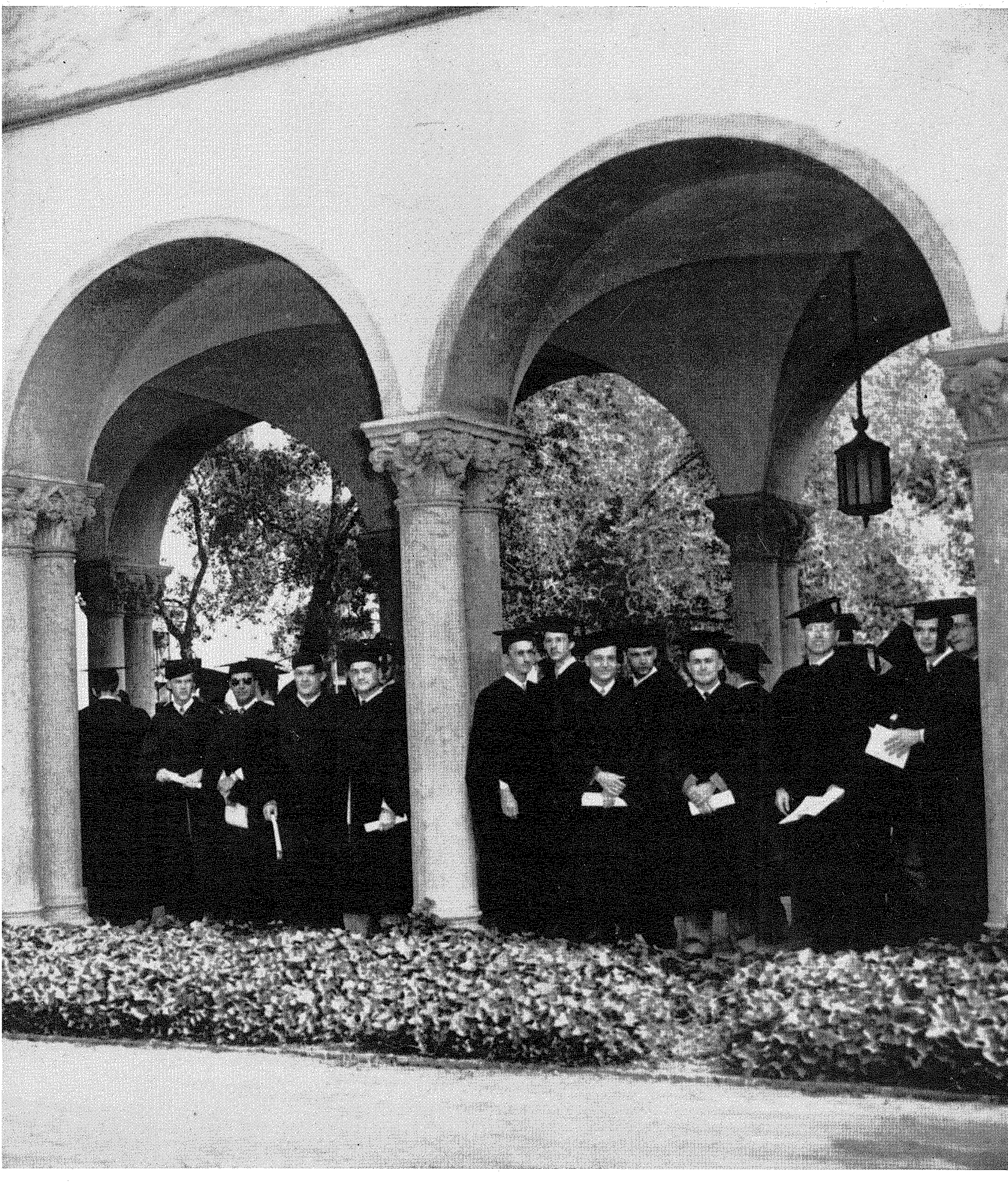
ENGINEERING AND SCIENCE

July, 1949



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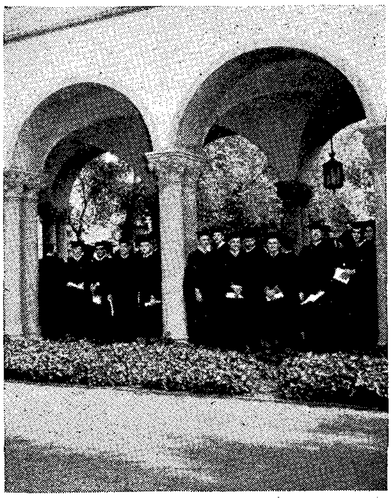

In this issue

On the cover is a picture of the Caltech class of '49, waiting, on the walk between the Student Houses, for the cue to join the academic procession on Commencement Day. For further notes on Caltech's 1949 Commencement, see page 14.

Robert V. Langmuir came to Caltech in 1948 as a senior research fellow. Here, he is now engaged in the very earliest stages of construction of a large electron synchrotron in the energy range between 600 million and one billion volts. If you are not sufficiently impressed by these figures, you can turn to Dr. Langmuir's article on high energy particle accelerators on page 3 and find out just how impressive such a synchrotron can be.

A graduate of Harvard, class of '35, Langmuir received his Ph.D. at Caltech in 1943. From 1942 to 1948 he worked for General Electric; on radar countermeasures until 1945, then on the construction of a 70 MEV synchrotron.

Jesse L. Greenstein, author of "The Age of the Universe" on page 9, is Professor of Astrophysics at Caltech, and a member of the staff of the Mount Wilson and Palomar Observatories. He was graduated from Harvard in 1929 and received his M.A. there in 1930. After several years in business in New York City he returned to Harvard to work for his Ph.D., which he received in 1937. From 1939 until he came to Caltech in 1948 he was a member of the staff of Yerkes Observatory, the research observatory and graduate department of astronomy of the University of Chicago. During the war he worked at the observatory on the optical design of military instruments.

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LETTERS

DEAR SIR: It is with a great amount of caution that I submit a solution to Professor Martel's problem concerning the pensive schmoo as presented in the June issue of E & S.* First, let me explain my reticence by describing one never-to-be-forgotten experience that I had with the distinguished professor.

As every C.E. graduate will recall, Prof. Martel would often test the general alertness and attentiveness of his class by drawing a "simple" problem on the blackboard, peer out the window, and at the proper psychological moment quickly turn to the assembled group for an answer to the implied question.

It was on these occasions that I would become mentally trapped by the tense atmosphere (not unlike "auction sale fever"), and blurt out anything that might come to mind. At rare times I was correct, or nearly so, but in most instances my spirited answers were met with a look of pity and scorn. Following a period of exceptionally poor batting average, I was called aside by Prof. Martel and told in a firm but pleasant manner, "You know, Cook, you have a very fertile mind—but why don't you pull out the weeds before you open the gate?" So you see, I have good reason to tred softly in presenting a solution to the schmoo dilemma.

In true Martelian manner, I will dispense with lengthy equations, and substitute "obvious" where needed.

1. From the equation of the schmoo's bottom it is obvious that the surface described can be formed by revolving the ellipse $\frac{x^2}{6} + \frac{y^2}{4} = 1$ about the Y axis.

2. The statement of the problem reveals that O, the center of gravity of the schmoo, lies in the Y axis—as must the point of contact between the rock and seat of the schmoo, since he (she) is in equilibrium at that time, and ΣM must equal zero.

3. Designating the original contact point between schmoo and rock a_s, we find that this point is on the Y axis and that O_a, is the minor axis of the ellipse used to generate the bottom surface.

*For handy reference, the problem is presented again on page 24.

PICTURE CREDITS

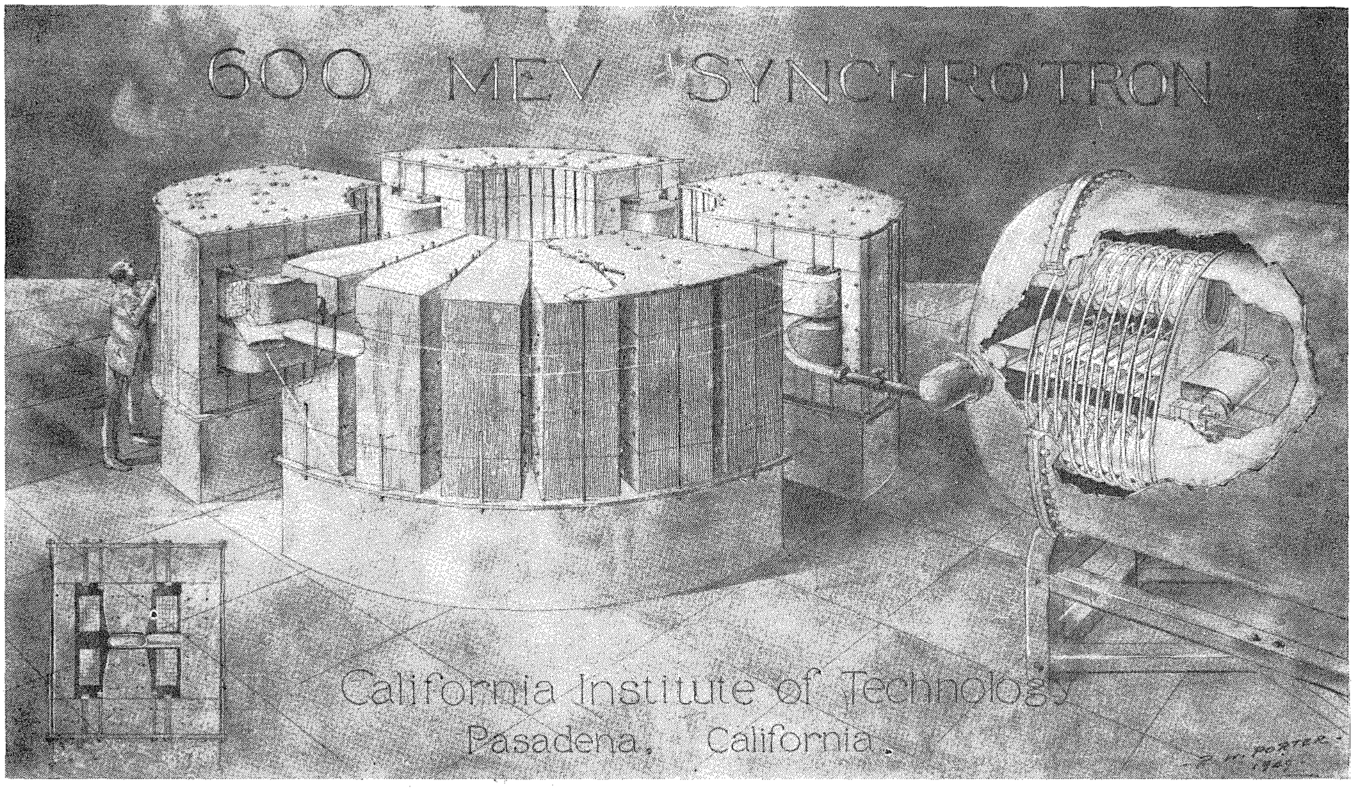
Cover—Pasadena Star-News

p. 9—Ian Campbell

p. 14—Pasadena Star-News

p. 15—James Fassero
Los Angeles Times

p. 20—Drawings by Harry Diamond



Caltech's proposed synchrotron, drawn by Russell Porter. Present plans call for an energy greater than 600 MEV.

Exploring the Atom

What's a synchrotron got that a cyclotron hasn't got? Are Bevatrons necessary? Here's a sound account of the function and purpose of the mammoth machines known as high energy particle accelerators.

by ROBERT V. LANGMUIR

THE nucleus of an atom was once said to be "a hard little black thing about which we know nothing." A good many of the physicists of the world have spent a good deal of their time trying to remedy this situation. The result of their work is an extensive amount of information about radioactivity, energy levels in nuclei, and other detailed—and rather unrelated—properties of nuclei. But there is still no basic "Theory of the Nucleus." The fundamental law of force between nucleons is not known, and nuclear spectra are not understood in the sense that atomic spectra are now understood in terms of a well-tested theory such as that of modern wave mechanics.

The reason for this unsatisfactory state of affairs can be seen by comparing the state of nuclear physics today with that of atomic physics in the year 1910, just before the successful attack on the mysteries of the atom was begun by the introduction of the Bohr model of the hydrogen atom. At that time atomic spectroscopy was a fairly well organized though largely empirical science. The general construction of atoms—a heavy, charged nucleus surrounded by electrons—was known from the work of Rutherford. The law of force was known to be the simple Coulomb law similar to that controlling charged bodies in electrostatics. What was lacking was a new mechanics governing the motion of charged particles acted on by known forces. This was supplied with great success by Bohr's application of Planck's quantum hypothesis to the problem of the hydrogen atom, and by the later development of modern quantum mechanics.

The situation is reversed in the case of nuclear physics today. We are fairly certain that the mechanics which will be used in a successful nuclear theory will be quantum mechanics; but the laws of force between nucleons (protons and neutrons) are not known. It is now believed that interactions between particles in a nucleus will be explained in terms of mesons—charged particles with a mass intermediate between that of electrons and protons. The existence of mesons was originally predicted on theoretical grounds—by the Japanese physicist Yukawa in 1935—in order to account for the observed nuclear forces. About a year later mesons were observed for the first time in cosmic rays.

There are thus two obvious methods of attack on the basic problems of nuclear physics. One is to develop a nuclear spectroscopy similar to atomic spectroscopy, so that various theories can be compared with experimental evidence. The other is to learn as much as possible about the properties of mesons and their interactions with matter, so as to guide theoretical studies in the most profitable direction. Both methods are being vigorously prosecuted at present. This article is concerned with some of the recent advances in the technique of high energy particle acceleration. One of the main objects of this technique is the creation of mesons in the laboratory—a process which occurs only at energies above 100 million electron volts (MEV). It is hoped that experimental knowledge of mesons produced by high energy machines will lead to a better understanding of some of the fundamental questions of nuclear physics.

OUR knowledge of the nucleus of the atom has come almost solely from the bombardment of nuclei by energetic particles. The bombarding energies needed for nuclear reactions range from a few hundred thousand electron volts up to many millions of electron volts. The earliest experiments were done with alpha particles (helium nuclei), which have energies of several MEV as a result of the decay of natural radioactive materials such as radium. Later, protons were accelerated by means of high voltage transformer-rectifier sets to an energy of about 1 MEV, and were used to investigate nuclear reactions in the lighter nuclei. The modern equivalent of this type of accelerator is the electrostatic generator operating up to 5 MEV, which is used for very accurate measurements of nuclear energy levels.

This is the same type of information as is obtained from atomic spectra, and it leads to what is called nuclear spectroscopy. However, it is much more difficult to investigate one nuclear level than it is to obtain the whole spectrum of an atom giving information about hundreds of electronic energy levels. The practical difficulty of obtaining and controlling high voltages restricts the energies of such accelerators to the region below about 5 MEV.

The necessity of working directly with very high voltages was removed by the development of the cyclotron by E. O. Lawrence in 1932. In this accelerator charged particles are made to travel in a spiral path and to cross an accelerating gap a few hundred times. (Actually the path is a series of semicircles of gradually increasing radius.) The particle is forced to travel in this path by the magnetic field and a small acceleration takes place whenever the charged particle crosses the gap between the "dees," as shown below. If an alternating voltage of constant frequency is applied across the dees, repetitive acceleration will take place if the time taken for a particle to travel through 180° of its spiral path is a constant independent of the radius of the spiral path. This is approximately the case, for it can be shown that the angular velocity, ω, of a particle of charge e and mass m in a magnetic field B is

$$\omega = \frac{eB}{m}$$

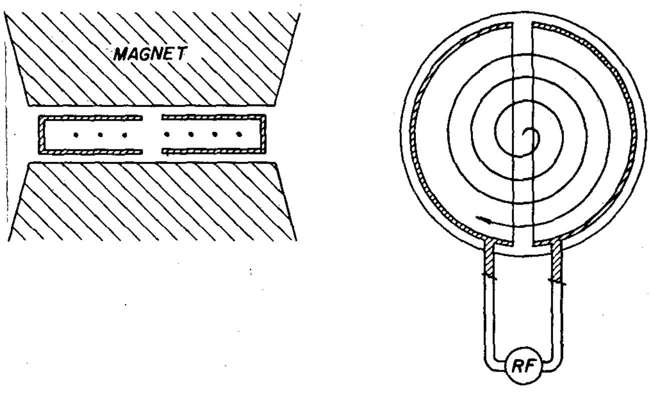
Thus if e, B, and m remain constant and if the frequency of the alternating voltage across the dees is $\omega/2\pi$, the particle may be said to be in resonance with the dee voltage and successful acceleration can take place.

In the 1930's this was the basis for the construction of a large number of cyclotrons operating at energies up to 10 or 15 MEV. However, when cyclotrons were designed for higher energies, it proved to be very difficult to keep the charged particles in resonance with the accelerating voltage without going to extremely high dee voltage. This is explained by the theory of special relativity, which shows that if the energy of a particle is increased, its mass also increases. For a proton, the relation is such that the mass of a proton is doubled when its energy is 937 MEV.

This has serious consequences for the operation of high energy cyclotrons, for a proton of 50 MEV has a mass five per cent larger than its mass at lower energies and, by equation (above), a resonant frequency which differs by five per cent from its resonant frequency at low energies. Thus a 50 MEV proton in a cyclotron will tend to drift out of resonance with the accelerating voltage in a few revolutions and will not be accelerated. A possible solution to this problem is to have very high dee voltage so that the acceleration is over in a few revolutions of the particle in the cyclotron, though this calls for extremely high power oscillators to supply the dee voltage. Thus, before the war, cyclotrons seemed to have reached an upper energy limit of about 50 MEV, and larger machines seemed impractical.

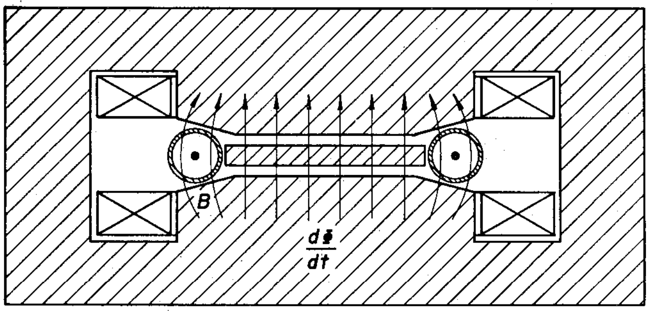
High energy protons and other heavy particles are not the only agents which will cause nuclear reactions. High energy electrons and X-rays can also interact with the nucleus, though such reactions do not occur as easily. Just before the war D. W. Kerst successfully constructed an electron accelerator called a betatron. The principle

NORMAL CYCLOTRON (PROTON ACCELERATOR)



Spiral curve in this diagram represents path of an accelerated proton. Each half of the split pillbox in which acceleration takes place is called a "dee."

BETATRON (ELECTRON ACCELERATOR)



Schematic diagram of the operation of a betatron. Shaded areas shown above consist of laminated iron.

of this machine (see above) is quite similar to that of a transformer. The electrons circulate in an evacuated doughnut-shaped glass tube, which is placed in a ring-shaped magnetic field varying at a 60 cycle rate. Every time an electron goes around its orbit once it picks up some energy from the changing magnetic flux which passes through its orbit. By placing a single turn of wire at the orbit position, a voltage V is induced in the wire by the changing magnetic field through the loop of wire. Every time an electron makes a revolution its energy is increased by V electron volts. The electron orbit is, in effect, the secondary of a transformer. The ratio of the rate of change of the flux through the orbit to the magnetic field at the orbit is so arranged that the orbit radius is independent of the energy of the electrons. Thus the magnetic field needed to bend the electrons in a circular orbit does not extend over a large volume and the energy stored in the guiding magnetic field is kept to a minimum.

As the electron rapidly reaches velocities close to that of light, its rate of energy increase is quite large. The electrons are accelerated in this fashion from about 50,000 electron volts up to as much as 100 MEV. By pulsing the magnetic field when the electrons are at maximum energy, they can be made to strike a tungsten target and produce high energy X-rays. It is usually these X-rays that are used to cause nuclear reactions.

A large number of these machines are in successful operation at energies below 100 MEV. However, as in the cyclotron, when higher energies are desired, new difficulties arise. Whenever a charged particle is accelerated it radiates energy. The acceleration in this case is centripetal. When the electrons are forced to travel in a circle at very high energy, they lose energy in the form of electromagnetic radiation. This loss of energy causes the electron orbit to shrink and strike the inner walls of the vacuum tube containing the orbit. The physics of the problem is such that this is not important for heavy particles, but becomes of great importance for electrons of over 100 MEV, and—since the effect increases as the cube of the electron energy—it is the limiting factor in the construction of high energy betatrons.

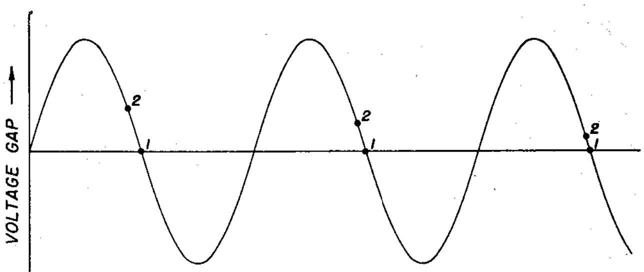
When the need for a new invention arises, the required invention is often made independently by several people. This was the case in the solution of the difficulties in extending the range of high energy accelerators. Independently, and at about the same time, the principle of phase stability was discovered by V. Veksler in Russia and by E. M. McMillan at the University of California. The principle of phase stability is demonstrated in the diagram below. Consider a charged particle rotating in a magnetic field at constant energy. Once every revolution the particle crosses an accelerating gap across which is impressed an alternating voltage, and on crossing the gap the particle picks up or loses an amount of energy which depends on the phase of the accelerating voltage at that time. In the diagram below the points marked *1* show a particle crossing the gap when the voltage at the gap is just changing from accelerating to decelerating. If the time required for one revolution of the particle in its orbit is equal to the period of the gap voltage, the particle will always cross the gap when the gap voltage is zero.

The important question now is whether such a motion is stable or not. Points marked *2* in the diagram show the motion of a particle which initially has a slightly higher energy than that of the resonant particle. Since this particle has a higher energy, it will traverse a slightly larger orbit and will take longer to make one revolution than the first particle. Thus it will cross the gap at a slightly later time than the resonant particle and so will be decelerated and have its energy reduced. It can be shown that such a particle will execute slow oscillations about a phase angle of 180° on successive transits through the gap. The motion is thus stable and this particle is said to be locked in synchronism with the alternating voltage at the gap.

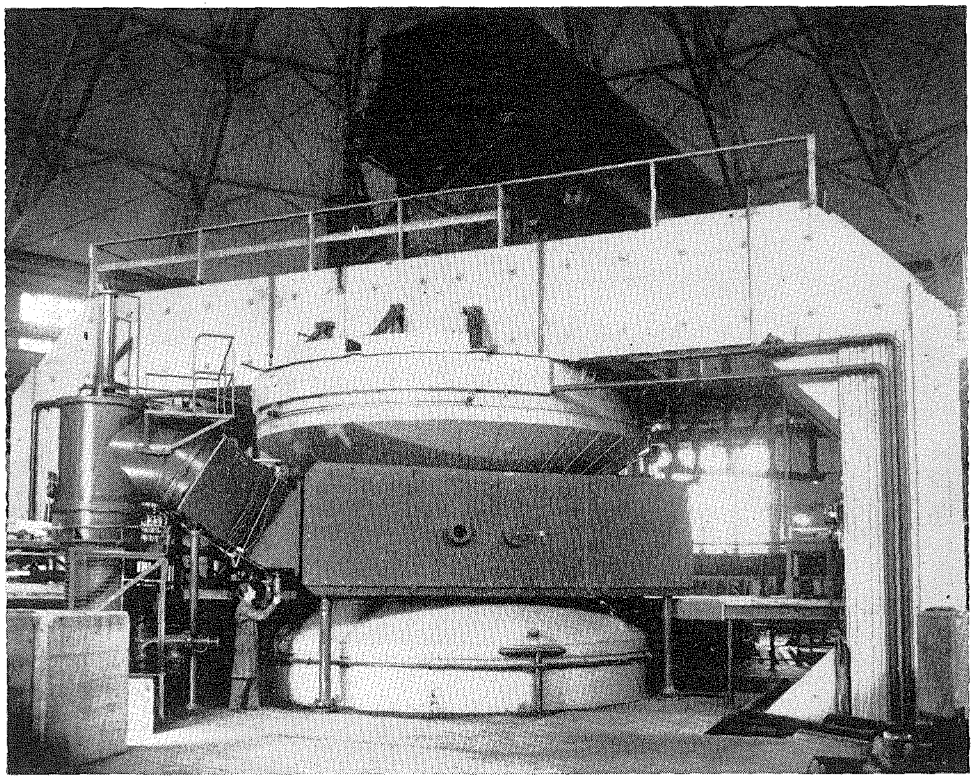
The application of this principle of phase stability to accelerators lies in the use of the adiabatic principle, which states that when slow changes are made in the external conditions, the particle will tend to stay in synchronism with the driving voltage, and if this requires the particle to gain energy by always crossing the gap at a time such that it is accelerated, the particle will do so. In this case "changing the eternal conditions" means slowly changing the magnetic field, the frequency of the gap voltage, or both. These three possibilities lead respectively to three new types of accelerators, the synchroton, the synchro-cyclotron or FM cyclotron, and the proton synchrotron or Bevatron.

The synchrotron is an electron accelerator which uses a constant frequency accelerating voltage and a slowly changing magnetic field at the orbit of the particle. Since operation is desired at an approximately constant orbit radius, the particle must have a relatively constant velocity during the synchrotron acceleration. This means that the velocity of the particle must be close to that of light at all times, for the theory of relativity tells us that particle velocities can never exceed that of light, no matter how great the particle energy. For electrons

PHASE STABILITY



Plot of the accelerating voltage showing operation of the principle of phase stability which is responsible for extending the range of high energy accelerators.

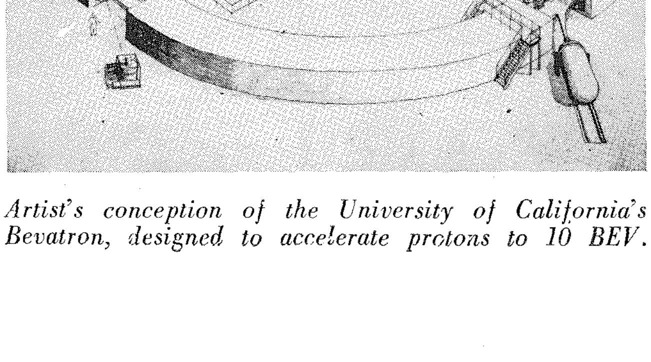


University of California's cyclotron, the largest and most powerful atom-smasher in the world, fires protons of 350 million electron volts.

this means that synchrotron acceleration must start at an electron energy above about 1 MEV. The radiation of electromagnetic energy by the electron during its acceleration is of little importance in this type of accelerator, for it is merely another of the "external conditions" mentioned above. If the electron needs more energy to stay in synchronism with the gap voltage, either because the magnetic field changes or because it has radiated some energy away while traversing the orbit, it will obtain this energy by crossing the gap at a suitable time and so remain in synchronism. The electromagnetic radiation is emitted in the form of visible light, and can be seen in synchrotrons and betatrons operating above 30 MEV. Electron synchrotrons have been operated at energies of 300 MEV and can be designed for operation at energies as high as one billion electron volts (1 BEV).

The application of the principle of phase stability to cyclotrons has led to the synchro-cyclotron or, as it is sometimes called, the frequency modulated cyclotron. This is a heavy particle accelerator and differs from an ordinary cyclotron in that the frequency of the dee voltage is slowly changed during the acceleration period. The magnetic field remains constant. The principle of phase stability says that the particle will remain in synchronism even though the frequency is slowly changed. The equation on page 4 shows that if the frequency is slowly lowered, the particle can remain in synchronism only if it increases its mass. This of course means that the particle must gain energy. The large synchro-cyclotron at Berkeley has accelerated protons up to energies of about 400 MEV and has opened up the extremely interesting field of high energy nuclear physics. Mesons were first produced in the laboratory with this machine.

The principle of phase stability permits the design of extremely high energy machines. Construction of cyclotrons in the billion volt region is not feasible because of the large volume of magnetic field which is needed, and the consequent high cost of the magnet. Electron synchrotrons above 1 BEV are not practical because of the energy loss caused by radiation which must be supplied by the oscillator driving the accelerating gap. Thus a very high energy machine should accelerate protons, which do not have radiation troubles, but should also have an orbit of constant radius, rather than the spiral orbit of the cyclotron. Such a machine is called a proton synchrotron or Bevatron (so called because it operates in the energy region of several BEV). These gigantic machines accelerate protons by varying both the frequency of the oscillator and the magnitude of the magnetic field at the orbit in such a fashion as to accelerate the protons and at the same time keep the orbit radius constant. Proton energies between 1 and 10 BEV are expected. Two such machines are now under construction in this country, one in Birmingham, England. It is not known what types of nuclear reactions will occur at these extremely high energies; this of course is the main reason for constructing such large accelerators.



Artist's conception of the University of California's Bevatron, designed to accelerate protons to 10 BEV.

Caricatures of men of science

by E. C. WATSON

IN 1869 Carlo Pellegrini, in the English *Vanity Fair*, began a series of portraits of public men that must be considered the most remarkable example of personal caricature ever attempted. The unextenuating likenesses of "Ape," as Pellegrini signed himself, were continued by "Spy" (Leslie Ward) and others until about 1910. In all, over 2000 portraits were published and many men of science of the period are to be found among them. On the whole the artists chose remarkably well and most of the scientists caricatured would be recognized even today as among the most outstanding of the period.

The likenesses were published with the purpose of providing "a permanent gallery of portraits of living men, drawn in their habit as they live, with their tricks as they move—not with a desire to caricature them, but with the desire to give the honest and brutal truth about them. . . . The attitude, the gesture, or the expression of face which often so cruelly epitomizes the man has been seized and recorded." Clever, observant to the point of mischievousness, but with caustic, penetrating and convincing truth, they show us better than written accounts can possibly do what these scientists were like as men and individuals.

John Tyndall, "a man of muscle . . . of imagination . . . and of conversation, almost as much as a man of science."

Each caricature was accompanied by a tersely written account of the man portrayed. The writer, who signed himself "Jehu Junior" (he was actually Thomas Gibson Bowles) states that "whatever else they may be they are honest; they have been written with the single object of telling the exact truth . . . there are no generalities in them nor any vagueness of purpose, because they represent distinct and clear conceptions. Every phrase rests upon the basis of fact, and is intended to have the full weight of its words and to suggest an opinion which the reader is left to work out for himself in the direction indicated." He says also regarding both the caricatures and the written accounts that "features are exaggerated which have the effect of stamping the personality more vividly on the mind than an ordinary portrait would do. A photograph, which gives every feature with absolute correctness, may yet fail to convey the distinct idea of character at which the artist and the writer have alike aimed."

Some of these caricatures have been reproduced, but to the best of my knowledge the written accounts have not. This is unfortunate as "the written account and the printed effigy are each the complement of the other" and should not be separated. Moreover, the written accounts are often very revealing, not of the mere facts of the subject's life—these are easily learned elsewhere—but of the attitude of the public of the time towards him and his work.

From Huxley to Marconi

Among the scientists caricatured in this remarkable series are Thomas Huxley, Charles Darwin, John Tyndall, Lyon Playfair, George Biddell Airy, Richard Anthony Proctor, William Robert Grove, Louis Pasteur, Rudolf Virchow, William Thomson (Lord Kelvin), John William Strutt (Lord Rayleigh), William Crookes, William Huggins, Oliver Lodge, the Curies, William Ramsay, Robert Ball, Guglielmo Marconi, and many others. It would be interesting to reproduce all these caricatures in this series of historical reproductions. Unfortunately, however, the copyright laws prevent and so we must content ourselves for the present with reproducing during the next few months a few of the earlier ones.

John Tyndall, whose picture is shown here, was probably better known to the general public during his own lifetime than he is today even among physicists. The friendly account, reproduced below, that accompanied his caricature, makes this clear, as does the excellent biographical sketch in the eleventh edition of the *Encyclopaedia Britannica.* It also shows the high regard in which science was held by the general public during the Victorian era.

Tyndall; A caricature in words

"Science is before long to rule the world, and Mr. Tyndall is one of the pioneers of its kingdom. He is one of the most distinguished of that band of eminent men whose devotion to methods and subjects of research, by which the bases of prejudice are sapped, is by this time condoned, or on the road to condonation, by the children of prejudice themselves. He is an Irishman, and has the combativeness of his race; but he has its persuasiveness in a still larger measure, and though never known to decline a challenge, and generally victorious in the issue, knows the arts which make him a little less challenged than some of his brethren in the same pursuits. Only lately we have seen him, in the enthusiasm of friendship, exercising his rhetoric to convince the Philistine that Mr. Huxley was less a foe to his tribe, and therefore better fitted for the London School Board, than had been commonly supposed. Mr. Huxley and Mr. Tyndall are generally classed together in popular estimation in virtue of their approximate parity of years and standing in their respective pursuits, as well as of their high philosophical and literary ability and stirring ways in our midst. Mr. Tyndall is for Europe and America the representative of English chemistry and physics as is Mr. Huxley of English physiology; and Science is proud of both her sons. As an experimentalist and also as an expounder, the mantle of Faraday is popularly understood to have fallen upon Mr. Tyndall, who succeeded to his place at the Royal Institution. There his lectures make the delight of young and grown-up audiences in a scarcely less degree than those of his famous predecessor, though the riotous spirits and self-conscious arts of the brilliant junior are very different qualities from the modest and absorbed simplicity of Faraday. It is in adding to the great discoveries of German *savants* concerning heat and light as modes of motion, the results of masterly original research and experiment of his own, that Mr. Tyndall's most characteristic fame as a leader of Science has been won. But he is a man of muscle, and a man of imagination, and a man of conversation, almost as much as a man of science; and it is these three gifts by which he is appreciated in unscientific circles, and at the hands of society at large. His muscle makes him so that he delighteth in his own legs; and he scales virgin Alps one after another, for the pleasure of the exercise as well as for the study of natural phenomena. His imagination makes him bring home fascinating accounts of these exploits, or sometimes, during the course of an excursion, takes to meditating on itself, with a result embodied in that famous lecture, which most people have read, on "The Scientific Use of the Imagination." Social habits have taught him also the scientific use of conversation, and he is one of the most welcome and expansive of table companions. In a word, whether in the laboratory where he conducts his investigations, whether in the theatre where he charms crowded audiences in showing off their results; whether on the peaks and passes where he risks his neck with so much enthusiasm, whether in the smoking-room of his club, whether in those corners of drawing-rooms where Birth and Beauty encircle Intellect in a sea of muslin and attention—Professor John Tyndall is a man at all times to be envied, and at nearly all to be admired."

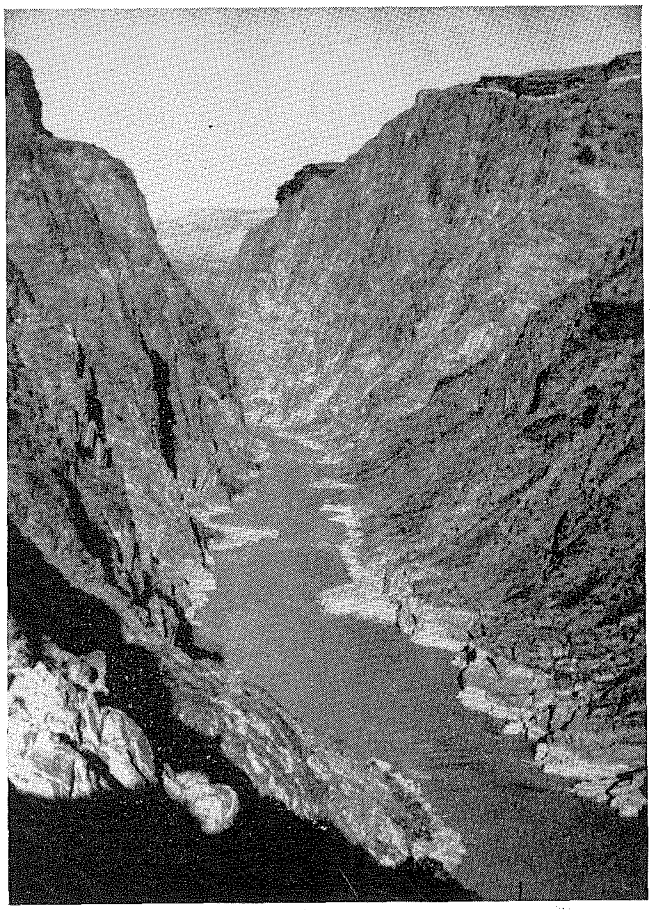
●

John Tyndall, born in County Carlow, Ireland in 1820, first became known through his magnetic investigations, and was elected a Fellow of the Royal Society in 1852. In 1854 he was chosen Professor of Natural Philosophy at the Royal Institution, where he was a colleague of Michael Faraday's—whom he succeeded as superintendent of the Royal Institution in 1867.

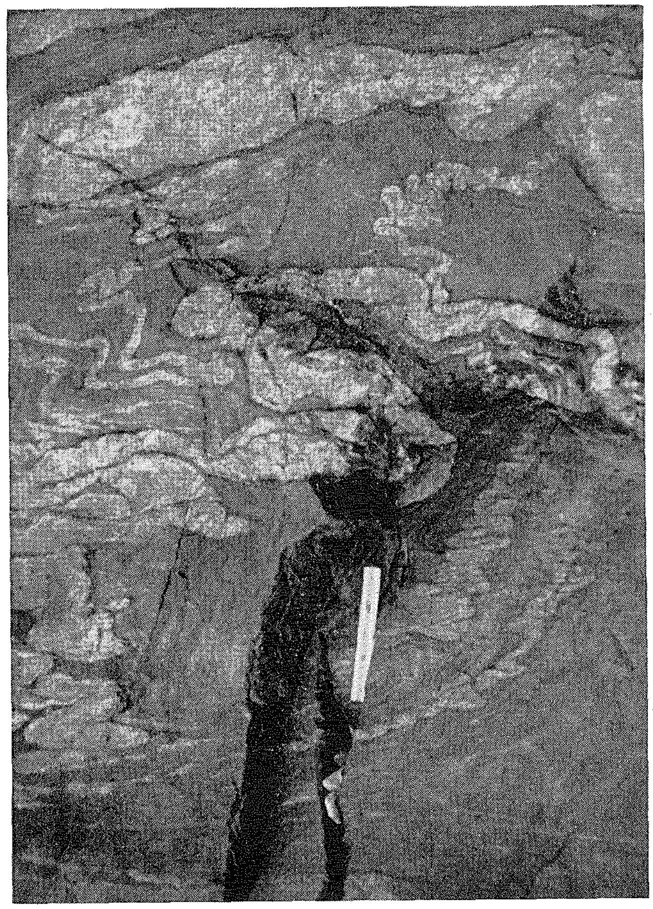
His investigations of the transparency and opacity of gases and vapors for radiant heat are perhaps his chief scientific work, but his scientific activities and interests covered a broad field. With his friend Huxley he studied the motion of glaciers. He established the absorptive power of clear aqueous vapor—a point of great meteorological significance. He made brilliant expositions elucidating the blue of the sky, and discovered the precipitation of organic vapors by means of light. He called attention to curious phenomena occurring in the track of a luminous beam. He examined the opacity of the air for sound in connection with lighthouse and siren work. And he finally verified what had already been substantially demonstrated—that germ-free air did not initiate putrefaction.

His contributions to science, however, are probably due more to his personality and to his gift for making difficult things clear rather than to his original researches. One of his early books, *Heat as a Mode of Motion* was the first popular exposition of the mechanical theory of heat. Others included *The Forms of Water, Lectures on Light, Floating Matter in the Air,* and *On Sound.*

He died in 1893, at the age of 73.



Ancient rocks like these in the granite gorges of the Grand Canyon help geologists date the age of the earth.



The geological ages have been dated by gauging the amount of radioactive decay in the oldest exposed rocks.

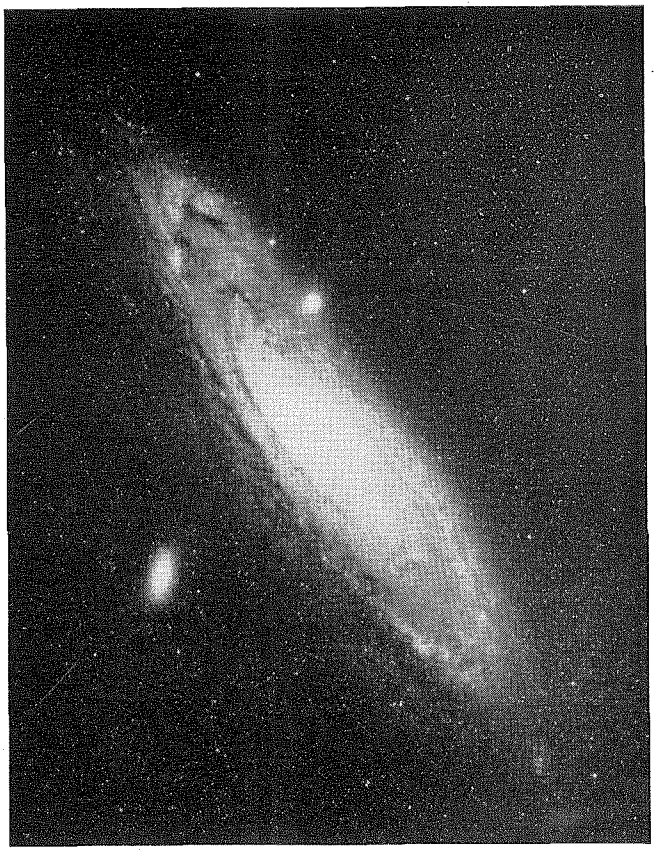
The Age of the Universe

Three branches of science tackle the problem and come up with the same answer

by Jesse L. Greenstein

HOW old is your copy of *Engineering and Science?* Obviously it was, in one sense, created when its pages were bound—in another sense, when the paper was made—in another, when the tree which furnished the wood pulp began to grow. But before all that, the tree grew out of the earth and the air, and the true age of everything on the earth is the same as that of the earth itself. Is that far enough back to look? Are the individual atoms of matter enormously older than the earth, sun and stars? Our question keeps traveling backwards in time, and we may doubt whether an answer exists for the question, "how old" is anything.

For the astronomer there are several ways of tackling the problem. The most attractive is to appeal to the authority of other sciences—geology and nuclear physics, which date the earth and meteorites. The evolution of life on earth, we know, took a long time, but the fundamental long-term time scale of geology comes from nuclear physics, and goes back before the beginning of life on earth. Spontaneous radioactive decay, unaffected by temperature and pressure, provides a dependable clock which, we hope, always ticks at the same rate. The radioactive elements uranium (either U^{238} or U^{235}) and thorium are naturally unstable. Their nuclei lose



Studies of spiral nebulae like the great Andromeda, right, furnish some evidence as to the age of the universe. A relatively short lifetime exists for the spiral arms of these typical stellar systems. Such galaxies make one turn in about 0.1 billion years. The arms, which are regions of higher density of stars and interstellar gas and dust, are young and impermanent features.

mass and turn into various stable isotopes of lead, with the emission of alpha particles which become stable helium atoms. If matter were extremely old, all naturally radioactive atoms would have disappeared from the universe. The existence of any naturally radioactive material immediately suggests that matter is either relatively young, or that the heavy radioactive substances are being continuously formed.

No evidence for the latter process exists—certainly not in the relatively undisturbed minerals at or near the earth's surface. The rates of decay are slow. The half-life (the time within which half of the original mass of an element disintegrates) is 4 to 6 billion years for U^{238}, 0.7 billion years for U^{235} and 14 billion years for thorium. Nowadays the number of atoms of U^{235} is about 1/139th that of U^{238}. But since U^{235} disappears relatively fast, as we go backwards in time, there must have been relatively more U^{235} as compared with U^{238}. Six billion years ago, for example, there would have been an equal amount of each isotope in uranium. From a rough consideration of the nuclear physical properties of the elements it seems very improbable that U^{235} was ever more abundant than U^{238}—and so it appears that uranium on earth is less than 5 billion years old.

A similar argument is obtained from a consideration of the ratio of the numbers of atoms of lead isotopes to those of the uranium isotopes. If all the lead in uranium-bearing rocks at the surface of the earth has been produced by radioactive disintegration, the present number of lead atoms would be the same as the numbers of uranium and thorium atoms which have disappeared. Comparing this number of disintegrated atoms with those still existing gives the maximum age of the mineral (maximum, since some lead may have been initially present). Again a lifetime of less than 5 to 7 billion years is indicated.

If we could be certain that our rock had never been subjected to heating, pressure or weathering, we could use the actual amount of helium in the rock, as compared with the amount of uranium, to provide more definite age estimates. However, these tend to be less certain—and often give minimum ages—since helium, chemically uncombined, leaks out of rocks easily.

Very elaborate work by geophysicists such as Arthur Holmes, employing all possible radioactive decay processes, has dated the geological ages, and by sampling the geologically oldest exposed rocks leads to the remarkable fact that few or no well-established ages exceed four billion years. The maximum frequency of age determinations for samples from the oldest minerals is at 3.35 billion years. Only a tenth as many samples can be dated back 3.9 billion years. Perhaps further exploration will reveal older materials on or in the earth, but we may take the 3.35 billion year figure as an indication of how long ago the crustal rocks were formed. And we may guess, from the very existence of the unstable isotopes of uranium, U^{235}, that the age of uranium itself is less than 5 billion years. (Of course one should not take these numbers too seriously, but 1.5 billion years might be enough time to form the galaxies, the interstellar gas and dust, the stars, and incidentally—and accidentally—the earth.)

Meteorites are our only contact with non-terrestrial matter. They are interplanetary fragments large enough to survive impact and heating in the atmosphere; they have been analyzed chemically and by the newer methods of nuclear chemistry. While their mineralogical properties differ from those of rocks, it is now apparent that they are a sample of matter which in the large has the same atomic species, in the same abundance ratio, as does the earth. For years they provided a strangely discrepant age for their atoms. Many meteorites averaged 7 billion years (twice as old as the earth) because they contained relatively large amounts of helium, which was considered the end product of a long cycle of naturally radioactive disintegrations.

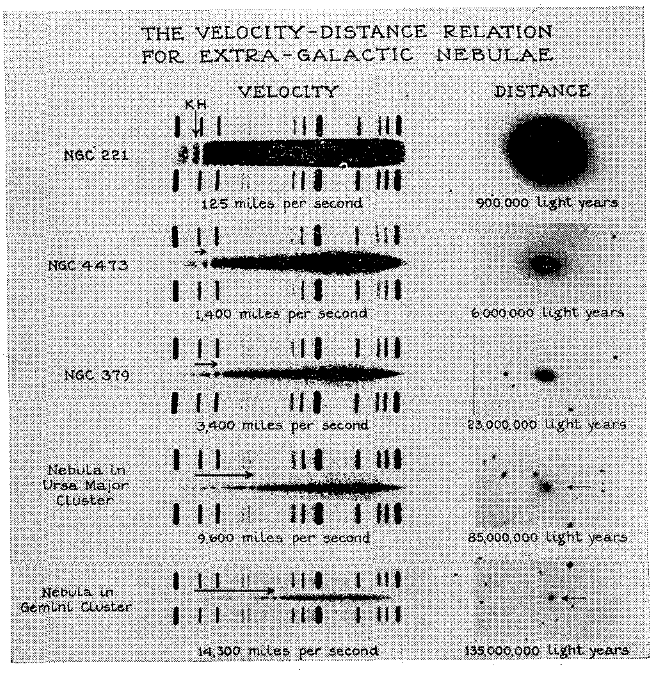
Recently it was pointed out that cosmic rays—a useful source of high-energy nuclear disintegrations in the laboratory—have had enough time to crack many atoms in a meteorite. In such high-energy nuclear collisions, artificially radioactive elements are produced from almost any common stable nucleus—and helium is a common end product of artificially induced radioactivities. Thus the meteorites contain helium produced by cosmic-ray bombardment, and the helium/lead ratio cannot give a correct age. Naturally radioactive potassium, K^{40}, (half-life 1.4 billion years) is found in meteorites together with ordinary K^{39}. We could get a maximum age from the mere existence of K^{40}, but more important is the observation that the ratio K^{40}/K^{39} is the same in meteorites as in terrestrial rocks, within an accuracy of three per cent. This means that the time elapsed since the formation of meteoritic calcium is the same as that since the formation of terrestrial calcium, within about 60 million years. This is an unexpectedly precise agreement and indicates that our search for a beginning may have real meaning.

Modern astronomy provides several ways of dating beginnings—in general less precise. One of the most convincing, however, is the argument based on the simple nuclear physics of the energy generation in stars. The stars have poured out enormous amounts of radiation. The sun, for example, has emitted two ergs per second per gram for at least a billion years, the probable age of life on the earth. This is equivalent to 500,000 billion horsepower. This much energy cannot be supplied by chemical processes, gravitational contraction, or natural radioactivity.

The only plausible energy source is the conversion of matter into radiation, and the most probable process is the Bethe cycle of captures of four successive hydrogen atoms by an original stable carbon nucleus, until an unstable oxygen nucleus is formed which disintegrates, yielding carbon and a helium atom. Now four hydrogen atoms weigh less than one helium atom by 0.0287 of the mass of a hydrogen atom. Thus 0.0072 (0.7 per cent) of the mass of each hydrogen atom has disappeared in the process—and from the famous Einstein equation $E = mc^2$, we have 10^{-5} ergs of radiation energy made available in the creation of one helium atom from four hydrogen atoms. This much energy would keep the sun shining 100 billion years at its present rate, if it were made completely of hydrogen. Since the sun is in fact about 90 per cent hydrogen, its future life is long indeed. If initially it had been all hydrogen, and had produced the helium now found, by the above process—and at the present rate—it would be 43 billion years old. Since we have no reason to suppose that primordial matter was completely hydrogen, we can be certain that the sun is less than 43 billion years old. (As with all speculative certainties, we must limit ourselves to the qualification, "unless a new energy source is found!")

The sun is a typical star, in mass and brightness. However, exceptional stars of very great brightness and mass exist. Such objects, while rare, provide a difficult problem. Spendthrift stars are known, with masses about ten times that of the sun, which are perhaps 10,000 times as luminous. They would convert their hydrogen into helium completely 1,000 times as fast as the sun—so they could not have shone for more than 0.1 billion years at their present rate. It is almost certain that these stars of high luminosity are either younger than the average star, or are being refueled with fresh hydrogen from interstellar space. The latter process may occur if a star passes through a sufficiently dense cloud of gas in space. But newness is an equally satisfactory conjecture. These bright stars are rare and are confined to regions of space in the galactic system where spiral arms and interstellar gas and dust exist. It seems quite possible that stars are still being born, and that the supply of giant bright stars is being replenished.

One strange (theoretical) consequence of the burning up of hydrogen in a normal star is that it cannot gradually lose its brightness as its hydrogen becomes exhausted. It must become brighter, even though its fuel is disappearing. The process then eventually becomes catastrophic—perhaps novae and white dwarfs are the end products of this hydrogen-exhaustion. But before the explosion, a hydrogen-poor star of the mass of the



Studies of extragalactic nebulae add further information on the age of the universe. These nebulae are found to be moving away from the earth; and the further away they are, the faster they appear to move. A linear relation between distance and speed is indicated in the picture at the left. Arrows above the nebular spectra (left) point to H and K lines of calcium, show the amounts these lines are displaced toward the red end of the spectra. Comparison spectra are of helium. Direct photographs (right) illustrate the decrease in size and brightness with increasing velocity, distance, and red-shift.

sun would have had to be considerably brighter than the sun. Thus, if some very old stars (say 20 billion years) existed in our part of space together with younger stars, we might well expect to find the older stars to be objects with the mass of the sun, but perhaps ten times as bright. Now observation indicates that there is a good mass-luminosity relation, and that there are no stars of the mass of the sun which are very much brighter. This provides a strong argument against many stars being much older than the earth. It does not exclude the recent formation of stars like the sun. In 3 billion years the sun cannot appreciably exhaust its energy supply, or change its brightness, and new sun-like stars would be unrecognizable.

Other methods of dating stars

Not all methods of dating stars or stellar systems are dependent on nuclear physics. Gravitational forces balance dissipatory forces in stellar systems. Dense clusters exist in which stars which were probably formed together some time in the distant past have moved nearly parallel through space. Members of such flights of stars are subject to near collisions with field stars, or to close approaches to each other, or to the tidal distortion of the massive center of our own galactic system. Depending on how great the cohesive mutual gravitational attraction of the group is, compared with the disruptive forces, the cluster will be stable or unstable. Loose swarms of stars are known which are disintegrating—dense ones which may be permanent for many billions of years. Actually most clusters in our part of the galactic system are probably relatively young, some perhaps only 0.1 billion years old. A similarly short lifetime exists for the spiral arms of typical stellar systems. These galaxies make one turn in about 0.1 billion years, and in very few spiral nebulae are more than three or four turns visible in the spiral pattern. The arms, which are regions of higher density of stars and interstellar gas and dust, are young and impermanent features. Presumably they dissipate into the general field of stars—perhaps to be replaced by new spiral structures.

Evidence from extragalactic nebulae

The study of the extragalactic nebulae, the most distant objects we can observe, was some years ago the source of striking evidence for a finite age of the universe and of the matter it contains. These nebulae are all found to be moving away from the earth—and the further away they are, the faster they appear to move. Within the observational accuracy, and with allowance for the individual motions of the nebulae, it seems probable that a linear relation exists between distance and speed. So far, a recession of 25,000 miles a second is the largest measured, and there is little reason to doubt that the 200-inch Hale reflector will nearly double that figure. A linear increase of speed with distance can be interpreted kinematically, and naively, as a pure expansion. If we simply reverse the direction in which time flows, and ask what the situation was at a zero epoch about 1.9 billion years ago, we would find all the nebulae concentrated together at the earth, with all their mass at one point.

This extraordinary situation might well be the kind of zero point of time that we had been searching for, indicated by ages of perhaps 3 to 5 billion years for atoms and stars, based on nuclear radioactivity, or on astronomical considerations. Unfortunately, the agreement is not too good—and is made worse by application of the theory of relativity. The late Professor Tolman's analysis of the observational results obtained at the Mount Wilson Observatory has suggested that the initial moment of time was only 1.2 billion years ago. While it is not impossible that the stars, and even the earth, are older than the nebulae, which are aggregates of stars, it seems highly improbable. For as we go backward in time toward the zero epoch, the space density of matter rises and becomes so enormously high that it seems unlikely that anything as delicate as the solar system would survive.

The earliest epochs, with high density of matter and radiation, seem to be ideal times to form stars and systems of stars. In fact, if we consider the very earliest few minutes, when all the matter of all the nebulae was concentrated to the density of nuclear matter, we have the only possible conditions for the formation of the chemical elements from "something simpler."

Not all relativistic cosmologies lead to such high densities, or to the short (1.2 billion year) time scale now apparently indicated by work on the expanding universe. It is possible that the 200-inch can supply new observational data which will more closely describe the early history of our universe. Cosmology is sufficiently complex at present, however, to make it unsafe to assert what the earliest stage of the expansion was like, or when it occurred. But if we may speculate a bit, we can use the present abundances of the different chemical elements and isotopes to describe conditions at the zero epoch, when the elements were born.

The relative abundance of the elements

One of the common goals of geophysics and astrophysics is the determination of the relative abundance of the elements. The earth proves to contain an undersupply of the light elements, presumably lost in the early days of its formation. The stars contain by weight about 70 per cent hydrogen, 28 per cent helium, 1.5 per cent oxygen, carbon, nitrogen, and 0.5 per cent heavy elements. But in spite of their stellar rarity the elements heavier than nitrogen in general seem to have the same abundance relative to each other in most stars, the sun, the earth and in meteorites.

This common constitution points to a common origin, and various theories have been developed to explain how the elements were formed in a very dense, hot cloud of neutrons, by successive nuclear collisions. The most elementary considerations give fantastic initial conditions. If nuclear collisions are to occur, and are to be able to build up by successive captures the elements with atomic mass 200, the initial density and average energy must be very high. The first attempt to explain the cooking up of a nuclear brew of simple particles in such a way as to give the present heavy-element abundance required a temperature of 8 billion degrees and a density of 200 tons per cubic inch.

More complicated recent treatments diverge somewhat in their picture of the initial moment. One pictures the heavy elements formed in the centers of primitive, massive, unstable stars which exploded and mixed these elements in with the original pure hydrogen gas. In another picture, enormous amounts of radiation were present, although the density of matter was relatively low initially. In still another, the density of matter was enormously high, up to a million tons per cubic inch. These speculations make a pleasant end to my subject—but they are not completely foolish. It is obvious that the zero epoch of our universe was an extraordinary moment—we can date it approximately 3 billion years ago—and we can be sure that whatever existed before was quite unlike anything we know now.

THE MONTH AT CALTECH

Dr. Hubble, scientific director of the Schmidt Survey.

Sky Survey

While the mirror of the big 200-inch telescope was being given a final polishing, to remove a few millionths of an inch of surplus glass from its surface, the 48-inch Schmidt telescope at Palomar was launched this month on a project to produce a photographic map of the skies. A joint research effort of the Institute and the National Geographic Society, the survey will result in the first definitive atlas of the sky.

The Big Schmidt, a wide-angle photo telescope, will take four years to make its sky survey. The 200-inch telescope, which has tremendous penetration but limits vision to a pin-point field, would take something like 5,000 years to do the job. The Schmidt can get clear, sharp pictures of objects as much as 300 million light years away. Using the same technique that aerial photo-mappers employed in the war it will make a complete record of the heavens in some 2,000 photographic plates. These will be the subjects of intensive, small-area study by the 200-inch telescope later on.

A major aim of the survey is to make the Schmidt's sky atlas available at cost to observatories, astronomers and higher educational institutions throughout the world. The completed atlas will fill some twenty oversized volumes, and cost about $2,000 a copy. Whatever the final price, though, it will be relatively inexpensive because of the extensive financial aid of the National Geographic Society. Dr. Edwin P. Hubble will be scientific director of the survey.

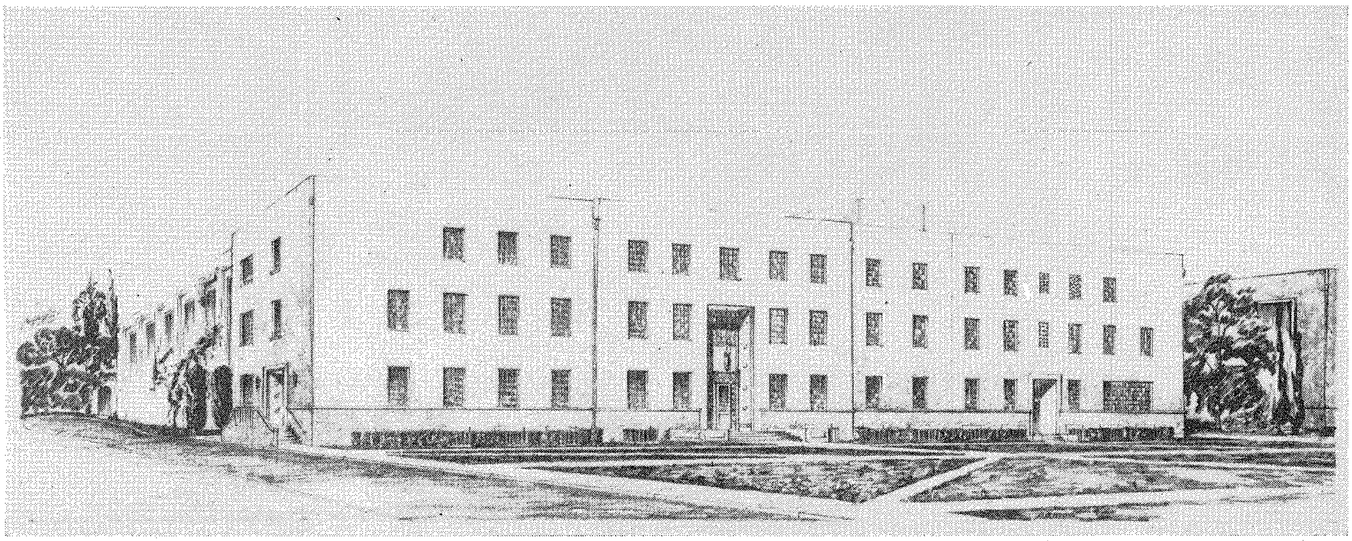
New engineering building

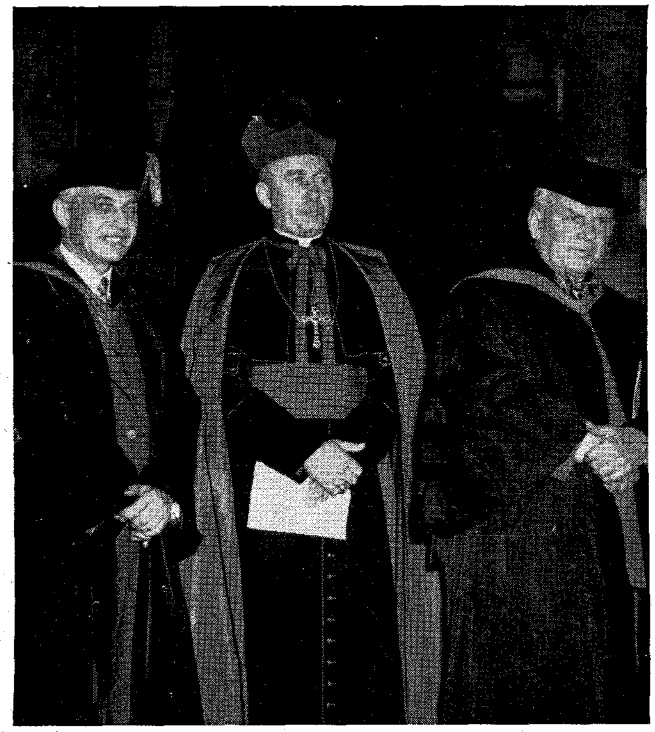
Bids were being received this month for construction of a new $500,000 engineering building on the campus. The new building will adjoin the present Mechanical Engineering building, and face Aeronautics. It's to be a three-story structure, with two basements, and 34,000 sq. ft. of floor space. It should be completed about a year after the contract is let. It will house all civil engineering offices and classes—now crowded into Throop Hall—as well as applied mechanics, metallurgy, the thermodynamics lab, concrete structures lab, strength and materials lab, and a lab for earthquake studies.

Anderson resigns

Mason Anderson, head football coach, resigned his Caltech post last month to enter the banking business in his home town of Breckenridge, Texas. Anderson first gained recognition at Caltech in 1944 when, as

Going up — a $500,000 engineering building to adjoin ME. Structure at right is artist's version of Old Dorm.





President DuBridge, Bishop Joseph T. McGucken, and Dr. R. A. Millikan, about to join the Commencement procession.

a member of the V-12 Training Staff, he coached the football team through an undefeated and unscored-on season. After his discharge from the Service in 1945, he returned to Caltech to coach football, "B" basketball (in '46-'47), and Varsity track (in '49). No replacement for Coach Anderson has been made yet, but it is hoped the new man can be selected by midsummer.

Honorary degree

At the latest count, four Caltech faculty members were awarded honorary degrees during the 1949 commencement season.

George W. Beadle, Professor of Biology and Chairman of the Division of Biology, received the degree of Doctor of Science from his alma mater, the University of Nebraska.

Linus Pauling, Professor of Chemistry and Chairman of the Division of Chemistry and Chemical Engineering, was awarded the degree of Doctor of Humanities by the University of Tampa.

Alfred H. Sturtevant, Professor of Genetics, was given a Doctor of Science degree by the University of Pennsylvania.

And Franklin Thomas, Professor of Civil Engineering and Dean of Students, received a Doctor of Engineering degree from the University of Southern California.

Chairman Millikan

Dr. Clark B. Millikan, Professor of Aeronautics and Director of the Guggenheim Aeronautical Laboratory, has been named Chairman of the Guided Missiles Committee of the Research and Development Board. A member of the committee since it was organized in 1946, Dr. Millikan succeeds Dr. Frederick L. Hovde, president of Purdue University, as chairman.

1949 Commencement

The big news of the month, of course, was Commencement. And the big news of the 1949 Commencement was the size of it. Five hundred students were graduated this year—the same number as last year—which was the largest number in the history of the Institute.

The 60 Doctor of Philosophy degrees which were awarded this year established a new record too. Last year's total was 45.

Ninety men received the B.S. degree in Science—16 of them with honors; 121 men received the B.S. in Engineering—15 with honors.

Forty-one men were given the M.S. in Science—5 in Chemistry, 8 in Chemical Engineering, 7 in the Geological Sciences, 6 in Meteorology, 15 in Physics. The M.S. in Engineering went to 134 men—47 in Aeronautics, 22 in Civil Engineering, 36 in Electrical Engineering, and 29 in Mechanical Engineering.

Fifty-four men were awarded Engineer's Degrees—32 Aeronautical Engineers, 9 Aeronautical Engineers in Jet Propulsion, 2 Chemical Engineers, 1 Geophysical Engineer, 9 Industrial Designers, 1 Mechanical Engineer.

Scholars

James Hummel, editor of the *California Tech*, had the highest scholastic average in the graduating class—3.584 out of a possible 4 points. Second and third were Hardy Cross Martel and Robert E. Kofahl. Richard Allen Ferrell '48, who received his M.S. in Physics this year, broke a few records by getting straight A's in every course in his graduate study—including quantum mechanics and mathematical analysis, spectroscopy, geometrical and physical optics, and analytical mechanics. The newspapers, operating on the premise that Caltech is the "toughest" school in the country, decided that Ferrell must be the "Nation's Smartest College Boy."

Hinrichs award

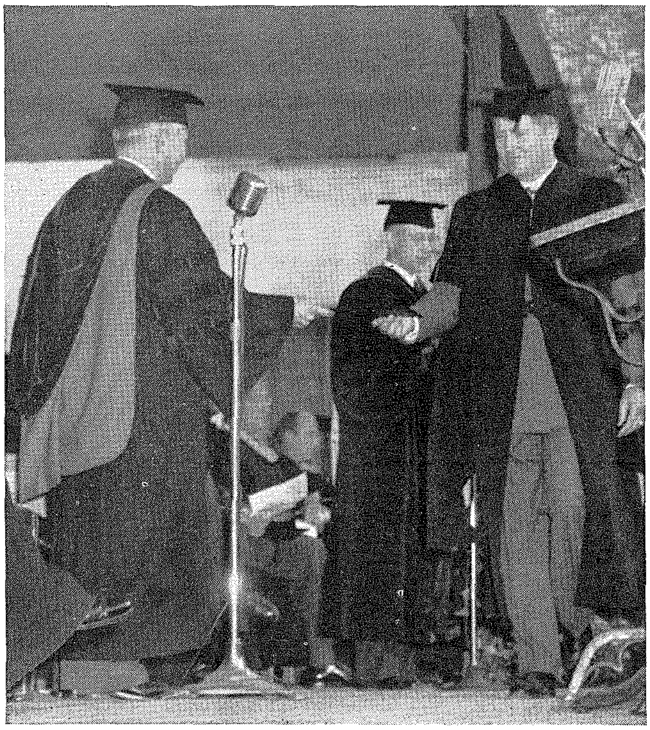
The annual Frederic W. Hinrichs, Jr. Memorial Award—$100 in cash, a certificate, and a suitable memento—which goes to the outstanding senior, on the basis of leadership, responsibility and contributions to student body welfare, this year went to Paul D. Saltman who, among other things, was ASCIT Athletic Manager, Beaver, Basketball Captain, owner of two honor keys, and columnist for the *California Tech*.

Physics and politics

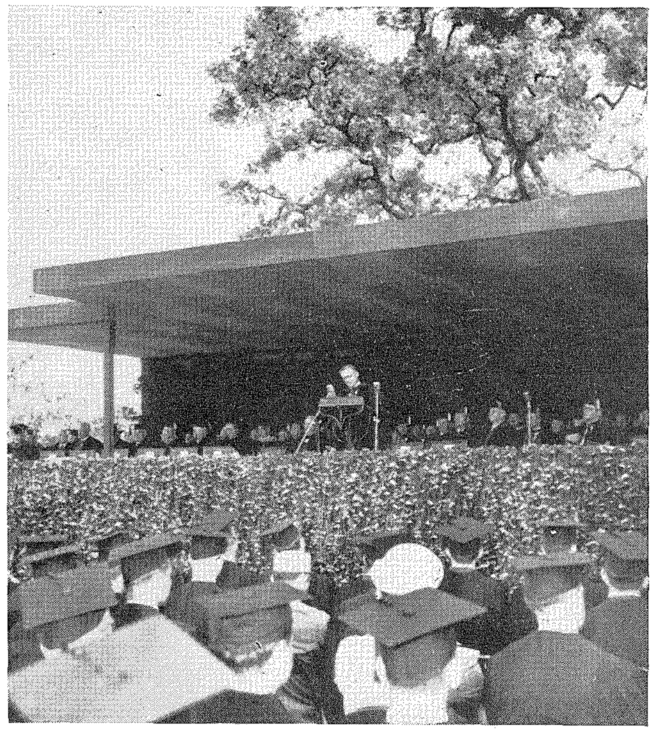
Peter H. Odegard, Professor of Political Science at the University of California in Berkeley, and former president of Reed College in Portland, Ore., was this year's Commencement speaker. In his address on "Physics and Politics" Dr. Odegard reviewed the long and often stormy history of the partnership between science and technology and government and politics.

"When the gap between technology and social organization, between physics and politics, becomes too great," he said, "when the manifest promise of life runs too far ahead of the actual daily experience of the masses of the men and women, it becomes a major cause of social conflict and instability."

Perhaps the poorest suggestion of all for doing away with this conflict and instability, said Dr. Odegard, is to declare a "moratorium" on science. "We could not have a moratorium on science without declaring a moratorium on civilization. Our problem is not to put curbs on science and technology, but to accelerate their development and utilization in the service of mankind.



President DuBridge presents degree to one of the 500 graduates who made this Caltech's largest Commencement.



Commencement Speaker Peter H. Odegard, University of California, delivers address on "Physics and Politics."

Our difficulty is not that science has outdistanced civilization, but rather that civilization, which has made science possible, has not yet learned how best to use it for constructive ends."

Chaplain's address

The Most Rev. Joseph T. McGucken, Auxiliary Bishop of the Archdiocese of Los Angeles, struck the same key in his Chaplain's Address. "Hiroshima has shown us that we can't get along without philosophy and religion," he said. "We have come dangerously near the destruction of the gains of 2,000 years. Your task is nothing less than the reconstruction of civilization."

President's charge

Said President DuBridge, in his charge to the graduating class: "For the rest of your lives you will be continually being tested as to whether you learned anything while you were here. And what, may I ask, have you learned? . . . What I hope you have learned is just one thing—that you have learned how to learn. Your experience here should have prepared you to learn far more during the coming five years than you have learned during the past five. Your diploma . . . means not that you have completed your education, but that you have prepared yourselves to begin it."

If any other record was broken at the 1949 Commencement it was in the number of graduates' offspring in attendance. Above (right) a typical family group has some typical family trouble (left) getting a picture.

BEAVER'S

MONTH

IT was phenomenal the way the school year had ended. Right up to the last Thursday, every evening had been gripped in a net of homework requirements and other things that had to be done. Then Thursday morning, when the Beaver dropped his bluebook on the desk and walked out of his last exam, the tension suddenly broke. He looked up at the warm sky and suddenly realized that summer was here, and, more incomprehensible, that he had no work to do that afternoon, or that night, or that weekend, or at all.

Added to this shock was the fact that all his friends were leaving. The Houses were turning quiet and empty, their corridors hollow, haunted shells. He felt adrift and lonely, and he smiled a little, thinking how he had condemned that attitude as characteristic of so many snakes who didn't know what to do with themselves when they had no assignments. Still, summer did involve an adjustment.

His friends were adjusting to summer in many ways. Some who could afford it were working in labs and on research projects. Others, who needed money, were working in factories and on construction jobs. A sign of the times, thought the Beaver, that that summer work paid the most which took the least knowledge and skill. Some of his friends, financially more fortunate, were even now lying on beaches with long-legged, tanned girls. He would at any rate inevitably hear all about these varied summers in September, over coffee in the Greasy or cold beer at the Skip Inn.

The Beaver sighed and picked up a sheaf of mimeographed sheets on his desk that purported to prove that Caltech students do everything better—like Duz. Under the imposing title, "A Statistical Picture of the Caltech Student Body," several pages of data had been assembled, tabulating the Techman's comparison with State University men. The state university, which preferred anonymity, was a meager place where apparently everyone did nothing but study—and then, for all its pains, found Caltech, with its scintillating array of parties and activities, well out in front scholastically.

The Beaver decided it must be a cruel world for State students and made a note to write his Congressman. Perhaps, on the other hand, it was only the statistics which made Tech look like such a meteor of varied youthful endeavor. He thought of activities like the several Student Body offices that went uncontested in the last election; and the members of the drama club, who slapped a dozen rehearsals into one play once during the year and the rest of the time were indistinguishable from pedestrians.

He was sympathetic, though, with the comparison between Student Houses and fraternities. The Houses at Tech were a brilliant thought, combining all the close comradeship and lasting memories of fraternities with a happy freedom from their snobbish selectivity. He also knew that House parties were frequent, and certainly no one could complain of not getting his money's worth.

But all through the reading of the statistics he couldn't help thinking of those single-tracked individuals he met only at the dinner table, or when he went from room to room soliciting and found them snaking. They were the ones who never came to the House's six parties a month—the ones who sat with resigned ennui in humanities courses. How many of these "active" Techmen ever really got out of their muddy technical rut?

The Beaver decided a great lurking number of these people with "activities" were EE's who belonged to the AIEE, ME's who belonged to ASME, physicists who belonged to the Radio Club. He burrowed through his packed trunk and came up triumphantly with the 1949 *Big T*, eager to check his hypothesis. Then, after considerable checking and pencil-chewing, he sat back and surveyed the results: Very close to 60 per cent of those who had "activities" merely belonged to the professional societies of their respective trades. On a note of bitterness he leaned back in this chair, feeling he'd suspected it for some time—and wishing it weren't true.

The value of technical knowledge

Of course, the Beaver admitted, good sound technical knowledge had often been put to useful purposes. It had certainly led to some excellent tricks of diabolical hilarity. Not too many years ago a small Model A had been laboriously dismantled, carted piecemeal, and reassembled in the room of a House brother who had unwittingly left for the weekend without locking his room. The hapless one returned on Sunday night, tired and lugging suitcase, to hear the ominous chugging of an enthusiastic Ford motor issuing from his normally quiet snakepit. How many days Hapless lived with the monster the Beaver didn't know, but he grinned to himself thinking of the poor guy sitting on its fender before the sink to shave, or setting his alarm clock on its running board by his bed before sacking out. Perhaps he even sat in it and ran the motor in the evenings to obtain inspiration from its musical purr.

During the past year, though, no wild, ingenious putz had arisen to divert the troops. It's true they had filled a mammoth meteorological balloon with water and left it, sprawled like a gargantuan jellyfish, on the floor of someone's room in Fleming. It had broken, of course, when he tried to budge it, and flooded the alley—but this was not the kind of spectacularly executed putz that rapidly becomes part of the legend of the Houses. There had really been nothing like the revolving, oil-flinging cement mixer that went into a House prexy's room a couple of years ago, or the ill-fated Mount Wilson safari that aroused such a storm of newspaper bungling in the spring of 1947. Even the Ricketts brake-drum seemed to be getting rusty this last year. The Beaver had worried for some time over this evidenced lack of joie de vivre. Now, suddenly, a fiendish idea came to him, and he began to work out the details for a fine, epic-making putz that he could bring about next year. Things looked rosy again.

—Jim Hendrickson '50

BOOKS

The philosophy of materialism

PHILOSOPHY FOR THE FUTURE

Edited by Roy Wood Sellars, V. J. McGill and Marvin Farber

Macmillan, New York, 640 pp. $7

Reviewed by Hunter Mead
Professor of Philosophy and Psychology

IT is unfortunate that the word "event" has been so much used to describe the publication of various books, for when the term really applies it has become too threadbare to have much meaning. However there is no other word to categorize the appearance of *Philosophy for the Future*. Its subtitle, *The Quest of Modern Materialism*, indicates the eventful character of this book.

Philosophical materialism has been under an intellectual cloud for so long now—roughly half a century—that its sudden re-emergence as a fully articulated system that makes no concessions to idealism, theism, deism, or any of their philosophical fellow-travellers, cannot fail to produce shock waves which will reach even the most isolated metaphysical ivory towers. The present volume is made particularly significant by the fact that its three editors are all top names in American philosophy, and the majority of its twenty-seven contributors are equally well known in their respective philosophical or scientific fields.

Naturally a volume of six hundred and forty small print pages, with thirty separate essays by almost as many contributors, cannot be of uniform quality throughout nor of uniform interest to any single reader. After three weeks of careful reading, however, this reviewer is impressed by the excellence of nearly all the essays; perhaps even more impressive is the integration of the book and the consistency of the general viewpoint set forth by the many different authors. In only one case (C. W. Churchman's "A Materialist Theory of Measurement") is there an impression that the article is here for a free ride on the coat tails of materialism.

For this is no loosely knit collection of random essays masquerading as a book, but rather a full expression of a single pervasive position as formulated by more than a score of separate thinkers. After a brief but challenging Foreword by the three editors, there are five articles on the history of materialism. Of these, perhaps the best is that by Christopher Hill on "Hobbes and English Political Thought," which is a fresh treatment of what would appear to be an exhausted subject. Next come two difficult but worthwhile essays on some epistemological aspects of materialism by Roy Wood Sellars and E. J. Nelson. Four essays on mathematics, astronomy, cosmology and quantum mechanics follow. All seem excellent, although experts in these areas might find some points to criticize which escape a mere philosopher.

The biological and psychological section contains particularly good chapters on "Levels in the Psychological Capacities of Animals" (T. C. Schneirla) and "Psychoanalysis" (Judson Marmor). The social science chapters which follow are less even in quality and significance, but Leslie White's "Ethnological Theory" is extremely enlightening and thought-provoking, at least for a non-expert. The concluding essays are more strictly philosophical; here again the general level is high, with Abraham Edel's essay on the theory of ideas and John Reid's "Nature and Status of Values" particular favorites of mine.

In terms of general intellectual significance, the Foreword indicates the radical character of the book. Especially revolutionary (philosophically speaking) is the criticism of philosophical naturalism: "Unfortunately, the historical forms of naturalism have often been distinguished by their readiness to compromise, or cautiously to set limits to the use of scientific method."

In another passage the most popular form of naturalism in America today, that influenced by Dewey and his followers, is attacked as " . . . reluctant to commit itself to a positive theory of the world, (whereas) materialism endeavors to set forth a synoptic view of man and the universe implicit in the sciences at their present stage of development."

Nor will the editors of the present volume take refuge in the usual precaution of repudiating their historical antecedent as "crude" materialism. Acknowledging that all systems become more refined as they are filtered through the minds of successive thinkers, and acknowledging also that the concept of "matter" has undergone much change of late, these resurgent contemporary materialists still believe that their "crude" eighteenth and nineteenth century predecessors were far nearer to philosophical truth than either their historical opponents or the twentieth century anti-materialists.

For the present reviewer, long accustomed to having his own philosophical naturalism attacked as everything from "degrading" through "crude" to "atheistic," it is an unusual and refreshing experience to be told by the authors of *Philosophy for the Future* that his viewpoint is "cautious," "compromising" and "conservative." It is, in fact, a pleasant relief to fall back from the front-line trenches to a comparatively safe rest area while Sellars, McGill, Farber and their many collaborators carry on up front where the battle is hottest.

ALUMNI NEWS

Annual meeting

Two hundred and sixteen alumni, including 65 men from the class of 1949, attended the annual meeting of the Alumni Association, held at the Los Angeles Athletic Club on June 8.

The program opened with reports from the classes of 1924, 1929, 1934, 1944, and 1949 on their respective reunions. After a short talk by President Lee A. DuBridge on recent activities of the Institute, H. R. Freeman reviewed the financial status of the Alumni Association and reported with some satisfaction that there would probably be a small surplus at the end of the fiscal year.

After presenting his annual report (which appears on page 21) President Howard B. Lewis announced the election of J. W. Lewis, Jr. as president of the Association for next year. Taking up the gavel, Joe Lewis reported the election of George K. Whitworth as Vice-President, and the re-election of Donald S. Clark as Secretary, and H. R. Freeman as Treasurer.

Main speaker of the evening was Horace N. Gilbert, Caltech Professor of Business Economics, who talked on "World Economic Prospects" (right), and the highly successful meeting ended with Manton Barnes, composer of the Caltech Alma Mater, leading the singing of "Hail C.I.T."

Chapter notes

The June meeting of the San Francisco Chapter was held at the Piedmont home of Mr. and Mrs. Howard Vesper on Saturday, June 18. More than 65 alumni, families and guests attended the garden party. Guests of honor were Professor and Mrs. Royal W. Sorensen.

After an excellent barbecue, a short business meeting cleared the way for sound, colored motion pictures of the Tournament of Roses and the South Sea Islands, and the evening wound up with some fine group singing. The business meeting succeeded in producing three new officers for the next year: J. J. Hollaran '35, President; R. I. Stirton '30, Vice-President; and J. Kohl '40, Secretary and Treasurer.

The next scheduled meeting will be the annual swim and barbecue at the Bowmans' on August 27.

—*J. Kohl, Secretary-Treasurer*

Thirty one alumni and guests turned out for the New York Chapter's final meeting of the season, held at the Hotel Holley on June 1. Main event of the evening was the Palomar movie. In a brief business meeting, preceding the film, the following officers were elected for next year: President, Dick Brice; Vice-President, Dick Pond; Secretary-Treasurer, Erwin Baumgarten; Director (two-year term), Reuben Snodgrass. Dick Brice, in his first official act as President, appointed Ed Shanahan as chairman of a committee to study the by-laws of the Chapter, and to recommend changes.

—*Cliff Burton, President*

World economic prospects

E & S wasn't able to produce enough space this month to run the complete text of the talk given by Professor Horace N. Gilbert at the annual meeting of the Alumni Association. For the benefit of those who didn't get to hear the talk, however, Prof. Gilbert has prepared this abstract of "World Economic Prospects":

Some years ago the British tried to raise the standard of living of the Hottentots of South Africa by introducing them to the raising of livestock. At least at the start these well-meaning efforts were a failure because the Hottentots could see only one simple use for the animals given them for breeding purposes: They killed the stock as soon as the British experts left them, and enjoyed a few good meals.

Do we ever do things that are as short-sighted as this action of the Hottentots? In presenting my analysis of world economic prospects, I claim that we are today proceeding along some wrong lines, and that the prospects for improvement in the economy of the world, accordingly, are not good. I accuse the American people today of failing to see 1) the advantages of a trading world, 2) the necessity of investing large amounts of capital to secure high productivity, 3) the direct connection between our heritage of freedom and our high material standard of living, and 4) the dangers of a centralized government. In these and in other ways we are continually cutting off our noses, and not even for so good a reason as to spite our faces.

The nations of the world appear to be struggling in something of a confused way with two related matters: political nationalism and economic nationalism. Until substantially greater progress is made along the line of solving these two problems than we have made thus far, the prospects for the peoples of the world living together well, and in peace, are not good. We are making some progress, so there is a basis for optimism. But the present rate may be so slow as to be inadequate to meet today's Russian challenge. We are in an emergency and we should be conscious of a sense of urgency in making more rapid progress toward understanding the problems that face us.

The present world economic picture is dominated by the destruction and disruption caused by World War II. The Marshall Plan is the most important single program trying to remedy these conditions. The Communist threat is the political force behind the Marshall Plan, but even without the Russian problem, the United States would probably be extending aid to western Europe.

How successful has the Marshall Plan been? This month we are celebrating the second anniversary of the declaration at Harvard and already some $5,000,000,000 has been poured into the recipient countries. We can make a tentative appraisal of results. The dominant factor has been the gradual and persistent tendency for the countries concerned to return to their prewar relationships. Industrial production has returned to 1938 levels in all but a few cases, and in some that level has been exceeded. This recovery was well along before Marshall Plan funds had been allocated.

But within the past few months an alarming condition has developed in several of the Marshall Plan countries. Export surpluses have appeared in textiles, light electrical, and light metal products in particular, for which markets cannot be found. Whether Marshall funds are responsible or not cannot be clearly stated, but it is clear that something has gone wrong. Unemployment is raising its ugly head again, long before satisfactory reconstruction has been accomplished.

What has gone wrong? My conclusion is this: The Marshall Plan took care of only half of the problem; namely, the provision of dollar exchange. The rest of the problem had to do with markets, and it has not been handled successfully. It does not appear to be possible, in the short run, to reconstruct the countries of western Europe by having them produce for each other. Germany experienced the same failure after World War I, after succeeding remarkably well with the reconstruction of her industrial economy, financed by private loans from us.

What could have been done? In my opinion the Marshall Plan should have included not one, but two ideas. In addition to offering funds we should have offered access to the United States market for goods produced in the countries to be helped. A definite period of perhaps 15 years might have made the proposal politically acceptable to our Congress. With access to our rich market possible, the native energies of enterprisers in the countries affected would have been released and put to work. The need for a flow of Marshall Plan funds from the top down would have been greatly reduced, and gradually the nations to be aided would have begun to earn their way.

One single statement appears to me to convey the central fact about the world economic problem today: there is only one market that will permit the countries of the world to make a sufficient economic comeback to stop Communism, and that is the United States market. Later on, access to this country as a market will probably become less important, but now it is essential to permit countries like Great Britain, France, Belgium, and Holland to earn their way.

Are we like the Hottentots, unable to see the advantages to all resulting from greater world trade? Further, in the present emergency, are we unable to see that the way we can make the greatest contribution to world recovery is through opening our markets to the goods produced by the countries that must make an economic comeback to stop Communism?

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The San Francisco Chapter meets for lunch at the Fraternity Club, 345 Bush Street, every Thursday.

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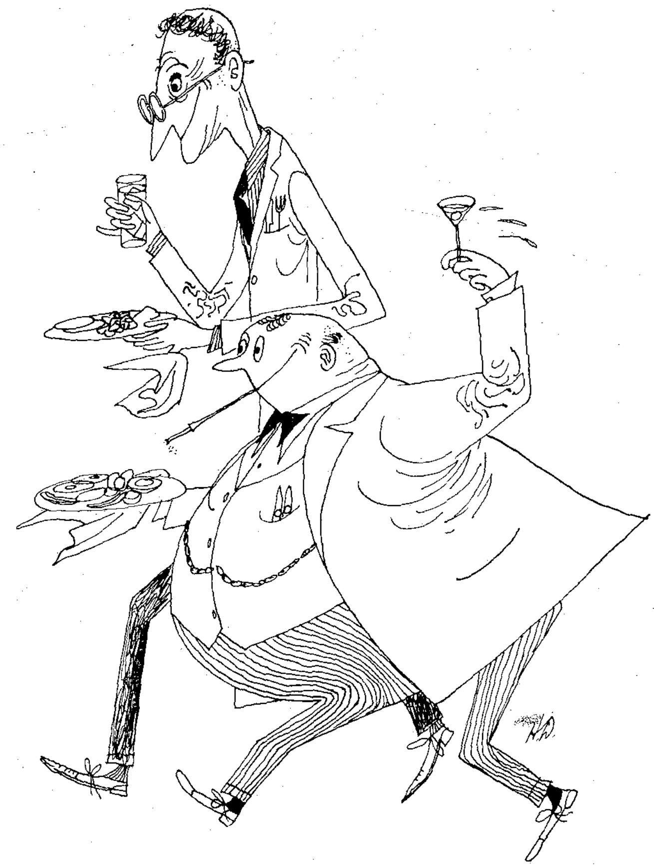
Twenty-Five Years Out



The class of '24 has a 25th reunion

"LET'S do this every five years" was the resolution made by the 41 alumni of the class of '24 as they wound up their jovial 25th reunion at a dinner meeting at the Pasadena Athletic Club on June 7th, one day previous to the annual meeting of the Alumni Association.

From a class of 77, of which 73 are still living, this 56.2 per cent was a good turnout, considering the dispersion of the group. Leonard Forbes was conceded to have come farthest, from Denver. The San Francisco contingent consisted of Kenny Anderson, Paul Stoker, Eugene Smith, Ed Wilson and Ed Dorrestein. Ed Groat arrived from Sacramento. Letters were read from Max Moody in Honolulu, Doug Tellwright, who had been transferred to New York the preceding week, "Captain" (to us) Hans Kramer, and many others. The group was honored by the presence of Dr. DuBridge and Professors Judy, MacMinn, Sorensen, Lindvall, and Musselman.

Several of the men had not seen each other in the intervening 25 years, and in a few cases, recognition was not altogether instant. Holly Moyse had extended himself out of bounds. Most of those in attendance had developed a marvelous expanse of forehead, though Lyle Pardee and Elmer Weitekamp appeared to have found the best fur storage and had no noticeable change in cranium coverage.

Bill Holladay had computed the usual statistics. The class is healthier than life insurance mortality tables would indicate, and has contributed 1.8 children per person. Cheers were given for Larry Hall with five children, the eldest of which was graduated from Tech last year. Emmett Irwin also came in for a hand as he told of having a son who has now completed his Frosh year on the Tech campus. "Tule" Smith created the illusion of having the clearest memory, as he described the individual plays and players involved in the 1924 championship Tech football team, aided, abetted and interrupted by Holly Moyse.

Following cocktails and a cold plate handout, Emmett Irwin introduced Dr. Fred Lindvall who described the difference between the campus and curricula of 1924, and that of today. He even detailed the budget to the closest one-tenth "megabucks." Fred had been a classmate of Bill Holladay and Loys Griswold at UCLA. When the latter two transferred to Tech, Fred went to the U of Illinois. According to the learned Doctor, only this chance move kept him from "sitting at the table with you fellows, listening to some other joker give this talk." Irwin then introduced Dr. Lee DuBridge, whose presence was doubly appreciated inasmuch as he had broken away from other commitments in order to attend this gathering. Dr. DuBridge won the admiration and esteem of the group as he told of present aims of the Institute, presented a view of the physical resources, and described the high qualifications of the candidates now seeking admission.

That the reunion was an overwhelming success was evidenced by the fact that the group did not want to break up. Twenty five years was much too long, they said, and a resolution for repeats at five year intervals met with instant and unanimous response. Harold Gandy and his committee, consisting of Bill Holladay, Ed Lownes, Larry Hall, Emmett Irwin and Ed Layton, were given a heartfelt vote of thanks for taking the initiative and staging the affair.

—Robert S. Ridgway '24

The President's Report

A review of the year

by Howard B. Lewis

OFFICIALLY I am rendering a report to the members on the state of our Association's affairs and on our conduct of those affairs during the past year, but I would like, with your tolerance, to enlarge that official duty and try to give you a little broader view of our Association, past, present and future.

A great and fundamental change has taken place in our own conception of our reason for existence and in our relationship with the Institute. A few years ago we were alternately tolerated and ignored by the Institute administration because we were too few and too young to count; now we are accepted and recognized as a member of a great team, composed of the trustees, the Associates, the Administration, the Faculty and the Association, working for the growth and advancement of Caltech. We are, it is true, a junior member of that team but, nevertheless, a real member. We have won this recognition as a member of the team because we have shown that, as an Association, and as individual alumni, we have both the desire and the ability to function as an effective member of the team.

In numbers, we are by far the largest member of the team. In terms of the amount of time and money each of us as an individual can contribute, we are the weakest member of the team. Because of our numbers we have the widest geographical distribution and perhaps the greatest diversity of interests and contacts.

What functions do these characteristics qualify us to perform? Obviously, we can contribute money for general or specific Institute purposes. Our large number of members means that even a small contribution from each will produce a substantial total. Somewhat less obviously, but none the less certainly, we can assist the faculty in interpreting the outside world to the students, and in orienting the students toward suitable careers. Conversely, we can help substantially in interpreting the Institute to the outside world, to industry, and to prospective students, their teachers and families.

We recognize that we cannot do much more than this. We cannot be sufficiently familiar with Institute problems to have much influence on Institute policies or programs. Our comments, criticisms and suggestions are and will be welcomed, but pressure would, rightly, be resented.

There is another group of functions which we have handled entirely in the past, and perhaps could continue to perform, but they require the services of full-time personnel. Part-time volunteers cannot handle a mass of clerical or accounting work, and a part-time committee can't publish a magazine worthy of the Institute and our Association.

The Institute has recognized these facts and has recognized the possibilities of increased efficiency through consolidation of some of these functions with similar Institute functions; the clerical work of the Alumni Office, our day-to-day accounting, and the labor of addressing and mailing to the alumni have been largely assumed by the appropriate Institute personnel. The Institute has recognized the value, present and potential, in a good magazine and has recognized, too, the fact that an Institute staff member could do a far better job of collecting and presenting the stories of the work at the Institute than could an outsider. They have employed a capable editor to help us put out the best possible magazine.

It has been the assumption of these functions by the Institute, not as a subsidy to the Association but as a part of its obligation to its graduates, as a part of an effective public relations program and as functions the Institute could handle more efficiently and effectively than could the Association, that has made possible the enlarged program of the Association and the conversion of a $1,000 deficit into a surplus this year.

I believe the past year has been a successful one in more ways than the balance sheet can show. Under the able direction of Ed Hoge and George Whitworth and their hardworking committees we have had a highly successful program. The Palomar trip last October, which drew well over 1,000 people, was by far the most popular affair in the history of our Association. The Seminar was outstandingly successful and our dinner meetings, the Alumni dance, and the theatre party were all well attended and well worth attending. A new affair, the joint Alumni-Student Body dance marked a new high in integration of undergraduate and alumni activities. I sincerely hope the example will be followed in future years.

It should be observed that the social and educational program has been supported entirely by those who attended the various functions. No income from dues is allocated to these functions.

Association membership did not maintain its rate of growth in the past year. Whether the cause was a little tightening of the personal budgets of our alumni, a lack of effectiveness in our publicity, or a disapproval of some of our policies, I do not know—and I would like to know. I do know that Nick D'Arcy, who has worked hard on the membership campaign, would appreciate any suggestions. We had a gratifying increase in our life membership rolls and can look forward eventually to an income from invested life membership funds which will give the Association a high degree of financial stability.

The Fund campaign also showed a somewhat disappointing dollar return when compared to the preceding year but it showed a most satisfactory increase in the number of alumni contributing. Last year we collected $20,200 from 483 donors. This year we have collected $16,300 from 731 donors, or a two-year total of $36,555 from 941 donors.

The Class of '49 set a grand precedent by contributing $500 as a class gift to the Fund. A full report of the Fund's progress to July 1 of this year will appear in the October issue of *E & S*. Names of donors will be published too.

E & S, as I have already intimated, is now a joint Institute and Association venture, with our Association the legal owner and the Institute our agent. Management policy is set by a management board of Alumni and Institute staff members and the actual editing is done by Ed Hutchings as a member of the Institute staff. The total budget of E & S is about $16,800 of which the Institute pays $9,300 in cash and services, the Alumni Association pays about $4,000 and advertising revenue pays $3,500. We hope that more circulation and more advertising will gradually reduce the Institute's share, or even make the magazine self-supporting, but this will be a very slow growth. Wendell Miller, Bob Lehman and Harry Farrar have ably represented the Association on the management board.

Doug Sellers and Rube Mettler have done an outstanding job this year in the field of student relations and placement counseling. In a series of weekly lectures by successful men in different industrial and professional fields, followed by opportunities for discussion, those students who were interested have had a chance to get a look into different possible vocations through the eyes of men active in those fields.

A panel of some 70 alumni, who have volunteered their services, has been organized to give any student a chance to meet and talk individually with a man or men experienced in a particular field.

Our Association has grown far beyond the boundaries of Southern California. New York and San Francisco have had strong and effective chapters for several years. Chicago and Washington have young but apparently very virile groups. Boston, because many alumni go to Boston for advanced study, has had a rapid turnover of membership and has had difficulty in maintaining a cohesive group. At the moment a strong effort is being made to re-activate the Boston chapter. These chapters are a great source of satisfaction to alumni resident in distant parts, whether they are exiled Californians or foreigners who came to Tech for a brief interlude. They are also a welcome point of interest for the traveling alumnus, as I can well testify for I have visited three of them this year and thoroughly enjoyed meeting old friends and new with a common interest in Caltech.

The Chapters are also of great value to the Association as outposts to stimulate interest in Association activities, and to the Institute as contact agencies which can help in evaluation of prospective students.

You have a strong Association; its financial situation is healthy, its membership is large and growing both in numbers and in ability and experience. You have sound reasons to support the Association in its program of assistance to Tech and to Tech alumni and students.

It's up to us to maintain our standing on the great team of which we are a part.

PERSONALS

1918

William R. Hainsworth is by now in Alaska with the Arctic Institute of North American Expedition. He says, "I hope to climb Mt. Vancouver with Walter Wood, leader of the expedition, and others. In this case, the 'old men' are going into the mountains and the young men will take care of the scientific work —a reversal of the usual procedure."

1922

Richard M. Bozorth, Ph.D., hasn't been back to Caltech since he got his degree, and doesn't appear to have had time to. Besides working for Bell Labs, he has (1) been in Japan for the Navy, in 1945, (2) written the current article on magnetism for the *Encyclopedia Britannica*, (3) written most of his book on ferromagnetism, (4) delivered a paper at the Amsterdam Conference on Metals last year. Next year he's invited to Grenoble for the International Conference on Magnetism, but hopes to make Pasadena in 1951.

1925

Edward H. Hart is in London setting up a color process there for his Cinecolor Corp. He's also helping an English company establish controls for their process.

Markham E. Salsbury has been named Temporary Chairman of the newly created California Legislative Council of Professional Engineers.

1926

C. Hawley Cartwright, Ph.D. '30, is Research Physicist for Corning Glass Works. He has a wife, Valentia, and a two-and-a-half-year-old son, Edgar Hawley.

Burt Beverly has returned to Arabia after a short vacation home, but he didn't ever get around to telling us what he's doing there.

1927

Frank A. Nickell, M.S. '28, Ph.D. '31, returned to Pasadena in June from a round-the-world air trip started last February. As a member of an international board of experts on high dams, Nickell made an inspection tour of dams in Nepal and United Provinces of India, to check on progress made since his last trip two years ago. He also spent two weeks inspecting similar construction projects in Afghanistan.

Robert L. Heilbron has been named Acting Principal of La Jolla Junior-Senior High School.

1928

Thomas C. Graham died April 22, of a heart attack, in Canton, China. He had been employed by Standard Vacuum Oil Company of Shanghai since 1928. From 1942 to 1945 Graham was in a Shanghai prison camp, and had never fully recovered his health since that experience.

1930

John D. Clark got his Ph.D. from Stanford in 1934, and has since worked for General Electric, J. Wyeth & Bro., and Hema Drug. Currently he's with Wallace and Tiernan in Belleville, N. J., doing research and producing, among other things, the Periodic Chart in the May 16th issue of *Life*. Clark says his posessions include 1 wife, 1 malemute dog, 5 turtles, 6 goldfish, and several incipient ulcers.

Howard E. Baker, after fourteen years on the West Coast, was transferred by his company to New York. He's been there since 1947, claims to like the East fine.

1931

Glenn J. Chamberlain, M.S. '32, is starting his second year as a consulting mechanical, electrical, and civil engineer in Palo Alto. He has three boys—Jack, 11, Bob, 10, Fred, 8—all interested in arithmetic and athletics.

Howard G. Smits has just moved into his recently completed house in San Marino. He has three daughters, aged 3, 10 and 13. Smits is Executive Vice-President of the Pacific Iron and Steel Co.

Rudolph C. Hergenrother, Ph.D., is working on cathode ray tube development for the Raytheon Manufacturing Co. in Waltham, Mass.

Paul G. Burman writes: "After ten years as Engineer in Charge of the Fuel Injection Laboratory at the American Bosch Corporation in Springfield, Mass., I have been made Section Engineer, Special Assignments. In this newly created post I will be directing longterm research projects concerned with new developments in fuel injection, governing, and engine combustion. In my spare time I'm writing a text and reference book on *Fuel Injection and Controls for Internal Combustion Engines*, which it is hoped will be ready for the publisher, John Wiley & Sons, this Fall."

Joshua L. Soske, M.S., Ph.D. '35, Geologist and Geophysicist of the Geophysical

Engineering Corp. of Pasadena, has recently been made Vice-President of Electric Supply Corp. of that city. His daughter Dorothy was graduated a year ago from the University of California and assisted him as geophysical computer until her marriage last August.

Halley Wolfe, M.S. '34, Ph.D. '35, is co-author of a new book, *Elements of Sound Recording*, published this Spring by John Wiley & Sons. Wolfe is currently engaged in research on new sound recording equipment and methods, including application of magnetic recording to motion picture sound technique, with the Western Electric Company in Hollywood.

1933

W. Andrew Ashton has sold his interest in the Howard Hardware Store, San Marino, and is moving to Seattle where he has purchased the H & H Hardware Store in Madison Park. The Ashtons say they would be glad to hear from Caltech alumni thereabouts.

1934

Richard S. Crutchfield, Head of the Department of Psychology at Swarthmore University, will be Visiting Associate Professor of Psychology at the University of California in Berkeley for the coming academic year.

George W. Van Osdol, who has recently returned from a two-weeks' cruise with the Naval Reserve, is on the verge of moving into his new house in Tujunga. "I have been toiling on this house for many months now," he writes. "If any of the alumni think it's a cinch to build a large house mostly by yourself in your spare time, I'll gladly disillusion them."

Robert M. Dreyer, M.S., Ph.D. '39, is Professor of Geology and Chairman of the Department of Geology at the University of Kansas.

1935

Carl R. Estep is still with station KFI in Los Angeles. Currently he's developing mobile equipment for field strength measurements on KFI-TV. Carl has two daughters, three and eleven, and says he "expects a boy" this October. He's active as a Sunday School teacher, a neighborhood Y leader, and as Engineer's Union Chairman at KFI.

Howard P. Gluckman is an Electrical Design Engineer for the Los Angeles Department of Water and Power. He has just completed work on the 355,000 KW Harbor Steam Plant, and is now working on the plans for the Owens Gorge hydroelectric development. Gluckman has a daughter, 10, and a son, 5.

Major Oliver C. Dunbar, whose marriage was announced in the June issue of E & S, writes to say that he has completed a six-months' course with Western Union and a three-months course with R.C.A. as part of his U.S. Army Signal Corps career training. In September he'll start a year's course with A.T.&T. in New York City, studying telephone communication.

Louis T. Rader, M.S., Ph.D. '38, has been named Assistant to the Manager of Engineering of General Electric's Control Divisions. Except for a two-year interlude at the Illinois Institute of Technology, as Head of the Electrical Engineering Department, Rader has been with GE since 1937.

1936

Raymond H. F. Boothe, M.S. '37, obtained his structural engineer's license in 1948. Later that year he left the Industrial Division of Bechtel Corp., where he was doing structural design, to enter the California Division of Architecture. He is now in the Planning and Construction Section of the Division. Art's second child, Carolyn, was born last August.

Verne L. Peugh, who was resident engineer on construction of the Morris Dam, has more recently been working on construction projects in Bogota, Colombia, for Winston Bros. Co. He will spend a month or two in the States this summer.

John L. Webb, Ph.D. '40, is in England, doing research work at Oxford University. He will leave in September for Zurich, Switzerland, for another year of study.

Holley Dickinson, M.S. 37, is with the Telecomputing Corp., developing methods and equipment for the automatic analysis of engineering and scientific data. He has also formed the Vibratab Co. to manufacture and market a new vibration pick-up under license from the Lockheed Aircraft Corp.

Everett B. Henderson was married last October in Ann Arbor, Michigan, flew himself and his bride on a honeymoon through Eastern Canada and home to North Hollywood in a Stinson.

John P. Klocksiem and his wife Dorothea announce the birth of a son, Steven John, on October 3, 1948. Their daughter, Bonnie Ann, is four years old. The Klocksiems moved into their new Westdale Village home about a year ago. J.P. has been with Douglas Aircraft, in Santa Monica, for five years. He's Design Engineer in the Structures Group.

1937

Nash H. Miller, M.S., started work with United Geophysical Co. of Pasadena the day after he got his diploma, and has been with them ever since. He's worked in Trinidad, Brazil, Venezuela, Canada, and in many parts of the U.S. Right now his headquarters are in Tulsa, Oklahoma, where he lives with his wife, Mildred, his two daughters, and his young son.

1938

Clyde W. Harris has joined the Research and Development Division of the New Mexico School of Mines, at Socorro.

Bob Custer is now working for Bechtel Construction Co. in San Francisco. He's completing — singlehanded — a six-room house in North Palo Alto. Says he's poured the foundations, done the framing, wiring, and pluming, finished the outside plastering, and, in fact, has already moved in, with wife Elsa and three children.

1940

H. E. Heywood, Jr., has recently been appointed Assistant Chief Engineer of the Toledo, Ohio, plant of National Supply Co.

Alexander F. Brewer was Project Engineer on Radar and Microwave Apparatus at Sperry Gyroscope Co., during the War. Since September, 1946, he has been with the Electronics Department of Hughes Aircraft Co., where he is now Assistant Head of Missile Electronics Section. Brewer married Barbara Catherine Gustafson in New York in 1945, has a two-year-old son, Gregory.

Don Loeffler writes: "I expect to get my Ph.D. in Chemistry at Stanford, June 19th. The following day I'll be married to Miss Sharon Nuss of Los Angeles, who is a senior here at Stanford. When we return from a honeymoon in Mexico, I'll begin work for the Shell Oil Co. in the Martinez Refinery."

1941

Harold Kenneth Fink, M.S., has a private practice in psychotherapy (modern electric psychoanalysis) in New York. In addition he devotes one evening a week to a clinic, teaches part-time at Pace College, and is doing some research in methods of increasing speed of therapeutic progress. In all these activities he is assisted by his wife, Charlotte Piez Fink, whom he married in 1946.

Alfred John Bersbach is the father of three sons, the newest being Peter, aged four months. Bersbach is still with GE, at present in the Los Angeles Engineering Division.

John H. Carr, M.S. '43, and his wife announce the birth of a daughter, Catherine Ann, on May 18, 1949.

1942

Robert E. Cunningham is in the Research Department of the Solvay Process Division of the Allied Chemical and Dye Corporation at Hopewell, Virginia. He married Miss Mary Mitchell in 1944. A son, Robert, Jr., was born last September.

John A. Drake, M.S. '43, was married to Miss Patricia Fay, in East Ely, Nev., on April 23. John is Chief Designer for Marquardt Aircraft Co. in Los Angeles.

Edwin R. Fay is an Aerodynamicist at Consolidated-Vultee in Fort Worth.

Stew Davis has a son, born January 10.

Roy Weller writes: "Graduated from Stanford University with degree of Master of Business Administration in July, 1948, and went back to work with Ingersoll-Rand Co. After a few months in New York City and Eastern factories, my wife and I were sent to St. Louis where I am more or less permanently located as a Sales Engineer. Proud father of a baby girl, Constance Ann, born May 24."

1943

Orin J. Mead finished Stanford's Graduate School of Business in June of last year and is working in Boeing's Propulsion Development Department in Seattle. On February 20th of this year he married Mary Ellen Harding (Stanford, '48).

R. E. McWethy is in the insurance business in Aurora, Ill. He's married, has three children.

William C. Thompson, Jr., is working as an electronics engineer at the U.S. Naval Ordnance Test Station at China Lake, Calif.

Married: **Harrison C. Lingle**, to Dorothy Jane Bragg, on May 14, in Champaign, Ill. **Douglas C. Reid**, M.S. '47, to Marian Paul, on May 7, in Carmel, Calif.

1944

William H. Bond is a thermodynamicist at Consolidated-Vultee Aircraft Corp. in San Diego. This month he's taking a Naval Reserve cruise to Hawaii. Bill, Jr., is now nearly two.

1945

Burton E. Freeman is at Yale University, working toward a Ph.D. in theoretical physics, which he expects to get next year. He was married to Elizabeth Forrest, of Santa Monica, in 1946, and has an eight-months-old daughter, Kay Marie.

Donald H. Bates, Jr., writes: "Am learning the fish business through odd jobs that turn up — very seasonal work but highly interesting. Just returned from Costa Rica aboard tuna freezership *Saipan*, and am heading for a salmon cannery in Alaska. Have worked in a cannery before, and with the Oregon Fish Commission . . . Engineering always comes in handy."

Charles R. Cutler graduated this June from the George Washington University Law School. He plans to practice law in Washington, D. C.

Donald C. Tillman is designing freeways for the city of Los Angeles, lives in Altadena with his wife and little Don, aged 2.

Robert Wilson Taylor is doing editorial work for McGraw-Hill Publishing Co. His engagement to Miss Virginia Ann Mays of Bronxville, N. Y., was recently announced.

Charles Melville Davis is teaching at John Muir College in Pasadena. In August he will marry Miss Carolyn L. Wolfe, of Alhambra.

1946

Douglas S. Ellis got his M. A. in Psychology from Occidental College in 1948, and is now working toward his Ph.D. at Northwestern University. He's a member of Sigma Xi, and holds a University Fellowship. Ellis expects to win his doctorate this January, and then hopes to work in industrial psychology on the West Coast. In 1946 he married Winifred Lambert. They now have a nine-month-old daughter, Christy.

James F. Chalmers was graduated from Harvard Graduate School of Business Administration this June and is returning to California.

1947

C. Burton Crumly spent a year at GE taking the A-Course, then returned to Caltech for grad work in Electrical Engineering. He held a Teaching Assistantship in that department, and received his M.S. this June. Next fall he goes to Stanford for study toward the doctorate.

Dave Caldwell worked at Los Alamos during the summer after his graduation, doing research in nuclear reactions. He spent the next year at Stanford, doing graduate work in physics, and then got a job as radar design engineer at Gilfillan, in Los Angeles. Now he's continuing his studies at UCLA, where he says he has encountered **Dale Meier** and **Herb Royden.**

George D. Shipway announces the birth of his second daughter, Karen Elaine, on February 26.

D. Murray Alexander, M.S., now teaching at Webb School, Claremont, joined the ranks of proud fathers on May 17th, when Patricia Stuart was born at Pomona Valley Hospital. Pat's mother also sojourned at Caltech—as Evelyn Deibert in the Meteorology Department.

1948

Vincent R. Honnold is the father of a baby girl, Maryanne, born April 1 at St. Joseph's Hospital in South Bend, Ind.

Reed A. Gray, Ph.D., is Assistant Chemist for the Pineapple Research Institute of Hawaii, in Honolulu. He's doing research on the biochemical nature of mealy bug wilt on pineapples.

Letters CONTINUED FROM P. 2

Therefore, by definition, Oa_s is also the shortest distance between the center of gravity and the bottom of the schmoo.

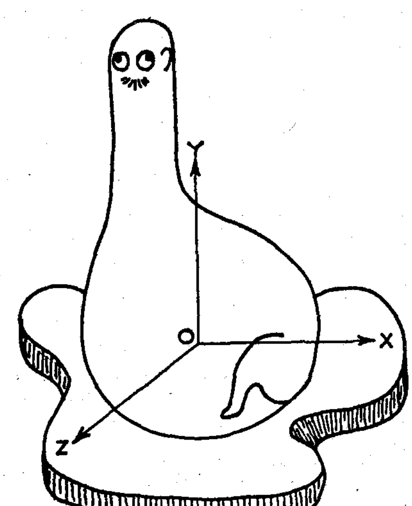
4. In tilting or jostling the schmoo, some other point a'_s on the animal's seat will be brought in contact with the rock, with the original point a_s now some distance y' above the rock. Thus, the vertical distance between O, the center of gravity, and the surface of the rock must have been increased since Oa_s is less than any other distance between O and the bottom of the schmoo.

5. In effect, jostling the animal in any direction will raise the center of gravity, providing of course that the center of gravity remains at the same point in the animal and that he (she) does not attempt to wiggle his ears or lay an egg at this moment. To raise the center of gravity, work must be done, and this will necessitate an opposing righting couple formed by the vertical displacement of the center of gravity from the point of contact between rock and posterior.

6. When the displacing force or couple is removed, the righting couple described above will continue to act until ΣM equals zero, and the center of gravity O is once again in its original nadir position with point a_s in contact with the rock.

Long Beach — William H. Cook '45

The shmoo is sitting on a flat rock and thinking. His center of gravity is at 0. With reference to a set of coordinate axes through 0, the equation of his bottom is $2x^2 + 3y + 2z = 12$. The shmoo is in equilibrium in his present position. If he is jostled slightly, will he fall over, remain in the displaced position, or return to a vertical position? Why?



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With this issue **Engineering and Science Monthly** suspends publication for the summer.

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