were made of the planet as the spacecraft passed nearby. In November 1962 the Soviets launched a space probe towards the planet Mars, but they lost communications with it in March 1963, when it was little more than halfway to the target.

These deep space experiments have given us much scientific information about the environment of deep space, about such things as the solar plasma, the magnetic fields, and the micrometeorites to be encountered in journeys through space. With Mariner II we also began the exploration of another planet by instruments placed near the planet.

In the area of technology, the investment in space has accomplished a number of very important things. First of all, it has given us a much greater insight into the problems of very complex systems. If we are going to conduct a space experiment, whether it is an astronaut going into orbit or a planetary probe going to Venus, we find ourselves dealing with a complex system involving large numbers of people and very large amounts of equipment, much of it automatic. The understanding of such complex systems is an important byproduct of the technological developments in space. Similarly, our space program has improved the art of rocketry because of the requirements on the space program of conducting rocket firings from parking orbits or from space probes after traveling great distances from the earth. The general techniques of rocketry have been advanced considerably as a result of the program. In the field of communications, the space program has required the ability to communicate over the vast distances, not only to the moon but even to the planets. This is something which would have been utterly inconceivable only a few years ago and it is really a remarkable achievement.

Likewise, space technology has taught us a great deal about the design of instruments. The requirements for operating in space, the requirements of reliability, of operating in limited weights and volumes – all of these things have taught us how to build better instruments, and much of this technology will be applied in other areas.

Sending a man to the moon

If we look to the future of space, the first and obvious thing, of course, is that we are engaged in the attempt to send a man to the moon and recover him successfully. This is the most difficult engineering task which has ever been attempted by any people anywhere. It is going to require very large rockets, very complex engineering systems, and it is indeed going to be a very expensive undertaking. The nation is committed to this and, as we all know, work is now seriously under way. I assume that the Soviets are likewise interested in sending a man to the moon, and I suspect that they also will be investing the same sorts of resources in this kind of project.

In addition to the lunar program, however, I think we should remember that there are many other scientific areas of space exploration which will be investigated to an increasing extent as time goes on. The exploration of the planets, for example, is obviously a most fascinating area of scientific investigation. The discovery of life on another planet would be one of the most exciting scientific discoveries of this century.

We must conclude that the space program, taken as a whole, is a continuing dramatic illustration of the advance of technology and science. The program requires the exercise of the utmost ingenuity to solve the technical and other problems. Success in space is therefore a clear demonstration of technological capability of the highest order. We are living in a civilization in which technological capability is an important index of success, and so a successful space program becomes an asset valued in national policy. Hence, we have the USA and the USSR supporting ambitious space programs. Other nations strive to enter the space arena. Western Europe is actively working on a cooperative project. Many smaller countries are helping in various ways. We are truly entering the space age.

Quite obviously, science and technology together are making very rapid changes in our way of life. Nothing like this has ever happened before, although the general ferment of thought associated with the Renaissance made almost as rapid changes in intellectual areas as the present developments have made in our material surroundings. I should, therefore, like to consider why this rapid scientific growth came about, what is sustaining it, and why it happened at this particular time.

Science in classical times

If we go back to classical times, we find a considerable interest in what we now call the physical sciences and mathematics. In fact, Greek thinkers contributed much of the basic knowledge which we still use. Euclid, with his geometry, established a body of knowledge which is still in use. Eratosthenes performed an experimental measurement of the radius of the earth which was surprisingly near the correct value. Democritus proposed an atomic theory which sounds very modern in many aspects. Back in Babylonian days astronomers, or rather astrologers, had a reasonably good observational familiarity with the heavens and were able to predict eclipses.

In spite of all this, science did not advance. Perhaps the principal reasons were a lack of appreciation of the universality of scientific truth, and of the value of experiment. Many classical scientists were mere catalogers, gathering data from hearsay and drawing doubtful conclusions therefrom. Consider the obvious errors in Pliny's *Natural History* or in the works of Aristotle.

Modern science begins with the Renaissance. The spirit of inquiry and the questioning of authority which marks this era extended into the scientific field. Men like Kepler, Copernicus, and Galileo began to make careful observations and perform careful experiments. There may be some doubt as to whether Galileo actually dropped two different weights off of the leaning tower of Pisa, but he certainly performed the experiment somewhere. It is a remarkable thing to realize that, though Aristotle said that a heavy weight would fall faster than a light one, no one performed this simple experiment until Galileo tried it and proved Aristotle wrong about 1900 years after he said it.

Newton and modern science

Newton was born in the year Galileo died, in 1642. With this man, modern science truly begins. His principles of mechanics, his law of gravitation, his experiments in optics, his developments in mathematics made him the outstanding scientific figure of the 17th century. His work has stood the test of time and still forms the foundation of our engineering work, from bridge building to rockets and satellites. The importance of Newton from the standpoint of the development of science is not that he made some remarkable discoveries, but that he developed a new approach to science, and that other men, his contemporaries and his followers, continued to use his methods.

Newton's approach is based on the idea that there are universal physical laws, that scientific truth is absolute and the laws of science are everywhere the same. A second point is the idea of proceeding from the particular to the general; in other words, the application of the inductive method. A third point is the importance of experiment; scientific truth is subject to experimental verification and can only be determined from careful experiments. Finally, scientific truth requires mathematical analysis for precise understanding and exact statement.

Based on these considerations, and particularly emphasizing the necessity for experiment and mathematical analysis, science began to develop rapidly in a variety of directions. There is no need to attempt to itemize the milestones of progress except perhaps to note that, as Newton developed the science of mechanics, so did Maxwell in the 19th century develop electricity and magnetism. With his great synthesis the 19th century picture of the physical world appeared to be complete; only the details remained to be filled out. However, a few years later experiments began to show discrepancies, and in the early 1900's Planck laid the foundation of quantum mechanics and Einstein proposed his relativity theory, building on to the laws of Newton and Maxwell the necessary modifications to describe the physics of the atom and of the universe.

And so it was in all fields of science. The initial steps taken in the 17th century served to start the rapid growth which has led to our present scientific heritage.

Our technological development is closely related to the development in science, simply because the understanding of scientific principles points the way to the utilization of these principles. In other words, the scientist is interested in discovering facts about nature, and the engineer is interested in using these facts to build something useful. And so by the 19th century we have the beginning of what we call the Industrial Revolution.

The Industrial Revolution

The first phase of the Industrial Revolution was essentially the application of power, other than human or animal, to operate machinery. At first this power principally replaced manual labor because it was cheaper and produced more goods. For example, the application of power, and the appropriate machinery, to the textile industry was the first important advance. However, it was soon realized that power machinery could also do more precise things than even a skilled craftsman, and many of our manufactured goods could not possibly be produced without these precision machine tools today. Finally, power machinery can do some things which are absolutely impossible with human or animal power. For example, the ability to pack a great deal of energy into a small space has made possible the airplane.

This phase of the Industrial Revolution has been responsible for most of the everyday technological devices we see around us. As power sources developed from large, inefficient, water or steam engines to small, efficient, electrical or internal combustion engines, whole new areas of application developed likewise. Now we are on the verge of widespread application of nuclear power plants. Although these will probably always be large and heavy, the potential of almost unlimited power production with negligible amounts of fuel must inevitably bring about further developments and applications.

The next phase of the Industrial Revolution is the cybernetics phase or the development of automation. We are now in the rapidly developing part of this phase. Automation depends on the fundamental principle of feedback. The machine is asked to compare its output, whatever that may be, against an expected output, and to stop working when it has reduced the difference to zero. A simple example is a thermostat in your house; the furnace stays on until the output (the temperature of the room) matches the desired output (the setting of the thermostat) and then it turns off.

The principle of feedback can be applied in numerous ways and with astonishing results. For example, automatic devices may replace skilled labor just as power machinery replaced unskilled labor. Automatic machinery has been used to run an oil refinery, to operate a power plant, even to operate a subway train. But automatic devices can also accomplish tasks to a much higher precision in much less time than a human operator, as in a guided missile which seeks out its target. Furthermore, automatic devices may operate using sensors which detect radiation, for example, to which a human being is not sensitive. Thus the control of nuclear reactors must be done by instruments that work in a region which would be a lethal environment to man.

The effects of automation

Although we are still in the early phases of this development, it is already clear that it will have just as great national and social consequences as the power phase of the Industrial Revolution. The earlier phase initially affected small craftsman, who were replaced by semi-skilled machine operators and large factories. Later it affected unskilled laborers, whose work was done more efficiently by large power machines. In the new phase of automation, skilled labor and white collar workers who have been engaged in simple repetitive work will now be replaced by automatic machines.

I do not believe there is any need to stress the reasons for the rapid growth of technology. Quite simply it is that machines do more things cheaper and better than manual labor. For example, today it costs about five times as much to dig a ditch by hand as it does to do the job by machine. In more skilled trades the difference is, of course, even greater than this — provided only that there is enough work to be done to keep the machine busy.

Improvements in machines and the introduction of automation continually decrease the number of man hours of labor necessary to manufacture goods or to raise and harvest agricultural products. It is estimated that since 1900 the productivity of labor in the U.S. has increased by a factor of three. As a specific example, in the General Electric Company over the years 1956-59, production was up 8 percent, but the number of workers decreased 25 percent.

In highly technical industries, developments go through a cycle of research investigations in the laboratory, to a pilot-plant type of production, and finally into complete production as a useful article or component of an article. This cycle, from laboratory to production, seems to be getting shorter as time goes on. It took about 50 years for electricity to come into practical use, but now it seems the time span is more like 10 years in going from research to production. Transistors were a laboratory curiosity in 1948 and were the basis of a full-fledged industry a decade later. The feasibility of a nuclear reactor was demonstrated in December 1942, and experiments for the production of useful electrical power were made shortly after the war. But the costs are still too high to justify nuclear power except in special cases. Nevertheless, 20 years after the first chain reaction, power reactors are in use in ships, in submarines, in the Antarctic, and in the United States, Great Britain, and the Soviet Union. To quote the example of one industry which is closely allied with technical developments, DuPont estimates that half their sales and 75 percent of their profits come from products that were in the laboratory 10 years ago.

The never-ending search

Hence I conclude that modern science, since Newton, has discovered a way to explore and understand the secrets of the universe. Because of the innate curiosity of man, science will continue this investigation. Every answered question raises more to be answered, and the search will never end. Closely allied with this scientific development is a technological development which applies the principle and understandings of pure science. Because of the obvious value in the sense of ability to make useful devices, or to grow more and better food, or to control the local environment, the technological development will continue to press hard behind the scientists; the rapidly expanding technology will continue to expand.

Now there are certain aspects of our situation as a result of this development which I should like to discuss.

First, there is the matter of resources. At one time the most important national resource was good agricultural land. Good land, in sufficient amounts, would insure food for the people. Now land is much less important. The efficiency of food production has been greatly raised so that equally important resources are raw materials and energy sources. As a matter of fact, even these resources are becoming of less importance. The most important single resource in the advanced nations of the world today is skilled technical brain power. Highly trained engineers and scientists are necessary if the nation is to keep its standing among other nations. The importance of education in these fields cannot be overestimated.

Technology and the good life

Second, modern technology is able to provide for all reasonable material wants of people all over the world. This is something completely new in the history of mankind. In primitive cultures the labor of all of the people is needed merely to sustain life. As civilization advances, a portion of the society is supported by the productive labor of the others. This portion may be a governing group, priests, soldiers, or rich landowners. Life for most of the members of the society, however, during almost the entire course of history, has been hard and near starvation. Now, however, in principle, technology has shown the way to provide all the members of the society with a reasonably good life. This is true because we have developed our production, both of food and material goods, much more rapidly than our population has grown. Technological advances have made this increase in productivity possible. At the present time there is only a portion of the world in which technology has advanced essentially to this point, but the post-war period has clearly been one in which nations all over the world are striving to enter into this technological era.

Granted that we are living in the midst of an explosive development of science and technology, which is continuing at an accelerated rate and is spreading all over the world, for the obvious reason that it holds the promise of freedom from want, what kinds of problems can we forsee resulting from this development? In other words, if technology can satisfy our material needs, why not utopia?

Technology is reducing the number of man-hours of production labor required to satisfy our needs. Of course, our needs are increasing. The luxuries of yesterday are the necessities of today, and our consumption of raw materials and energy is growing rapidly, but even so, the increase in productivity is so great that we have a problem of surplus plant capacity in many areas. The needs of the service industries and the government utilize a portion of the surplus labor, but the fact remains that there is a great increase in leisure time. This increase in leisure is perhaps the heart of the problem. How can we educate people to be able to use their leisure in a constructive fashion, and by what standards shall we judge whether this leisure is well spent? Western civilization has strongly emphasized the importance of labor and also of thrift. An economy of plenty wants neither. How do we readjust our standards?

For man to live a happy and useful life he must feel in tune with his environment and his fellow man. He must feel that his motivations and ideals are supported by his fellows; otherwise he is an outcast. Because of the rapid evolution of our technological society, much of our social culture has not been able to keep up, and it is better adapted to an earlier time. Therefore, we have the basic difficulty that is simply expressed by a yearning for the "good old days," and is really an admission that the technical world is moving too fast for us. In some cases this leads to serious emotional disturbances or a refusal to face the realities of the modern world. If we look to the future, it would appear that we must learn to evolve our cultural and moral standards more rapidly than in the past, or else find an increasing discontent with a potential utopia. In a word, the problem which must be solved can be stated thus: Given a growing technology, and its ability to provide us with all of our material needs, how can man learn to live with himself and with his fellow man?

Decisions which face humanity

I have posed some problems. Now I would like to consider some of the decisions which face humanity as a result of our developments in science and technology. As I have said, this phase of our cultural evolution appears to be proceeding at an ever increasing rate, and to be far outdistancing our social and biological evolution.

Therefore, we must examine the sorts of decisions which science has made inevitable. First, and most important, is the decision as to whether we want to commit race suicide. Science has given us the tools to do so. We could probably do it tomorrow; we could certainly do it a few years from now. It is not a subject to be dismissed as too improbable or too unthinkable. Even in the animal world some strange things happen to social groups. For example, the lemmings of Scandinavia are reported to march into the sea and drown in enormous numbers for no apparent reason except, possibly, the pressure of population. Likewise, in human history some very strange things seem to happen under the pressure of motivations which appear quite incomprehensible a few years later. An example is the Children's Crusade of the Middle Ages, or even the trench warfare of World War I; neither accomplished any useful purpose. Of course, the whole history of warfare is filled with examples of useless fighting for irrational purposes and prolonged far beyond any conceivable value. Thus we must conclude that man is subject to irrational urges to violent action, and that mass suicide is not out of the question.

The key decision

Since the power to unleash full-scale nuclear warfare is in the hands of a very few individuals, and since the decision can be reached in a matter of seconds, it might seem to be almost impossible to provide assurance that such a decision will not be made. In fact, the situation is potentially even worse because of an increasing tendency to rely very heavily on computers and radars to make the key decision, which leads to the danger of an electronic failure releasing a holocaust.

It is not yet clear how we can reach the decision to make race suicide impossible, but it is clear that there must be an increasing awareness of the necessity for such a decision, and a continuing search for the answer. If we do not find a solution, we are voting "No" by default, and the human race will be fortunate to see the year 2000.

Let us assume that I am too pessimistic and that either the situation is not as fraught with danger as I indicate, or else a real solution is found. What then?

A second vital decision area will face us when the biological sciences have attained the same kind of understanding of the living world that the physical sciences have attained of the inanimate world. Understanding will bring with it the ability to modify or control. Just as we are increasingly faced with the consequences of this ability in the physical world, so too — in a manner which will be of far more direct concern to individuals as human beings — will we have to face some very fundamental issues in the biological world.

Some of these problems are already upon us.

For example, medicine is able to do some remarkable things as a result of understanding disease and the chemical and physical actions of the human body. But, as a result, we are keeping alive an increasing number of people who find great difficulty in living normal happy and useful lives. The fundamental precept of medicine has always been to save life at any cost. As we become more skillful we are able to keep a spark of life in the very old or the very sick, even though they may be living only a sort of vegetable existence. In the future this will be more true. Therefore, the question of the ethical position which a doctor should take towards euthanasia is one byproduct of the development of medicine. Other examples of ethical decisions which have already arisen as a result of advances in biological sciences, include such matters as our attitudes towards birth control and truth serums.

If we look into the future a little way, we can see some remarkable possibilities with the psychological drugs, and, in the genetic area, with controls comparable to what has already been accomplished with domestic animals. Clearly, biological science will require an acceptance and understanding of the extent to which the scientist can be permitted to play at being God with the human body and the human mind. Again, if the decision is not made, we might some day face the misuse of science to an extent as devastating in its effects as the potential of nuclear bombs.

The responsibility of science

A third area of decision-making concerns the authority and responsibility of science. Within recent years the scientist has been given more financial and political authority than he has ever before enjoyed. The estimated expenditures of the federal government for research and development will reach $15 billion in the next fiscal year. In addition, private expenditures may reach $5 billion more. Comparable figures for 1940 are $100 and $300 *million.* Even in 1954 the figures were only $1 and $2½ billion. In the last decade, however, total R & D expenditures have been more than doubling every five years. Although most of this money is spent on applied science or developmental engineering, nevertheless science has control over very large resources.

In the political sense, too, government is increasingly aware of the necessity of inviting scientists into the inner circles of government policy, not only to help understand the significance and utility of the sums of money being spent on research and development, but because science per se has become an important instrument of national policy. Consequently, scientists as responsible citizens have a clear responsibility to conduct their research for the government to the best of their abilities and to be financially responsible in their expenditures of public moneys. Likewise they have a responsibility to advise the government on matters in which they are competent.

I am concerned, however, about another phase of scientific responsibility. As the resources and powers available to science increase, the possibility of performing experiments which have far-reaching or even irreversible effects on our environment increases. At one time, some people were concerned that nuclear experiments might blow up the whole earth. This, of course, is a groundless concern; but the problem of nuclear fallout is not. Fortunately, the scientists involved have indeed been responsible and no serious harm has resulted.

There are other experiments, however, with more subtle results. For example, the widespread use of DDT has caused a significant change in the balance of wildlife in some areas; the recent very-high-altitude nuclear explosion has significantly changed the innermost Van Allen radiation belt.

Dangerous experiments

Probably no experiment has yet resulted in any very harmful unexpected result, but with increasing capabilities the possibilities must increase. Any such experiment, therefore, whether it be in weather control or insect elimination, should not be performed without a public understanding of the consequences. The decisions which have to be made relate to the extent to which the public is willing to allow the scientist to experiment with the environment. I do not believe the consequences of allowing this decision to go by default would be very harmful, because I have a great deal of confidence that scientists will not perform an experiment of this sort without proper analysis. But I do think it is a matter for public debate and understanding if relations between certain scientific groups and the public at large are not to be unduly strained.

Finally, a fourth area where vital understanding and decisions are needed is the broad area of learning how to live in a world which is capable of a technology of plenty. Even though it is possible to produce ample food and material goods, we have not yet solved the problem of distribution — or the problem of developing a successful mode of life for large portions of humanity.

In a biological evolutionary sense, very little separates modern man from Stone Age man. Occasionally, in fact, the more primitive aspects of humanity break out in strange fashions; consider Nazi Germany in the immediate prewar years, for example.

Actually, of course, we live in a world which contains a very wide variety of social cultures, down to the very primitive. Every year modern communications bring the world closer together, so that we have very advanced technological civilization only a few hours away from the most primitive social groups, barely able to sustain life by crude agriculture or hunting. Therefore, it is necessary to develop an understanding of the proper relationships which should exist between various social cultures. Decisions must be made as to how to implement these relationships. In the early days of this country many problems were caused by giving alcohol and firearms to the Indians. Whether this was good or bad is not the point, but, translating this situation into modern terms, we must consider the consequences of disturbing a primitive social culture by suddenly adding some of the gadgets of modern technology.

Some personal views

I started by asking if we were headed for a negative utopia, founded on a scientific dictatorship. I will say, probably not. One reason is that science and technology are moving away from the rigid mechanistic determinism of the late 19th century. At the end of that century the pattern of physics was represented by the mathematical laws of Newton and Maxwell. All actions were the result of applied forces and, given the forces, the actions could be exactly calculated. In other words, if we knew the exact condition of every atom in the universe at a certain instant of time, we could, in principle, compute exactly what would happen at all future time. Along with this determinism was a belief that all the basic laws of the physical world were understood. It seems to me that the orderly scientific dictatorships of Edward Bellamy and H. G. Wells are a consequence of this orderly mechanical physical world.

Science today, however, not only knows a great deal more about the physical world; it has a much more humble attitude towards its knowledge and its lack of knowledge. Furthermore, science has found that at the atomic level the certainty of Newtonian mechanics disappears into the probability functions of quantum mechanics. And, on the very large scale of the astronomical universe, Newtonian mechanics must be replaced with the laws of Einstein. In both cases, the very small and the very big, the behavior of the physical world does not obey the dicta of "common sense."

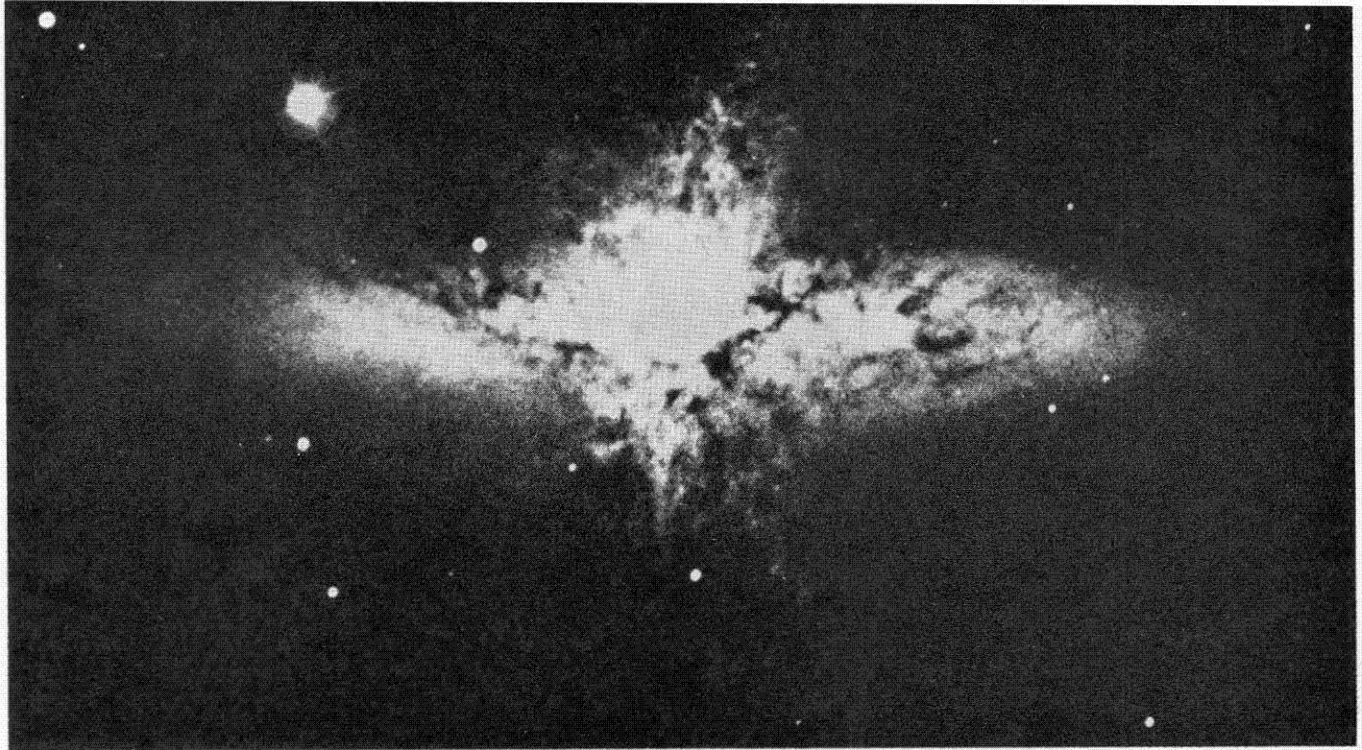
Coupled with these developments in science are the developments in technology which carry us further into the realm of cybernetics. The more that we make machines automatic, the more we can make them responsive to individuals. Thus, many buildings have room temperature control which you can adjust to suit yourself. The modern automobile with power steering and automatic shifting and all the rest does not require a trained engineer to drive it. The modern telephone allows you to talk to your friend anywhere without invoking messenger boys or switchboard operators.

The important individual

Hence, it appears to me that science and technology together are moving into an area where the individual is becoming increasingly important. He is no longer a cog in a vast machine, and therefore we are moving away from the threat of scientific dictatorship.

We are living in one of the Golden Ages of history. Never before have so many people been able to live the good life. But, regardless of whether there is a scientific dictatorship or not, there is still no guarantee that this Golden Age will last. There is, first of all, the need to keep our present physical powers within bounds and to assure that our future biological knowledge and power is kept under control. There is the need to keep our productivity ahead of our population, and to develop satisfactory means of incorporating modern technology into less advanced culture. Finally, there is the necessity that the cultural evolution of our society should be able to find new ethics, new motivations, new principles appropriate to the dynamics of material and technological developments.

One final thought: Civilization has always seemed to require a governing elite and slaves to provide the elite with food, shelter, clothing and all the other material appurtenances to life. Since the Industrial Revolution, the slaves have been machines. Now the machine is acquiring judgment and perhaps a little intelligence. Our material civilization is so successful because we have so many machines working for us. In the past, many civilizations have fallen because of a revolt of the slaves. Will we ever have to face that problem with our machines?



The exploding galaxy M 82, which is 10 million light years from the earth.

EXPLODING GALAXY

The most violent type of explosion known to man — an exploding galaxy — has now been photographed for the first time by the 200-inch telescope at Palomar Observatory. The photograph, taken by Dr. Allan R. Sandage, of the Mt. Wilson and Palomar Observatories staff, is that of the galaxy M 82, which is comparatively nearby (only 60 billion billion miles, or 10 million light years, away). Tremendous jets of matter, stretching out 60 billion million miles (10,000 light years), are shown streaming from the galaxy's nucleus above and below the flattened galactic disk, which is about 20,000 light years across.

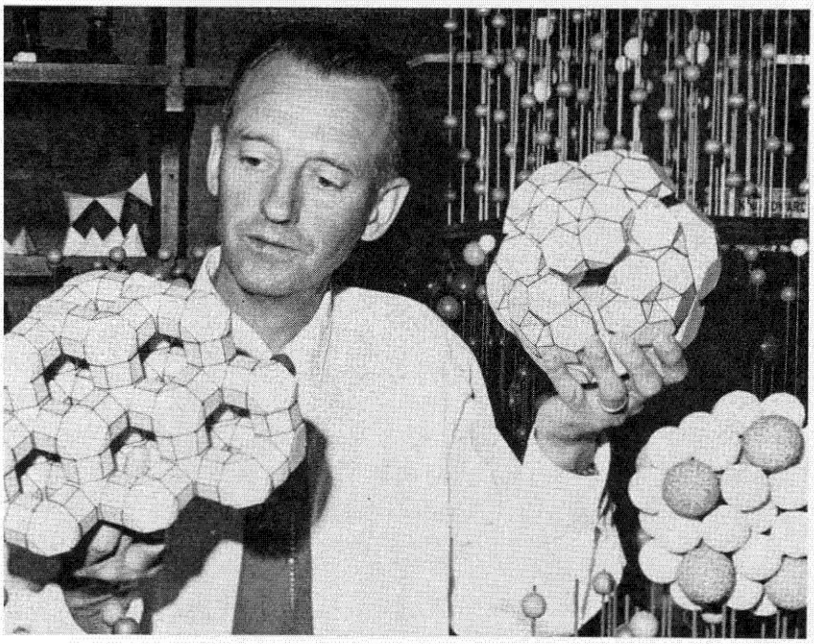
Spectral work on the galaxy was done at Lick Observatory by Dr. C. R. Lynds of the Kitt Peak National Observatory. From spectroscopic examination of the jets, it was determined that the material is rushing out at velocities ranging up to 20,000,000 miles an hour at the most distant points. From these velocities, it was calculated that the explosion started 1,500,000 years ago. It is still going on.

Earlier photographs of M 82 indicated only that something chaotic was going on. In obtaining the new photograph, all the light from the galaxy except that emitted by excited hydrogen was filtered out. Astronomers believe that this is the material that would be most affected by the explosion and that a photograph only of the hydrogen would best reveal the configuration of the explosion.

While the photograph does show only the turbulent hydrogen, it is assumed that other material also is affected by the blast. Drs. Sandage and Lynds calculated that all the matter being exploded outward is equal to that of 5,000,000 suns.

Explosions of this magnitude may well be the prime source of cosmic rays, the astronomers say. Cosmic rays are chiefly composed of the nuclei of atoms that have been energized to tremendous speeds by events such as explosions in stars and galaxies. Until recently, exploding stars were thought to be the principal source of these high energy cosmic rays.

The importance of M 82 is that this galaxy is also a source of radio radiation, as discovered by Dr. Lynds, while a staff member at the National Radio Astronomy Observatory. It is believed that M 82 provides an essential clue to the mechanism for the generation of radio noise in most cosmic radio sources. High energy electrons may be created in the explosions and these interact with the magnetic fields to produce radio noise. The magnetic field in M 82 can possibly be traced in photographs, appearing as loops in the hydrogen alpha photograph on the cover of this issue.



ATOMIC ARRANGEMENT

Dr. Sten Samson, senior research fellow in chemistry at Caltech, is making major contributions to metallurgy by investigating how the metal atoms in certain alloys organize themselves into geometric, flower-like patterns.

Dr. Samson and Dr. Linus Pauling, pioneer in this field, have received a $41,000 grant from the National Science Foundation, which is joining the Office of Naval Research in support of this work.

These complex structures of intermetallic compounds are of particular value because in them each kind of atom can be studied in many different environments. The distances reveal the atoms' bonding properties, and the forces that bind one atom to another are responsible for many physical properties of metals.

While the nature of the chemical bond in many substances is fairly well understood, considerable work has yet to be done to elucidate the nature of the metallic bond.

Dr. Samson recently made an important step forward in his field by determining the precise locations of all 1,192 atoms in the structural unit of an intermetallic compound of sodium and cadmium. This is the most complex inorganic compound to ever have its atomic arrangement determined. The job took more than a year, with Dr. Samson working up to 16 hours a day seven days a week.

The structural unit of the sodium-cadmium compound is a cube whose sides are less than one eight-millionth of an inch long. There are 1,192 atoms neatly packed inside it. The atoms are arranged in 8 identical sub-units of 144 atoms each. Each sub-unit, in turn, is composed of symmetrically arranged smaller units, which are polyhedral. The largest polyhedron consists of 12 of the smaller cadmium atoms and 4 of the larger sodium atoms forming a shell around one sodium atom.

It is the arrangement of the atoms in these polyhedra and the arrangement of the polyhedra with respect to one another in patterns like petals on a flower that may reveal many of the secrets of the properties of alloys.

Dr. Samson is now working on the structures of two other complex intermetallic compounds—one of copper and cadmium that contains about 1,116 atoms; and the other of magnesium and aluminum, whose unit structure is composed of about 1,200 atoms.

Precisely pinpointing the position of every atom in such a complex structural unit is a formidable task. There is no straightforward way of working out these complex structures. Intuition and educated guesses are necessary to determine the model of the structure. Subsequently, the correctness of the model must be verified by comparing calculated data with data that have been obtained by x-ray techniques.

Dr. Samson has simplified the problem of working out cubic metal structures with a special technique he developed. It makes use of all the symmetry represented in the structural unit. Transparent templates of sectioned polyhedra are fitted together on symmetry charts designed by Samson, like pieces of a puzzle. The charts then guide the search for a reasonable structural pattern, or motif.

"It is interesting to see how nature, even in this submicroscopic realm, insists on symmetry and beautiful geometric designs," says Dr. Samson. "Despite the complexity of these designs, there appears to be a striving for simplicity. Similar structural building blocks of atoms are used over and over again in a variety of combinations, leading to ever more complex-appearing structures."

The Summer at Caltech

Three New Caltech Trustees

Three new members were elected to the Institute Board of Trustees this month: Lloyd L. Austin, chairman of the board and chief executive officer of the Security First National Bank in Los Angeles; Augustus B. Kinzel, vice president of research for the Union Carbide Corporation; and William E. Zisch, president of Aerojet-General Corporation.

Lloyd L. Austin was born in Leadville, Colorado, in 1904. He attended the University of Southern California, 1921-22, and the University of Arizona, 1924-26. From 1926 to 1933 he was an accountant with Lybrand, Ross Brothers and Montgomery in Los Angeles.

He began his career at the Security Bank in March 1933 and has been chairman of the board since 1961. He is a director of a number of corporations, immediate past president of the Childrens Hospital of Los Angeles, and a director and president of the Automobile Club of Southern California.

Augustus B. Kinzel was born in New York City in 1900. He received a BA cum laude in mathematics from Columbia University in 1919, a BS in engineering from MIT in 1921, and doctorates in metallurgical engineering and science from the University of Nancy in France.

He joined Union Carbide in 1926 as a research metallurgist, and became chief metallurgist in 1931. In 1955 he became vice president of research.

Dr. Kinzel is regarded as one of the country's leading research metallurgists and has pioneered in the theory of stainless steel and the theory and application of the structural low-alloy steels and new ferroalloys. More than 40 patents have been issued in his name. His extensive background in mathematics and physics, as well as in metallurgy, has been useful in the field of nucleonics, and he has served as consultant to Atomic Energy Commission installations such as Los Alamos, Oak Ridge, Argonne, Knolls and Brookhaven Laboratories. As a member of the initial Manhattan District Committee for the World Control of Atomic Energy, he helped draft the classified report that led to the Lilienthal and Baruch plans.

Dr. Kinzel is a member of the National Academy of Sciences and has held a number of government advisory posts.

William E. Zisch was born in 1917 in Denver, Colorado. He attended Sawyer's School of Business and Caltech. From 1935 to 1938 he worked as a chemist for the Great Western Sugar Company in Johnstown, Colorado, and then became supervisor of laboratory operations for the American Sugar Company in Oxnard, California. In 1939 he came to Caltech as an assistant in aeronautics and assistant to the comptroller, which brought him in close contact with Dr. Theodore von Kármán and other founders of Aerojet. In 1942 he joined Aerojet as contract administrator and rose through various administrative positions until he became executive vice president in 1961. Last spring he was appointed president of the corporation.

Sponsored Research Administrator

George Canetta, business manager of the Denver Research Institute of the University of Denver for the past 12 years, is now sponsored research administrator of the Institute. He is responsible for research grants and contracts exclusive of the Jet Propulsion Laboratory.

Mr. Canetta was born on the Isle of Jersey and attended school in England and Italy. He studied business administration at New York University and obtained his degree in it at the University of Denver.

Prior to his work in Denver, Mr. Canetta administered contract negotiations at New Mexico State University's Physical Science Laboratory. During World War II he was an administrative assistant at the University of New Mexico in research on the proximity fuse for aerial bombs and artillery shells.

Industrial Associates Director

Emory L. Ellis, new executive director of the Institute's Industrial Associates, replaces Dr. Arthur H. Warner, who retired in June. Dr. Ellis had represented the Operations Research Groups of the U.S. Department of Defense in England and Europe since 1961, serving as liaison between these groups and the United Kingdom and NATO.

Dr. Ellis received all of his degrees from Caltech—BS in 1930 and MS in 1932 in chemistry; PhD in 1934 in biology. He worked with Dr. Max Delbruck, professor of biology, in developing the technique of isolating pure strains of virus.

During World War II he was associated with the development of artillery rockets at Caltech and later continued this work at the Naval Ordnance Test Station at China Lake. He served as supervisor of the station's Rockets and Explosives Department until 1955, when he was made head of ordnance planning for the Rheem Manufacturing Company of Los Angeles.

In 1957 Dr. Ellis became project leader of the Institute for Defense Analyses in Washington, D.C., in the Weapons Systems Evaluation Group, which serves the Joint Chiefs of Staff and the Department of Defense.

Director of Libraries

Harald Ostvold, chief of the reference department of the New York Library, was appointed director of libraries at Caltech this summer. He succeeds Dr. Roger F. Stanton, director of the Institute libraries since 1949, and professor of English. Dr. Stanton, who has been on the Caltech faculty since 1925, will devote full time to professorial duties.

Mr. Ostvold is a native of St. Paul, Minnesota, and received his BA from Hamline University there in 1936. He received his BS in Library Science and his MA from the University of Minnesota.

In Memoriam

Over the summer, the Institute suffered the loss of four distinguished staff members:

ROBERT L. MINCKLER

Robert L. Minckler, chairman of Caltech's Board of Trustees, died of a heart attack on August 6 while on vacation in Banff, Alberta, Canada. He was 65.

A native of Minneapolis, Mr. Minckler was an alumnus of the University of Washington. In 1924 he joined the General Petroleum Corporation and in 1948 became president of the company. He served as president for 12 years before his retirement in 1960. During World War II he was director of petroleum supply of the Petroleum Administration for War in Washington, D.C. He was a senior member of the National Industrial Conference Board, a vice president and director of the California State Chamber of Commerce, and president of the World Affairs Council of Los Angeles.

Robert L. Minckler

Mr. Minckler became a member of the California Institute Associates in 1948 and a member of the Board of Trustees in 1954. He had been chairman of the Board since 1961.

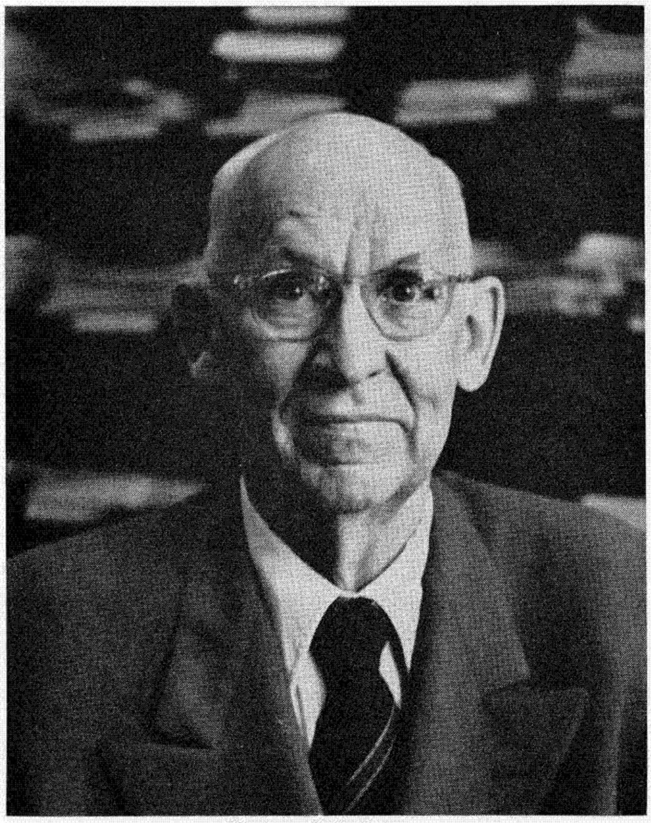
He is survived by his wife; a son, Robert; a daughter, Mrs. Barbara Waterman of Pasadena; and four grandchildren.

Friends of the Institute have established a memorial fund in his honor.

HOWARD J. LUCAS

Howard J. Lucas, professor emeritus of organic chemistry at Caltech, died on June 22 at Huntington Memorial Hospital of a heart ailment. He was 78.

Born in Marietta, Ohio, Dr. Lucas graduated from Ohio State University and received his MS in chemistry there. He taught at the University



Howard J. Lucas

of Chicago, then became a chemist for the U.S. Department of Agriculture. In 1913 he came to Caltech as an instructor and served on the faculty for 42 years until he retired in 1955.

Dr. Lucas, a member of the National Academy of Sciences, was one of the first scientists to use knowledge about the electron in organic chemistry. He published more than 60 scientific papers on his work.

In 1953 he won a $1,000 prize as the nation's outstanding chemistry teacher for that year. His book *Organic Chemistry,* published in 1935, is credited with establishing the pattern for modern elementary organic chemistry textbooks.

Dr. Lucas was a member of the American Chemical Society, American Association for the Advancement of Science, American Association of University Professors, Sigma Xi, and Phi Beta Kappa.

A memorial fund has been set up in Dr. Lucas's name in honor of his long years of service to the Institute.

SETH B. NICHOLSON

Seth B. Nicholson, member of the Mount Wilson and Palomar Observatories staff for 42 years, died of cancer on July 2 at Queen of Angels Hospital. He was 71.

Dr. Nicholson was born in Springfield, Illinois. He received his BS from Drake University in 1912 and his PhD from the University of California in 1915.

In 1914, at the Lick Observatory, Dr. Nicholson discovered the ninth of Jupiter's satellites and in the late 1930's and early 1950's at Mount Wilson he discovered the tenth, eleventh and twelfth of the planet's moons.

At the Observatories, he studied solar phenomena. He supervised the collection of data on sunspots, including the strength and polarity of their magnetic fields. He collaborated with the late Dr. Edison Pettit in developing a very sensitive vacuum thermocouple with which to measure the heat radiated by celestial objects such as stars, the planets, and the moon.

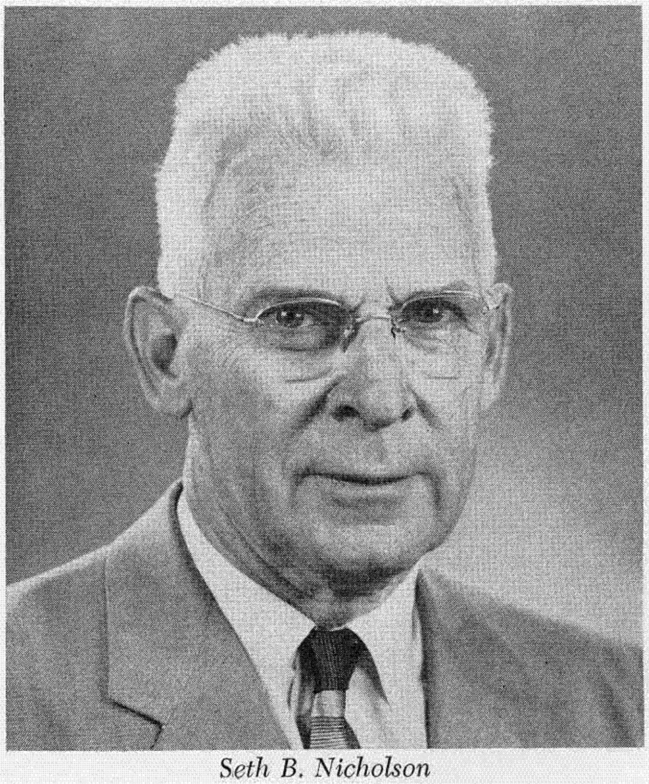
Dr. Nicholson was a member of the National Academy of Sciences, American Association for the Advancement of Science, American Astronomical Society, Astronomical Society of the Pacific, Phi Beta Kappa and Sigma Xi.

He is survived by his widow and three children: Don; Margaret; and Mrs. Jean Spicer; and two grandchildren.

MORGAN WARD

Morgan Ward, professor of mathematics, died on June 26 of a heart attack at the City of Hope Medical Center. He was 61.

Dr. Ward was born in New York City but spent most of his life in southern California. He re-



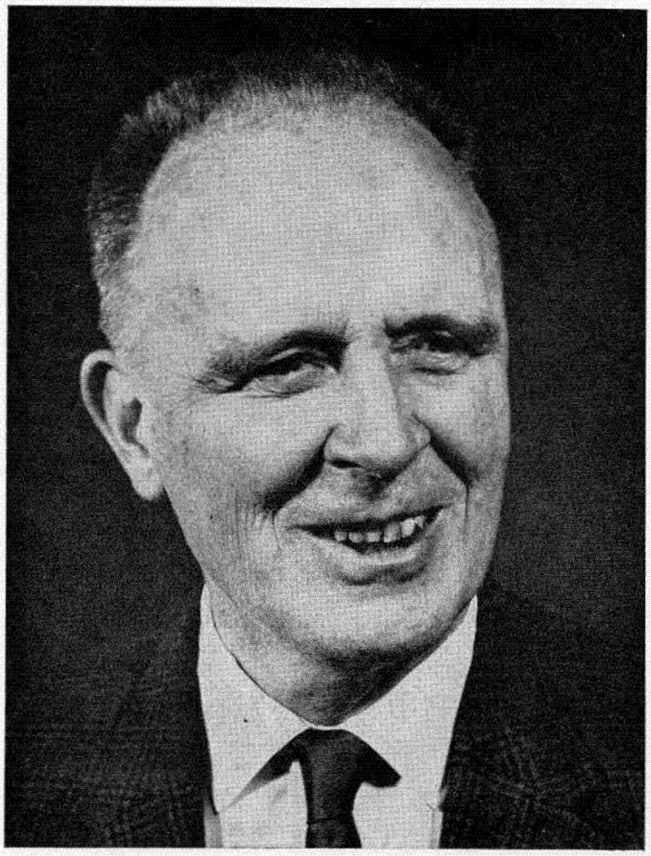
Seth B. Nicholson

ceived his BA from the University of California in Berkeley in 1924, and his PhD in mathematics from Caltech in 1928. He then joined the Caltech faculty as assistant professor of mathematics.

As a research mathematician, Dr. Ward was known for his work in algebra and number theory, with particular emphasis on arithmetical sequences. During the past few years he had worked with the school mathematics study group set up by the National Science Foundation to reform elementary school mathematics curricula.

In 1934-35 Dr. Ward did research work at the Institute for Advanced Study in Princeton, N.J., and from 1941 to 1944 he served as consultant to the Office of Scientific Research and Development on problems of underwater ballistics and anti-submarine warfare. He was a member of the American Mathematical Society and the American Mathematical Association. He was also an accomplished pianist, a student of poetry, and an expert chess and Go player. He is survived by his wife; a daughter, Audrey Ward Gray; three sons, Eric, Richard and Samuel; and five grandchildren.

Memorial services will be held in connection with a symposium on number theory to be held at Caltech in November. Friends of the Institute have set up a memorial fund to perpetuate his name.



Morgan Ward

Faculty Changes 1963-64

Promotions

TO ASSOCIATE PROFESSOR:

GIUSEPPE ATTARDI, MD — *Biology*
CHARLES J. BROKAW — *Biology*
ROBERT S. EDGAR — *Biology*
ROBERT A. HUTTENBACK — *History*
TOSHI KUBOTA — *Aeronautics*
MILTON LEES — *Mathematics*
BRUCE C. MURRAY — *Planetary Science*
WHEELER J. NORTH — *Environmental Health Engineering*

TO SENIOR RESEARCH FELLOW:

JOHN N. BAHCALL — *Physics*
WALLACE G. FRASHER, JR. — *Engineering*
HANS G. E. KOBRAK — *Physics*
J. OWEN MALOY — *Physics*
DAVID MORRIS — *Radio Astronomy*

TO ASSISTANT PROFESSOR:

DON L. ANDERSON — *Geophysics*
CHARLES D. BABCOCK, JR. — *Aeronautics*
FRED E. C. CULICK — *Jet Propulsion*
DIN-YU HSIEH — *Engineering Science*
RICHARD C. SEAGRAVE — *Chemical Engineering*
JEROME LEE SHAPIRO — *Applied Science*
RONALD H. WILLENS — *Materials Science*

NEW FACULTY MEMBERS

WALLACE S. BROEKER, visiting associate professor in geochemistry, from Columbia University, where he is associate professor of isotopic geochemistry.

MORRIS BROWN, Arthur A. Noyes Research Instructor in chemistry, from Harvard University, where he was an NSF Postdoctoral Fellow.

RONALD F. BROWN, visiting associate in chemistry, from the University of Southern California, where he is professor and head of the chemistry department.

SUNNEY I. CHAN, assistant professor of chemical physics, from the University of California, Riverside, where he was assistant professor of chemistry.

HUGH NAN CHU, visiting associate in aeronautics, from the Rocketdyne Division of North American Aviation, where he is a senior technical specialist.

PETER L. CRAWLEY, assistant professor of mathematics, from the University of Minnesota, where he was assistant professor of mathematics.

E. W. DENNISON, staff member, Mt. Wilson and Palomar Observatories, from Sacramento Peak Observatory, New Mexico, where he was solar physicist.

RICHARD E. DICKERSON, associate professor of physical chemistry, from the University of Illinois, where he was assistant professor of chemistry.

WILLIAM J. DREYER, professor of biology, from the National Heart Institute, National Institutes of Health, where he was a research biochemist.

LINCOLN K. DURST, visiting associate in mathematics, from Rice Institute, where he is associate professor of mathematics.

SHELDON K. FRIEDLANDER, professor of chemical engineering and environmental health engineering, from Johns Hopkins University, where he was associate professor of chemical engineering.

Continued on Page 22

THE BELL TELEPHONE COMPANIES SALUTE: JOE FRASE

Joe Frase (B.S.E.E., 1959) has been responsible for providing transmission recommendations for all telephone carrier and toll terminating equipment installations in the San Diego division of Pacific Telephone. Quite a big job for a young engineer.

Joe finds his work stimulating because of the personal rewards of seeing many of his ideas put into use. The latitude of responsibility gives him ample opportunities to express himself and prove his capabilities.

Obviously Joe's talents have been recognized. He has completed a number of other special assignments, and while on one job he even attended a four-month course in communications at the University of California.

He was recently promoted to Senior Engineer in charge of the Direct Distance Dialing improvement program.

Joe Frase, like many other young engineers, is impatient to make things happen for his company and himself. There are few places where such restlessness is more welcomed or rewarded than in the fast-growing telephone business.

BELL TELEPHONE COMPANIES

TELEPHONE MAN-OF-THE-MONTH

BYRD LUTHER JONES, instructor in history, from Yale University, where he was an assistant in instruction.

TARAS KICENIUK, lecturer in engineering design. He has been a research engineer and group leader at Caltech since 1950, when he received his MS here.

MAJOR W. R. KNIGHT, assistant professor of air science, from Headquarters, 5th Air Force, Fuchu Airstation, Japan, where he was Chief, Records and Analysis Branch.

DONALD E. KNUTH, assistant professor of mathematics, who received his PhD from Caltech in June 1963.

HEINZ-OTTO KREISS, visiting associate in mathematics, from the Royal Institute of Technology, Stockholm, Sweden, where he is a lecturer.

ARON KUPPERMAN, professor of chemical physics, from the University of Illinois, where he was associate professor of chemistry.

ALVIN L. KWIRAM, Arthur A. Noyes Teaching Fellow in chemistry, who received his PhD from Caltech in June.

E. RALPH LAPWOOD, research associate in geophysics, from Emmanuel College, Cambridge, England, where he was a fellow and director of NSF studies in mathematics.

FRANK B. MALLORY, visiting associate in chemistry, from Bryn Mawr College, where he is associate professor of chemistry.

MAURICE E. MATHISEN, visiting associate in chemistry, from Loma Linda University, where he is professor and chairman of the department of chemistry.

W. L. MIRANKER, senior research fellow in engineering, from IBM Research Center, Yorktown, New York, where he was a research staff member.

D. B. NARASIMHAIAH, visiting associate in civil engineering, from the University of Mysore, where he is professor and head of the department of civil engineering.

JEROME PINE, associate professor of physics, from Stanford University, where he was an instructor and assistant professor.

RUSSELL M. PITZER, Arthur A. Noyes Research Instructor in chemistry, from Harvard University, where he received his PhD this year.

RAPHAEL SIVAN-SUSSMAN, assistant professor of electrical engineering, from the University of California, where he received his PhD this year.

LOLITA SAPRIEL, lecturer in French, from UCLA, where she was a teaching assistant.

HEINZ SCHUSTER, senior research fellow, from the Max Planck Institute for Virus Research in Tübingen, Germany, where he was a member of the scientific staff.

CAPTAIN D. L. STEARNS, assistant professor of air science, from Fort MacArthur, California, where he was Weapons Controller, 670 Radar Squadron.

MINORU TAKAHASHI, senior research fellow in electrical engineering, from Tohoku University in Sendai, where he was assistant professor in the magnetic materials laboratory.

ROBERT D. VOLD, visiting associate in chemistry, from the University of Southern California, where he is professor of chemistry.

DAVID M. VOWLES, senior research fellow in biology and electrical engineering, from Oxford, England, where he was a lecturer at the Institute of Experimental Psychology.

EDWARD J. WELLMAN, visiting associate in engineering, from Purdue University, where he is associate professor of mechanical engineering.

JOHN F. WHITE, visiting associate in geology, from Antioch College, where he is chairman of the department of earth sciences.

ARNE A. WYLLER, senior research fellow in astronomy, from the Institute of Theoretical Astrophysics, Blindern, Norway, where he was a research associate.

ON LEAVE OF ABSENCE, 1963-64

FRED C. ANSON, professor of analytical chemistry, to the University of Brussels in January, where he will conduct research on electrokinetics on a Guggenheim Foundation Fellowship.

JAMES F. BONNER, professor of biology, to Oxford University in England, where he will be Eastman Visiting Professor for 1963-64.

ROY W. GOULD, professor of electrical engineering and physics, to the Max Planck Institute in Munich for research in plasma physics.

C. HEWITT DIX, professor of geophysics, to the University of Tokyo in Japan, as a research scholar on the faculty of science.

THOMAS LAURITSEN, professor of physics, to the Institute for Theoretical Physics in Copenhagen for one year of research.

JURG WASER, professor of chemistry, to Europe on a Guggenheim Fellowship to study undergraduate chemistry education in Switzerland and other European countries.

RESIGNATIONS:

JAMES C. DAVIES, professor of political science, to the University of Oregon as professor of political science.

ANTHONY DEMETRIADES, senior research fellow in aeronautics, to join the staff of Aeronutronics in Newport Beach.

RENATO DULBECCO, professor of biology, to join the staff of the Salk Institute of Biological Studies at La Jolla.

KARL R. JOHANSSON, associate professor of environmental health engineering, to the National Institute of Neurological Diseases and Blindness as Chief of the Research Grants Branch.

LEON KNOPOFF, professor of geophysics, to UCLA as professor of physics and geophysics.

ROBERT A. PHINNEY, assistant professor of geology, to Princeton University as associate professor of geophysics.

MATTHEW SANDS, professor of physics, to Stanford University as professor of physics and deputy director of the Stanford Linear Accelerator Center.

PAUL TS'O, senior research fellow in biology, to Johns Hopkins University as an associate professor in the department of radiological sciences.

SITARAM R. VALLURI, senior research fellow in aeronautics, to the Indian Institute of Technology in Madras, India, as senior professor and head of the department of applied mechanics.

MARGUERITE M. P. VOGT, senior research fellow in biology, to join the staff of the Salk Institute of Biological Studies at La Jolla.

Floating on air...cushioned in foam

Sleeping is like floating on air, when the mattress is made of urethane foam . . . a mattress that "breathes" air through every cell, and weighs so little that a housewife can lift it over her head! ▶ By combining exact proportions of five chemicals from Union Carbide, this versatile foam can be made soft, firm, or rigid. Mattresses, upholstery, and pillows can be given their own degrees of resilience. Other formulations produce superior insulation in the form of prefabricated rigid panels or foamed in place. In a refrigerator trailer body, this insulation can be used in much thinner sections than conventional materials, so cargo space is increased substantially. ▶ Recently, Union Carbide introduced "climate-controlled" polyether, which results in uniform foam properties despite such curing variables as summer heat and humidity. Another Union Carbide development is production of the first polyether for flame-lamination of thin foam sheets to cloth, adding warmth without noticeable bulk. ▶ In their work with chemicals, the people of Union Carbide have pioneered in developing polyethers and silicones for urethane foam, found new uses for the foam, and shown customers how to produce it.

A HAND IN THINGS TO COME

UNION CARBIDE

WRITE *for booklet DD, "The exciting Universe of Union Carbide," which tells how research in the fields of chemicals, carbons, gases, metals, plastics, and nuclear energy keeps bringing new wonders into your life. Union Carbide Corporation, 270 Park Avenue, New York 17, N.Y. In Canada: Union Carbide Canada Limited, Toronto.*

Alumni Speak Out

Some random comments from the Alumni Survey questionnaire

In the 5,000 Alumni Survey questionnaires that have been returned to the Institute to date, responses to the back-page invitation for "comments" have been gratifyingly numerous. Although there is no such thing as a typical comment, some representative ones appear on these pages. Remember, however, that for every comment below, there is at least one other stating an opposite point of view.

If I had known then what I know now – and I don't mean academically!

Social ineptitude caused me more trouble at Tech than any other single cause.

On the other side of the ledger, I can think of no other school where *I* myself could have finally got my social bearings. I only wish that I had had more time to devote to academic problems. At a school such as UCLA, for example, I would have been at a *complete* loss socially. I don't believe I would have done better academically because I would have worried even more about my social life. At Tech, the social atmosphere was one I could finally cope with, and I think I came out on top. I even managed to graduate – and I sure don't have any complaints there!

Give more closed-book exams in physical science courses. Otherwise lazy people like me tend not to memorize many things that one should have in one's head and not in a book. A lot of inventiveness comes from having a large number of facts memorized.

Instructors were competent technically, but most lacked a real talent for teaching (notable exceptions were Linus Pauling and several in the humanities). It is hoped that by now the Development Program has stimulated the quality of undergraduate instruction so that it begins to match the excellent programs in graduate study and research.

I am now convinced that every student, and particularly the high-capability student that is attracted to Caltech, should concentrate *first* on obtaining a diversified, "liberal" education, and only secondarily on becoming trained for a future occupation. A full understanding and personal involvement in philosophy, economics, psychology, and sociology is necessary for a well-planned life and a successful career. Such a background can become a motivation for technical study.

All physics majors study too much physics and not enough mathematics. Physics, like medicine, should be undertaken only at the graduate level, after a thorough training in applied mathematics.

More concentration on modern politics and practical economics and finance would be advisable. There are too many Caltech PhD's taking orders from second rate students who graduated from third rate schools.

There is a popular notion abroad today that one must have broader studies in the humanities and solid sciences – even to the neglect of good solid

BURIED UNDER WORK?

Haven't got around to that alumni questionnaire yet?
There's *still* time to send it in.
Fill it out. Send it in now.*

*You mean you've *lost* it?
Then fill out this handy coupon and we'll send you another.

Name...

Address..

City.. State..................

engineering subjects . . . I never had any subjects except technical ones beyond my freshman year at Yale . . . I do not consider myself uneducated. There are great book programs, discussion groups, books to read, lectures to attend, etc. I believe I have as broad an education as many of my contemporaries who took majors in the liberal arts areas at Yale.

At Caltech emphasis on humanities may be needed. It is certainly not needed for engineers at Yale, who are in the distinct minority and are in no way segregated in living quarters, etc.

I am highly disturbed that our schools and colleges *do not* instill an abiding faith in our free-enterprise system without the need of the deadening hand of bureaucratic government and welfare statism. I often ask myself and antagonists, "How did our nation become the greatest in the world long before we had the welfare state philosophy?"

My feeling is that CIT tends to produce graduates with an excellent background in science. Unfortunately, this 4-year cramming-in of knowledge may tend to drastically reduce the student's drive and interest in the very science in which he is so well trained. This I have found to be true in my own case, at least.

I do not believe in the epistemological worth or fairness of questionnaires; this one is particularly offensive in its attempt to elicit a check in one of *three* boxes on issues about which we have perhaps thought long and deeply – and I feel that way about many of the questions asked me. A check in a box simply does not communicate my ideas.

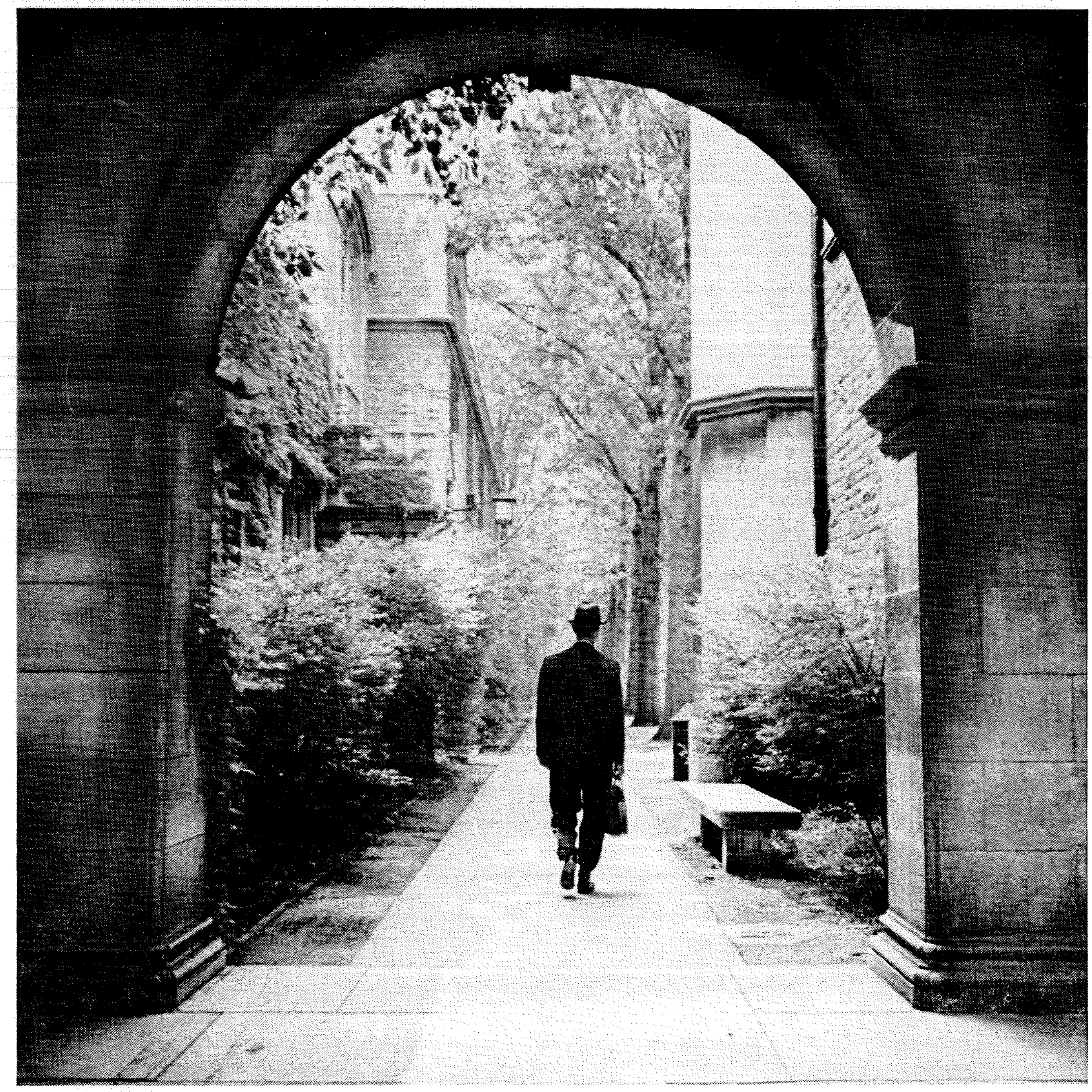
What price "science"?

What price "objectivity"?

Page 5-6 is particularly ludicrous. Were I not a compulsive complier, I should not return this folder.

I think the instruction of *undergraduates* at Caltech is left too much in the hands of graduate students.

I regard Caltech as a great institution. I'm glad to have spent the time there but wouldn't relish doing it again.



Letters

Department of Amplification

New York, N.Y.

GENTLEMEN:

If you have a feature roughly the equivalent of *The New Yorker's* Department of Amplification, you might be interested in the following anecdote that amplifies a personal attribute of the late Dr. Theodore von Kármán.

In the June 1963 issue of *Engineering and Science* the excellent article by Prof. W. D. Rannie emphasized Prof. von Kármán's personality as an instructor interested in students. I recall vividly an incident occurring circa spring 1942 that emphasized this trait. I was then taking Professor Ward's course in Complex Variable Function Theory, and was in the library, along with several other members of the class, working on problem assignments. As was common with all graduate course homework problems, this was open book, and *any* source was legitimate in helping to do the problems.

A particularly tough problem on the Gamma Function had a group of us stumped — this group including some of the bright boys, such as Dave Bohm, Charlie Wilts, and Abe Zarem. We saw Professor von Kármán enter the library, and someone suggested that we ask him how to do the problem. The problem was not from Coplon's text, but was one which Professor Ward had formulated. I was elected to approach Professor von Kármán. This I did with trepidation, but was very pleased to see his face light up when I posed the problem to him. He asked, "Where did you get this one?" and when I told him, a twinkle came into his eye and he said, "Oh, that Ward, he's a foxy one!" He then promptly proceeded to outline the approach to the solution of the problem, in a few deft equations. He insisted that we work it out for ourselves, which we then did.

The next day in class the student who presented the problem on the blackboard received a compliment from Professor Ward, and the student admitted the source of the hint for solution. "Oh," said Professor Ward, "that von Kármán, he's a foxy one!"

Very truly yours,

VICTOR WOUK, *president*
Electronic Energy Conversion Corp.

More Amplification

Stanford, California

EDITOR:

Just noticed no credit for the von Kármán picture in the June issue of *E&S*. You may not know it was taken by Ben Olender of the LA *Times*, when he and I were both on the Pasadena *Star-News*. Von Kármán always said it was the best portrait ever taken of him. And guess who was holding the slave light that lent the nimbus to that imposing mane of grey hair?

JEFF LITTLEBOY
News and Publications Service
Stanford University

Personals

1906

HILDA WOOD GRINNELL died on June 7, 1963, at the age of 80. She graduated from the "Academy Department" of Throop Polytechnic Institute in 1902, and received her BS from the "College Department" in 1906. From 1904 to 1906 she was teaching assistant in zoology at the Institute to JOSEPH GRINNELL '97, professor of biology. They were married in June 1906. The Grinnells collaborated on many books, and even after Dr. Grinnell died in 1939, Mrs. Grinnell continued her interest in the natural sciences and was an active member of a number of scientific societies right up until the time of her death.

1912

BEN FERGUSON died at his home in Phoenix on June 5 at the age of 74. He had served as chief engineer for the Arizona Corporation Commission from 1912 to 1924. He founded his own engineering firm, the Headman, in 1932. After serving eight years on the Phoenix Planning Commission, he resigned in 1953. He is survived by his wife, sons Archibald and Benjamin H., and eight grandchildren.

1929

THOMAS H. EVANS, MS'30, dean of engineering at Colorado State University for the past 14 years, is now dean of engineering at Fresno State College. Fresno State is the only college in the San Joaquin Valley that offers engineering. This is a "return of the native" for Evans; he was born in California and never left the state until he had graduated from the Institute.

1930

LOREN P. SCOVILLE, MS, has been appointed executive vice president and general manager of the Arizona Agrochemical Corporation in Phoenix.

1932

CHARLES D. CORYELL, PhD'35, professor of chemistry at MIT, returned last month after 9 months as a Guggenheim Fellow and Fulbright Lecturer at the Institut du Radium of the University of Paris.

E. CHET KEACHIE, associate professor of industrial engineering at UC, Berkeley, writes that his older son, Steve, has graduated from Stanford with an EE degree (where his dad got his PhD). Steve is in business for himself, making his own invention — an instrument power supply for sailplanes.

1933

GREGORY K. HARTMANN, technical director of the Naval Ordnance Laboratory, was one of ten people to receive a National Civil Service League annual Career Service Award last spring.

E. RAY LOCKHART, MS'34, has been elected president of the El Paso Electric Company in New York. He was formerly vice president and director of the Stone and Webster Service Corporation.

1935

ARTHUR T. IPPEN, MS, PhD'36, professor of hydraulics at MIT, received the Vincent Bendix Award last spring for outstanding research contributions. The award was established through the efforts of the Engineering College Council and the Bendix Aviation Corporation, and is given to staff members of U.S. engineering colleges. Ippen has been on the MIT faculty since 1945.

GEORGE G. GRIMM, JR., MS, consultant in the Missile and Space Division of the Lockheed Aircraft Corporation, died on May 28 of acute coronary thrombosis. He was 52. He leaves his wife and four children; Mina, 25; Carolyn, 20; George III, 18; and Charlotte, 6.

ADRIAN H. GORDON, MS'36, now on a UN Technical Assistance Mission in Teheran, Iran, writes, "Much to my surprise, I found a colleague meteorologist, JOSEPH CAPRIO, '48, here. Joe is one of the three world meteorological organization experts in Teheran. Upon looking through the alumni directory, I find that KAMAL DJANAB, PhD'38, is teaching physics to the postgraduate class of meteorologists I am in charge of. Finally, I see that my namesake, GARFORD GORDON, '34, is also on UN Technical Assistance work in Karachi. As I have been asked to go there when I have finished here in February next, I might run into him. As for the family—my son Marty is 15, and daughter Susie, 12."

1937

WILLIAM C. PUTNAM, PhD, died on March 16, 1963, of a heart attack. He was 54. He was professor of geology at UCLA and had been a member of the faculty for 25 years. He leaves his wife and a daughter, Margaret.

1951

GRAYDON D. BELL, MS, PhD '57, writes: "The 1963 Alumni Directory has two errors that I would like to call attention to. In the alphabetical list, my MS degree is listed as '41 and should be '51. Also, I am now associate professor of physics at Harvey Mudd College. I guess I failed to notify you at the time of that promotion.

"Starting in September, 1963, I am on a sabbatical leave and will work at

Personals . . . *continued*

the National Bureau of Standards in Washington, D.C. where I will do research in the plasma physics division. My wife and three children will accompany me."

1958

RICHARD VAN KIRK is now associate director of development in Caltech's Development Program. Dick worked for Procter & Gamble at their Long Beach plant from June 1958 to May 1963, when he returned to the Institute. He writes: "Among the CIT alumni I worked with at Procter & Gamble or ran across during that time were DONALD STOCKING, systems engineer at IBM Corp., L. A.; LAURENCE BERRY, engineer; ROBERT EMMERLING, project engineer at The Cosmodyne Corporation; and CLARKE REES who is studying architecture at USC – all of the class of '58. Then I saw RICHARD HODGES '54, group manager of synthetics for Procter & Gamble in Chicago, Ill.; WILLIAM CHAMBERS '55, product manager for Procter & Gamble in Cincinnati; JAMES HOLDITCH '48, MS '49, mechanical group manager for Procter & Gamble in Long Beach, Calif.; ARNE KALM '56, MS '57, staff assistant at Space Technology Laboratories; VICTOR WILLITS '35, technical engineer for Procter & Gamble in Long Beach; WILLIAM ADAMS '32, group manager for Procter & Gamble in Long Beach; WILLIAM HUMASON '36, formerly general production manager of Procter & Gamble in Long Beach; and MILLS HODGE '32, MS '33, personnel manager of Procter & Gamble in Long Beach.

"I was married in 1959 to Janet Labory from Occidental and we now have one son, Richard, Jr., 3, and a daughter, Karen, born on June 29."

1960

MARSHALL LAPP, PhD, physicist at the General Electric Research Laboratories in Schenectady, sends some Eastern news: "Eighteen Caltech Alumni held a luncheon in honor of Dr. Royal W. Sorensen at the Mohawk Golf Club in Schenectady, New York, on June 6. Much table talk revolved around California smog, current work, smog, good ol' Joe, family life, and smog. Dr. Sorensen, who was on an extended visit to Schenectady, Pittsfield, Philadelphia, and Toronto, described the present-day Caltech campus, the building program, and apprised the group of the whereabouts and work of those who were and are now active in Caltech life."

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There are two ways in which the Placement Service may be of assistance to you:

(1) To help you seek new employment or a change of employment.

(2) To inform you when outstanding opportunities arise.

This service is provided to Alumni by the Institute. A fee or charge is not involved.

If you wish to avail yourself of this service, fill in and mail the following form:

To: Caltech Alumni Placement Service
California Institute of Technology
Pasadena, California 91109

Please send me:

☐ An Application for Placement Assistance

☐ A form to report my field and operation so that I may be notified of any outstanding opportunities.

Name .... Degree (s) ....

Address .... Year (s) ....

....

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Contact Mr. Farrar, EX 9-5277, on Thursday morning for reservations

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4535 Marble Way, Carmichael, Calif.

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2551 Carson Way, Sacramento 21, Calif.

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ALUMNI FUND

Here are the final results of the 1962-63 Alumni Fund as compared with the previous year:

	1962-63	1961-62	Two-year Total
Gifts to endowment	$55,172.35	$47,387.78	$102,500.13
Gifts restricted	$39,906.10	$18,171.45	58,077.55
	$95,078.45	$65,559.23	$160,577.68
Alumni solicited	8,050	7,835	
Alumni participating	1,703	1,764	
Percent of participation	21.2%	22.5%	

This year our Alumni Fund has a new purpose designed to increase your interest in Caltech's program of education and research. All gifts to the Fund will be credited to the *purpose of your choice.* In the coming months *Engineering and Science* will be describing a variety of important needs to you: athletic facility requirements, the endowment problem, our faculty salary position, and other Institute needs. But the important thing, of course, is that you participate.

Consider this: Only one alumnus of every five participated in the Fund last year (and the year before). Should this small group carry the whole load by themselves? We hope that this year *you* will make it a point to contribute to the Alumni Fund. Whether large or small, your gift will help the Institute in its vital program of education and research.

—G. Russell Nance '36 and David L. Hanna '52
Directors of the Caltech Alumni Fund

ALUMNI ASSOCIATION
CALIFORNIA INSTITUTE OF TECHNOLOGY
Pasadena, California

BALANCE SHEET
June 30, 1963

ASSETS

Cash in Bank			$ 2,989.50
Investments:			
Share in C.I.T. Consolidated Portfolio		$ 80,791.43	
Deposits in Savings Accounts		17,041.44	97,832.87
Investment Income Receivable from C.I.T.			4,362.26
Postage Deposit, etc.			219.23
Furniture and Fixtures, at nominal value			1.00
Total Assets			$105,404.86

LIABILITIES, RESERVES AND SURPLUS

Accounts Payable			$ 902.73
Deferred Income:			
Membership Dues for 1963-64 paid in advance		$ 10,345.00	
Investment Income for 1963-64 from C.I.T. Consolidated Portfolio (earned during 1962-63)		4,362.26	14,707.26
Life Membership Reserve			60,800.00
Reserve for Directory:			
Balance, July 1, 1962	$ 3,931.53		
1962-63 Appropriation	2,000.00	$ 5,931.53	
1962-63 Directory Expense		5,586.01	345.52
Surplus:			
Balance, July 1, 1962		$ 22,475.36	
Share of Profit on Disposal of Investments of C.I.T. Consolidated Portfolio for 1962-63		6,281.07	
Excess of Expenses over Income for 1962-63		(107.08)	28,649.35
Total Liabilities, Reserves and Surplus			$105,404.86

STATEMENT OF INCOME AND EXPENSES
For the Year Ended June 30, 1963

INCOME

Dues of Annual Members		$ 18,303.50
Investment Income:		
Share from C.I.T. Consolidated Portfolio	$ 4,032.22	
Interest on Deposits in Savings Accounts	1,087.39	5,119.61
Annual Seminar		5,178.95
Program and Social Functions		1,948.45
Miscellaneous		25.05
Total Income		$ 30,575.56

EXPENSES

Subscriptions to Engineering and Science Magazine:		
Annual Members	$ 12,815.25	
Life Members	3,034.50	$ 15,849.75
Annual Seminar		4,558.25
Program and Social Functions		2,351.09
Fund Solicitation		2,145.00
Directory Appropriation		2,000.00
Administration (Directors' Expenses, Postage, Supplies, etc.)		1,734.73
ASCIT Assistance		1,150.00
Membership Committee		893.73
Total Expenses		$ 30,682.64
Excess of Expenses over Income		$ 107.08

AUDITOR'S REPORT

Board of Directors, Alumni Association, California Institute of Technology
Pasadena, California

I have examined the Balance Sheet of the Alumni Association, California Institute of Technology as of June 30, 1963 and the related Statement of Income and Expenses for the year then ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as I considered necessary in the circumstances.

In my opinion, the accompanying Balance Sheet and Statement of Income and Expenses present fairly the financial position of the Alumni Association, California Institute of Technology at June 30, 1963, and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

CALVIN A. AMES, Certified Public Accountant
1602 West Thelborn St., West Covina, California

September 24, 1963


EASTMAN