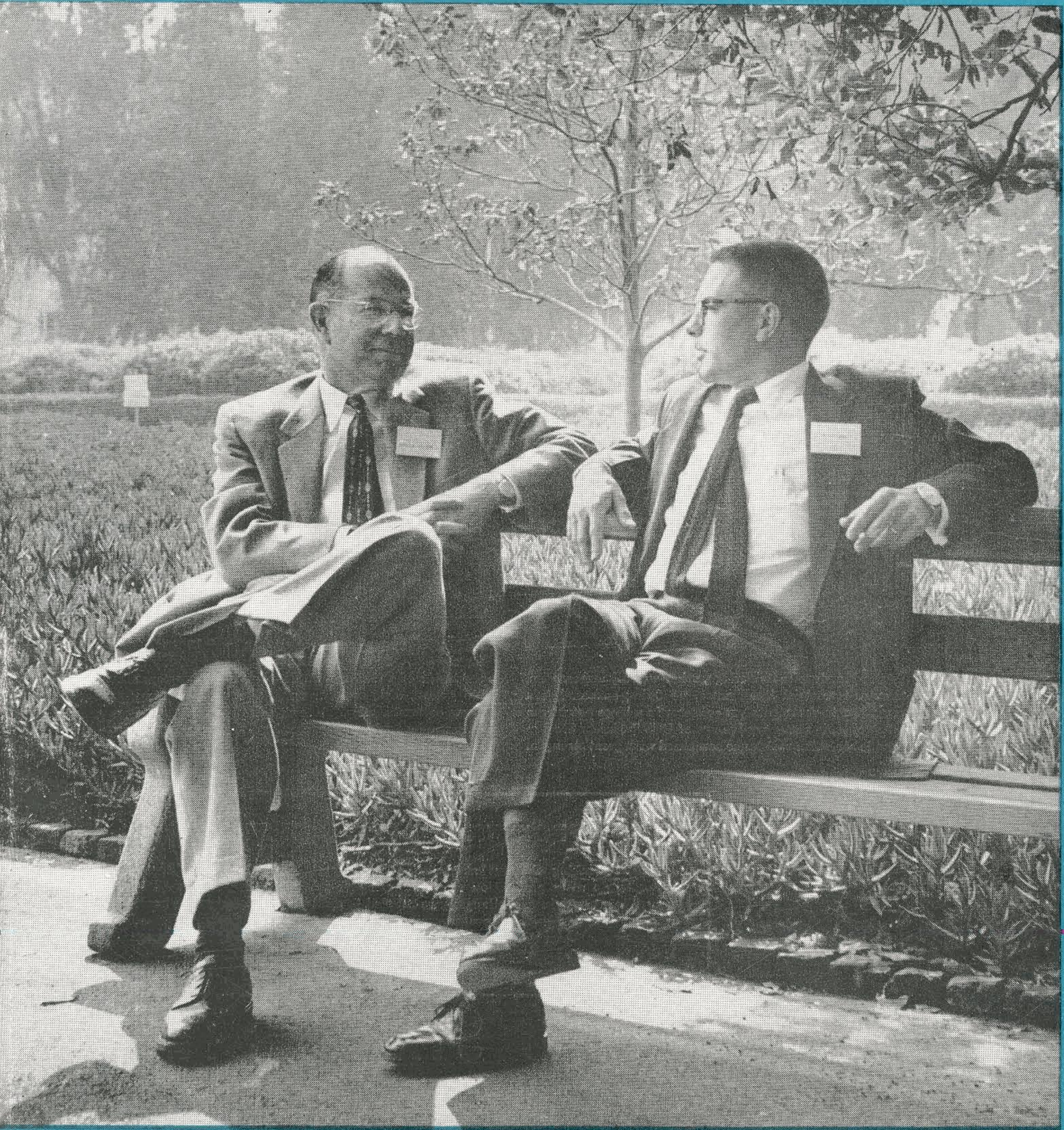
ENGINEERING AND SCIENCE

APRIL/1954



Alumni Seminar . . . Page 26

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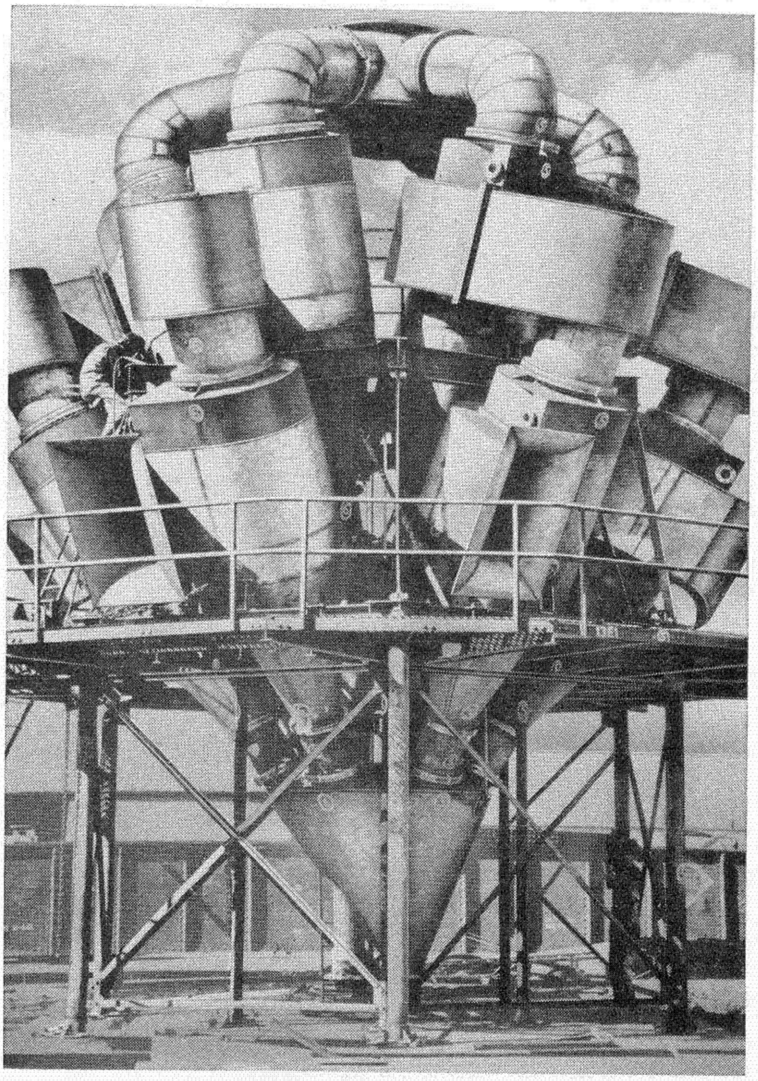

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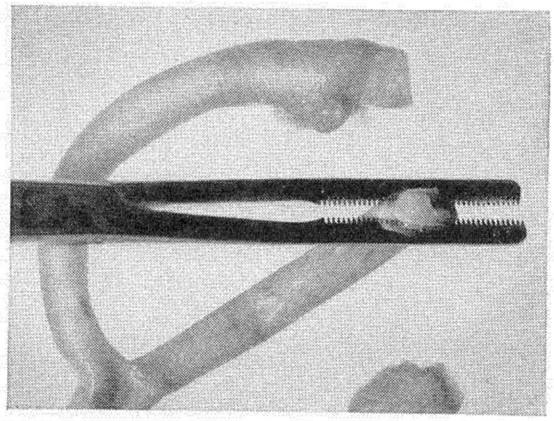

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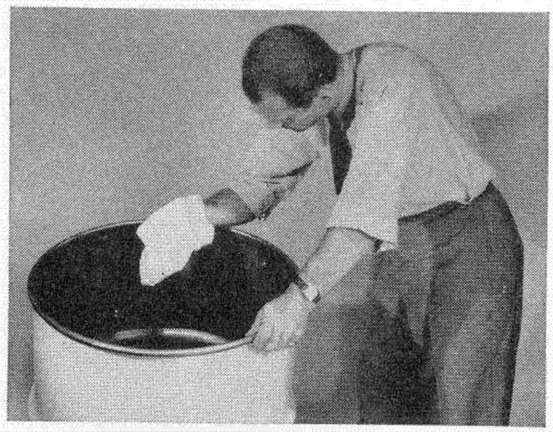

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ENGINEERING | AND | SCIENCE

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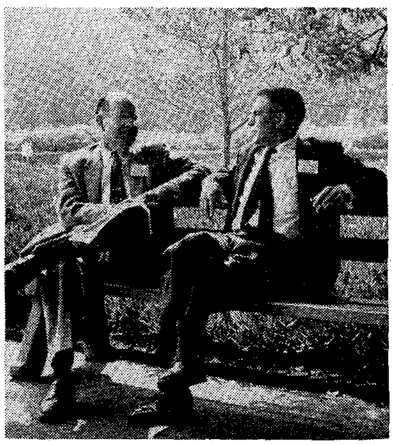

On the cover this month is a scene that is repeated time and again on Caltech's Alumni Seminar Day. This time it is Seminar Day, 1954—and the cover shows two alumni, between lectures, in earnest conversation on one of the campus benches. You'll find more pictures taken on Seminar Day on page 26.

On page 11 of this issue, Thomas M. Smith, assistant professor of the history of science at Caltech, writes on "Some Valuable, Mistaken Notions on Matter in Motion." Dr. Smith's article has been adapted from the talk he gave at the Alumni Seminar this year, "Falling Apples to Splitting Atoms." Dr. Smith joined the Caltech faculty in the fall of 1953. Next year he will introduce a course in the history of science here; in the meantime he is engaged in research on the history of flight under pressurized conditions—under a $56,000 fund established by the AiResearch Manufacturing Company for the support of teaching and research in the history of science at the Institute.

On page 15 Samuel Epstein, senior research fellow in Geochemistry, describes the work of this latest addition to the research program of the Institute's Division of Geological Sciences . . . On page 28 Henry Borsook, professor of biochemistry, gives a lucid account of the current research in this vitally important branch of biology.

PICTURE CREDITS

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LETTERS

THE CHALLENGE OF MAN'S FUTURE

Sir:

May I draw the attention of your readers to a few misconceptions which occur in Prof. Harrison Brown's interesting article, "The Challenge of Man's Future" (*Engineering and Science,* February, 1954).

In discussing the position of those who fight against conception control on the grounds that it is "unnatural," the author makes the mistake of equating "unnatural" with "artificial." This, of course, makes the position of the anticontraceptionist rather ludicrous. Dr. Brown ought to credit other people with a little more intelligence.

Popular usage may, indeed, frequently identify the two words, but in this context the term "unnatural" is used in the technical sense proper to treatises on moral philosophy. Used in this sense, it would, for example, be unnatural to remove a gangrenous limb, although both procedures are highly artificial. Again, the use of contraceptive devices is artificial and homosexual practices are non-artificial, yet both are "unnatural" in the technical moral sense of that word.

These examples are not cited in order to *prove* anything, but merely to illustrate the fact that for a moral philosopher the terms "artificial" and "unnatural" are poles apart in their connotation.

Reference is made to "an almost impossible degree of continence" as an alternative method of control of population. It would be very difficult to estimate just what degree of continence would be necessary, for instance, to keep world population at any given level. Be that as it may, I think it not unreasonable to say that continence in the domain of sex, like the due restraint of any appetite, is largely—though not entirely—a matter of adequate training and motivation in the formative years. In the absence of a goal clearly perceived and earnestly desired, restraint is not only impossible but psychologically hurtful. But given strong motivation, much can be done that otherwise seems impossible. The toil of a student, the labors of research workers, fathers and mothers, Arctic explorers, all bear witness to this fact. If a higher degree of sexual continence seems impossible in our times, the blame must fall upon the culpable lack of moral and religious training of youth, and the constant incitement to incontinence that is provided in advertising, entertainment, dress and social customs in the average modern city.

Wild and whirling

In speaking about "the guilty ones in this grizzly drama" (this is only one of many examples of what can best be described as "wild and whirling words" in this article), the author refers to those whose name is legion who are "frightened by the creedists."

Most of us are frightened, and rightly so, by signs which warn against high voltage or cancer. Provided that the truth of a moral code or a religious creed can be established and defended on a rational basis, it is a virtue to be "frightened" by it. One suspects that the root cause of Prof. Brown's indignation here is that he has been educated in that school of thought which holds that *all* creeds are without rational foundation, all moral judgments relative, and if any practice is physically, chemically or biologically possible and makes for greater human comfort, one ought to adopt it without any further nonsense.

It would be impossible in the course of a brief letter to state adequately, let alone establish and defend, the position of the moralist in regard to contraception. But since Prof. Brown undertook to write a book on the serious problem of increasing world population and took occasion thereby to criticize the moralists, he had the grave duty of any scholar to give serious study to their point of view. If he did this, it certainly does not appear in the extract published in your February issue.

As a constant reader of *Engineering and Science* and one who will always be grateful for the privilege of having studied for several years at the California Institute, I protest against this assertiveness-without-knowledge being put forth under the banner of science.

Rev. James O'Reilly, *PhD.*

Department of Physics and Mathematics
Mt. St. Mary's College
Los Angeles

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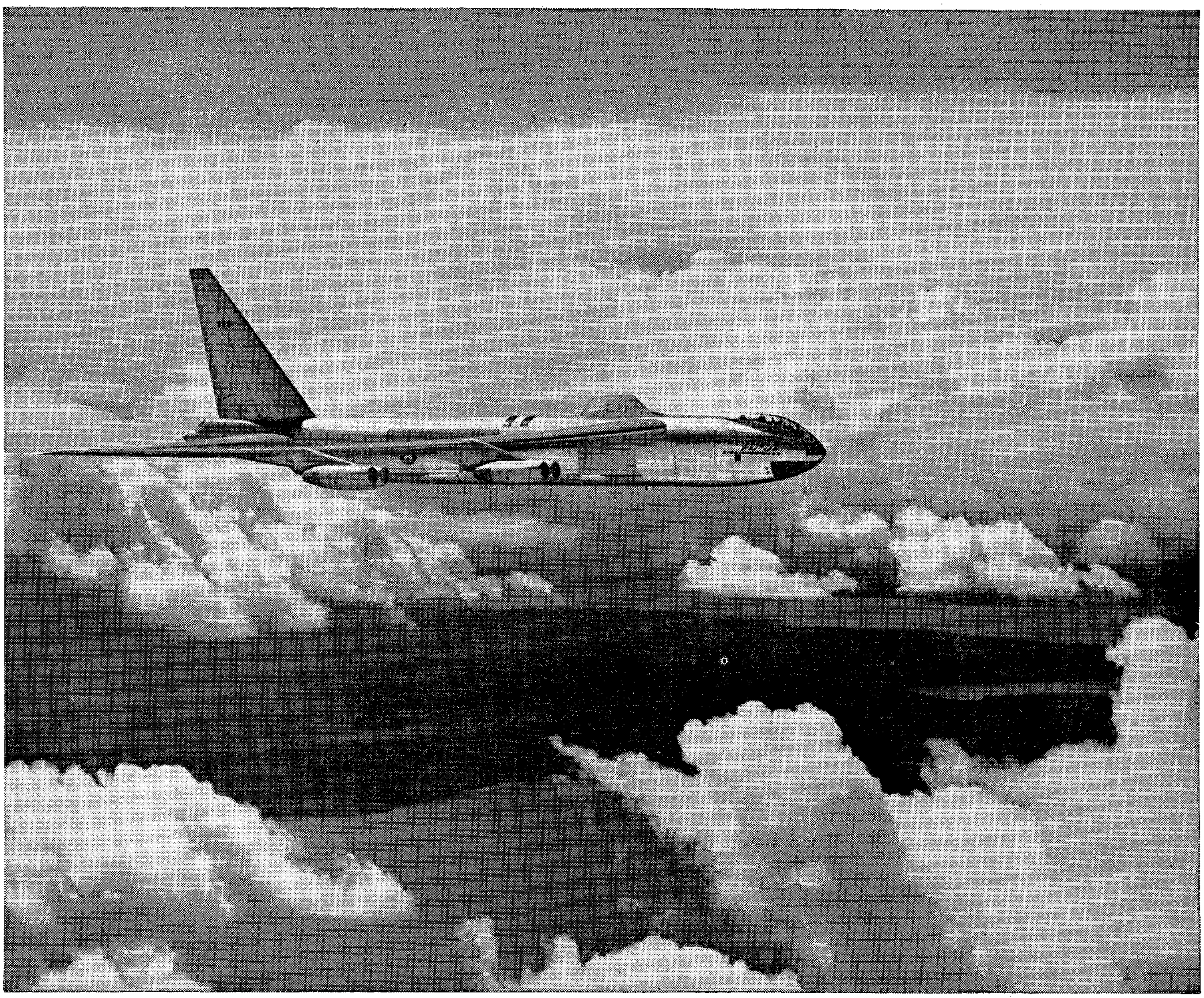

Boeing eight-jet B-52 global bomber

THE LIMITS OF THE EARTH

by Fairfield Osborn
Little, Brown $3.50

Reviewed by Arthur W. Galston
Associate Professor
of Biology

SEVERAL YEARS AGO, Fairfield Osborn wrote a book called *Our Plundered Planet* which shocked many complacent people into the sudden unhappy realization that the physical resources of this earth are not inexhaustible, and in fact are well on their way to depletion in some critical areas. This verbal blow struck by Osborn found its echo in many subsequent books on the same subject by such authors as William Vogt, Robert Brittain, Josué de Castro and most recently by our own Harrison Brown.

Having served his primary purpose of sounding the alarm and awakening public interest in the conservation of natural resources, Osborn next turned to a rather more detailed analysis of man's food prospects for the immediate future. His intelligent appraisal of this situation is the subject matter of the present book. It is interestingly and warmly written, all the while managing to steer a realistic course between the gloomy viewers-with-alarm and the uncritical visionaries of plenty.

The basic facts are these: There are now 2.4 billion people on earth, and they are increasing at the rate of about 1.2 percent per annum. This means that each year, there are 26 million more mouths to feed than there were the year before; each day 75 thousand more than there were the day before; each second one more than there was the second before. At this rate, the population will double about every 60 years, so that even if we manage to double our output of food in 60 years (an optimistic estimate!), we shall be no better off than we are now.

Furthermore, where we are right now is not so good, since about two-thirds of mankind exists on an average daily caloric intake considered no better than barely minimal. In addition, we are continuing to lose ground, for in the years since 1939, there has been a 12 percent increase in the world's population and only 9 percent increase in food production. Obviously, this cannot go on forever, and so we are brought face to face with "the limits of the earth."

Haves and have-nots

Unlike those who consider the global resources problem from an integrated point of view, Osborn prefers to operate within the framework of existing political and geographic boundaries, and to consider the implications of localized areas of "haveness" and "have-notness." He thus takes us on a tour of the major areas of the earth, considering each as an integrated geographic-agronomic-sociological complex of problems, frequently cast against a revealing historical past.

It never hurts to be reminded that civilizations as mighty as ours have come and gone, or that areas like Greece and Spain, currently barren, denuded and eroded, were once highly productive and fertile. How prodigal can we be of our "endless resources" before we suffer a similar fate? In these days of recurrent dust storms, erosion, forest fires and floods, this question is not an idle one.

East and West

Osborn views the current clash between East and West as more than a conflict of ideology. It is a battle not only for the minds of men but for the resources of the earth which are every day less than they were before. (Why else so much concern over Indo-China?)

If the strength of any political system resides in the long run upon its capacity to provide the basic necessities of life to its people, then war obviously becomes the greatest enemy of all men, whatever the system under which they live. To the extent that capitalist economies give way to socialist or communist organizations of society in times of extreme need, our system will be at a greater and greater disadvantage

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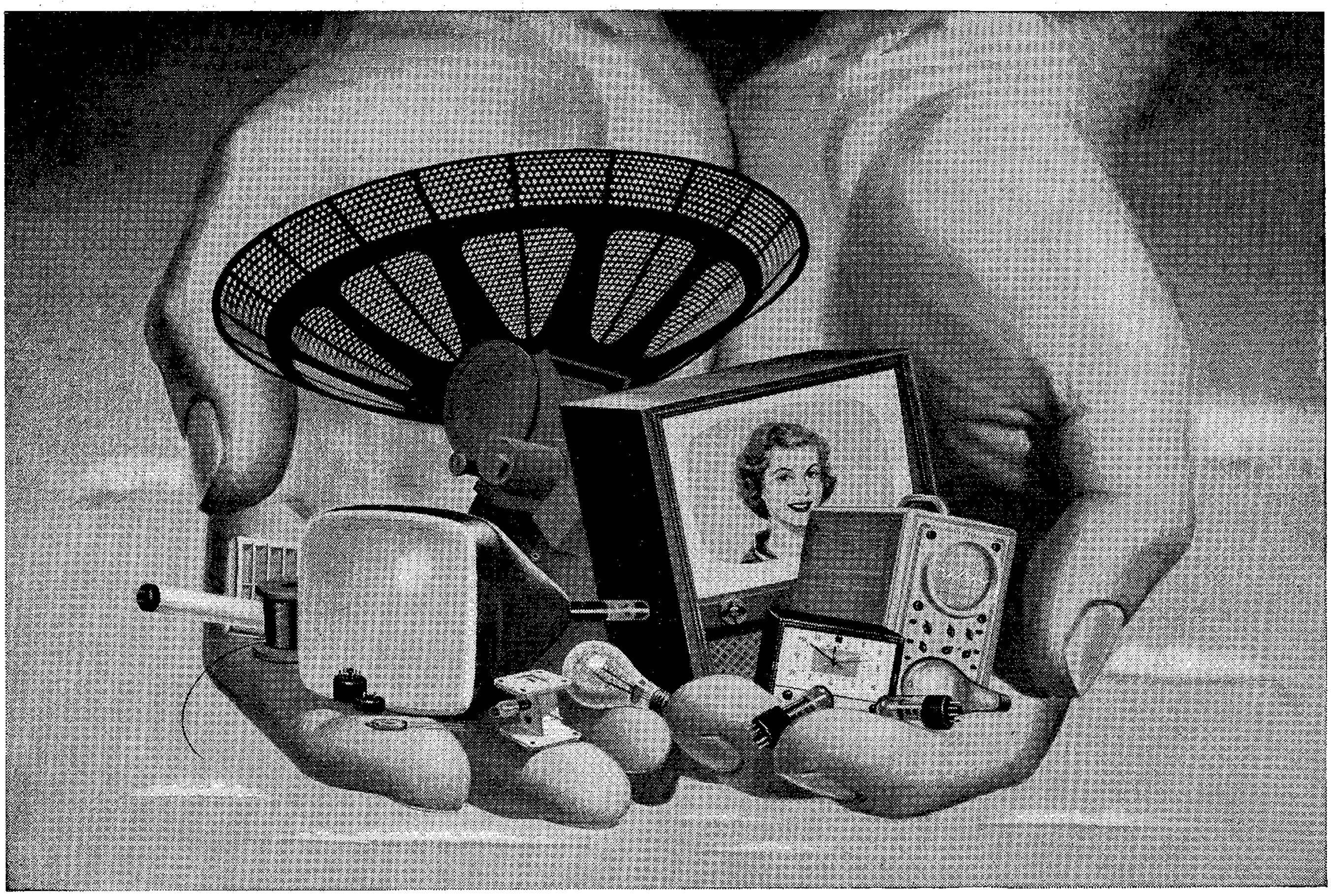

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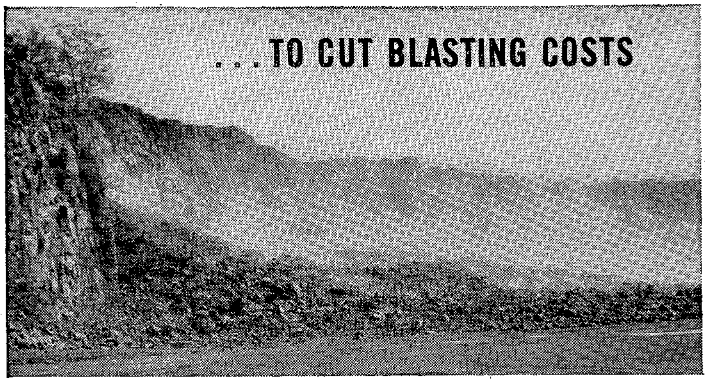

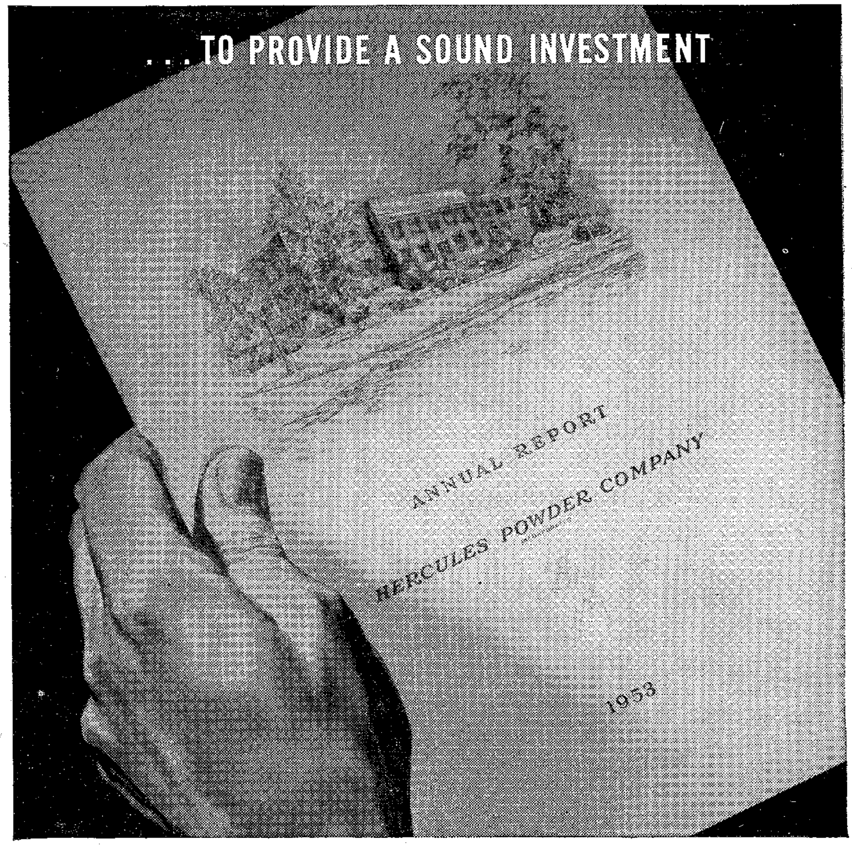

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The "well" itself is almost a mile deep—4900 feet, to be exact. Waste fluids from the plant are forced down this well, to be absorbed by non-oil-bearing sands—far below the level of any surface water. Piping near ground level is in the form of concentric shells, and fresh water is delivered to the annular opening around the waste pipe. Furthermore, the water pressure is higher than that of the fluids in the waste section. In this way, any leakage in the pipe system causes fresh water to enter the surrounding sands (or the inside waste system) and prevents objectionable materials from reaching the sands at surface levels.

Other interesting procedures are used throughout Du Pont's many plants to guard against river pollution. For example, scientists were asked to make a complete marine-life census on one river before a plant was built nearby. The company wanted to be certain that no waste would be discharged which would challenge the natural pattern of marine life.

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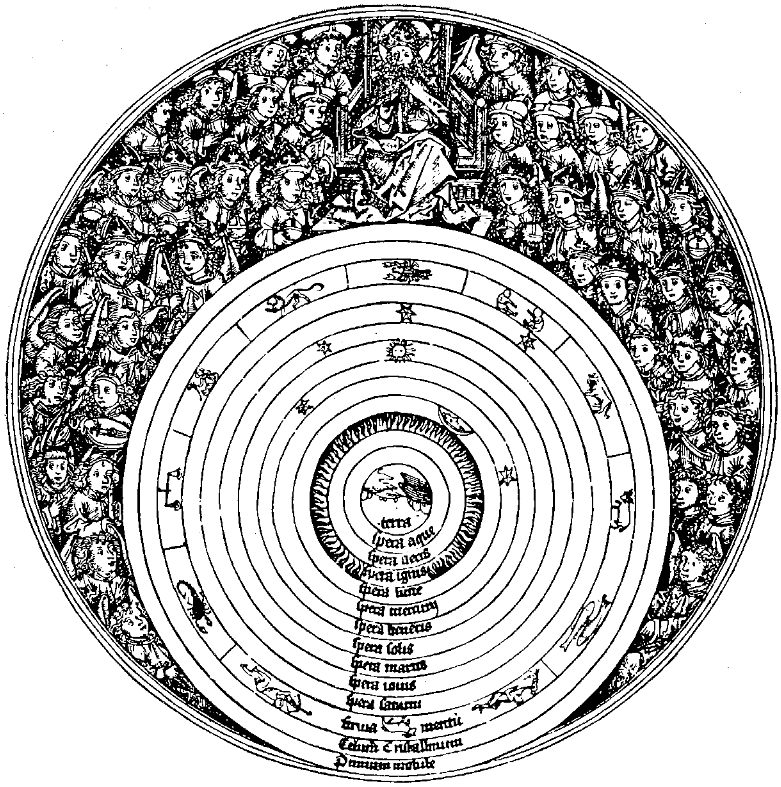
The order of the Aristotelian cosmos. Woodcut from the Schedel Chronicle, published at Nuremberg in 1493.



Some Valuable, Mistaken Notions on

MATTER IN MOTION

by THOMAS M. SMITH

Assistant Professor of the History of Science

ARISTOTLE'S VIEWS on matter in motion are firmly forgotten today. So dead are they that they have long since stopped receiving wide credit for assisting the rise of modern science. Instead, they are more apt to be regarded as obstructing the rise of science. Yet they were an inspiration and a goad to the creation of modern physics and astronomy, and the fact that they encouraged and discouraged better ideas all at the same time is only typical of the provocative way scientific knowledge grows.

In many respects Aristotelian mechanics was more credible than some of the far-fetched ideas Newton and his precursors invented. Above all, it placed the earth at the center of things. The idea that the earth is the center of all things has always been a very appealing idea. It underlies the natural importance of man and, as far as the ancients were concerned, it removed all doubt as to where man was going. He wasn't going any place. He was staying right where he was, at rest in the center of the universe. Whatever went on in the cosmos went on *around him,* as anybody who lifted an eye to the celestial regions could see.

When Newton and his precursors shattered this view of things, neither man nor the earth remained at the center of the world. Instead, the cosmos became a vast, impersonal mechanism in which the earth was a very minor and scarcely essential cog. Fortunately, it also became a more understandable and predictable cosmos.

This change from the Greek to the Newtonian view was a slow, rather toilsome process, in its way extremely dramatic, and by no means a finished job. Indeed, at the present moment there is little evidence that the job is finished yet, for we do not altogether understand the world we see.

The whole story revolves around an age-old question: What is physical reality? The answers offered by Greek scientists and philosophers have persistently affected European and American thought because of the way they approached the problem. These answers rested on observed facts. Then, as now, some of the observed facts were obvious and impressive. These Aristotle was able to incorporate into a massive, impressive, persuasive system, a view of the physical world that accounted for a wide variety of observed phenomena on earth and in the sky and that infused purpose into the process of events. In a sense, purpose was presumed to be the reason for the obviously complicated orderliness of nature.

Poor ideas and good

Aristotelian physics enjoyed a long life. True, it did not satisfy everyone, but with a few modifications it withstood assault century after century before finally, weakened by earlier attacks, it yielded to the view we associate with Isaac Newton's name. We are tempted to look back upon this Aristotelian cosmology as absurd and a fine example of the ignorance of the experts, but it was a very live and acceptable and persuasive idea. If we can understand why it was a useful, long-lived world-view, we shall have a keener feeling of the difficulty men perpetually encounter in separating the poor ideas from the good.

It helps to grasp the view of the universe that was most widely held in Europe for about 2,000 years if the reader will forget all he knows, abolish all he takes for granted, and willingly suspend his disbelief. Then, with the slate wiped clean, it's easier to accept the idea that all matter on earth is made up of four elements, as Aristotle said, borrowing from Empedocles. These are earth, water, air, and fire. Further, in accord with Parmenides' assumption of a plenum and denial of a vacuum, these elements fill all space out to the moon. The moon and beyond are of different stuff, for the celestial regions are different. They are perfect. They suffer no generation or corruption, no beginning or ending, no birth or death, no novel occurrences. Comets and meteors are probably atmospheric phenomena.

The perfect heavens continue perfect, changeless. They are filled with a perfect substance, a fifth element, aether. This fifth essential (whence our extravagant word, "quintessence") is the stuff of which the moon, sun, planets, and stars are made, and it makes up most of the cosmos. But it has its limit; the world is finite. It is a sphere in shape—that most perfect "animal" and geometric figure, according to Plato's *Timaeus*.

And in the center is man. The sub-lunar region he dwells in is neither perfect nor changeless. If this seems difficult to face, nevertheless the experience of living compels it. His is a world of being, becoming, beginning, and ending, and its lack of static perfection is explained by the nature of the four elements. Each of these elements has its natural place: earth at the center, next water, around these air, and finally fire. This helps explain why rocks fall and why flames rise, why the oceans seem to be bottomed and the atmosphere to be light. The elements always tend to seek their *natural places*.

Now none of the crude substances we perceive is one of the four pure elements, for these in their pure form we never see. We know only the coarse approximations and compounds of these, and *all* that we know are composed of some or all of the four elements.

Ideally we could arrange these elements in four concentric spheres with earth at the center and fire the fourth and outermost, but actually the sub-lunar region we live in is not so arranged. Why? Because of the four qualities the four elements share. These qualities are: hot and cold, wet and dry. Earth is dry and cold, water is cold and wet, air is wet and hot, and fire is hot and dry. These qualities are always acting to change any one element into its neighboring elements, and this process accounts for change and generation and corruption in the physical realm. It is a kind of natural transmutation of unstable elements. But here the fortuitous resemblance to modern nuclear physics stops, for Aristotle had no use for the atomic ideas of his predecessors, Leucippus and Democritus. One of their assumptions he could not swallow was the idea of a void in which the atoms swarmed. A void meant a non-full universe, and Aristotle (like Descartes) preferred a filled-up cosmos.

The nature of physical reality

These speculations upon the nature of physical reality explained many phenomena. The existence of clouds was just what one would expect in a world where air was continually changing into water. Stones and rain fell because the dominant elements in these objects tended to seek their natural places, just as air and fire tended to rise in seeking their natural places. A stone twice as heavy would contain twice as much material seeking its natural place, so it would fall twice as fast, and this explained why a heavier object made a deeper dent when it struck.

Now let us pause to make a simple picture of this cosmos we have constructed with the help of Aristotle and his commentators. We start at the center with earth. Around that is water, around that air, and around that fire. Finally, from the moon on out to the fixed stars—the end of the cosmos—all is aether. Here we have pictured all the matter in the universe.

This matter is in motion, as we know very well, so let us add motion to our picture. We shall start at the center again, with the sub-lunar world. The four elements come in pairs of opposites, water and fire, earth and air. The natural motion of each of the elements is up or down, and each of these opposite elements is paired with an element whose natural motion is in a direction contrary to its own: water down, fire up; earth down, air up. And just as weight is an expression of the natural tendency downward toward the center, so is levity an expression of the natural tendency up out from the center. Levity, then, is not mere lack of weight; it is a positive force that air and fire possess. Like weight it is a *tendency*, a tendency of an object to seek its natural place in the cosmos.

The motions of these elements, which are simple bodies, are simple motions. They are also motions in a straight line, up or down: rectilinear motion, natural motion. The fifth element, aether, is likewise a simple body, and it has its simple motion, too. This is curvilinear. Has the fifth element an opposite, like the other four? No. So neither has its motion an opposite.

Since circular motion has no contrary, it is essentially nobler, according to Aristotle. So the simple body to which circular motion is natural will not be subject to change, but will be eternal. Which objects in human experience fit this definition? Those in the sky, of course.

So we have put the matter in our picture in motion. The four elements of the sub-lunar region seek their natural places by moving in straight-line paths, and the nobler aether without a contrary moves eternally in circular paths at constant speeds. And though all of this explains much that we see—has empirical, common-sense support—it has a curious and rather drastic consequence: the sub-lunar world is a different kind of world from the celestial. The kinds of things that go on in man's realm are not the things that go on in the changeless, perfect heavens. Significantly, every astronomical system devised by the astronomers, through Copernicus, accepted this fact. The cosmos was not a *uni*verse.

Projectile motion

Aristotelian physics was not flawless. Generally credible though it was, it had a few small difficulties. One of these was the problem of projectile motion. Another was the acceleration of falling bodies. Before the Galilean and Newtonian explanations appeared, there were many discussions of these two difficulties. As we look back we can see how our widely divergent modern explanation depended on these discussions, for it was out of them that our contemporary knowledge grew.

Projectile motion was not natural motion, in the Aristotelian scheme; it was "violent motion." It was a stone hurled in a direction away from its natural place. The problem was, what kept it moving? For objects not being moved toward their natural place must have a mover, whether it be the hand that pushes the chair across the floor or the horse that draws the chariot. Usually, in such cases, the mover remains in physical contact with the moved, and when the mover stops applying its force, the moved stops.

Not so in a projectile, however. How explain this? Aristotle suggested weakly that perhaps the agitation of the air kept the stone or the arrow in motion until, finally dissipated, it allowed natural motion to take over and drop the object toward the earth. It is interesting to see how he speaks of this. In his discussion he is also concerned with denying that there can be a void.

Aristotelian explanation

"In point of fact," he says in the fourth book of his *Physics*, "things that are thrown move, though that which gave them their impulse is not touching them, either by reason of mutual replacement, as some maintain, or because the air that has been pushed pushes them with a movement quicker than the natural locomotion of the projectile wherewith it moves to its natural place. But in a void, none of these things can take place, nor can anything be moved save as that which is carried is moved. Further, no one could say why a thing once set in motion should stop anywhere; for why should it stop here rather than there? So that a thing will either be at rest or must be moved *ad infinitum*, unless something more powerful get in its way."

To Aristotle, such a possibility was preposterous, yet note its similarity to Newton's first law of motion: that objects at rest tend to remain at rest or objects in motion tend to remain in motion until acted upon by some outside force.

It's not always easy to know good ideas when we see them. Aristotle had as much trouble as the rest of us, and in this instance he had other reasons for denying these ideas. In his always full world, a force moved an object through a resisting medium. If you varied the force or the density of the medium, you varied the speed of the object in motion. The more you reduced the resistance of the medium, the faster the object would go. Indeed, if you eliminated the medium altogether, all resistance would be gone, and the speed would reach infinite dimensions. An object would move instantaneously from here to there. This was patently absurd; therefore, the existence of a void was impossible.

Against this array of interlocked ideas systematically worked out to explain the nature of physical reality, what could be more absurd than the idea that all objects fall to earth at the same speed, regardless of their weight? What could be harder to stomach than the idea that an object in motion tends to keep on moving in the same direction without help forever? What connection did this have with the world of chariots and stones that men knew, or with the perfect world of the heavens? What could be more fantastic and inscrutable than the mysterious property of inertia or the attractive force of something called "gravitation"? No, the Aristotelian system had answers that were generally much easier to digest and relate to the world around us.

Except that today we know the physical and astronomical views of the Greeks were just about all wrong. They described two worlds that didn't exist.

Their breakdown occurred gradually, partly because few had as complete and satisfying a system to substitute, and partly because many critics were simply interested in testing single timbers, not in rebuilding the whole structure. Take John Philoponus in the sixth century, A.D., for instance. He wrote:

"According to Aristotle, if the medium through which the motion takes place be the same, but the moving bodies differ in weight, their times must be proportional to their respective weights. . . . but that is wholly false, as can be shown by experience more clearly than by logical demonstration. For if you let two bodies of very different weights fall simultaneously from the same height, you will observe that the ratio of motion does not follow their proportional weights, but there will be only a slight difference in time, so that if their difference in weight be not very great, but one body were, say, twice as heavy as the other, the times will not perceptibly differ."

Logical demonstration

The method of logical demonstration continued to dominate, however, and the method of experience that Philoponus found so clear received no widespread attention until Francis Bacon's and Galileo's time. Still, Philoponus did not go unread. Some of the Islamic natural philosophers read him attentively. They knew that Aristotelian physics described motion as the consequence of a force acting against a resistance, and that movement was unthinkable without a resisting medium (else there could be a void). Philoponus, on the other hand, pointed out a kind of motion that could well exist in a vacuum—the motion of a body revolving in place upon its axis.

Philoponus went further. Suspecting that a resisting medium was not necessary to motion, he argued that the medium, air, was not what kept a projectile in motion. Rather, an impressed force, some kind of incorporeal power to move, was put into the projectile by its hurler and kept it moving until finally overcome by the tendency of the body to seek its natural place.

This intangible "dunamis" was a provocative idea to the great Islamic philosopher of the early eleventh century, Avicenna. In his *Book of the Healing of the Soul*, a compendium on Aristotelian ideas, he supported Philoponus and even went beyond him. He suggested that two kinds of tendencies could accomplish motion. One was the natural inclination of the falling body to seek its natural place, the other was the violent inclination of the projectile to remain in motion. Here emerged the "*mayl* theory" of projectile motion.

Avicenna defined *mayl* as the inclination in a moving body which can be perceived sensibly and which is a tendency or power for the body to keep moving. The *mayl* resists attempts to stop the body or immobilize it, and seeks to continue the motion.

The germ of an intertial idea can be detected in the *mayl* theory. However, Avicenna never suggested that rest and motion could be interchanged in this regard.

He was interested in the effects of violent *mayl*. Could it last forever? Supposing you impressed a *mayl* in a stone in a void. . . . Then the stone would continue to move indefinitely. Absurd, said Avicenna; Aristotle was right, the existence of a void is impossible.

Abu'l Barakat (who died about the middle of the twelfth century) added another twist to the discussion. He raised the idea of a *mayl* whose function fell in between the two kinds Avicenna had listed. *Mayl*, said Abu'l Barakat, could be used to explain the acceleration of a falling body. He took from Simplicius, a contemporary of Philoponus, the idea that some of the upward force remained in a stone thrown up in the air, even after the stone had started down. This would explain why the stone dropped slowly at first. But the tendency to seek its natural place is acting on the stone throughout the whole of its fall. In each succeeding instant of fall this natural tendency impressed more *mayl* into the body, and the *mayl* increased its speed. Speed thus was proportional to, and a result of, the amount of *mayl* impressed.

Here was a relation of force to acceleration, but in an Aristotelian-physics frame of reference, not a Newtonian. For the Aristotelian view required a constant force to keep a body in motion at a constant speed, and an increased force was necessary if acceleration were to occur. Like Aristotle and unlike Newton, Abu'l Barakat had to increase his force—the amount of *mayl* in the body —to obtain accelerated movement.

Testing and replacing

So Abu'l Barakat, too, was wrong. But Abu'l Barakat, like Avicenna and Philoponus and Simplicius before him, and like a handful of others that followed him, was engaged in the essential job of testing weak timbers in the Aristotelian structure and trying to replace them with something better. Al-Bitruji in twelfth-century Spain carried on these inquiries, as did Aquinas, Roger Bacon, and Peter John Olivi among those in the thirteenth century, and as did Gerard Oddo, Jean Buridan, and Albert of Saxony in the fourteenth century—but that is another story.

The result of their efforts was an accumulation of ideas along one line of development in physics. Similarly, the astronomers were engaged along another line of development, inquiring into the implications of the Aristotelian cosmology and improving upon the Ptolemaic system. Still others, medieval schoolmen, engaged in elaborate discussions on the kinematics of moving bodies. All contributed toward a loose continuity of events, and it was this continuity, this sort of an approach—the piecemeal efforts of a handful of men over many centuries, inspired and goaded by the Aristotelian explanations to understand them and test them —that finally culminated in the creation of Newtonian mechanics and the overthrow of Aristotelian physics.

GEOCHEMISTRY AT CALTECH

The Division of Geological Sciences moves into another new field of research, in its program to integrate the efforts of geologists, physicists, chemists and biologists.

by SAMUEL EPSTEIN

In recent years students of geological problems have felt an increasing need for the type of data that can only be obtained by methods developed and employed by physicists and chemists. Recognition of this need prompted physicists and chemists to become interested in geological problems and their contributions to the field of geology have been well established.

On the other hand, it has not been a common practice in universities to integrate the efforts of the geologists, the physicists, and the chemists towards training students or towards the solution of geological problems. Caltech has been among the first institutions to incorporate a coordinated program of physics and geology, both in teaching and research, in its geophysics and geology programs.

Two years ago, under the directorship of Professor Harrison Brown, a geochemistry program was set up to enable undergraduate and graduate students and staff members to undertake a variety of problems and to carry on this research under favorable conditions for exchange of ideas among the students of the various branches of geology. As a result of this conducive academic atmosphere, geological research related to paleontology, geomorpholgy and metamorphism has already elicited cooperative efforts involving geologists, geophysicists and geochemists.

The new facilities available in the Division of the Geological Sciences satisfy the needs of a large range of geological interests. Rock crushing, sizing and mineral separation facilities have been established for the purpose of preparing analytical samples under conditions where contamination is controlled carefully. The mineral separation processing employs heavy liquids, electromagnetic separators, centrifuges and other equipment. The principal use of these facilities recently has been made in research on acid soluble trace elements in igneous rocks.

Wilbur J. Blake, a silicate analyst formerly with the United States Geological Survey at Denver, is in charge of facilities for making the highly specialized and difficult silicate analyses. Such analyses have become very important to geologists in efforts to precisely delineate chemical compositional differences of different rock types as related to the environment in which they are found in the field.

Prof. Harrison Brown and Sam Epstein, Senior Research Fellow, check the recorded results of the mass spectrometer in the Institute's new geochemical laboratories.

In many cases rapid qualitative chemical analyses for a series of rock samples are desired. For this purpose an emission spectrograph has been installed, with spectroscopist Arthur Chodos, formerly of the U.S.G.S., in charge. By recording photographically the intensity of characteristic light frequency emitted by the different elements of a vaporized rock sample, rapid analyses for most chemical elements present can be readily made.

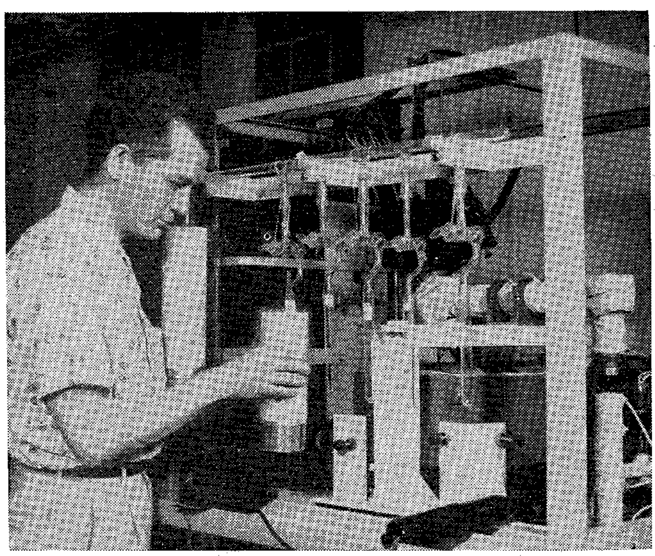
This instrument is particularly useful in determining concentration of minor constituents of a rock. Concentrations of as low as a few parts per million can be readily determined by using the spectrograph, whereas such determinations by wet chemical means are practically prohibitive. The importance of data on minor constituents as clues for evaluating the genesis and history of rock formations is well recognized, and is evidenced by the number of members of the Division using this instrument as a tool in their research.

Mineral analysis

X-ray equipment including powder cameras, goniometer-spectrometer and Brown recorder are available for mineral analysis. This equipment has been extensively used for studying calcareous fossil remains for their aragonite-calcite composition in Professor Heinz Lowenstam's pioneering work. Important relations between the mineral compositions have been observed.

In addition to these facilities there are two modern general chemistry laboratories which are equipped for qualitative and quantitative wet chemical analyses. These have been in continuous use by chemists Walter Nichiporuk, Richard Kowalkowski and Aiji Uchiyama in studies pertaining to chemical composition of meteorites and in studies pertaining to uranium and thorium distribution in igneous rocks.

For those interested in radioactivity studies, four low level alpha counters and two beta counters are available. The counters have been used extensively in determinations of natural radioactivity in rocks and in radioactive tracer techniques.



Sam Epstein freezes out a sample of carbon dioxide from the gas sample line of the mass spectrometer.

The facilities described above have been available, to some degree, to many geologists throughout the country, either in having been set up in some geology departments or else in having been provided as a service by the United States Geological Survey.

Among the most recently developed techniques and tools now set up at Caltech are those associated with isotope work. Two mass spectrometers for lead isotope analyses and one mass spectrometer for isotopic analyses of the lighter elements have been constructed under the supervision of C. R. McKinney, Senior Research Fellow, and will be available for research.

Since Professor Aston, the English physicist, first showed that the lead isotope method promised to be a method of absolute time determination, great interest in this method has existed. Naturally occurring uranium isotopes 238 and 235 and thorium 232 decay radioactively, with known characteristic rates, to produce lead isotopes 206, 207 and 208, respectively. By precisely determining the ratios of these isotopes by means of the mass spectrometer, the time of formation of the rock sample in which the lead is found can be determined.

There are of course many complicating factors, including the existence of non-radiogenic lead, which may affect the accuracy of dating by this method, but in any case the method promises to be a powerful tool to evaluate chronologically and geochemically many geologic events.

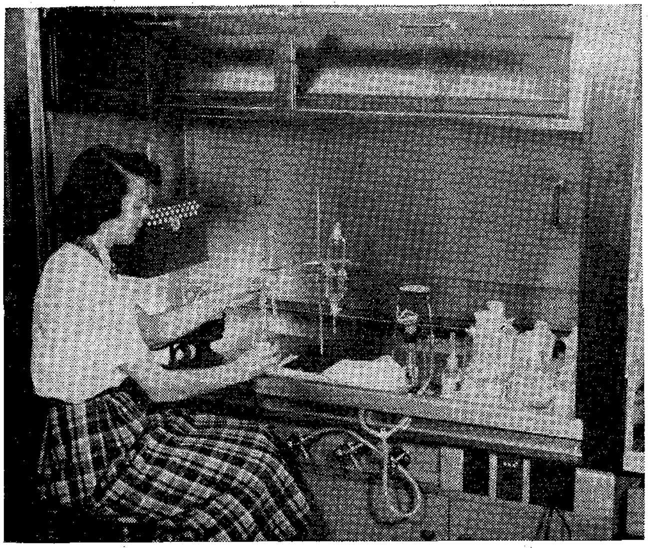
Lead isotope data

The scarcity of good lead isotope data is primarily due to the difficulty and expense in constructing specialized equipment and to the difficulty of the chemical techniques. In recent years, Claire C. Patterson, Senior Research Fellow, Professor Brown and their associates at Caltech have developed techniques whereby they are able to extract microgram quantities of lead from commonly occurring rocks and minerals. These lead samples can then be analyzed mass spectrometrically.

Most of the lead data now available are from lead ores whose origin is usually a complex one and do not represent the typical widely occurring rock formations. The development of these refined techniques for lead extraction from common rock types like granites and basalts represents an important step in increasing the usefulness of the lead method of dating. In addition, they promise more powerful methods for investigating many geochemical processes.

The extraction of such small quantities of lead from large rock samples introduces a serious problem of avoiding contamination with isotopically different lead.

Lead has become so commercially important and widespread that we virtually live in a cloud of lead. As a result, under normal conditions, the chemical steps taken



This lead-free laboratory has filtered air, lead-free paint, stainless steel work benches and fume hoods.

to extract the minute quantities of lead from the common type of rocks will introduce sufficient quantities of common lead to invalidate the subsequent isotopic determinations and time measurements.

To avoid such contamination, a special lead-free laboratory was constructed. The air entering the room is cleaned and filtered. The air pressure in the room is kept somewhat higher than the outside so that there is little danger of air diffusing into the room through small openings or while doors are being opened. The room is painted with lead-free paint and the work benches and fume hoods are constructed of stainless steel so that they may be washed with nitric acid and kept scrupulously clean at all times.

Recent work by Dr. Patterson has borne out that these precautions are indeed effective. He was able to extract minute quantities of lead of unique isotopic compositions from meteorites, with insignificant contamination with common lead, and as a result was able to assign the oldest experimentally determined age to the earth; namely, 4.6 billion years.

Non-radiogenic geology

Finally, facilities have been set up to do research in the field of non-radiogenic isotope geology. This field of endeavor consists of studying the isotopic composition of the lighter elements, such as oxygen and carbon, as they occur in nature.

In many cases the isotopic composition of these elements reflects the origin and history of the compounds in question because isotopic fractionation (a preferential separation of an isotope of an element relative to the other isotopes of that element) accompanies many chemical and physical processes.

Thus, for example, the isotopic composition of the oxygen of water and ice is affected by the cycles of evaporation and condensation; processes involved in the formation of igneous, metamorphic and sedimentary rocks are in most cases accompanied by isotopic fractionation of the elements of which these rocks are composed.

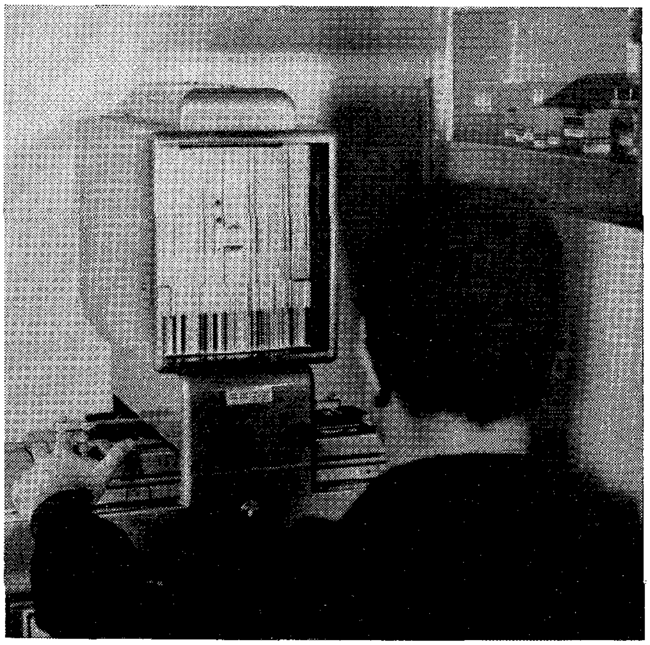
A modified Nier (60°, 6 inch) type of mass spectrometer for high precision isotope analyses and sample preparation apparatus developed by Professor Harold C. Urey and his associates at the University of Chicago have now been set up here and research in this field is now in progress.

Joint research

Drawn from many scientific disciplines, the members of the Division are actively pooling their training and interests in joint research where sound basic data have been limited or unavailable in the past. The availability of excellent equipment has given the cooperating workers the tools necessary to attack their problems more effectively.

The graduate and the undergraduate geology student have also become aware of the existence of a geochemistry group. The new two-year graduate course encompassing lectures dealing with subjects ranging from astronomy to biology includes many geochemical topics.

Undergraduate courses dealing with both theoretical geochemistry and laboratory experiments are now available, where the students have the opportunity to do a variety of experiments involving the use of most of the instruments discussed in this article. In most cases the student may not be able to do independent work with some of the more complex instruments and techniques, but in many cases the mere awareness of what these things can do should prove very useful in subsequent work involving either field or laboratory problems.



Arthur Chodos evaluates plates from emission spectrograph to analyze for chemical elements in rock sample.

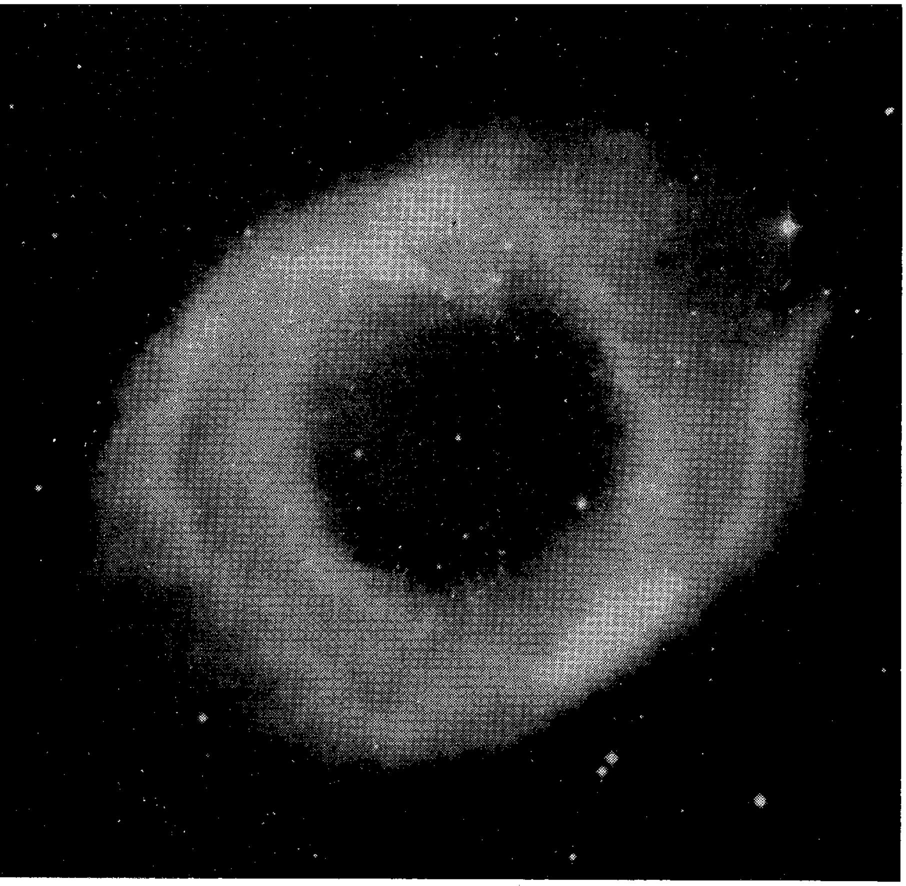
Nebulosity in Cassiopeia

PALOMAR PORTRAITS

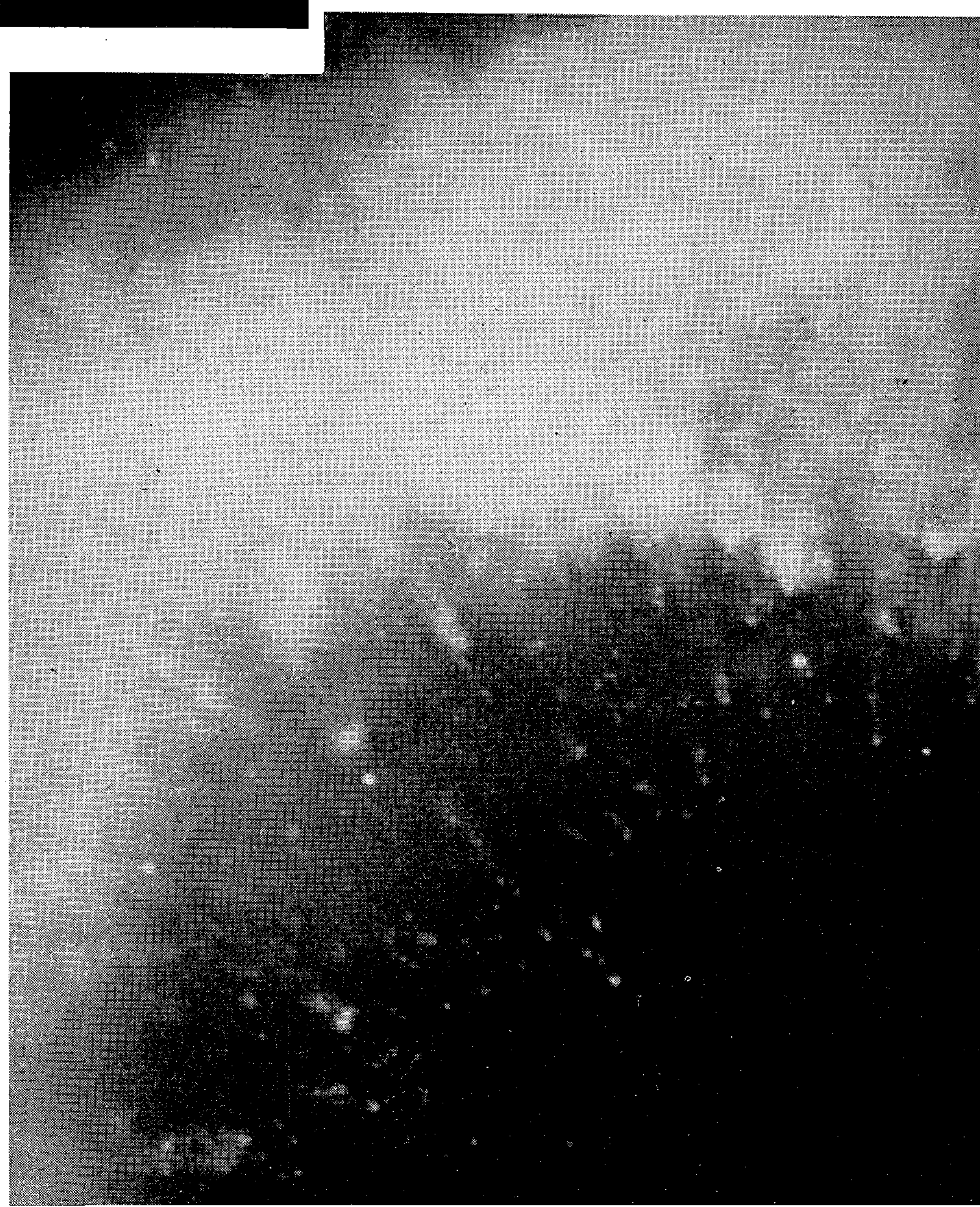
Same samples of recent photographs made with the 200-inch Hale telescope

The 48-inch Schmidt's picture of the spiral galaxy Messier 33.

The 200-inch telescope's close-up of the central region of Messier 33.



Planetary nebula in the constellation of Aquarius, photographed on a red-sensitive plate with the 200-inch telescope.



Section of the upper left quadrant of the planetary nebula shown above — enlarged about seven times. 200-inch photograph.

Richard P. Feynman

THE MONTH AT CALTECH

Einstein Award

DR. RICHARD P. FEYNMAN, professor of theoretical physics, was named winner last month of the Albert Einstein Award. The award, consisting of a $15,000 cash prize and a gold medal, is made every three years for an outstanding contribution to knowledge in the mathematical and physical sciences.

Dr. Feynman is widely known for his quantum theory of electricity and magnetism, which resolved the difficulties and inaccuracies inherent in early theories of quantum electrodynamics dealing with the interaction of atoms with radiation fields. In the last year or so he has been working on a theory of liquid helium.

The Albert Einstein Award, one of the highest honors in science, was established on March 14, 1949, on the seventieth birthday of Dr. Einstein, by Lewis Strauss, chairman of the Board of Trustees of the Institute for Advanced Study and chairman of the U. S. Atomic Energy Commission. It was first awarded in 1951 to Professors Kurt Godel of the Institute for Advanced Study at Princeton, and Julian Schwinger of Harvard University. Selection of the winner is made by a committee of the Institute for Advanced Study, which administers the award.

Dr. Feynman is the first to win the award alone. An M.I.T. graduate (1939), he received his PhD from Princeton in 1942. During the war he worked on the Manhattan District atom bomb project at Los Alamos, and in 1945 became associate professor of theoretical physics at Cornell University. He joined the Caltech staff in 1950.

Dean of the Faculty

PROFESSOR ROBERT F. BACHER, chairman of the Division of Physics, Mathematics and Astronomy, has been named dean of the faculty, to serve during the absence of Dean E. C. Watson, professor of physics, who is on a year's leave in Europe.

Dr. Bacher came to Caltech from the U. S. Atomic Energy Commission in 1949. One of the country's leading physicists, Dr. Bacher was professor of physics at Cornell University before the war. In 1941 he joined the Radiation Laboratory at M.I.T., which was headed by Dr. L. A. DuBridge. In 1943 he was released to become chairman of the bomb physics division of the Los Alamos Laboratory. He returned to Cornell at the end of the war, as professor of physics and director of the Laboratory of Nuclear Studies, until he was called to serve on the Atomic Energy Commission in 1946.

Dean Watson is on his first extended leave in 35 years. He came to Caltech as an assistant professor in 1919, became professor of physics in 1930 and dean of the faculty in 1945. After a quarter-century as right-hand man of Dr. Robert A. Millikan, he served first as acting chairman and then as chairman of the physics division from 1946 to 1949, when Dr. Bacher succeeded him.

ACS Awards

THE AMERICAN CHEMICAL SOCIETY, at its 125th national meeting in Kansas City last month, honored Caltech scientists with two awards. Dr. John D. Roberts, professor of organic chemistry, received the $1,000 ACS Award in Pure Chemistry, and Dr. Harvey A. Itano, senior research fellow, received the $1,000 Eli Lilly and Company Award in Biological Chemistry.

This is the second year in ACS history that two staff members of the same school have received national awards. In 1950 Dr. Verner Schomaker, professor of chemistry, received the Award in Pure Chemistry, and Dr. A. J. Haagen-Smit, professor of bio-chemistry, received the Fritzche Award.

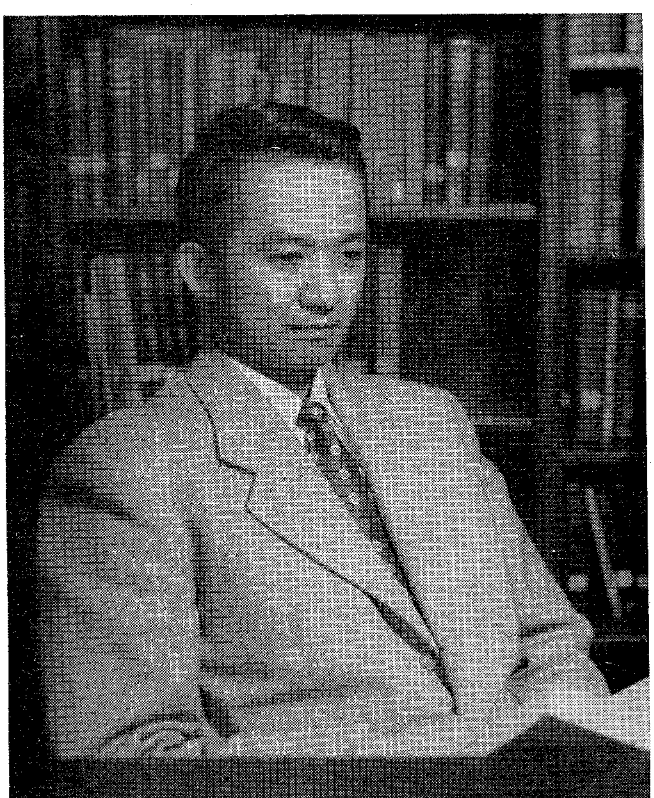
Dr. Roberts is an outstanding researcher in the chemistry of organic compounds. His experimental and theoretical investigations, particularly with the use of radioactive tracers, have added much to the understanding of how carbon-containing compounds react.

Dr. Itano is a senior research fellow at Caltech under assignment by the U. S. Public Health Service, which he serves in a research capacity as a senior assistant surgeon. His investigations of hemoglobin have been cited as bringing medical science its first precise molecular interpretation of a disease (sickle cell anemia), and this work is considered a start on understanding physical and chemical processes basic to diseases.

John D. Roberts

Deep Quake

ALL EARTHQUAKES are more or less unexpected, but some are exceptionally so. Perhaps the most surprising earthquake of recent years occurred on March 29, 1954. It was felt over a wide area in western Europe, with some damage occurring in regions of southern Spain.



Harvey A. Itano

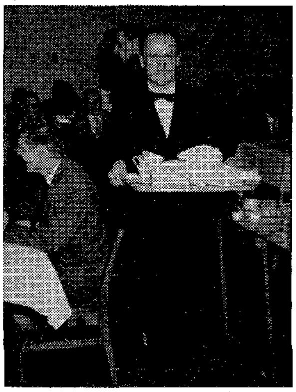
Workers at the Caltech Seismological Laboratory were startled to find that they had recorded an earthquake of major magnitude (about $7\frac{1}{4}$) originating at about the right distance for Spain, but at a depth of over 600 kilometers.

Shocks of this kind write very complicated seismograms, so there was room for other interpretations, but within a few days confirmation was received via the internationally organized exchange of data. The epicenter of this extraordinary shock was in the Sierra Nevada (the original one in southern Spain, after which the California range was named).

Up to 1954, shocks originating at such depths were known only from the regions surrounding the Pacific Ocean, including the East Indies. And theorists had even developed far-reaching patterns of forces and movements in the earth's interior which "explain" why the earthquake-producing stresses extend to the 600-kilometer level only in the Pacific region. The recent quake under spain, at the 600-kilometer level, means that a good many of these carefully constructed theories will have to be reappraised.

Dr. Beno Gutenberg, director of the Seismological Laboratory, and Dr. Charles Richter, Professor of Seismology, had just completed final proofreading on a second, revised edition of their compendium, *Seismicity of the Earth*, when the quake came. An airmail addendum went off to the press—but if the quake had happened sooner, there would have been a good many changes of language scattered through the text.

FACULTY WAITERS



For their second consecutive victory in the ASCIT Consolidated Charities Drive interhouse competition, the men of Dabney House were rewarded on Thursday, March 4, with a formal banquet of four courses and an after-dinner show featuring distinguished members of the Caltech faculty with their hair more or less down.

Faculty members waited on tables as part of this prize last year as well as this year, but the entertainment was a new feature which certainly met with general approval.

The ASCIT Charities Drive is sponsored by the student body and was directed this year by George Johnston, ASCIT vice-president. Solicitations are made of graduate students and members of the faculty by students in the undergraduate houses, and the house whose men have solicited the biggest total is treated to this evening of fine food and fine entertainment.

The festivities started shortly after six o'clock with the serving of the first of the four courses by the faculty waiters, who were led by Headwaiter George Beadle and who included on their impressive rolls Drs. Pauling, Davidson, Kyropoulos, Paul, and Eagleson, and Deans Strong and Eaton. Even the kitchen of the student houses got into the holiday mood and served up New York steaks for the lucky Dabneymen.

The dining room atmosphere was lush and formal and illumination was by candlelight. Music was furnished for this elegant setting by a chamber music group composed of Drs. Brown, Erdelyi, and Duwez, with Mr. Campbell at the piano.

The waiters, who were doing pretty well despite their inexperience (well, it *was* their second year at that), had cleared the tables by 7:40 and the entertainment began.

Dr. DuBridge was to have served as master of ceremonies but he explained that his duty led him elsewhere, and with regrets he turned the toastmastership over to Dr. Whaling (Physics), who introduced the rest of the program.

Dr. Whaling told the audience that some years ago, when the plans for educational television first reached the drawing boards, the Caltech administration had felt that it should prepare an educational seminar for programming. After many months of hard work it had finally readied this seminar for presentation. The evening at Dabney, he explained, was the "dress rehearsal,"

RIDE AGAIN

and if it was successful the seminar—entitled "Science Speaks"—was to go on the air "at an unannounced time in the future."

The program was sponsored by "nackle—spelled N-A-C-L—the stuff that makes you crackle," and two instructors who shall remain nameless here presented what might possibly be called a commercial. Tirelessly they praised the virtues of NACL, "the new wonder tonic." "Use it in place of salt," they suggested; "wherever salt is used, NACL may be safely substituted!"

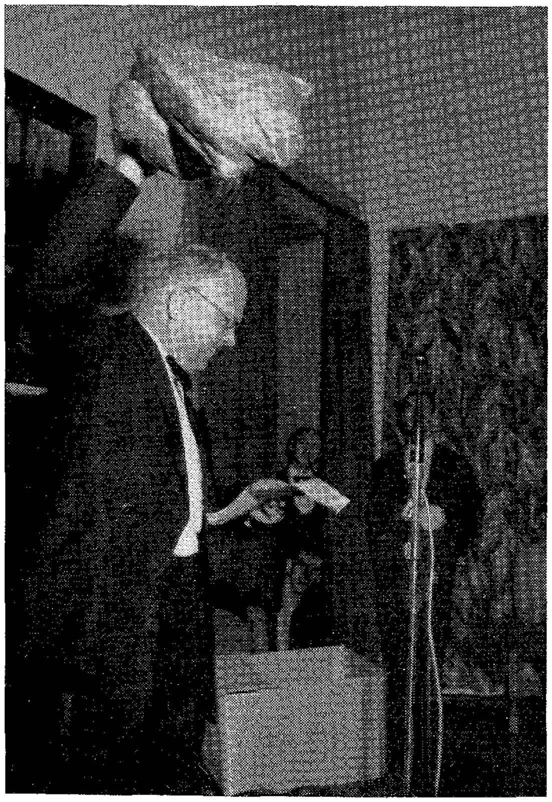
The seminar then began with a lecture by Dr. Cowan (Physics) regarding the velocity of escape of flies from flypaper. Studies of the rather low coefficient of restitution of such collisions, Dr. Cowan reported, were expected to lead to information on the mean free paths in an equilibrium mixture of gnats and mosquitoes. Unfortunately, he said, the experiments had been carried out on a very cold day, reducing the partial pressure of flies in the atmosphere to an extremely small quantity and invalidating the results of the experiment.

Professors Small (Air Science) and Clark (English) then gave a "demonstration lecture on aeronautics" which actually amounted to a somewhat bawdy song entitled "I Wanted Wings" ("until I got the — —— things"). The two gentlemen, dressed as they were in almost unrecognizable "monkey suits," were only slightly fazed by the realization that their profanity was falling on the ears of several feminine guests whom the gallant Dabneyites had invited to the dinner. The girls, however, were good sports about the whole thing, and Small & Clark were permitted to retain their commissions.

Dr. Harrison Brown (Geochemistry) then produced some excellent piano renditions of "St. Louis Blues" and "The Sheik of Araby." The unusual nature of the arrangements could not hide the fact that there was real musical talent here.

The program ended with a lecture by Dr. Fowler (Physics) on the pecking order ("order of peckulation") in domestic fowl, the practical sociology of the coop, and application to the genetics of lower animals.

By 8:15 it was all over except the reminiscing. Some may have gone up to snake, others out to celebrate; but all were surely in a good frame of mind, and Dabney to the man could be pleased and proud of its record and its reward. —*Martin Tangora '57*



Cable specifications and

THE POSSIBILITY of fires and personal injury connected with distribution of electricity by means of wires and cables, means that such wires must conform to certain minimum requirements. This was recognized in 1881 by New York's Board of Fire Underwriters, when it outlawed the use of bare or uncovered wires for the distribution of electricity in buildings and adopted "A standard for Electric Light Wires, Lamps, etc." This standard contained five rules, one for the conductivity of the conductor, one describing the insulation and the other three dealing with installation of electrical equipment. The rules for the conductor and insulation read as follows:

"1. Wires to have 50 percent excess conductivity above the amount calculated as necessary for the number of lights to be supplied by the wire.

"2. Wires to be thoroughly insulated and doubly coated with some insulating material." These two rules constitute the first effort to set up limits or to be specific with regard to insulated wire for power distribution. In other words, they constitute the first specification for insulated wires and cables for the distribution of electricity.

Historically, the next important concept concerning the covering was that of its insulating properties or its ability to confine the potential to the conductor. This was established by setting up minimum thickness of the insulation for the various conductor sizes and providing requirements for test voltages and insulation resistances for these thicknesses. Such requirements were included for the first time in the National Electrical Code for 1899. The insulation thickness for rubber insulation for a given voltage service and conductor size was essentially the same as that used today, namely, 3/64" on size 14 Awg. for 600 volt cable. The test voltage requirement was 3000 volts per 1/64" of insulation thickness, after immersion in water, distinctly more severe than present requirements. The insulation resistance requirement for 600 volt wire was 100 megohms per mile. The 1899 code also contained requirements for the dimensions of copper conductors and for tinning of conductors for rubber insulated cables. There appeared here, for the first time, a requirement for braids.

This was followed by the establishment of minimum requirements for tensile strength and elongation of rubber insulations in the original specification of the Association of American Railroads in 1905 and Underwriters' Laboratories, Inc. Standard about 1911. The 1905 specification of A.A.R. also included requirements for the chemical composition of thirty percent rubber insulation. These requirements were later adopted by Underwriters' Laboratories, Inc. and the American Society for Testing Materials.

Although aging requirements for rubber insulation were proposed in connection with the first specification of the Association of American Railroads, it was not until 1933 issue of Specification D 27 of the American Society of Testing Materials that aging became an industry specification requirement for rubber insulations. The requirements for heat-resisting rubber were included for the first time in A.S.T.M. specifications for 1937. The requirements for moisture resisting rubber insulation were established about this time. The requirements for Polyvinyl Chloride and Laytex insulations were established in the National Electrical Code of 1940. Since then the requirements for the various synthetic rubber insulations have been set up.

During this period, other types of insulations such as paper, varnished cambric and asbestos and many types of sheaths and coverings for wires and cables were developed. More detailed requirements for conductors were also established. There are today, therefore, a wide variety of cables for use in the distribution of electricity for power and control purposes.

Practically every element of these wires and cables is covered by detailed specification requirements or standards. There are specifications for bare or uninsulated wires and cables, for covered wires, such as weatherproof wire and all insulated wires and cables, regardless of the type of insulation or coverings. Such specifications cover, in detail, the construction and requirements for the conductor, the thickness, physical, aging, electrical, moisture

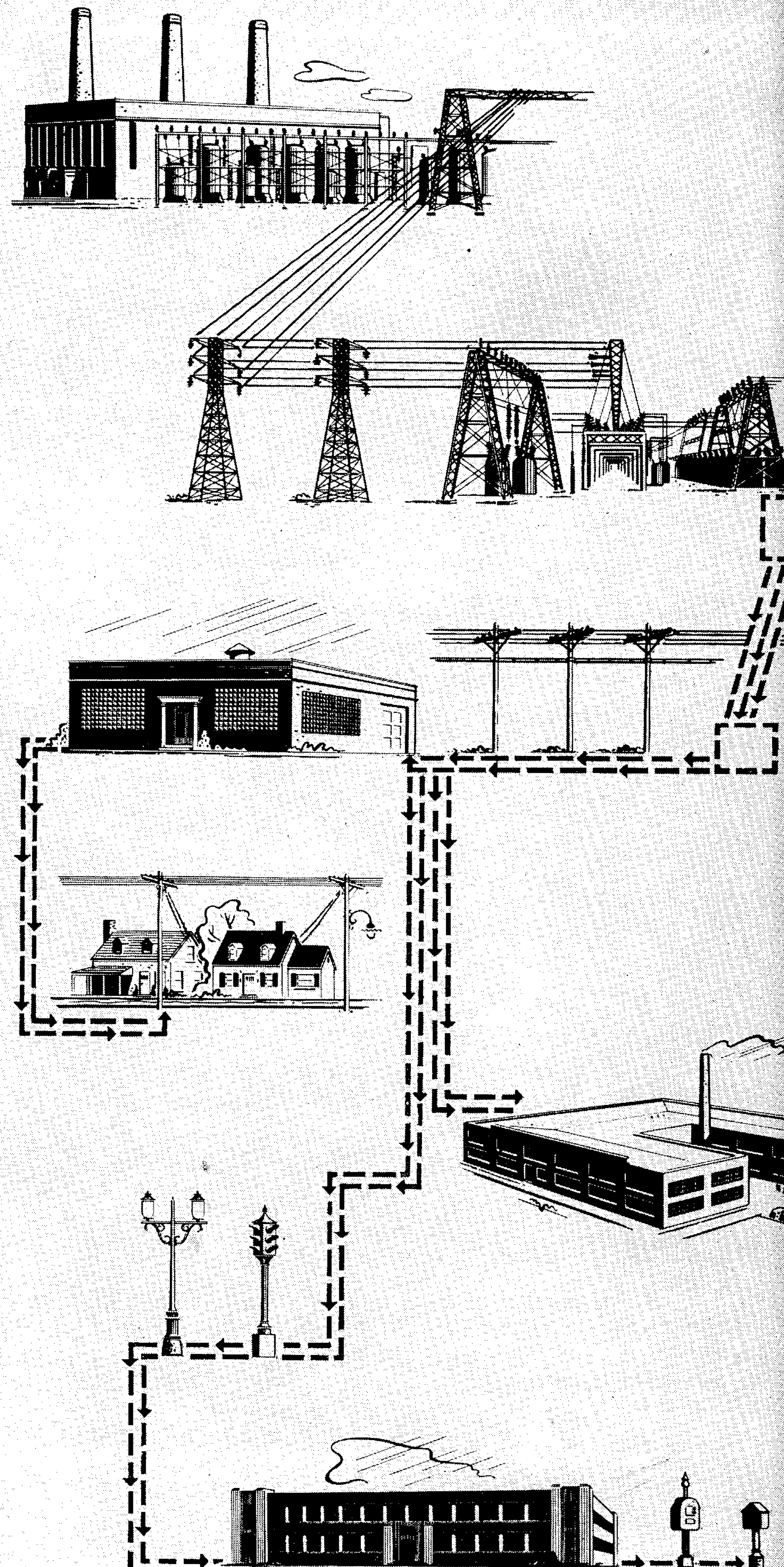
standards

and ozone resisting properties of the insulation, the construction details of the cables and the thickness and other properties of the covering or sheath. These specifications are issued by literally hundreds of manufacturing organizations, municipalities, railroads, utilities, government agencies, etc. They may differ only slightly but significantly, in certain details, thus making it necessary to run many wires on special orders. The wire and cable industry is thus obviously specification conscious. In fact, it is probably true that all types of wires and cables used today are more completely covered by specifications than any other class of commercial products of equal complexity.

Specifications have thus become a necessary and important part of the wire and cable industry. When properly prepared on the basis of sound engineering, information and manufacturing practices, they provide for durable, economical and safe cables for any particular application. They describe the item in a clear and concise manner that can be readily understood by any one familiar with the industry. They form the basis for contracts between cable users and cable manufacturers, and eliminate or minimize any questions that might arise concerning the construction or quality of the cable under consideration. A working knowledge of wire and cable specifications is essential for those interested in the development, manufacture and use of wires and cables.

US RUBBER

No. 5 in a Series



Mrs. Joe Lewis, Mrs. Francis Greenhalgh, Fred Felberg '42, Francis Greenhalgh '41, Charles Strickland '43, and Joe Lewis '41 enjoy a break between lectures.

ALUMNI SEMINAR DAY, 1954

THE 17th Alumni Seminar brought 550 alumni, wives and guests to the campus on April 3. The daytime program featured a series of ten lectures—on everything from desert flowers to molecular diseases—and lunch in the Student Houses. Dinner speakers, at the Pasadena Elks Club, included President DuBridge and Dan Kimball, former Secretary of the Navy, and now president of the Aerojet General Corporation.

Above: Jerry Foster '40 and Ken Kingman '29, president and vice-president of the Alumni Association.

Right: Prof. Linus Pauling, one of the day's speakers.

Below: Hugh Carter '49, chairman of the Seminar Committee.

Dr. Henry Borsook,
Caltech Professor
of Biochemistry

BIOCHEMISTRY

A Report on Research in Progress

THE FOLLOWING ARTICLE *is a transcript of a radio interview with Dr. Henry Borsook, Caltech Professor of Biochemistry. Dr. Borsook, an M.D. who chose biochemistry as a career, is doing research on the biological synthesis of protein. His research is supported in part by a grant from the American Cancer Society.*

This interview was conducted on the program, "Report to the People," a monthly report from the American Cancer Society, and was broadcast over KABC, Los Angeles, and the ABC Coast and Mountain Network.

That your work is supported by the American Cancer Society, Dr. Borsook, means, I take it, that it has a bearing on the problem of cancer.

Yes. To explain how, I think I had better say a word or two about my subject in general. The aim of biochemistry is to know what all the substances in a cell are, what happens to them, and how, in their combined action, they make a cell or an organism do what it does. Of all the substances in animals and plants, proteins and nucleic acids are most characteristic of living things. From the time I began to study biochemistry I have been mainly interested in proteins.

What is so special about proteins?

Of all the solid matter in our bodies there is more of protein than of any other class of substance. The bulk of muscle, liver and all other organs is protein. We think of protein as meat and eggs. But hair, finger nails and toenails, horn are proteins. Skin is mostly protein. That is not all. The machinery of all cells, substances we call enzymes—without which little, if anything, would go on—all enzymes are proteins. Some hormones, like insulin and ACTH, belong to the class of proteins.

And you are studying the biological synthesis of protein?

Yes.

By that you mean how cells build proteins up?

"Build up" is the exact phrase. Proteins are very large molecules built up from 20 different kinds of bricks called amino acids. Hundreds, even thousands, of these 20 different kinds of bricks go to make one protein molecule. Given 20 different kinds of bricks, using a hundred or more of any one kind, you can make structures of many different shapes and sizes. Most animal proteins have pretty much the same average composition. Yet they carry out quite different operations. The differences between them reside in that their constituent amino acids are arranged in different patterns and in structures of different sizes. There is something in cells which guides them to making these complicated patterns always the same. Not only that, but they make pretty much the same number of each kind of pattern.

Does each cell do all its own construction of protein?

We think so; but really we don't know whether each cell does the whole job itself, or only finishes the job.

Do you mean that it may be that when we eat foods, such as meat, milk and eggs, the cells in our bodies take the proteins in these foods and just change them around a little bit?

No. When we eat these foods the whole, fine, complicated structure of their proteins is wrecked in our stomach and intestines. They are broken down to their constituent bricks, the amino acids. Digestion is, chemically speaking, a wrecking operation. For example, a baby: At first it gets only milk; the milk proteins are broken down in its stomach and intestines to amino acids; these now pass into the blood; each tissue takes from the blood amino acids to build itself. That is how, from milk, a baby makes muscle, skin, all its organs, blood, everything. That is how milk is transformed into a growing baby. It is the same with us.

How do you mean "it is the same with us"? We aren't babies; we aren't growing.

Although we aren't babies, we are continually renewing ourselves. You know that hair grows all our lives. But what I mean is more deep-rooted than that. For example, every seven days about half the liver has broken down and rebuilt itself. It rebuilds itself as fast as it breaks down. In some tissues this process is faster than in the liver, in others slower. Take again the picture of a protein molecule as a large brick structure. What goes on in the body is as if bricks were flying out all the time, and immediately being replaced by the same kind of bricks in exactly the same places. The result is that on ordinary analysis the body appears not to change. And yet it is always changing and it always remains the same.

How, then, can you tell, if it always appears to remain the same?

By the use of what we call labeled molecules. The molecules are literally tagged. The amino acids are synthesized with one or more of their carbon atoms radioactive. The radiation we use is too weak to have any significant effect in the cell; but we can measure the radioactivity after isolating the substance in which it is. The amount of radioactivity is a measure of the number of molecules so tagged.

When we want to measure the changing process of protein synthesis we begin with a tissue in which none of the molecules are tagged. We then introduce the tagged molecules, which otherwise are exactly the same as the ordinary kind. After a short time, the protein is isolated and the amount of radioactivity as measured in a Geiger Counter gives the number of tagged molecules in the tissue protein; and this tells how many of the fresh tagged molecules have gone in to take the place of an equal number that have gone out. It was by this method that we learned that the liver, for example, is breaking down and rebuilding itself all the time.

How does the body know how to balance breakdown and rebuilding so nicely?

That we don't know and are trying to find out. In normal growth, building up in all tissues is a little faster than breakdown. In wasting diseases there is more breakdown than building up. In recovery from these diseases, in the repair of wounds, only in tissues that were damaged is the building up faster than breakdown. A growing tumor or cancer takes amino acids that come from food protein and the breakdown products from other, normal cells, and uses them for its own growth, at such a rate that the body as a whole slowly loses. A small fraction of the loss in the body as a whole is represented by gain in tumor mass. Just how a tumor or cancer drains material away from other, normal tissues we don't know yet. It isn't the size of the tumor, because this often happens when the tumor is quite small, relative to the whole body mass. Something has happened to the regulation.

In your studies of protein snythesis how do you go about it? What tissues do you use?

We use immature red cells. This enables us to study protein synthesis outside the body under conditions that we can control much better than in the whole animal. In the right salt solution, kept at body temperature, these cells remain as intact and as alive as in the body. Protein synthesis is relatively fast in these cells, two or three times faster than in the liver.

Do you think that what you learn from these immature red cells may apply to tumor growth?

Yes, for two reasons. The first is that biochemistry of the last thirty years has found that all living forms, whether animals, plants, or micro-organisms, carry out even very complicated processes in the same way. In fact, much of the machinery, the enzymes, is identical and the steps in the process are the same. So whatever we learn from one tissue, even a normal tissue, probably holds in a growing tumor. And so all biological studies, in all biological forms, throw some light on the biology of cancer. The second reason is that immature cells and cancer cells, biochemically, resemble each other. The similarity is closer between them than between normal adult cells and cancer cells. The fact that immature cells and cancer cells are growing, that is, increasing in mass, while normal adult cells are not, points up the similarity.

How do you think your findings on protein synthesis in immature red cells may throw light on tumor growth?

A cancerous growth is abnormal. We can't understand how it is abnormal unless we know something about the normal. Most of the growth is of protein. Having learned some of the salient features of protein synthesis

in normal tissues, it will then be possible for us to examine whether cancerous tissues are in any way different, i.e., abnormal. This may seem a slow and roundabout way to attack the problem, but the whole history of science teaches that, in the long run, it is best to get fundamental information. By this I mean first getting information that is generally applicable, and then applying this fundamental knowledge to a specific problem. This is a faster way of getting results than by just trying things.

One of the reasons for choosing immature red cells to work with is that it is not difficult to get a lot of them whenever you want them. Another reason is that we can isolate easily for these cells a single, well-defined protein, in this case hemoglobin. We can learn more about the synthesis of proteins in general by learning how the special pattern of one is put together. Dealing with a mixture of patterns, one can't learn anything special.

This is rather general. Can you tell us anything specific from your own work?

I can tell you about some of our most recent findings. But I want to make clear and emphasize that I have no idea at present what their bearing may be on the cancer problem. We have found that in blood, liver and organs there are small amounts of certain special substances that stimulate protein synthesis in immature red cells. The rate may be increased two to four times. They are a family of chemically related substances that were not known before. We have learned how to isolate them in a relatively pure state, and how to identify and measure them in very small amounts. We can measure a millionth of an ounce. And we think we have a pretty good idea of their chemical structure. Now, turning to cancer, either we or others will investigate how much of these stimulating substances is in tumor tissues, whether these tissues have more or less of these stimulating substances, as compared with normal tissues, and whether they are the same kind.

Would you care to speculate on other possiblities from this finding of yours?

Speculation is a precarious business for a scientist talking to a lay audience. His guesses may be taken for predictions, even promises, when they are only guesses, really. Nevertheless, I think I may, without giving a misleading impression, refer to the work of others to indicate how our findings may lead to a new line of exploration. Most biochemical processes are carried out by a special class of proteins called enzymes.

Enzymes are, as I've said, the machinery of the cell. For a substance to be acted on by an enzyme, the sub-

SCIENCE WRITERS

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stance and the enzyme must fit together very closely, like a key in a lock. When a key is not quite the right one, you may get it into the lock but then it jams the lock, and you may have a hard time getting the key out.

One line of investigation begun and carried on extensively by many other workers has been to make substances that are very like the natural substances that enzymes work on, but still just a little different. They attach to the enzyme because they fit nearly perfectly, but because they don't fit exactly the enzyme can't do anything with them, and (like the right key in a jammed lock) the natural substances that do fit perfectly can't get to the enzyme. So, because the enzyme can't operate, the whole process stops, and if it persists for long the cell will die.

The stimulators you have found operate by fitting on to enzymes that build up protein?

In a way we don't yet understand the enzyme needs these stimulators to join the amino acids together to make a whole protein. Knowing the chemical structure of these stimulators, it may be possible for us to make others like them, but just a little different, to see if certain enzymes needed for protein synthesis can be blocked. The difficulty is to find such an unnatural substance that will block the enzymes in cancer cells much more effectively than those in normal cells. If they block the enzymes in normal cells, then they will be poisons and of no therapeutic value.

What are the chances of finding such a substance that will block enzymes synthesizing proteins in cancer cells more than in normal cells?

I don't know. My guess is that the chances are not great. It will take a lot of work, testing a great many such compounds. And the silver bullet may be found in some quite different line of investigation. Penicillin was first found in a study in which the investigator had no thought of an antibiotic in mind. In fact antibiotics were entirely unknown then.

I hope I have made clear the need for investigating the cancer problem on a broad front, and the usefulness to the cancer problem of studies of processes in normal tissues. This is the reason that the American Cancer Society, advised by leading scientists of the country, is supporting investigations along many lines, with normal as well as abnormal cells and tissues, in order to get the necessary fundamental information to attack the cancer problem in an informed, intelligent way.

I will conclude with one prediction. The fundamental information so gained will be found useful not only in the cancer problem but in the understanding, prevention and treatment of other diseases.

PROF. BROWN'S REPLY

Sir:

I was interested in Rev. James O'Reilly's comments concerning the abstract of a chapter from my book, *The Challenge of Man's Future*, which appeared in *Engineering and Science*.

An abstract of an article is usually unsatisfactory and an abstract of a part of a chapter from a book, where one chapter is dependent upon another for substantiation of an argument, is usually doubly unsatisfactory. I say this, not because I believe that this particular abstract in any way gave the wrong impression concerning either my convictions or the facts upon which they are based. Rather, I say this because Dr. O'Reilly clearly believes that I have been unfair in my presentation. In this connection, it is my sincere hope that he will convey his impressions to me after he has read the complete argument.

Clearly, there is little possibility of our agreeing on the issue of birth control, for *a priori* we occupy different positions by virtue of the different conditioning processes to which we, as individuals, have been exposed. But I do believe that it is possible for us to agree upon whether or not I have been unfair, for I doubt very much that Dr. O'Reilly considers a person to be unfair simply because that person expresses convictions which differ from his own.

At the outset, I would like to stress that I, in common with many of my colleagues, am weary of the cliché of the amoral, Godless scientist. Had I no clear set of moral values, I would not have written *The Challenge of Man's Future*. To be sure, my set of moral values differs from that of Dr. O'Reilly in many respects. And I admit that I do not consider my set of moral values to be absolute. Dr. O'Reilly has found what he believes to be the Truth. I can only say that I search for the Truth, to possess moral values which, although not absolute in Dr. O'Reilly's sense, have nevertheless been held by men throughout the ages, among them Jesus. And in this connection I cannot restrain myself from adding that many of the moral judgments of the Church to which Dr. O'Reilly has dedicated himself have changed not only with time but with geography and with culture.

If my interpretation of the creedist's use of "unnautral" to mean "artificial" instead of "perverted" is contrary to Dr. O'Reilly's understanding, it certainly accords with the meaning as understood by many Catholic laymen of my acquaintance. This is indeed a question of semantics and I apologize if I have offended that small segment of the Catholic faith which understands the subtleties of technical moral language in the way that Dr. O'Reilly does.

A more important point involves my statement concerning the "fear of creedists". Here, Dr. O'Reilly confuses respect for the truth of creedists' creeds, which I did not mean, with fear of their political power, which I did mean. This latter fear is felt by large numbers of people, as the most casual observation of the day-to-day political scene shows clearly.

It is obvious, for example, that the Catholic Church officially opposes the right of any person, of any creed, to use contraceptives. This opposition has led to the prevention or break-up of meetings of non-Catholics where birth-control was to be discussed, to attempted boycotts of magazines, to the incredible campaigns of misrepresentation involving birth-control legislation in Massachusetts. I believe

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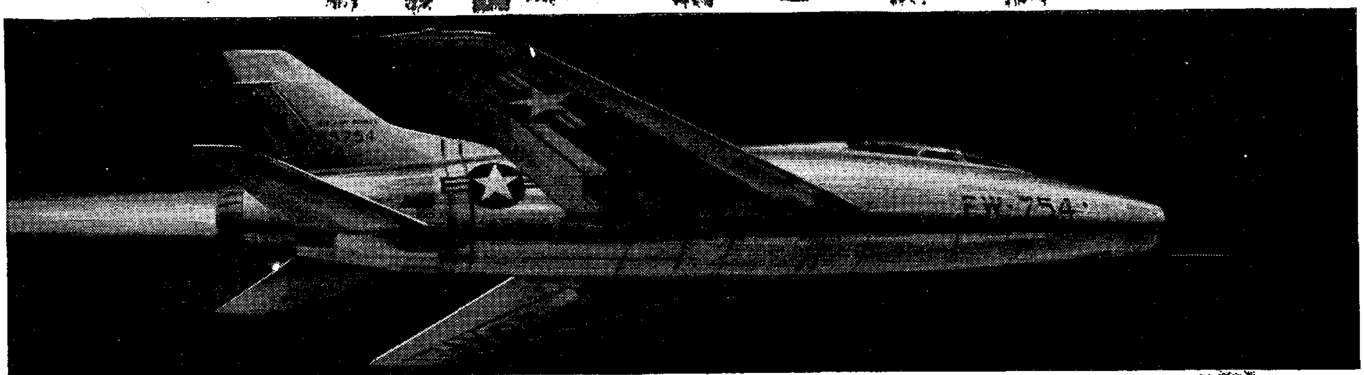

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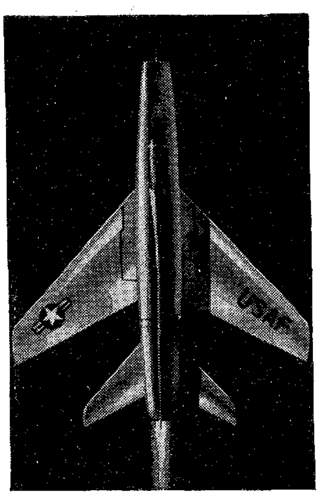

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that Dr. O'Reilly himself would agree that the lack of attention to birth control given by both national and international public agencies and by our great foundations results not from "fear of creed" but from "fear of creedists".

Dr. O'Reilly discusses continence at some length, and it seems clear that he believes that the proper solution of the world's population problems lies in the direction of restraining sexual activity. I believe that we could join in serious debate as to whether continence is more "unnatural" (or "artificial") than the use of contraceptives.

To be sure, a degree of continence has resulted in lowered birth rates in Ireland, but I seriously doubt that it is either desirable or possible to create such a culture on a world-wide basis. Even in strong Catholic countries such as France and Italy, to what extent does strict continence contribute to lowered birth-rate? Can we imagine a France and an Italy in which populations are stabilized without recourse to unnatural or artificial means?

In conclusion, I cannot refrain from c o m m e n t i n g upon Dr. O'Reilly's accusation that I have resorted to the use of "wild and whirling words". I found the accusation surprising, for I personally considered my description of attitudes and actions concerning contraception to be both moderate and polite. Indeed, as Dr. O'Reilly knows full well, my words were mild when compared to some that have been uttered by his fellow churchmen in opposition to birth control. Here, I refer to Father Daniel A. Lord's reference to women who use contraceptives as "daughters of Joy" and to Father Dominic Pruemmer's statement that "birth control is nothing else than mutual masturbation or unnatural lust."

Such statements indicate that when it comes to the use of "wild and whirling words," I am a novice.

Harrison Brown

Division of Geological Sciences
California Institute of Technology

as the economic problems confronting all men become more serious.

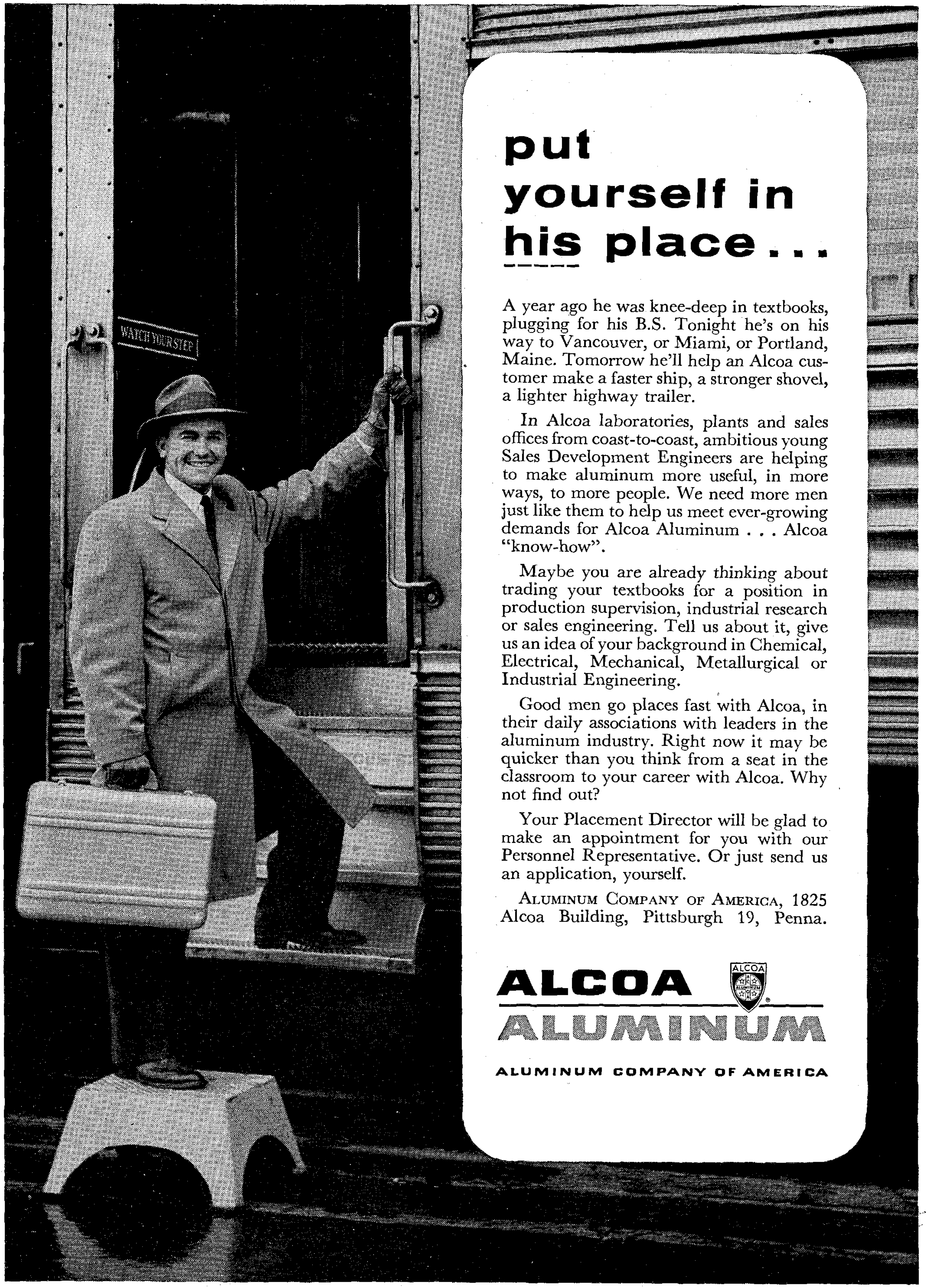
Thus, it is not merely a question of how many people can the earth support, but also, how will our economy and society adjust itself to the complex problems associated with cutting a smaller and smaller pie into more and more pieces?

What of science and technology? Can they not save us from the apparently inevitable drift towards want? In a chapter entitled "Horizons and Mirages," Osborn takes a close look at certain limited possibilities for increasing food production. Recent trawling operations in the Bering Sea and off the coast of Washington have revealed astounding storehouses of edible marine life on the ocean floor in these regions. In addition, plankton, seaweeds, pond culture, yeasts and algae can be of some help. But all these put together, even if intensively developed, would only delay, not avoid, the inevitable "Hour of Decision" (Osborn's final chapter). The brute fact is that we are behaving, population-wise at least, like a hutch full of rabbits, and our capacity to reproduce far exceeds our capacity to produce those things upon which life itself is based.

Global birth control?

Inevitably, we must decide to extend the practice of the limitation of the human capacity for reproduction. Already two nations of the world have declared it in the national interest to practice birth control. Interestingly, although one of these nations (India) is beset by a serious food shortage already upon her, the other (Sweden) is operating with unusual and commendable foresight, being under no greater population pressure than are we at the present time. Opposition to global birth control will certainly be widespread, especially in Catholic circles, yet Osborn is confident that under the press of circumstances, even religious dogma can be altered.

In brief, then, either we make the decision to stabilize our population to match some existing or future level of production, or other forces (perhaps the Four Horsemen of the Apocalypse) will make it for us. We cannot evade the choice. In clarifying the nature of this problem, Osborn has scored again, with a worthy successor to *Our Plundered Planet.*



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PERSONALS

1918

Gene Heywood writes from Chicago that his old firm, Harris, Hall & Co., recently merged with Dean Witter & Co., investment bankers, with headquarters in San Francisco. Gene will continue to be in charge of the corporate buying department of the new organization in the Middle West.

1922

Harold S. Ogden is serving on the Gannon College Engineering Advisory Committee, directing vocational guidance activities for engineering in the Erie, Pa., City Schools. As Supervising Engineer of Electric Locomotive Control at General Electric, Harold has a hand in the design of some rectifier-equipped locomotives for the New Haven Railroad. Back in 1952 he won a Modern Designs Award from *Design News* Magazine.

Jochim F. Voelker has been superintendent of Plant 4 at the Penn-Dixie Cement Corporation in Nazareth, Pa., since May, 1951. Previous to this he was at the Portland Cement Company plant in Riverside, California.

1927

Bill Minkler reports that he is still actively engaged in atomic energy research at Westinghouse in Pittsburgh, Pa.

1928

Tomizo Suzuki has been transferred from Okinawa to Tokyo, where he is now working for the Japan Construction Agency with the title of Civil Engineer in Construction Branch of Construction Division.

Charles F. Lewis writes from Houston: "Same old job, same old grind—too old for family additions—too young to die a millionaire with the other Texans."

1931

L. D. Huff, PhD, has been head of the physics department at Clemson College, South Carolina, since 1946. The Huffs have two sons—Charles, 3, and Edward, 1.

1932

James E. Bradburn has been named as executive vice-president of the newly formed ElectroData Corporation, a subsidiary of Consolidated Engineering in Pasadena. He will direct operations of the new corporation, which will continue the engineering, manufacturing and sales activities formerly conducted by Consolidated's Computer Division.

Jim served in a variety of engineering and administrative posts with General Electric and the Eastman Kodak Company before joining Consolidated Engineering in 1945 as treasurer and assistant to the president. During World War II he was in the U. S. Army Ordnance Department, attaining the rank of major. In 1946, he was named director of sales and vice president in charge of commercial engineering at Consolidated, and subsequently served as vice president and director of engineering. In December, 1953, he was made vice president and director of Consolidated's Computer Division.

1934

A. A. Fomilyant is now general manager of the Tulsa, Oklahoma, plant of the Rockwell Register Corporation.

Robert A. Howard, MS, writes from Norman, Oklahoma, that he became chairman of the School of Engineering Physics at the University of Oklahoma last September. This is in addition to his job as chairman of the department of physics, which he has held since 1952.

1935

Charles M. Blair, PhD, is now president of the Petrolite Corporation of St. Louis, Mo.—where he has worked since graduation, first as research chemist and later as director of research. Petrolite manufactures chemicals, electrical equipment and waxes. Its chemical division, the Tetrolite Co., maintains plants and laboratories in St. Louis and Los Angeles, and other divisions operate plants and labs in Long Beach, Calif., Houston and Kilgore, Texas.

1936

Leo J. Milan is still in Tulsa with the Douglas Aircraft Company, as plant engineer. The Milans have a daughter, 16, and a son 12 years old.

1937

Robert C. Jones has been promoted from engineer to research engineer, at the Shell Development Company's California Research Center, in Emeryville.

Jack Kinley announces the arrival of Laura Louise on November 17th. The Kinleys are living in Houston, Texas. Jack also reports that his first patent was finally issued last spring, after five years in the Patent Office. For the record, it is No. 2,638,681 on a "Tubing and Casing Caliper".

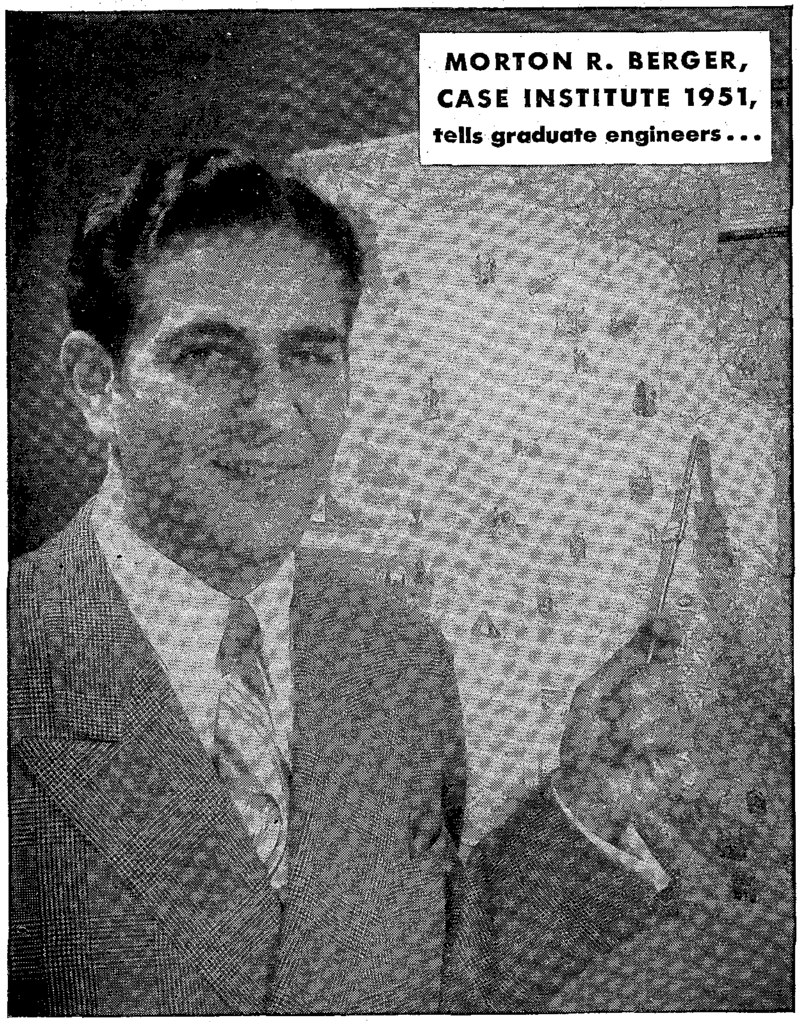
1938

Robert S. Custer is now with the Refinery Engineering Company, in Tulsa, Oklahoma, as chief process engineer. Prior to this, he spent five years with the Bechtel Corporation—four years in San Francisco and one year in New York. The Custer family now includes four children—one boy and three girls, ages 9 to 4.

Franklin Page, Jr., PhD, recently left the Sierra Engineering Co. to join in the formation of Conzelman and Page Inc., in Arcadia, Calif. He specializes in human engineering, with activities both in the aero-medical and prosthetic branches of this field. Frank has retained his close interest in the Caltech YMCA and for the past two years has been treasurer of the Y Board of Directors.

1943

DeWitt A. Gayle, Jr., MS, is consulting metereologist with A. H. Glenn and Asso-



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THE SIGN OF VALUE AROUND THE WORLD

ciates in Houston, Texas. He now has three children: Carolyn, 5, DeWitt III, 3, and Betsy, 1.

1945

Charles E. Neyland, MS, is a Project Aerodyamics Engineer with Convair in Fort Worth, Texas. He is married and has a six-year-old daughter and a 14-month-old son.

1946

Frank H. Lamson-Scribner is now a sales representative in Chicago for Du-Pont's Petroleum Chemicals Division. He was called back in the Navy in 1950 (where *Harry Brough* '45, served on one of the ships with him), and went back with DuPont on his release from the Navy in 1952.

Herbert W. Strong, Jr. joined the Colton Chemical Co. in Cleveland, Ohio, last summer as manager of New Products. His two boys are now six and three years old, and Herb says he notices a few grey hairs already—"on me, that is."

William F. Horton is working for Westinghouse in Pittsburgh, on magnetic amplifier development. He has two daughters: Theresa, 2, and Katherine, 2 months old.

1947

Paul B. Johnson PhD, writes: "The Johnson family is spending the year at Haverford, Pennsylvania. Outside of the usual Pennsylvania colds, no deaths, births or levitations." He is visiting professor of mathematics at Haverford College and plans to return to Occidental College in the fall, where he is chairman of the mathematics department.

Robert L. Walker, after finishing the V-12 program here in 1945, was commissioned as an ensign in the USNR, went to Pearl Harbor and was assigned to a Navy oiler at Sasebo, Japan. He was later assigned to the task force at Bikini and witnessed the first atom bomb test in 1946. Then he "returned, retired and finished at Tech", and married Jean Butcher of Long Beach. They have three boys and a girl now. Bob went to work for the Fluor Corp. of Los Angeles and was transferred recently to Tulsa, Oklahoma, as District Sales Engineer.

Lt. Commander A. E. Rice writes from Goat Island, Newport, Rhode Island: "My present duty gives me an opportunity to apply some of the technical knowledge I was able to assimilate at Caltech." He is Research and Development Officer at the H. S. Naval Underwater Ordnance Station, engaged in applied research and development of torpedoes.

Lucien Pascoe is finishing his G. E. Sales Training Program at the Philadelphia plant, and is eagerly waiting for an assignment on the West Coast as a switchgear specialist. Familywise, Lu "became a father for the second time, about 17 months ago, to a very active boy—and am about 7 months short of becoming a father for the third time." His oldest, daughter Diane, has had a rough year as far as health is concerned but is on the mend.

1948

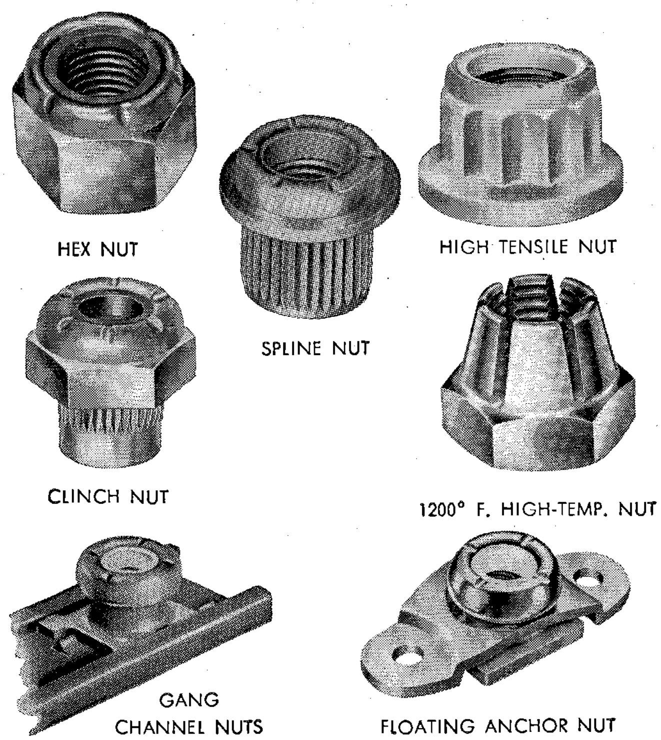
Paul Rogell, MS, writes that he has just taken a new position with the Westinghouse Electronic Tube Division in Elmira, N. Y. He is joining a newly formed headquarters sales group to handle sales and to investigate customer requirements of tubes for special applications, and new products such as transistors.

Conway W. Snyder, PhD, is still doing nuclear research at the Oak Ridge National Laboratory, Tennessee. He has recently "added a little variety to life by traveling around lecturing at several southern universities on Atomic Energy and Space Travel, a subject which seems to have a peculiar appeal." He's already been to Florida, Alabama, Louisiana and Kentucky, and has lectures scheduled in Texas and Maryland.

CONTINUED ON PAGE 46

self-locking fasteners

Elastic Stop nuts



HEX NUT

SPLINE NUT

HIGH TENSILE NUT

CLINCH NUT

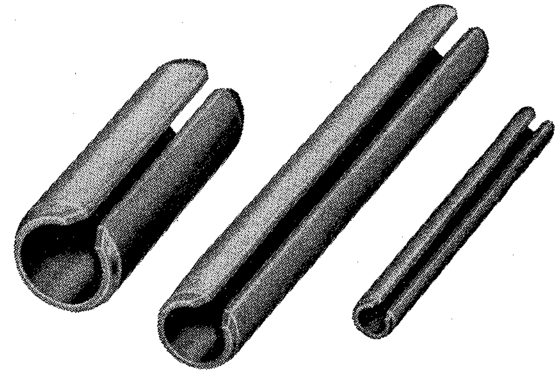
1200° F. HIGH-TEMP. NUT

GANG CHANNEL NUTS

FLOATING ANCHOR NUT

Every major aircraft now being assembled relies on the vibration-proof holding power of ELASTIC STOP nuts. Only ESNA manufactures a complete line of all types and sizes of self-locking nuts.

Rollpins



dia. from 1/16" to 1/2"

Rollpins are slotted, tubular steel, pressed-fit pins with chamfered ends. They drive easily into holes drilled to normal tolerances, compressing as driven. Extra assembly steps like hole reaming or peening are eliminated. Rollpins *lock* in place, yet are readily removed with a punch and may be reused.

Cut assembly costs by using Rollpins as set screws, positioning dowels, clevis or hinge pins. Specify them in place of straight, serrated, tapered or cotter type pins.

ESNA TRADE MARK

ELASTIC STOP NUT CORPORATION OF AMERICA

ROLLPIN TRADEMARK

Mail Coupon for Design information

Elastic Stop Nut Corporation of America
Dept. N34-152, 2330 Vauxhall Road, Union, N. J.

Please send me the following free fastening information:

- ☐ Elastic Stop Nut Bulletin
- ☐ Rollpin Bulletin
- ☐ AN-ESNA Conversion Chart
- ☐ Here is a drawing of our product. What fastener would you suggest?

Name__________ Title__________

Firm__________

Street__________

City__________ Zone____ State__________

1949

Robert T. Terriere is on leave from his job with the U.S.G.S., working on a PhD in geology at the University of Texas in Austin. He hopes to finish up most of his course work this semester and do the remainder on a part-time basis after returning to his job.

1950

Frederick W. Drury, Jr. brings us up to date with the news that in October, 1952, he was released from the Navy to inactive duty as a Lt. (JG), USNR, after 27 months on active duty as an anti-submarine warfare specialist and instructor. He promptly joined the Airox Company in Los Angeles as a field engineer and is now Chief Engineer and Assistant General Manager. The Drurys have three sons—the third one, Douglas Rockwell, being just three months old.

1951

E. B. Crichton is an instructor at Anatolia College, Thessaloniki, Greece, and enjoys the job very much. His appointment is for one year, and he is back at work now after a sick leave occasioned by a bout with pneumonia.

Woldemar Jaskowsky, MS, is director of research and development of Ultra Violet Ray Products in South Pasadena. In 1949 Woldemar came to the United States from Germany (where he was educated in physics and optics, at Gottingen and Munich), as a student under the sponsorship of Caltech and the Pasadena Rotary Club. Two years ago he faced return to Germany, but action of the Pasadena Rotary Club, through its international headquarters, brought the matter to the floor of the Senate, and a bill recently passed by the U. S. Senate gives Woldemar a right to permanent residence in the United States.

Barrie Bieler, M.S. '52, has been working on his PhD in mineralogy-geology at the College of Mineral Industries at Pennsylvania State University since the autumn of 1952. He has his thesis under way now, hopes to have it finished by June, 1955.

1952

George S. Kenny, PhD, is a Senior Research Physicist for the Field Research Laboratories of the Magnolia Petroleum Company, in Dallas, Texas. He has four sons—2, 4, 6, and 9 years old.

Jim Liverman, PhD, is now an assistant professor in the biochemistry and nutrition department of Texas A and M College.

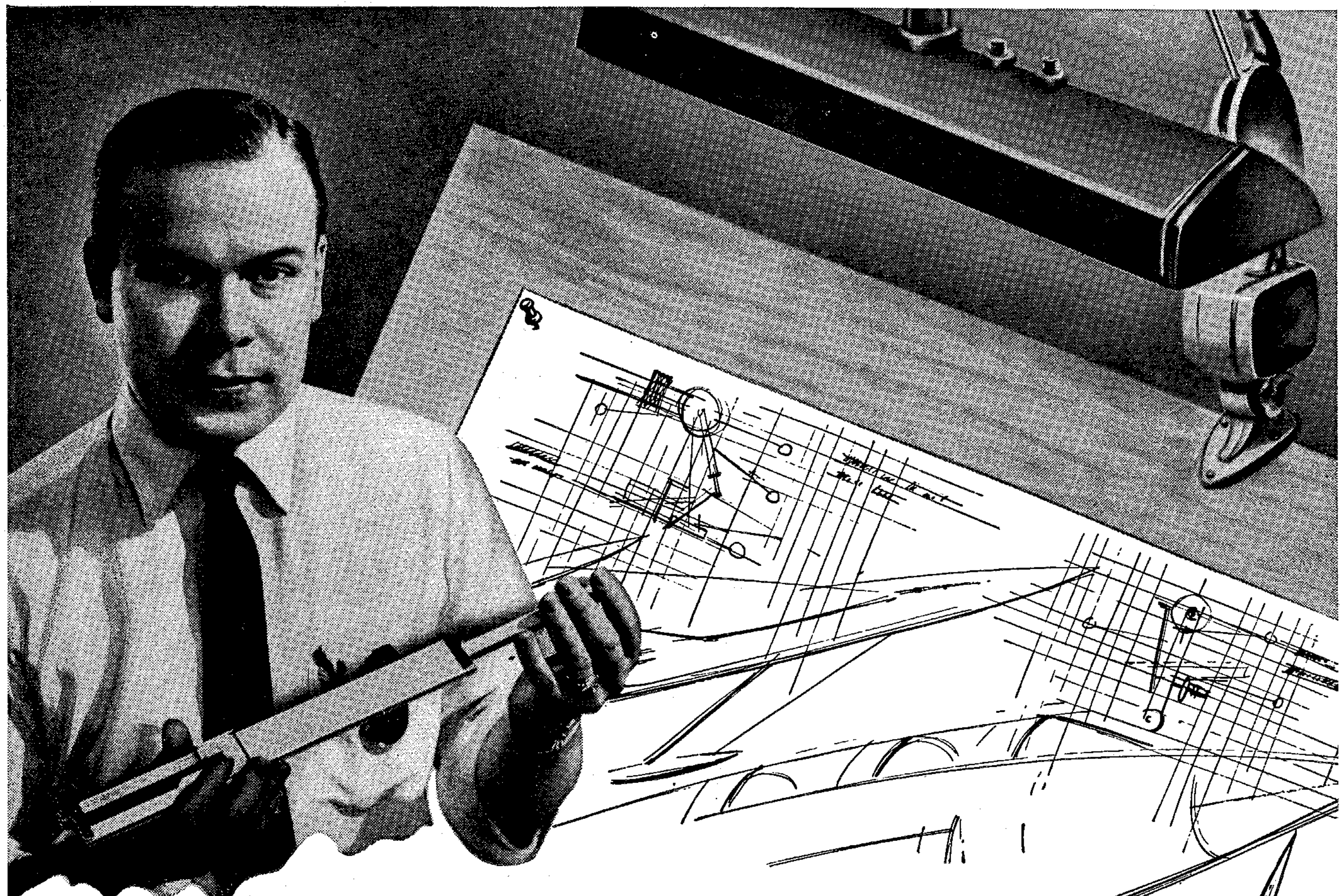
1953

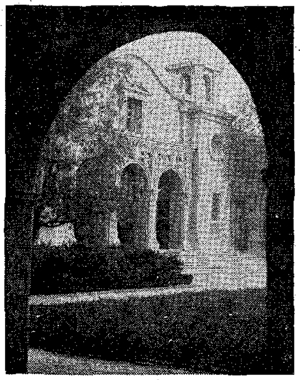
Robert H. Morrison, MS, is working as a seismologist with the Shell Oil Company in Houston, Texas. He and his wife Margaret (whom he married in December, 1953) hope to be back in California before too many months, so he can get started on his PhD thesis.

Charles Benjamin is still single, deferred, and working for Westinghouse Research Labs in Pittsburgh, Pa. Chuck writes that his "total alumni activities consist of a beer every Monday night with *Chuck Paulsen,* '51; we're both taking night school courses at Pitt". One tidbit he gleaned on a recent business trip to Ithaca: *Ted Stannard,* who would have been '53, is now doing graduate work at Cornell in the Indonesian phase of their Far East program.

Thomas F. Talbot, MS, is in the USAF, stationed at the Arnold Engineering Development Center at Tullahoma, Tennessee. He has been promoted to 1st Lieutenant and is working now on the Ram Jet Facility as Mechanical Engineer.

Philip K. Bates, Jr. is living in Chillicothe, Ohio, and working for the Goodyear Atomic Corp. of Peketon, Ohio, as an engineer in Turnover Acceptance and Coordination. The Bateses have been in Ohio since July and "find the weather some different from California."





CALTECH CALENDAR

April, 1954

ALUMNI ACTIVITIES

June 9 — Annual Meeting
June 26 — Annual Picnic

ATHLETIC SCHEDULE

BASEBALL

April 22, 4:15 p.m.
Cal Poly (SD) at Caltech

April 24, 2:15 p.m.
Occidental at Caltech (Varsity)
Caltech at Occidental (Frosh)

April 27, 4:15 p.m.
Nazarenes at Caltech

May 1, 2:15 p.m.
Caltech at Pomona (Varsity)
Pomona at Caltech (Frosh)

May 4, 4:15 p.m.
Chapman at Caltech

May 8, 2:15 p.m.
Whittier at Caltech (Varsity)

May 11, 4:15 p.m.
Chapman at Caltech (Varsity)

TRACK

April 23, 7:30 p.m.
Redlands at Redlands (Varsity and Frosh)

April 30, 3:00 p.m.
Frosh Conference at Caltech

May 1, 7:30 p.m.
Varsity Conference at Occidental

GOLF

April 23, 1:30 p.m.
Southern California Tournament at Bel Air

April 30, 1:30 p.m.
Caltech at Pomona

May 7, 1:30 p.m.
Occidental at Caltech

TENNIS

May 1, 1:30 p.m.
Redlands at Caltech (Varsity)
Caltech at Redlands (Frosh)

SWIMMING

April 23, 4:30 p.m.
Redlands at Redlands (Varsity and Frosh)

April 30, 4:30 p.m.
Whittier at Caltech (Varsity and Frosh)

May 6, 3:00 p.m.
Conference Preliminaries at Occidental (Varsity)
Conference Preliminaries at Occidental (Frosh)

May 8, 1:15 p.m.
Conference Finals at Occidental (Varsity and Frosh)

DEMONSTRATION LECTURES

Friday Evenings
7:30 p.m. — 201 Bridge

April 23, 1954—Density Currents and Geologic Catastrophies," by Professor L. C. Pray.

April 30, 1954—"X-Ray Diffraction and the Structure of Crystals," by Dr. R. E. Marsh.

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