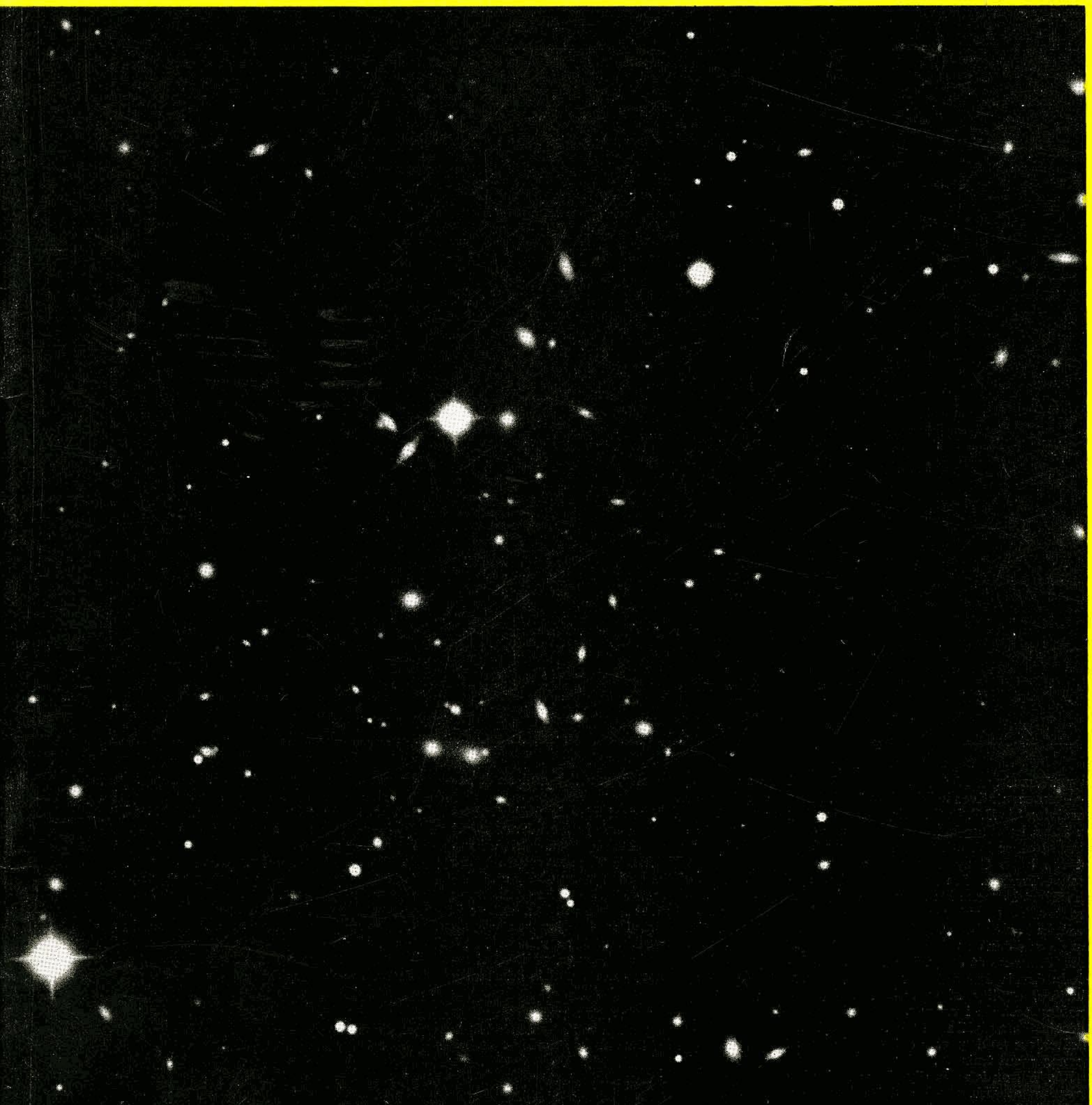
ENGINEERING AND SCIENCE

FEBRUARY/1955



Views of the universe . . . page 9

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

Sanford W. Wilson, class of '48
speaks from experience when he says . . .

"U. S. Steel offers a great combination—opportunity, security <u>and</u> an interesting job"

Mr. Wilson was interviewed by U.S. Steel representatives in March of 1948. After receiving his B.S. in Chemical Engineering in June, he chose his U.S. Steel offer over several other job offers and began working at the huge Gary Works as a Foreman Relief Trainee. He gained experience in the Blast Furnace Department and in the front office learning the business end as well. In November of 1954 Mr. Wilson was made assistant to the superintendent of blast furnaces at Gary. His duties now include developing data for control of production, quality of materials, costs, and making technical reports. In addition, he directs the activities of Technological Co-Ordinators and part of the training of management trainees.

Mr. Wilson is naturally pleased with his progress at U.S. Steel and he feels that U.S. Steel offers qualified and ambitious engineers the very best in three important areas—opportunity, security *and* an interesting job.

He says, "Opportunity is unlimited at U.S. Steel and openings for advancement are frequent." In addition, Mr. Wilson feels that U.S. Steel affords a secure future because of the basic nature of the steel industry and the constant need for engineering talent. But most important, Mr. Wilson is deeply interested in his job because he knows he is really playing a vital role in a vital business. And he says, "The steel industry has many facets and is constantly changing. Talk to anyone who has been in the steel industry for any time and he will tell you that steel has gotten into his blood."

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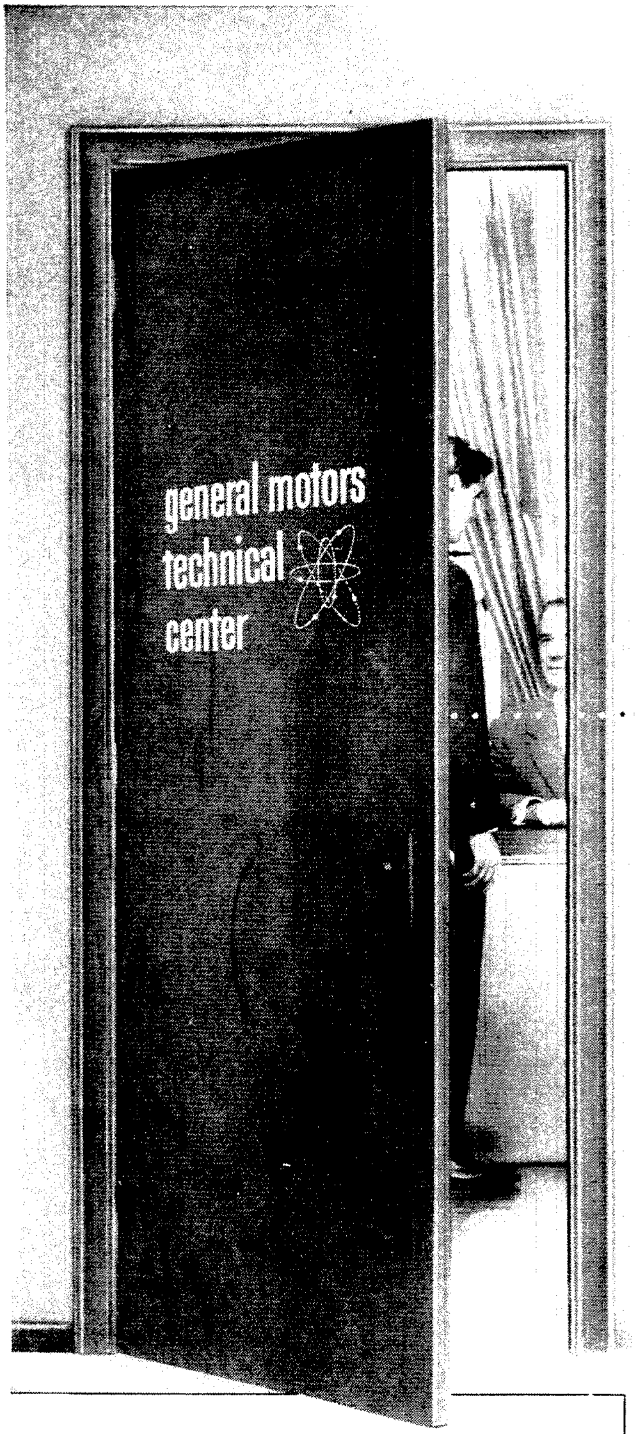

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ENGINEERING AND SCIENCE

FEBRUARY, 1955 VOLUME XVIII NUMBER 5
PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

IN THIS ISSUE

On our cover this month is a view of the universe from the 200-inch Palomar telescope—showing, specifically, a cluster of nebulae in *Corona Borealis*, about 120 million light-years away from us.

To give you a better idea of how far away this really is, it might be explained that a light-year is the distance light travels in one year, at the rate of 186,000 miles a second.

"Views of the Universe," the article on page 9 of this issue, was originally presented as a radio talk—in a series of such lectures given to commemorate Columbia University's bicentennial year—by Dr. H. P. Robertson.

Dr. Robertson, Caltech Professor of Mathematical Physics since 1947, is now on leave from the Institute to act as Scientific Advisor to the Supreme Allied Commander in Europe. His work in the field of mathematical physics has been largely devoted to the Einstein theory or relativity, and he has made important contributions to cosmology and the theory of the expanding universe. His article on page 9, about our modern views of the universe, might well be subtitled, "Cosmology for the Common Reader."

Richard H. Jahns, who wrote "How to Buy a Gem Stone" on page 14, is Professor of Geology at Caltech. A Caltech graduate ('35), he got his MS at Northwestern, then came back to Caltech for his PhD in 1943. On the staff

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IN THIS ISSUE . . . CONTINUED

of the U. S. Geological Survey since 1937, he joined the Caltech faculty in 1946.

Dr. Jahns' knowledge of gems is an outgrowth of his studies of pegmatite deposits—in which many gem minerals occur. Some of these minerals form the closest approaches in nature to perfect crystals, and their study throws much light on the general problem of crystal growth.

Dr. Jahns' interest in gems is sharpened somewhat by the fact that his wife is concerned with a different facet of the subject.

Strictly between us—she winds up with most of the work material.

Norman R. Davidson, author of "Microsecond Chemistry" on page 28, is Associate Professor of Chemistry at Caltech. Dr. Davidson has been a member of the faculty here since 1946, and his major research project at Caltech has been the work he describes in his article—investigations of the rates of very fast chemical reactions. Dr. Davidson has done a good deal of pioneering work in developing techniques to initiate and study these reactions—which is one good reason he was chosen the 1954 recipient of the California Section Award of the American Chemical Society last year.

Science writers—where are you?

Last spring E&S launched a contest which *we* thought was guaranteed to flush out science writers from all corners of the Caltech campus.

We couldn't have been wronger.

On May 1, 1954 we sent out the first call for articles to be submitted in our Science Writing Contest. These articles, we explained, should be based on some phase of scientific or engineering research, or some individual, connected with Caltech. They should run no less than 1,000 words and no more than 5,000. They should be typed, double-spaced. They should be turned in to the E&S office by May 1, 1955.

All articles submitted in this contest would be sent, after May 1, 1955, to an impartial board of judges—the editors of *Scientific American*—who would select the winning article, and a runner-up. The winner would receive, from E&S, a check for $100; the runner-up would pick up $50.

E&S would, of course, print the two prize-winning articles. It would also print any of the other entries which it found suitable. It would pay for these at the rate of about a cent a word.

Well, this is what we said last spring—and then sat back to wait for the deluge. To say that, to date, the results have been disappointing would be the height of understatement.

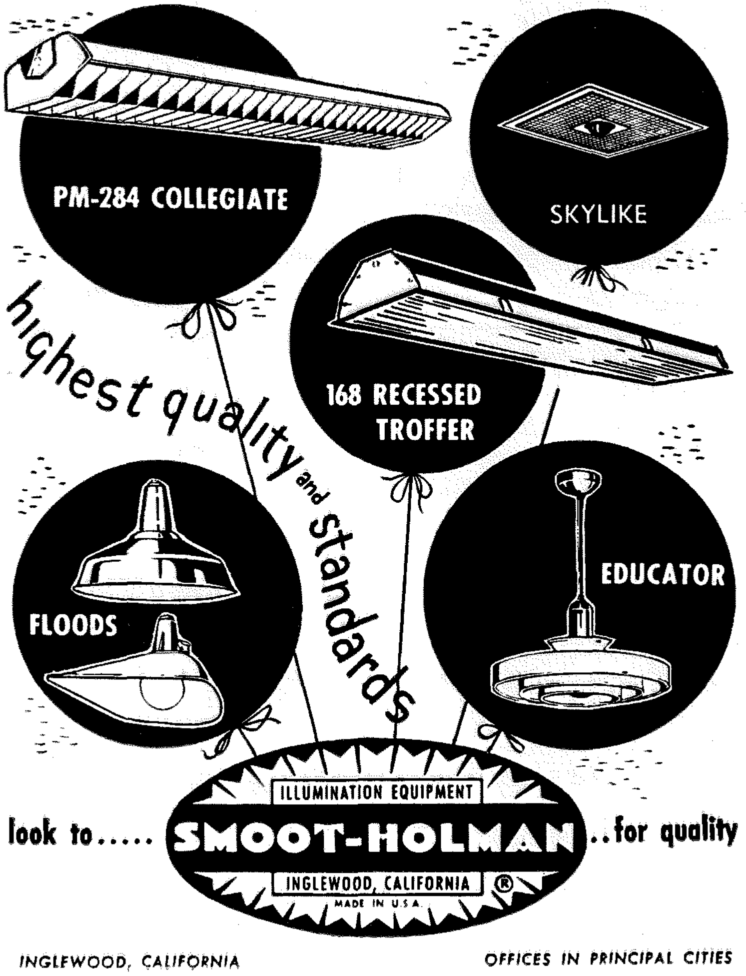
This contest has about four more months to run. We'd like to hear from anyone still planning to submit an entry; come in or call in to the E&S office and let us know what you're working on and when we can expect to see it.

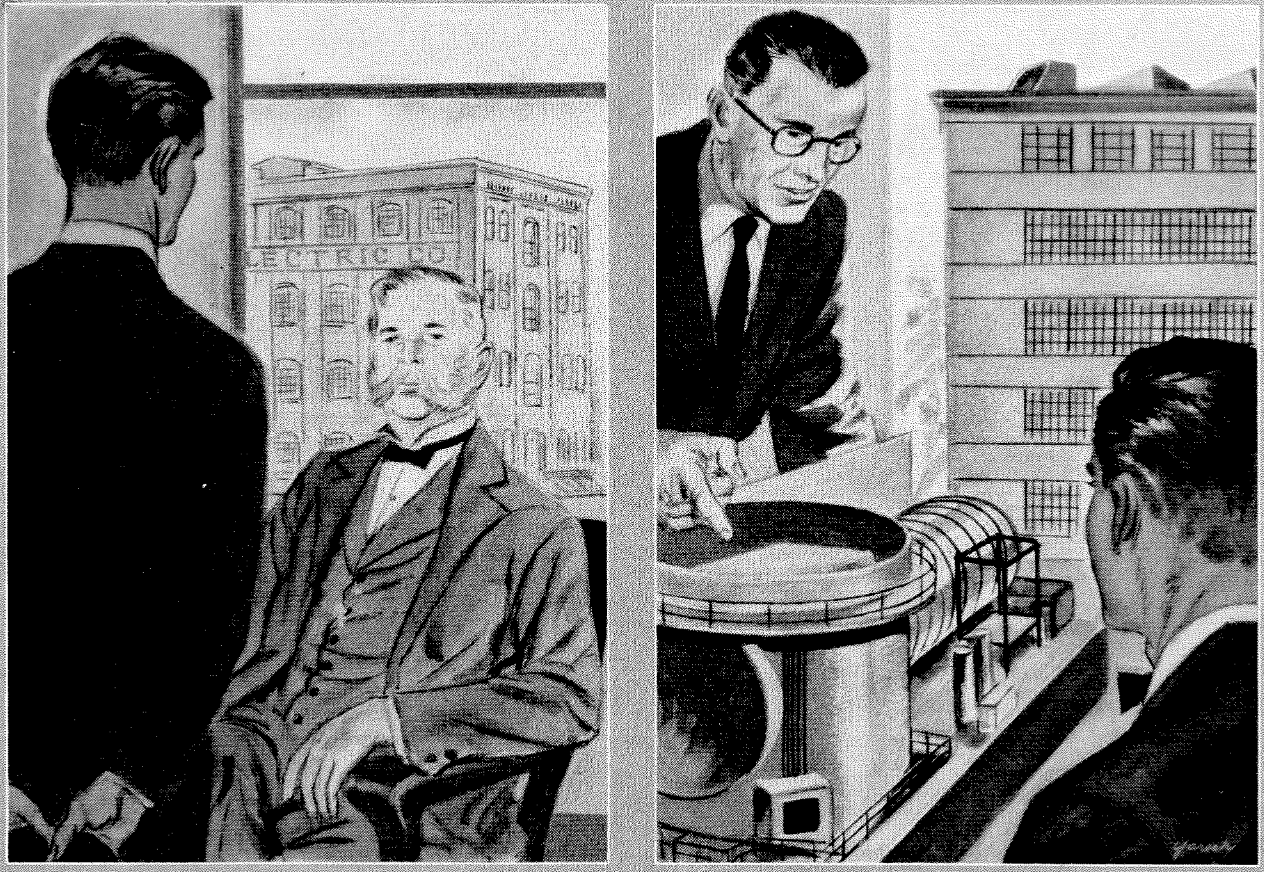
Frankly, unless we have a last-minute rush, the handful of writers whose articles are already in are going to pick up some very easy money.

Of course, we may be wrong in assuming that Caltech undergraduates and graduate students are interested in money.

Or writing.

Or, while we're at it—science?





Engineering graduates being interviewed at Westinghouse
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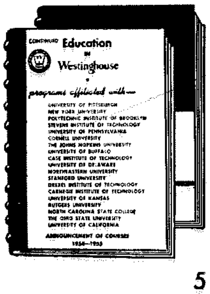

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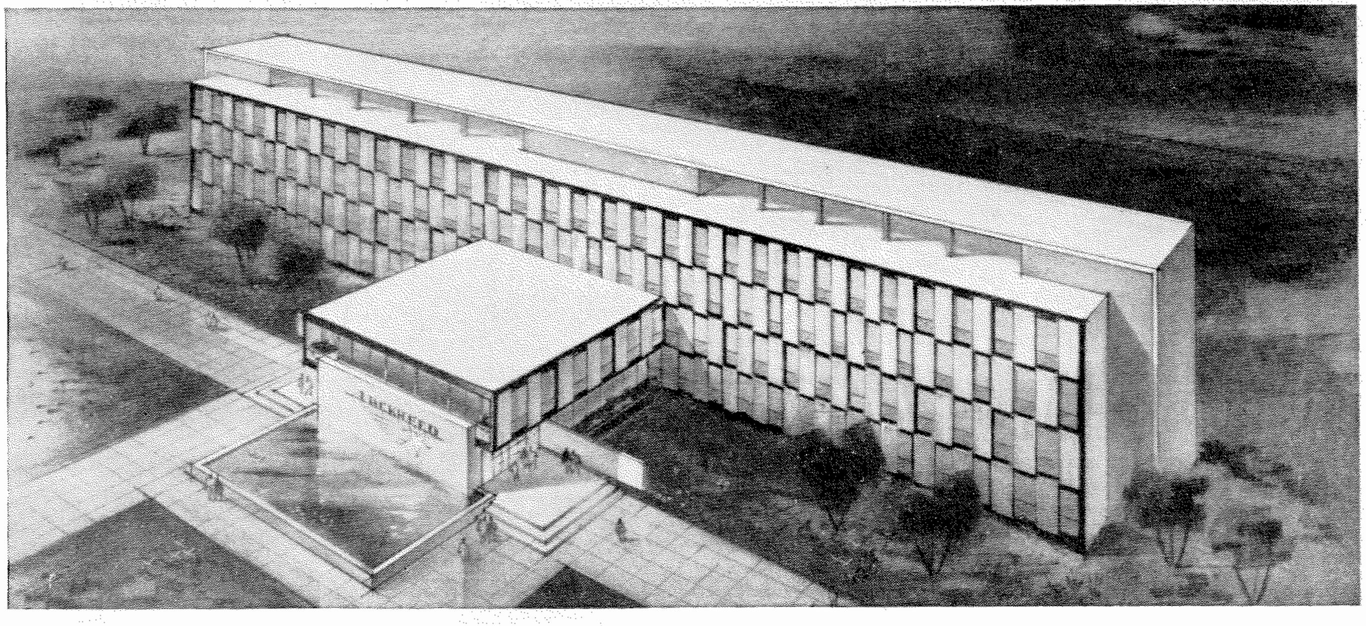
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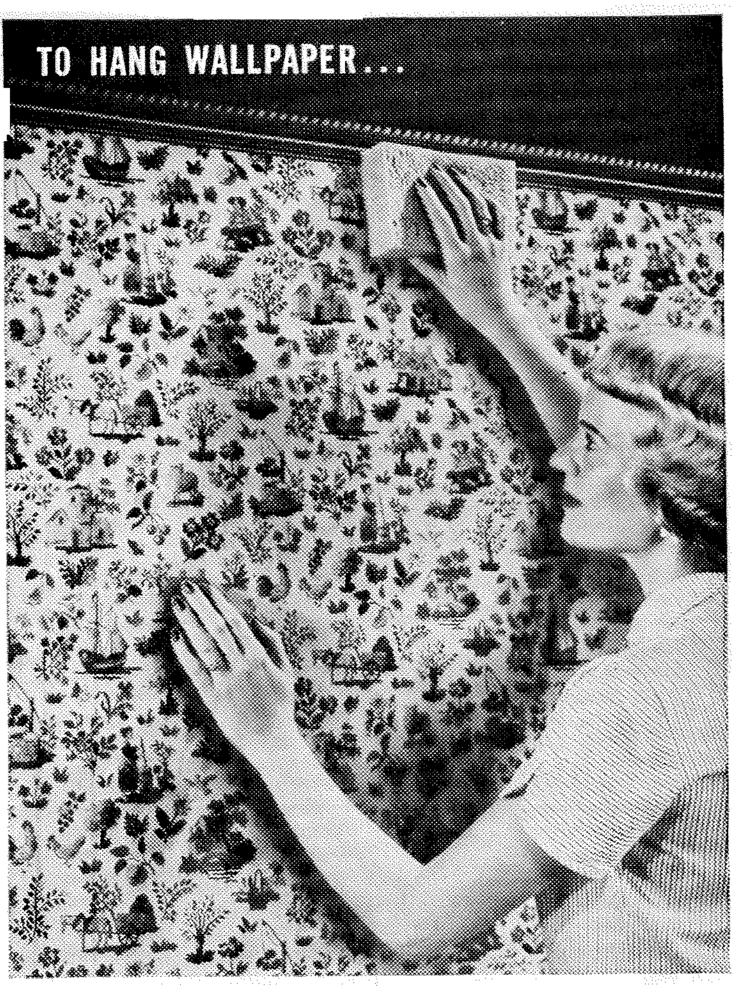

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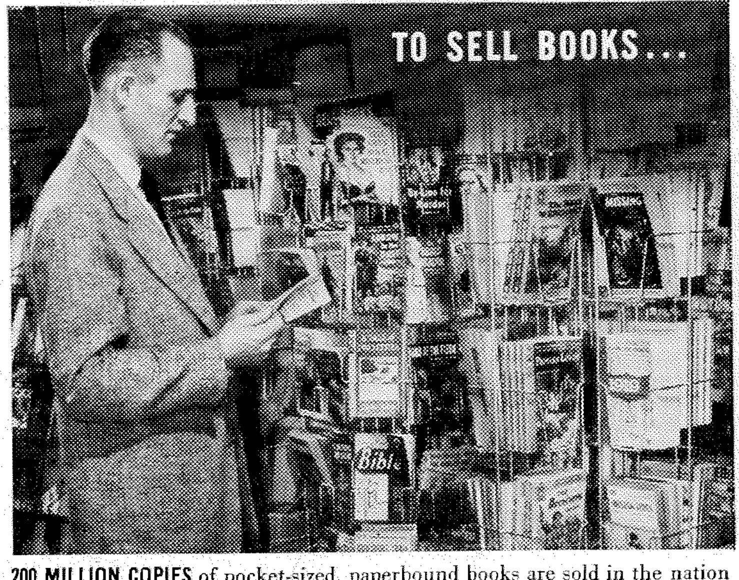

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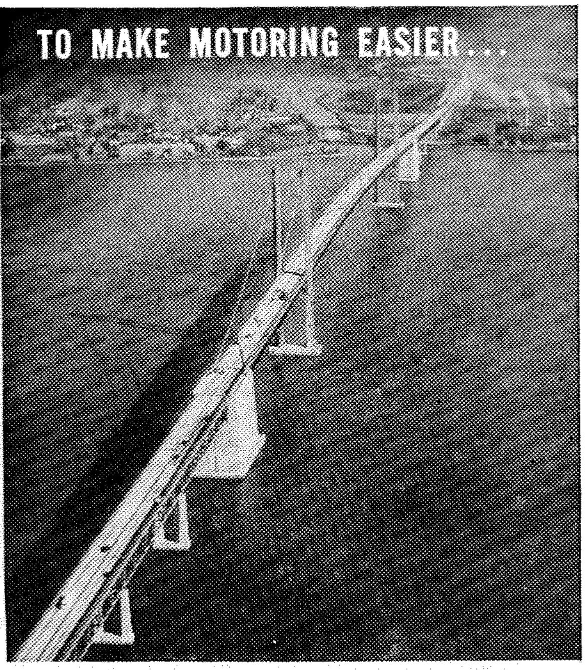

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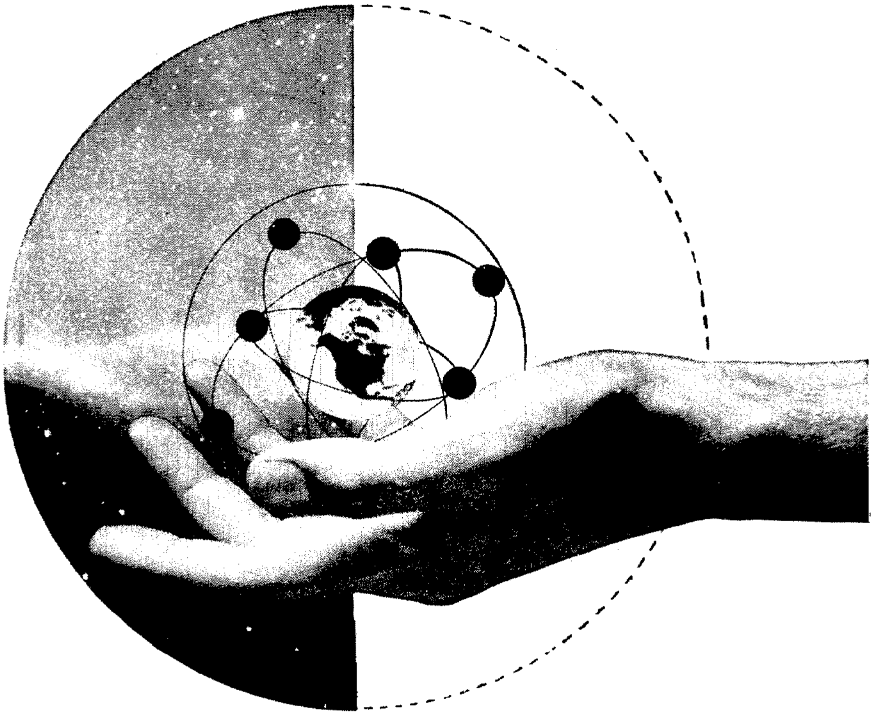


VIEWS OF THE UNIVERSE

Man has been led to various views of the universe at various times in his history. Here's how he sees it today.

by H. P. ROBERTSON

PERHAPS the greatest and the most universal of all the problems which have intrigued the mind of man are those which deal with his own place in the world in which he lives. But before he can even formulate these problems, before he can set himself out as something apart from the rest of the world and inquire about his relations to it, he must construct some picture or model or theory of the universe as a whole. He must, in the learned jargon which he has invented to help keep his thoughts in order, develop a *Cosmology*.

He may wish, however, at times to go beyond a mere description of his universe and speculate on its inner nature, or its purpose, or its origins; that is, again in the learned jargon, he may supplement his Cosmology with an *Ontology*, or a *Teleology*, or a *Cosmogony*.

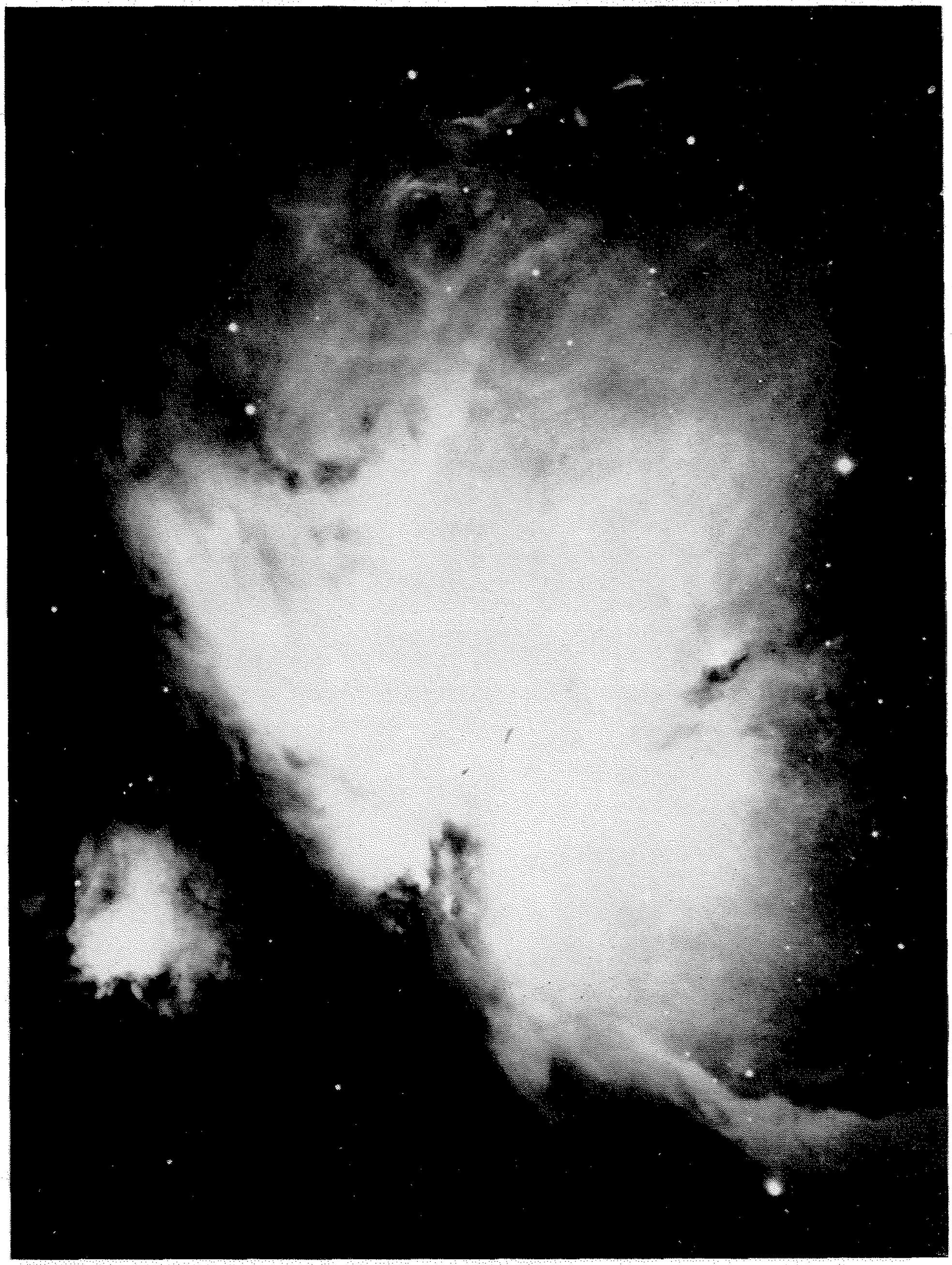
The views of the universe to which man has been led at various times in his history have invariably reflected the environment in which he belonged. Thus, one finds among the ancient peoples of India a primitive cosmology built out of objects and concepts common to their everyday experience; the Earth was pictured as a huge flat tea tray, supported on the backs of three elephants, who, in turn, stood on the shell of an enormous tortoise. Their cosmogony, on the other hand, seems not to have developed to the point of inquiring about the origin of the tortoise!

Again, the ancient Greeks, influenced by the Aristotelian dogma of the perfection of circles and spheres, considered the Earth as a solid sphere surrounded by the Moon, the Sun, and the planets, traveling in orbits built out of perfect circles. The whole system was contained inside a heavenly sphere, upon which the stars were fixed, and which rotated daily about its center within the Earth.

Our modern views of the universe are no less a product of the age in which we find ourselves, an age which has seen the development of science into a creed which permeates our every way of life. And because I intend to emphasize those aspects which fall within the sphere of science, my account will deal with those more philosophical aspects of inner nature or purpose or origins mentioned in my opening remarks.

I shall, in short, deal with those views of the universe to which we have attained by the scientific method of alternating observations and hypotheses—by peering into the heavens with the aid of those technological devices, such as the telescope and the spectroscope, which increasing understanding of the laws of nature has enabled

"Views of the Universe" was originally presented as a radio talk in the Columbia University Bicentennial Series.



Visible to the naked eye as a dim, hazy spot in the sword of Orion, the Great Nebula Messier 42 is more than 1,000 light years away from us. It weighs 1,000 times as much as the sun, and consists of gas and dust illuminated by very hot stars.

us to build, and by ordering what we there see in accordance with those laws which have proven successful in ordering our more limited earthly experience.

The objects with which I shall deal start with the Earth and its immediate companions in the Solar System. From them I go rapidly to the stars which make up our own Milky Way system, of which the Sun is but an undistinguished member among the hundreds of thousands of millions of stars in the galaxy. And finally, I want to take you—in the mind's eye only—out across the enormous reaches of space to those other island universes, the great nebulae, many of which are similar in size and structure to our own, separated from each other by distances so great that light, which takes only eight minutes to travel from the Sun to us, takes millions of years to pass from one nebula to another.

Throughout the most of human history the Earth, that seemingly solid platform to which we are as yet confined, was regarded as the center of the universe. The Copernican revolution in astronomical thought, barely four hundred years ago, first effectively replaced the Earth by the more stable Sun as the pivotal point about which all else moved. This change of view was in itself not nearly as significant as its consequences, for within the following century it led, through the observation and theories of Tycho Brahe, of Kepler and of Galileo, to the crowning achievement of the new dawn of science, the mechanics and the theory of gravitation of the incomparable Sir Isaac Newton. Here, for the first time, men saw in the uniformities of the heavenly motions the workings of the simple laws of nature, which governed the motions of the planets in their orbits as surely and as impartially as they did the fall of little green apples from the tree.

But with this extension of physical law from the terrestrial to the celestial realm, the Sun, as well as the

Earth, was destined to lose its claim to occupying the central position in the universe. Already in the seventeenth century there were those, like Thomas Digges and Giordano Bruno, who envisioned an infinite universe more or less uniformly populated by stars, stars which might even be accompanied by lesser bodies like the Earth and the other planets, which loomed so importantly in the earlier cosmologies.

A limited system

But this too simple picture was, in turn, destined to give way before the advancing front of observation, made possible by the development of the telescope from the puny tubes of Galileo to the mighty reflectors now studded over the face of the Earth. What these revealed to us was that while the Sun was indeed but a member of that system of stars which made up the Milky Way, this system was itself a strictly limited one—although one consisting of hundreds of trillions of stars, and so vastly extended that light would take a hundred thousand years to cross from one edge of it to the other.

This myriad of stars was found to be arranged like a great lens, with the Sun near the central pane but about half-way from the center to one side. From our vantage point on the Earth the stars then seem to be spread out like a great veil wound around the sky. And as we study it, guided again by Newton's laws, we see in the galaxy a universe of stars rotating slowly about its center, but so vast in extension that the "Cosmic Year" required for one revolution of the system is a hundred million times that year in which the Earth revolves about the Sun.

Is this, then, the universe? If so, we can place its center at that point, some tens of thousands of light-years from us in the direction of the constellation Sagittarius, about which the galaxy rotates. (And here, in measuring the vast distances with which we are forced to deal, I have used the astronomers' most expressive unit of distance, the *light-year*—that is, the distance light travels in one of our terrestrial years.)

The most striking feature of this galaxy of ours is its myriad of stars, which modern observations allow us to infer is moving in a stately procession about its center. But the telescope reveals that among these stars are other types of objects—compact clusters of stars, bright patches of luminous matter, and dark patches of matter dimming or even obscuring the light from stars lying behind them.

Among these other objects are little fuzzy blobs of luminous matter called *nebulae*—or, more precisely, *extra-galactic nebulae*, for the improvement in our observing instruments and methods within the century has enabled us to identify these tiny dim patches as themselves great collections of stars and other luminous matter, comparable in every way with our own galaxy, but lying far without its borders. The most conspicuous, and one of the very nearest of these, is the Great Nebula in the constellation Andromeda, which we now place at a distance of well over a million light-years from us. This distance has, within the past two years, been upped from the previously held figure of seven hundred thousand light-years to nearly twice that, largely through the researches of Walter Baade of the Mount Wilson and Palomar Observatories.

I will refrain from going into the intricate processes by which the astronomer assigns these distances—the extension of our terrestrial distance scale to the Moon and Sun, thence to the nearer stars, and then by successive steps to Andromeda and the other nebulae. It is enough here to indicate that the first two steps are a quite straightforward application of geometry to celestial mechanics, and that the guiding principle of the later steps is that, given two objects known (or suspected) to be of the same intrinsic brightness, that one which is further away will appear to us less bright than the other by a factor which varies inversely with the square of its distance from us.

To return to the world of nebulae, it is estimated from the number which show up on plates taken with the great telescopes, that there are, within the range of the 200-inch Mount Palomar reflector, almost a million million nebulae, and that these nebulae are more or less uniformly distributed throughout a sphere whose radius is two billion light-years.

The typical nebula of this great collection contains as much luminous matter as ten thousand million of our Suns—and could harbor, in addition, as much or more dark matter in the form of gas, dust, or dead stars. The uniformity of their distribution in space is, however, at most a statistical one, as the nebulae are often found to aggregate in groups containing from a few to clusters of hundreds of members, loosely bound together by their mutual gravitational attraction.

This, then, is the astronomical universe as we now conceive it to be, a grand aggregation of billions of nebulae, separated from each other, on the average, by millions of light-years. And since these nebulae are scattered pretty much at random throughout the whole of the visible universe, man's search for a true center has come to naught—every part of this vast domain is much the same as any other, and so there is no privileged position on behalf of which such a claim could be made.

Some observed facts

Let us therefore give up the search for such a center, and go on to describe certain of the gross properties of the universe of nebulae as now observed. We shall then try to "explain" these observed facts by ordering them in terms of physical laws extrapolated from our more limited terrestrial or galactic experience. And if, as appears likely to many competent men of science, this attempt proves too great a strain on the laws as heretofore formulated, we can inquire what modifications or new points of view can be called upon to bring order into our extended cosmos.

Perhaps the most striking feature of the extra-galactic nebulae, as we view them from our position within our own galaxy, is that they all (with minor exceptions) appear to be fleeing away from us, and that the further away they are, the faster they are going. I say "appear" to be fleeing, for we have already here a good instance of the process of extending our ways of thinking from the known to the novel.

We do know, from terrestrial experiments, that light from a bright source can be broken up by a spectroscope into component wavelets of certain characteristic frequencies or wave-lengths. When this same source is receding from us these characteristic wave-lengths are increased by a factor which depends sharply on the velocity of the source relative to us—that is, they are shifted to the red end of the spectrum. This is comparable to the Doppler effect of sound, where the pitch of the whistle on a receding locomotive is lowered by the motion.

Now, when light from a star or a nebula is observed through the spectroscope, bright lines appear which, because of their relative positions and intensities, are identified as characteristic of certain of the chemical elements whch can be isolated here on Earth, and which are therefore assumed to exist in the heavenly body under examination.

An expanding universe

But in the case of the nebular light these bright lines are observed to be shifted toward the red end of the spectrum, and the inference is quite reasonably made that this shift is caused by the motion of the source away from us, as in the familiar Doppler effect just described. The extrapolation is the basis for the assertion that the nebulae are fleeing our galaxy, and that the further away they are—that is, the dimmer they appear—the greater is their velocity of recession. Roughly, the velocities thus inferred increase in proportion to the distance of the nebula from us.

Observations with the great reflectors by Hubble and Humason, to whom much of the work on the velocity-distance relationship is due, yield Doppler shifts which are interpreted as due to velocities up to almost one-fifth the velocity of light. At the top end of the scale, then, we find objects whose velocities are well over 30 thousand miles a second, at distances approaching 700 million light-years! But nebulae can still be seen when their light is too weak to be spread out effectively into its component wavelets in a spectroscope; could we measure the Doppler effect in nebulae at the limit of our present capabilities of observation, and if its rate of increase held up at these greater distances, we should expect to find nebulae receding from us at half the velocity of light—more than 90 thousand miles a second!

It is time now to turn from an inductive amassing of observations, and to set up a simplified model of the universe which will exhibit the same salient features as those observed in the actual universe. The primary purpose of this exercise is to replace the practically unsolvable problem of predicting the motions of the actual nebulae in the actual universe with a more tractable problem, the solution of which may indicate the kind of behavior to be expected in the actual universe.

In so doing we are guided by an assumption, called by some the Cosmological Principle, that the model is spatially uniform—that is, that the ideal nebulae are distributed uniformly throughout space in such a way that the world-view obtained by an observer on one of them will not depend either on his position in space or on the direction in which he is looking. The inferred motion of the nebulae away from us is reflected in the model by assigning to each ideal nebula that velocity which corresponds to its distance away from us, in accordance with the smoothed-out velocity-distance relationship described a short time ago.

The future and the past

A little reflection—aided perhaps by pencil and paper—will convince you that this assignment of velocities in no way singles us out as a unique center of this Expanding Universe; an observer on any other nebula would find that all the nebulae, including ours, appear to be receding radially from him in accordance with exactly the same velocity-distance relationship as applies to our own observations. The Cosmological Principle is thus valid for observations of motions, as well as of the positions, of nebulae in this model Expanding Universe.

How, then, will this expanding model behave—what is its future, and what its past? If we ignore for the moment interactions between the nebulae, we would predict that each pair will continue to move apart at the same rate as at present, and that they have been so moving ever since the beginning of time. This would imply that about three and one-half billion years ago all of the nebulae must have been bunched together within a quite small region of space, and suggests that they are now flying apart with the velocities acquired in some great primeval explosion.

And here we run into our first hint of possible trouble with the model, for the geologists tell us that the Earth itself must be some three or four billion years old. This near coincidence is by no means fatal to the model, for it may well be that the Earth itself is some minor by-product of the initial cataclysm. Nevertheless, the time scale suggested by this first view is uncomfortably short, and alerts us to the danger of winding up with a model universe whose age is less than that of one of its minor inhabitants, the Earth!

The detailed investigation of the behavior of the model must be based on some theory of the interaction of matter in the large. The theory which is in best accord with our previous experience is Einstein's General Theory of Relativity, whose field equations are designed to account for the gravitational attraction between massive bodies. But these equations further imply that the geometrical properties of space depend upon its physical content—and I have so far tacitly assumed that the space in which the nebulae are imbedded is the flat, infinitely extended theatre of events with which we are all familiar from our early study of Euclidean geometry.

This opens up a new range of possibilities for our model, for although the uniformity of distribution of the ideal nebulae will induce a corresponding uniformity of the space, this space need by no means be the flat Euclidean one. It could indeed be a closed space, the three-dimensional analogue of an ordinary spherical *surface*, whose total volume is finite, and whose straight lines return into themselves as in the case of great circles on the surface of a sphere. In this case, we would truly have a finite, but unbounded universe, containing but a finite number of nebulae.

In contrast with the flat Euclidean space, such a space is said to have a *positive curvature*, which can be expressed in terms of a so-called *radius of curvature*, a significant distance analagous to the radius of the sphere in the two-dimensional example. Here the motion of the nebulae is reflected in the fact that the radius of curvature would vary in time in just the same ratio as the distance between any two of the nebulae—and a complete knowledge of the velocity-distance relationship would enable us to deduce the dependence of the radius on time. Still a third possibility is open to us—the universe could be an infinitely extended space of *negative* curvature, one which is harder to visualize, but which is again characterized by a radius of curvature whose change in time is proportional to the motion of the nebulae.

Relativistic Cosmology

Relativistic Cosmology, the study of the behavior of our model universe under Einstein's gravitational field equations, traces the mutual relationships between density and motion of nebulae on the one hand, and the curvature of space on the other. Unfortunately, the observations presently available to us do not suffice to single out one of the possible solutions as uniquely representing our actual universe. Some possibilities can be thrown out as leading to too short a time since the initial explosion, but among those which remain are several which quite adequately reflect what we now know for certain concerning the nebulae.

We can confidently look forward to future observations yielding the data required to narrow down our choice—or perchance to show that none of the relativistic models is adequate to portray reality. It does appear, however, that according to this line of thought we may expect the universe to continue, and even to accelerate, its expansion. The distant nebulae will then eventually escape from our causal universe (i.e., that part of the universe that has any effect on us), and we shall be left with only a few nearby companions, with whom we are caught in our mutual gravitational attraction.

The ghosts of our erstwhile Universe of Nebulae may still be present in the form of a dim infra-red light, drained by the Doppler effect clear out of the visible spectrum, but quite probably undetectable by any who may remain to see. But long before this the Sun will have burned up its atomic fuel, and the Torch of Learning will perhaps have been passed to, or kindled anew by, life on another Earth revolving about another Sun.

Is there, then, no escape from these grim conclusions? We have been led to them by an insistence on extending our knowledge of the near and familiar to the distant and novel. And even here we have allowed an untested element to creep into the process. For among the terms contained in the relativistic field of equations is one which implies a force tending to drive the nebulae apart, a term introduced by Einstein in 1918 in his initial attack on the cosmological problem—a term which has no observable consequences for nearby objects, and which has since been repudiated by its author. We surely cannot, in good conscience, leave the subject without probing some of the various alternatives which have been proposed—even though, as in the case of the cosmological term, there is no more immediate evidence of their validity.

Avenues of escape

The first avenue of escape which appears to one is that possibly the reddening of light from the nebulae is due to some unknown small influence on it during its tremendous journey to us, rather than to a Doppler effect caused by a motion of the source. Then, the nebulae may remain indefinitely where they are, and the degradation of the universe is one of frittering away of light rather than of loss of matter through escape. Such is indeed a possible out, but good scientific methodology demands that before we accept it some better picture—and preferably some more direct confirmation—of the process be advanced.

Yet another, and even more revolutionary, possibility is that somewhere in the universe matter is being created out of nothing to replace that lost in the vanishing nebulae. Such proposals have been made, by Hoyle and by Bondi and Gold in England, and by Jordan in Germany. They differ among themselves in method and in detail, but all would have the effect of creating new nebular matter—whether by the gradual accretion of newly created gaseous matter, or by the sudden and spectacular flaring up of super-novae, those fantastic "new stars" which are observed to occur every century or so in the nearer nebulae. Such proposals would compel us to give up one of our most tenaciously held general principles, that of the conservation of matter and energy.

These are but two of the more promising alternatives to the picture painted by Relativistic Cosmology. Which of these views of the universe, if any, will prevail is a question for the future to decide. Of this we can, however, be sure—the advancing front of science will always root out more questions than it can answer at the time, and the problem of the Universe of the Nebulae will be no exception to this fundamentally healthy state of affairs.

The stones Dr. Jahns holds in his hand are beautiful fakes, made from high-refractive-index glass like the chunk of "paste" shown on the table. The scattered stones are bonafide gems.

by RICHARD H. JAHNS

THE PURCHASE OF A GEM STONE

—— Or What To Do Until the Appraiser Arrives

HAVE YOU EVER had an uneasy feeling about that aquamarine you picked up so inexpensively in Mexico—or the one that the beady-eyed, serape-shrouded character assured you was "just off the boat" from Brazil?

Or perhaps you were tempted into a hasty purchase, while in the antipodes as a tourist or serviceman, by the sparkle of a flawless "ruby" or "diamond" set in an impressive background of rapid-fire chatter from the vendor.

More likely, though, you recall your visit to the jewelry store to select that diamond ring, and how the happiness of the occasion was tinctured a bit with your confusion over the variety of stones (and prices) flashed before you on the showcase. You probably decided that buying a new automobile was a comparatively simple matter!

Our social customs and standards of living being what they are, most people in this country either buy or receive as a gift at least one gem stone during the course of their lives, and the national average is said to represent slightly more than two purchases per adult person. Most of these purchases are made through established jewelers, generally by individuals who are aware of their ultimate dependence upon the seller's word for the identity, quality, and intrinsic value of a given gem stone. Fortunately, most jewelers recognize and accept the responsibilities implicit in this relationship, whether or not they are personally qualified to make accurate appraisals of their merchandise. Those who are not so qualified

What makes a gem valuable? How can you tell the real thing from a piece of glass? An expert answers some basic questions about gems.

ordinarily rely upon the judgment of expert gemologists operating as brokers or agents at the wholesale level. The appraisal of gem stones is a tricky business, however, and the most experienced brokers have been known to muff one now and then.

Any alert person is attracted, often compellingly so, by what appears to be an unusually good bargain, even though he may be urged to commit himself before he can determine the real value of the article in question. In transactions that involve gem stones, the "good deal" usually is built around some form of cozenage or outright fraud, mild in degree only if the victim is lucky. Thus the purchaser who obtains a stone outside an established jewelry store, whether it be through a friend, from a stranger on the street, or at an auction, is strictly on his own unless he has the benefit of expert and trustworthy advice.

Even within the trade there are operators who may subordinate their scruples in favor of expanded profits on "quickie deals," and who seem to take special delight in attempting to swindle one another. Though shunned by Better Business Bureaus and all reputable dealers, they seem to make a reasonably comfortable living. Typifying their level of ethics is the story, probably apocryphal but undoubtedly containing elements of truth, of two diamond brokers in New York City. One of them approached the other saying, "If you will sell me a 5-carat diamond at a bottom price, I'll raffle it off among the dealers in town at twenty dollars a chance, and I'll cut you in for ten percent of the profit." This proposition seemed attractive enough, and the second broker acceded to the arrangement. The temptation to gull his colleague was too great to resist, however, and he slyly substituted for the diamond that had been agreed upon a white sapphire of excellent quality but vastly lesser value.

As time went by, this second broker heard rumors that interest in the raffle was high, and finally that the stone had been won by a third broker. He grew mildly apprehensive as he considered the reactions and reprisals that might follow identification of the stone, either by his associate or by the winner, and he studiously avoided contact with both of them. One day, though, he came face to face with the first broker, who greeted him with surprising warmth and commented upon the success of the raffle. After a few moments his curiosity overcame his caution, and he remarked, "Say, that really wasn't a diamond I sold you!"

"Yes, I know," was the rejoinder, "You made a neat switch."

"Then you're not sore about it?"

"No, not particularly."

"But what about the fellow who won it?"

"Oh, him," was the prompt reply. "Why should he complain? I refunded his twenty dollars!"

Although the purely negative aspects of gem purchasing are worthy of strong emphasis, more positive factors also should be considered by the buyer who wishes to obtain maximum value for his money. Several of these relate to the physical properties of the various gem materials, others to the preparation of these materials, and still others to long-established methods of merchandising that are peculiar to the gem trade. Some can be evaluated by any intelligent purchaser, others only by experts, but all of them relate to major problems about which the purchaser should at least be prepared to ask penetrating questions. These problems can best be compared with those involved in a more "normal" type of purchase, say of a new automobile.

The prospective buyer, in looking through the showroom window at the 1955 Ossel Eight, can be confident that this automobile is indeed an Ossel Eight, and not a Deep Six or some other make. He cannot have such confidence if he is shopping for a gem stone, especially if he deals with a seller of unknown or questionable reputation. Even with a perfectly honest merchant, he faces a complex terminology of well-established gem names along with trade names that range in flavor from meaningless to misleading. Some gem names, like diamond and zircon, are precise in meaning because they are identical with the names of the minerals themselves, but other popular gem names either are different from the corresponding mineral names or are applied to different varieties of given minerals. Thus peridot is the mineral olivine, ruby and sapphire are varieties of corundum, and emerald, aquamarine, and morganite are varieties of the mineral beryl. The most common gem materials and their corresponding mineral names are listed in the table on page 16.

Even more confusing are special gem names that plainly are intended to deceive the unwary purchaser. They generally resemble the names of valuable gem stones, and are applied to stones of lesser intrinsic worth. Thus red varieties of garnet, a relatively common gem mineral, have been sold as "American ruby," and green varieties of the same mineral have been sold

THE MOST COMMON GEM MATERIALS

Gem name	Color	Mineral Name	Index of refraction†	Chemical composition
Diamond*	Colorless, blue-white, yellow, brown, red, green, blue	Diamond	2.42	C
Ruby*	Red, pink	Corundum	1.77	Al_2O_3
Sapphire*	Colorless, blue, pink, violet, green, yellow			
Emerald*	Green	Beryl	1.58 ±	$Be_3Al_2Si_6O_{18}$
Aquamarine*	Blue, blue-green			
Heliodor*	Yellow			
Morganite*	Pink			
Alexandrite*	Green in daylight, reddish by artificial light	Chrysoberyl	1.76	$BeAl_2O_4$
Chrysolite*	Yellowish green			
Almandite* (carbuncle)	Deep red	Garnet	1.70 to 1.90	$(Ca,Mg,Fe,Mn)_3$ $(Al,Fe,Cr)_2$ Si_3O_{12}
Demantoid*	Green			
Hessonite*	Yellow, green, brown			
Pyrope*	Red			
Rhodolite*	Rose pink to purple			
Topazolite*	Yellow			
Amethyst*	Pale violet to purple	Quartz	1.55	SiO_2
Aventurine	Yellow, brown, red, green			
Cat's eye	Gray, green, brown			
Citrine*	Yellow			
Rock crystal*	Colorless			
Rose quartz*	Pink			
Smoky quartz*	Smoky gray, brown			
Tiger's eye	Red, brown, blue			
Agate	Gray, red, brown	Quartz, extremely fine grained (crypto-crystalline)	1.55	SiO_2
Bloodstone	Dark green with red blotches			
Carnelian	Red			
Chalcedony	Gray, white			
Jasper	Yellow, red, brown, green, gray			
Onyx	Colored layers			
Sardonyx	Red and white layers			
Coral	Red, black, white	Calcite or aragonite, with or without impurities	1.66 1.69	$CaCO_3$
Mexican onyx	Colored layers			
Pearl	White, pink, yellow, green, blue, brown, red, purple, black			
Alabaster	White	Gypsum	1.53	$CaSO_4 2H_2O$
Moonstone	White	Feldspar (orthoclase or sodic plagioclase)	1.53 1.54	$K\ Al\ Si_3O_8$ $Na\ Al\ Si_3O_8$
Aventurine	Green			
Amazonstone	Green	Feldspar (microcline)	1.53	$K\ Al\ Si_3O_8$
Hematite	Black	Hematite	3.00 ±	Fe_2O_3
Jade	White to green	Nephrite or jadeite	1.63 1.68	$Ca(Mg,Fe)_3Si_4O_{12}$ $Na\ Al\ Si_2O_6$
Lapis lazuli	Blue	Lazurite	1.50 ±	$Na_4S_2Si_3Al_3O_{12}$
Opal	White, yellow, red, blue, green, gray, black	Opal	1.45 ±	$SiO_2.nH_2O$
Peridot*	Green	Olivine	1.70 ±	$(Mg,Fe)_2SiO_4$
Spinel*	Pink, red, yellow, purple, blue, green	Spinel	1.75 ±	$(Mg,Fe)Al_2O_4$
Topaz*	Yellow, red, blue, green, colorless	Topaz	1.63 ±	$Al_2(F,OH)_2SiO_4$
Tourmaline*	Yellow, red, blue, green, brown, pink, colorless	Tourmaline	1.66 ±	Complex borosilicate
Turquoise	Green, blue	Turquoise	1.65	Hydrous copper aluminum phosphate
Zircon*	Yellow, orange, red, brown, green, blue, colorless	Zircon	1.96 ±	$ZrSiO_4$

* Stones ordinarily used in transparent or nearly transparent form.

† The value of the maximum index is given for minerals that are optically anisotropic and hence have more than one index of refraction.

as "Uralian emerald." Similarly, "Balas ruby" is a name commonly applied to red spinel, a gem stone that is very attractive in its own right but scarcely commands the price of a true ruby. Modifying terms, especially those with a geographic connotation, should arouse suspicion in the mind of the purchaser, as a glance at the table on page 17 will indicate. The same caution is appropriate for coined trade names like "alexandrine," "rubicelle," and "sapphirine," which closely resemble valid gem or mineral names but are given to other, less valuable materials.

Attempts are being made in the jewelry trade to standardize the use of gem names, but much remains to be accomplished. Most unfortunate among the still-current deceptions is the widespread sale of yellow quartz for topaz, under names such as "Bohemian topaz," "Brazilian topaz," "Jewelers topaz," "Spanish topaz," or, worst of all, "topaz." Probably more than four-fifths of the "topaz" now in the hands of ultimate users of jewelry actually is quartz. This particular deception is rather serious, in part because the yellow color of much gem quartz is obtained by artificial heat treatment, and in larger part because true topaz (the "precious topaz" of the jewellers' trade) yields much more brilliant and attractive stones than does quartz.

The intelligent buyer, in comparing the Ossel Eight with other makes of automobiles, undoubtedly considers the materials of which it is made, the over-all appearance and quality of the final product, and its probable performance under the conditions of anticipated use. Similar considerations should be applied to the purchase of any properly identified gem stone. What are its fundamental characteristics? Is it sufficiently hard and tough to be durable? Are its brilliance and color permanent? Does it contain tiny inclusions, "feathers," or other imperfections that lessen its real worth? And does its particular combination of properties have maximum appeal for the intended user? Finally, perhaps, will it constitute a good investment or is its value likely to depreciate in response to market conditions or broad changes in fashion? In these respects the wide variety of available gem stones is very much to the buyer's advantage, as he generally can find at least one type of gem that fits the specifications most desirable to him.

MISLEADING NAMES COMMONLY APPLIED TO MATERIALS SOLD AS GEMS

Applied name	Identity of material
African emerald	Green fluorite or tourmaline
African jade	Green garnet
Alaska diamond	Quartz
Alexandrine	Synthetic "alexandrite"= synthetic corundum or spinel
Alpine diamond	Pyrite
American ruby	Red garnet
Arabian diamond	Synthetic corundum
Arizona ruby	Red garnet
Arkansas diamond	Quartz
Australian ruby	Red garnet
Balas ruby	Red spinel
Black diamond	Hematite
Bohemian diamond	Quartz
Bohemian ruby	Rose quartz
Bohemian topaz	Yellow quartz
Brazilian diamond	Quartz or zircon
Brazilian emerald	Green tourmaline
Brazilian peridot	Green tourmaline
Brazilian ruby	Pink topaz
Brazilian sapphire	Blue tourmaline or topaz
Brazilian topaz	Yellow quartz
Brighton emerald	Green glass
California moonstone	Chalcedony
Ceylon opal	Feldspar (moonstone)
Dauphine diamond	Quartz
Electric emerald	Green glass
Evening emerald	Green olivine
Garnet jade	Green garnet
Gold topaz	Yellow quartz
Herkimer diamond	Quartz
Indian jade	Green quartz
Indian topaz	Yellow quartz
Jewelers topaz	Yellow quartz
King topaz	Yellow quartz or corundum
Madeira topaz	Yellow quartz
Mexican jade	Zircon
Matera diamond	Dyed calcite
Occidental diamond	Quartz
Oriental alabaster	Calcite
Oriental amethyst	Pink corundum
Oriental aquamarine	Blue corundum
Oriental emerald	Green corundum
Oriental peridot	Green corundum
Peridot of Ceylon	Green tourmaline
Pomegranate ruby	Pink or red spinel
Quartz topaz	Yellow quartz
Rhine diamond	Beryl
Rubicelle	Pink or red spinel
Sapphirine	Spinel, quartz, or glass
Scientific emerald	Green glass
Scientific sapphire	Blue glass
Siberian chrysolite	Green garnet
Siberian ruby	Pink or red tourmaline
South African jade	Green garnet
Spanish topaz	Yellow quartz
Spinel ruby	Pink or red spinel
Spinel sapphire	Blue spinel
Tasmanian diamond	Topaz
Uralian emerald	Green garnet
Uralian emerald	Blue tourmaline
White emerald	Beryl

RELATIVE HARDNESS OF SELECTED GEM MATERIALS

Material	Relative hardness value*	Hardness rank on Mohs' scale
Gypsum	32	2
Calcite	75-130	3
Flint glass†	480	—
High-alumina glass†	550	—
Orthoclase	560	6
Quartz	700-900	7
Topaz	1050-1250	8
Spinel†	1100-1250	—
Corundum†	1700-2200	9
Diamond	8000-8500	10

† Synthetic material

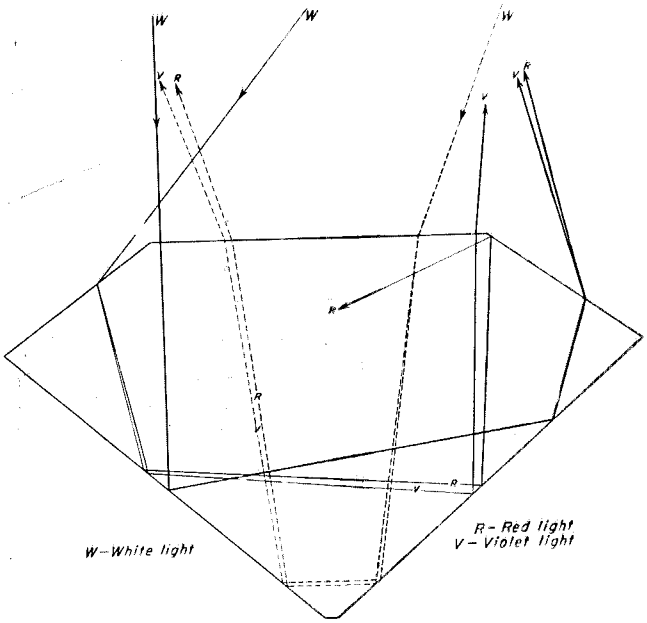
* Determined mainly through measurements, by several different investigators, of indentations made by a diamond blade. Most of the variations in hardness values for a single mineral species reflect actual differences in hardness for different crystallographic directions.

Many gem minerals differ markedly from one another in hardness, as shown for several species in the table above. The hardest minerals, like diamond, corundum, chrysoberyl, spinel, topaz, and some varieties of garnet, beryl, and zircon, can be cut into faceted stones that take an excellent and lasting polish. These gem minerals lie above quartz on the old Mohs' scale of hardness rank, and retain their polish despite daily contact with fabrics, the dust and grit in the air, and a number of additional materials that contain tiny particles of quartz or other abrasive substances.

The softer gem minerals, like jade, lazurite, olivine, opal, quartz, tourmaline, turquoise, and some garnet, beryl, and zircon, commonly become dull with daily wear unless they are handled very carefully. Relative softness also is one of the chief disadvantages of glasses that are used as gems. Loss of polish and sparkle through wear is most objectionable in facet-cut stones, whose faces become pitted and whose edges become ragged or rounded. These softer stones should not be worn continuously if they are set in rings, although they are wholly satisfactory for pendants, brooches, and necklaces.

Some gem stones are easily chipped when they are knocked sharply against another object, as a dish, table, or wash basin. This commonly is due to intrinsic brittleness of the mineral, as in some varieties of zircon and beryl, or to the presence of one or more directions of ready cleavage, as in topaz and some varieties of olivine. Brittleness also can be caused by strains set up during cutting and polishing of the gem, or, more commonly, by heat treatment that may be given the stone in order to improve its color. Many quartz, topaz, and zircon gems have been heat-treated, and should be examined very carefully under a lens for indications of potential fracturing or shattering.

Color is an important property of all gem stones, and is by far the most desirable feature of many. Almost any color can be found among the gem minerals, and several individual species occur in a wide range of colors (as in the table on p. 16). The desirability of a given color is largely a matter of individual preference, and



Reflection, refraction, and dispersion of light in a brilliant-cut diamond.

only for diamond, sapphire, ruby, and a few other high-priced gems are there firmly established correlations between color and value. Such gems ordinarily are graded by experts before they reach the showcases of the jewelry store.

Fortunately, the natural color of most gem stones is essentially permanent, and the purchaser need only concern himself with such features as hue, tone, intensity, and evenness of color. A few minerals, however, are known to lose a part of their color over long periods of time. Kunzite, a rare gem variety of the lithium-bearing mineral spodumene, is valued mainly for its transparency and beautiful lilac to purple color, but its color fades appreciably during years of exposure to sunlight. Gem varieties of opal, a mineral that contains considerable amounts of water, feature attractive plays of color caused by interference of light along minute cracks and other internal inhomogeneities. Some of the contained water generally is lost, with an attendant loss in "fire" of the opal, between the time when the material is mined and the time when it is sold. To forestall this partial desiccation, which often is accompanied by cracking, many dealers immerse their opal gems in water or protect them with films of oil. The purchaser must be prepared to adopt similar protective measures, especially if the stone is to be kept in a region of dry climate, or, better, he should attempt to obtain an opal that already has lost its loosely contained water and is of high quality despite this loss.

Artificial coloring

Some gem materials, notably agate and other extremely fine-grained varieties of quartz, are colored artificially by immersion in various solutions, with or without subsequent heat treatment. Heat treatment alone is commonly used to change the color of quartz from smoky or amethyst to yellow, of topaz from yellow to pink, of beryl from green to blue, of corundum from yellow to colorless, and of tourmaline from dark blue to green. Many colorless gems, obtained by heating reddish or brownish zircon, have been sold under names that emphasize their resemblance to diamond, and all of the attractive blue zircon that has been marketed for about 35 years owes its color to heat treatment. Some gem stones, like amethyst and ruby, may be heat-treated in order to smooth out irregularities in the distribution of their original color. The purchaser should be aware of these practices, which all too commonly decrease the mechanical strength of gem stones.

Exposure to X-rays, radium emanations, or certain other types of radiation causes color changes in many gem minerals. Thus diamond may become green, and colorless quartz may become brown or smoky gray. Some of the new colors appear to be essentially permanent, but many are short-lived. Stones thus treated have not appeared on the gem market in significant numbers to date.

Liveliness

The brilliance and sparkle, or general "liveliness," shown by facet-cut gem stones are related fundamentally to their indices of refraction. Reflection and refraction of light at an interface between substances of different optical density are such well-known phenomena that they scarcely require detailed treatment here, but it is worth noting that in faceted gems the effects of light refracted into the stones are more important than the effects of light reflected directly back from their surfaces. Maximum brilliance is obtained when the maximum percentage of the light entering a stone through its upper facets is totally reflected from its lower facets and ultimately emerges in upward directions, as shown in the drawing at the top of this page.

Leakage of light

For all practical styles of cuts, the downward or lateral "leakage" of light from a given stone can be held to a minimum if the index of refraction of the mineral is high and the critical angle hence is low, because total reflection then takes place within the stone for light rays incident upon the lower facets over a wide range of angles as shown on page 19. Thus diamond, zircon, and other minerals with high indices of refraction are distinguished by their sparkle and brilliance, whereas minerals with low indices of refraction, like quartz and beryl, perforce derive their value more from other properties.

Many gem minerals are optically anisotropic, and hence show double refraction. This complicates the paths of light transmitted through them, but ordinarily has little effect on their brilliance. Notable effects, however, are shown by minerals that have markedly different indices of refraction for frequencies of light corresponding to different parts of the visible spectrum (as above).

These minerals, which include diamond, zircon, and some varieties of garnet, are said to have strong dispersion, and when facet-cut they show the shifting flashes of color known as fire. This feature, incidentally, is quite different in origin from the play of colors that characterizes opal.

Cut stones

In his critical examination of the Ossel Eight, the buyer probably gives some thought to its general style. Is it fundamentally attractive? And is it well adapted to the other features of this particular automobile? The same questions might well be asked during the examination of a gem stone, even though just such questions have been anticipated in the preparation of most gems. Thus non-transparent minerals generally are cut *en cabochon*, with smoothly rounded and polished surfaces that emphasize color, play of colors, sheen, special markings, or other attractive features. Cabochon cuts also are used for star sapphire, star ruby, or other asteriated gems. Transparent gems, in contrast, are cut and polished into faceted stones, which have a pleasing form and also emphasize the clarity, color, brilliance, or other favorable characteristics of these minerals. The facets on any well-cut stone are symmetrically disposed and oriented, and corresponding facets are of corresponding shape and equal size. They are nicely polished, and the edges between facets are sharp and straight.

Gem stones are faceted in many different styles, most widespread among which is the brilliant cut (page 20). This cut has been popular since it was first introduced more than 250 years ago, largely because it is so effective in showing up brilliance and fire in transparent gems. The standard brilliant cut comprises 58 facets, including a large top facet, known as the table, and a tiny bottom facet that is termed the culet. Common modifications of this cut have 66, 74, or 82 facets, and special styles may be distinguished by more than a hundred facets. The upper part of a brilliant-cut stone is termed the bezel or crown, and the lower part the back or pavilion; these two parts meet along a sharp circumferential edge known as the girdle.

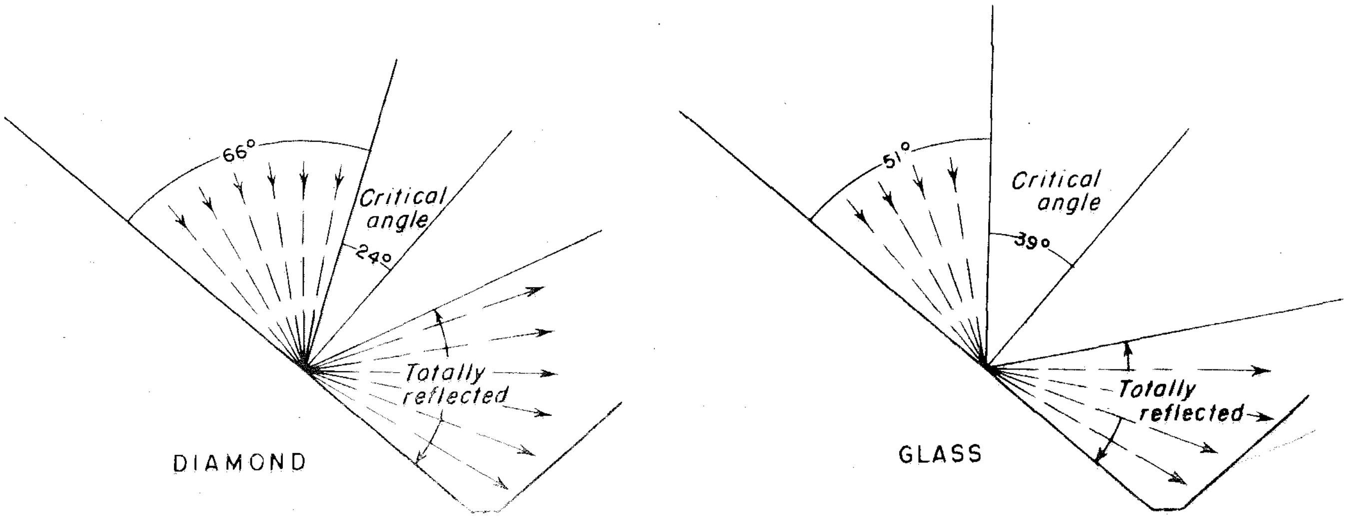
Correct proportioning

If a given brilliant-cut stone is to show maximum sparkle and fire, its facets obviously must be oriented in such a way that the greatest possible amount of light is totally reflected upward within the pavilion. Correct proportioning of the stone is vital for gems like the diamond, much of whose value depends upon its "liveliness." Many diamonds are cut too deep or too flat in order to reduce wastage from the original pieces of rough material. Although this practice is economically sound, it does not yield gems of top quality. If either the crown or the pavilion of the stone is too thick with respect to its diameter at the girdle, light is lost by refraction through the pavilion facets and the stone appears somewhat glassy and dark.

Undesirable leakage of light also takes place if either the crown or the pavilion is too thin or shallow with respect to the girdle diameter, and such a stone is so lifeless that it is said to have a "fish-eye" or "tapioca" appearance.

Loss of brilliance also characterizes stones that have properly oriented facets, but whose crowns are too thin and whose tables are thus unduly large. Although relatively "dead", these stones generally appear to be larger than they really are, and the term "swindled" is widely and aptly applied to them. They are likely to attract the eager buyer who senses a "good bargain."

The brilliant cut is often used to show off unevenly colored gems, such as amethyst, ruby, and sapphire, to the best possible advantage. If the darkest part of the stone lies immediately above the culet, the entire stone appears to be more deeply colored than it actually is. The relatively pale upper part of such a stone is easily



Effects of the critical angle on total reflection from a lower facet on a cut diamond (index of refraction = 2.42) and a similar facet on a cut stone of glass (index of refraction = 1.60) recognized if it is viewed from the side, or in a direction parallel to the table. Other types of cuts, generally square or rectangular in plan (shown below) are widely used for stones with uniformly-distributed color and relatively low indices of refraction, like aquamarine, emerald, and topaz. During recent years they also have been popular for the more brilliant stones, including diamond. Emerald, step, baguette, square, and a large number of special cuts vary considerably in their proportions, which may emphasize brilliance, lightness or darkness of color, economy of the original rough material, or other factors.

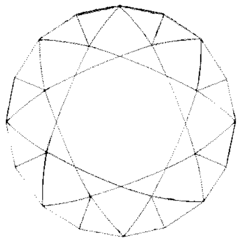
Of vital interest to the prospective purchaser are the so-called manufactured gems, which include synthetic, imitation, composite, and heat-treated or otherwise artificially colored stones. For all practical purposes, well-made synthetic gems have the same properties as the corresponding natural gems, but they have considerably lesser intrinsic values. Excellent synthetic sapphire, ruby, and spinel have been on the market for almost two decades, and during more recent years emerald, star ruby, and star sapphire have been manufactured on a commercial basis.

The latest addition to the ranks of synthetic gems is rutile, TiO_2, which is marketed under the name "Titania." It is extremely pale to deep yellow, has great brilliance, and is cut into very attractive stones. Synthetic corundum and spinel that appear grayish green in daylight and purplish or red in artificial light have been sold in large quantities as "synthetic alexandrite" and even as "alexandrite," especially in Asia and South America. Thousands of American servicemen purchased these stones during World War II under the mistaken impression that they were "the real thing."

Despite their close resemblance to natural stones, most synthetic gem stones can be distinguished as such by careful examination under the microscope. This is a problem best left to experts in the field. More easily recognized are imitation gems, which commonly are made of special glasses that are referred to as "paste." All glass stones are objectionably soft, and are suitable only for costume jewelry. Lead-bearing glasses have high indices of refraction and can be fashioned into sparkling stones, but they are particularly soft and hence liable to rapid wear. The lower facets of some glass stones are silvered or backed with foil, which increases their brilliance and also their price. These "gems" are sold under the general name "rhinestone."

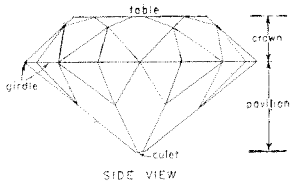
Perhaps the cheapest type of imitation gem is the molded stone, which consists of glass or a plastic that has been poured into a carefully designed mold, with or without subsequent polishing of the facets on the solidified material. Tourists in foreign countries seem to be especially susceptible to the impact of the color, clarity, and ridiculously low prices of such stones.

Composite or assembled stones consist of two or more parts that are cemented or fused together in order to increase their size or improve their color. Those that comprise two or three sections of genuine material are known respectively as true doublets or true triplets. False doublets, in contrast, generally comprise a crown or partial crown of genuine material, such as diamond, ruby, sapphire, or garnet, and a pavilion of colored glass or an inferior gem material. Most false triplets

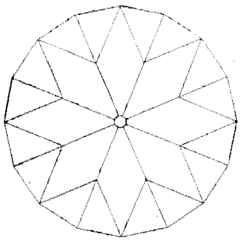


TOP VIEW

Gem stones are faceted in many different styles. Most widespread is the brilliant cut shown at the left—as it appears from the top, side, and bottom.

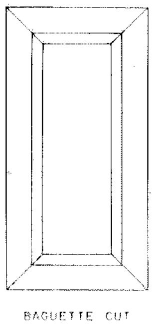


SIDE VIEW

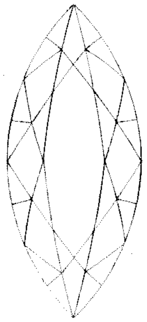


BOTTOM VIEW

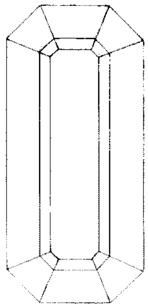
Other types of cuts, shown at the right, are widely used for stones with uniformly-distributed color and relatively low indices of refraction, like aquamarine, emerald, and topaz.



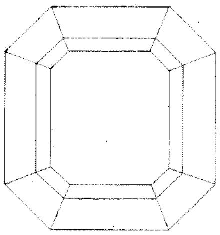
BAGUETTE CUT



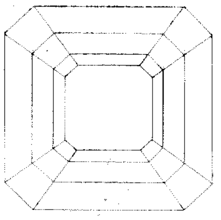
MARQUISE CUT



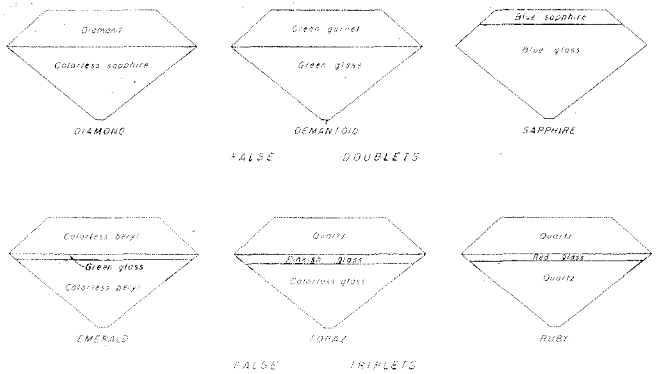
STEP OR TRAP CUT



STEP OR TRAP CUT



EMERALD CUT



Some typical false doublets and triplets—composite or assembled stones consisting of two or more parts cemented or fused together to increase their size or improve their color.

contain a slice of colored glass, pocket of liquid, or some type of colored film between two sections of harder material.

Typical examples, shown above, are the false emerald triplet, a "sandwich" of green glass between two pieces of colorless beryl, and the false topaz triplet, in which a thin plate of yellow or pinkish glass is placed between a crown of quartz and a pavilion of glass.

A composite stone, even if nicely made, can be recognized as such by immersion in a liquid whose index of refraction approximates that of the mineral the stone is supposed to represent. The cement, glass, or inferior gem material stands out distinctly when viewed in such a liquid.

Star sapphires and star rubies have been simulated by cementing appropriately colored foils or mirrors to the backs of stones that consist of milky asteriated quartz. Further, a milky stone that does not show asterism can be made to yield a star if the mirror is scribed with fine grooves or scratches arranged in a trigonal pattern. It is fortunate that mirror- or foil-backed stones are easily recognized, and any asteriated stone whose back is "protected" by a coating of lacquer should be viewed with suspicion.

How to buy a diamond

Let us conclude this discussion by placing ourselves in the position of an intelligent person who wishes to buy a diamond of high quality, presumably for setting in a ring. He is aware of the deceptive practices noted in the foregoing paragraphs, and so has sought the advice of an established retail dealer who is reasonably proficient in the appraisal of the gems that he handles. This dealer places before him three handsome stones, and the prospective buyer cannily notes that they are free of surface dust and grease, that they are displayed against a background of dark-colored velvet, and that they twinkle and flash in the direct illumination from a powerful unfrosted light bulb. He probably senses, and correctly, that the stones are being shown under optimum conditions, and that they might not be fully as attractive when they are worn in jewelry later on. He thus qualifies as a realist.

The dealer outlines the principal features of each stone. The smallest is flawless, perfectly cut in the proper form, and of the best blue-white color. The second stone is somewhat larger, and is perfect in every respect but color. It has a yellowish cast so faint that it is barely recognizable to the buyer, even when this stone is placed alongside the other and viewed under intense illumination. The third stone, which is still larger, is blue-white in color and also is properly cut, but it has a tiny imperfection near the culet. This flaw, the dealer states, will be visible only to an expert when the stone is worn in a ring. All three stones are offered at the same price.

The final decision

Which diamond should the buyer choose? He has been honestly provided with the significant technical data for each stone, and now he must make the final decision. Obviously this is as it should be, because only the buyer can know which combination of features has the greatest appeal for him. If he follows the dictates of his own feelings at this stage of the negotiations, he can make no serious mistake, because the three stones almost surely are of equal intrinsic worth.

After some thought, he chooses one of them, observes that it represents a considerable investment of money, and wisely requests a final appraisal by an authorized expert, so that the stone can be protected by insurance. An appraisal of this kind must be realistic, and will indicate whether the price he pays is a reasonable one. The purchaser finally leaves with the stone, knowing that he has made a sound bargain.

Are you and your wife still happy with the engagement ring you bought on that first visit to the jewelry store? Perhaps the stone looks smaller than it once did, and perhaps it frequently is filmed with dust and dishwater grime, but at least you can bet that if it is genuine it will continue to be attractive long after the Ossel Eight has seen its last used-car lot!

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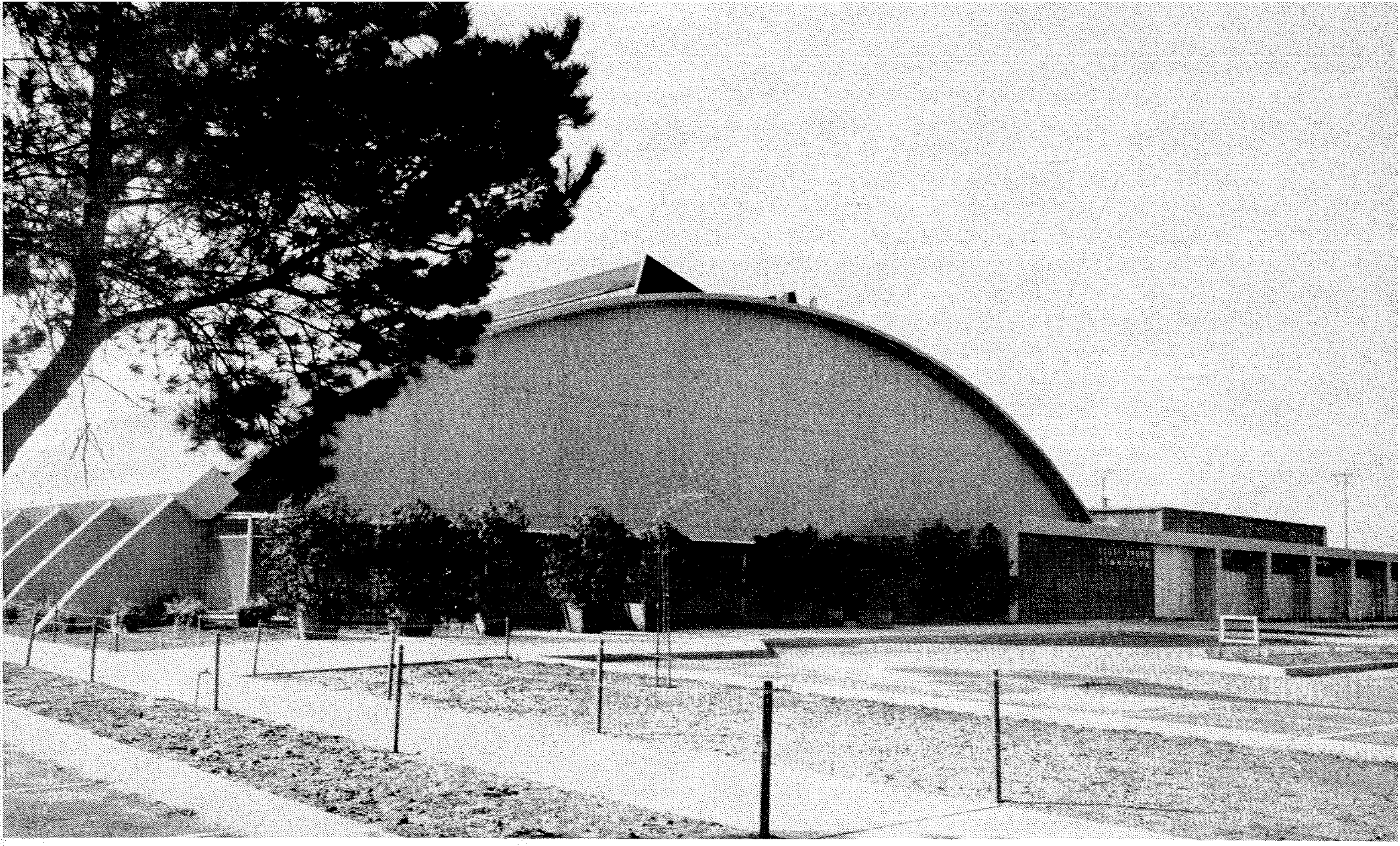
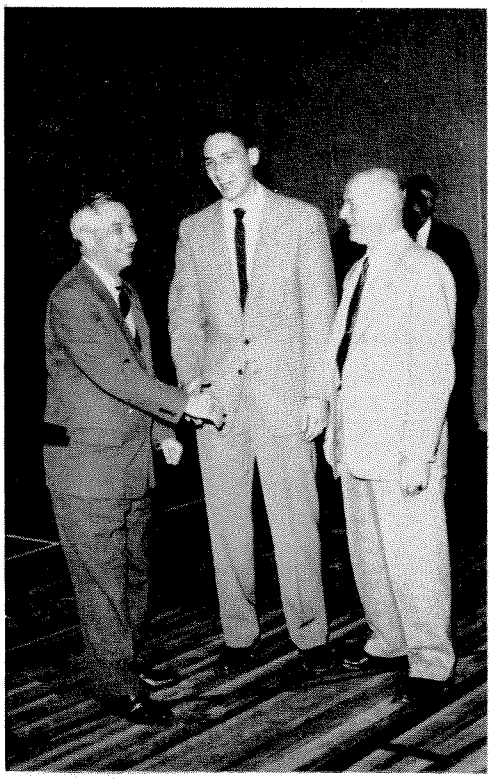

Caltech's new $400,000 Scott Brown Gymnasium



THE MONTH AT CALTECH

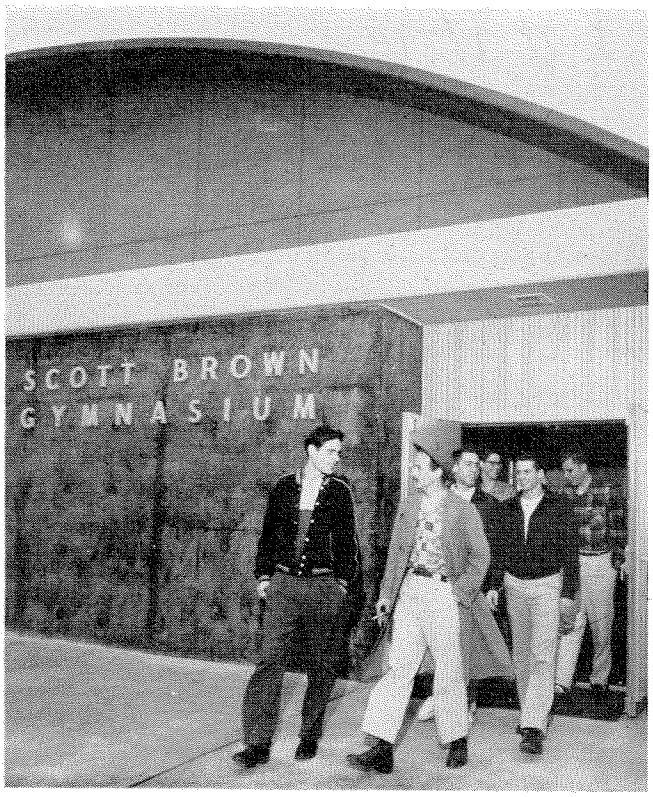
President DuBridge presents new gym at dedication ceremony to ASCIT president James Adams, accepting on behalf of student body. Athletic director Hal Musselman is looking on.

Gym floor is large enough for two practice basketball games to be played simultaneously on its cross courts.

CALTECH'S IMPRESSIVE, and long-awaited, athletic center opened for business last month. The Scott Brown Gymnasium was dedicated on January 11, between the halves of Caltech's first home game of basketball, with Long Beach State. The Alumni Swimming Pool, which is also now in use, will be officially dedicated on Alumni Seminar Day, April 16.

The $400,000 gymnasium, at the south end of the Tournament Park parking lot, looks like an airplane hangar, has a 94 x 114 ft. gym floor (large enough for two practice basketball games to be played simultaneously on its cross courts) with six 8-row sets of bleachers folded up against its north wall, and six more along the south wall; when these are pulled out they can seat close to 1,000 people.

The building also contains locker rooms, shower rooms, athletic offices, a medical room and a lecture classroom.



Reed Award

DR. CLARK B. MILLIKAN, Professor of Aeronautics and director of the Guggenheim Aeronautical Laboratory at Caltech, was chosen last month to receive the

1954 Sylvanus Albert Reed Award of the Institute of the Aeronauatical Sciences. The award—consisting of a certificate and $250—was given to Dr. Millikan "for his contributions to fluid mechanics, airplane aerodynamics, and wind tunnel technology, and for research leadership and guidance in aeronautical sciences."

Dr. Millikan, who has been teaching at Caltech since 1928, has been in charge of wind tunnel testing here since 1935 and has been director of the Southern California Cooperative Wind Tunnel since it began operations in 1945. He is also chairman of the Jet Propulsion Laboratory Board.

Currently he is serving as chairman of the Aircraft and Guided Missiles Panel of the Air Force Scientific Advisory Board, and as a member of the Ballistic Research Laboratories' Scientific Advisory Committee. He is chairman of the Subcommittee on Fluid Mechanics and a member of the Committee on Aerodynamics of the National Advisory Committee for Aeronautics.

Bruce Medal

THE ASTRONOMICAL SOCIETY of the Pacific has awarded Dr. Walter Baade its Catherine Wolf Bruce Gold Medal for 1955 for his investigations of the structural features and stellar content of systems of stars.

Dr. Baade, a staff member of the Mt. Wilson and Palomar Observatories, made the pioneering discovery that two entirely different stars exist in the great Andromeda nebula, in our galaxy, and in others. That led to his recalibration of the Cepheid variable stars, distance indicators in the Andromeda nebula and elsewhere, and the Baade correction in the cosmic distance scale. This work indicated that all objects beyond the Milky Way are about twice as far from us as had previously been thought.

A native of Schröttinghausen, Germany, Baade studied at the Universities of Münster and Göttingen—where he received his PhD degree in 1919. He served as an assistant and later as an observer at the Hamburg Observatory before joining the Mt. Wilson Observatory in 1931.

New Trustee

SHANNON CRANDALL, Jr., of Pasadena was elected to the Caltech Board of Trustees last month.

President of the California Hardware Company of Los Angeles, Mr. Crandall has been associated with that company since his graduation from Stanford University in 1921.

Mr. Crandall was also re-elected president of the California Institute Associates last month. He has been a director since 1951, and his father is a charter member of the group.

A commander in the U. S. Navy during World War II, Mr. Crandall served as director of procurement for the Aviation Supply Office in Philadelphia. A director of the Pacific Mutual Life Insurance Company, he is also active in community affairs and is currently a director of the Children's Hospital, the Barlow Sanitarium, the Community Chest, the University Religious Conference, and the Greater Los Angeles Area Building Fund.

Visitors

DR. LUDWIG BIERMANN has been appointed Visiting Professor of Astrophysics at Caltech for the current term. On leave of absence from the Max Planck Institute and the University of Göttingen, Germany, he is conducting a graduate course here on the astrophysical theory of stellar magnetism and plasma physics.

Dr. Biermann attended the Universities of Munich, Freiburg and Göttingen—where he received his PhD in 1932. He has been a staff member of the Observatories at Jena, Berlin, and Babelsburg, and a faculty member of the Universities of Berlin, Hamburg, and Göttingen.

DR. FELIX CHAYES, petrologist in the geophysical laboratory of the Carnegie Institution of Washington, has been appointed Visiting Professor of Petrology at Caltech for the winter term. A graduate of New York University, he received his MA and PhD degrees from Columbia University. Before joining the Carnegie Institution, he served as chemist-petrographer in the U. S. Bureau of Mines, and as a mineralogist at MIT.

DR. PAUL J. KRAMER, Professor of Botany at Duke University, is now at Caltech for a year, on a National Science Foundation Fellowship, to do research in the Earhart Plant Laboratory. A graduate of Miami University of Ohio, Dr. Kramer received his MS (1929) and PhD (1931) degrees from Ohio State University.

NACA Appointments

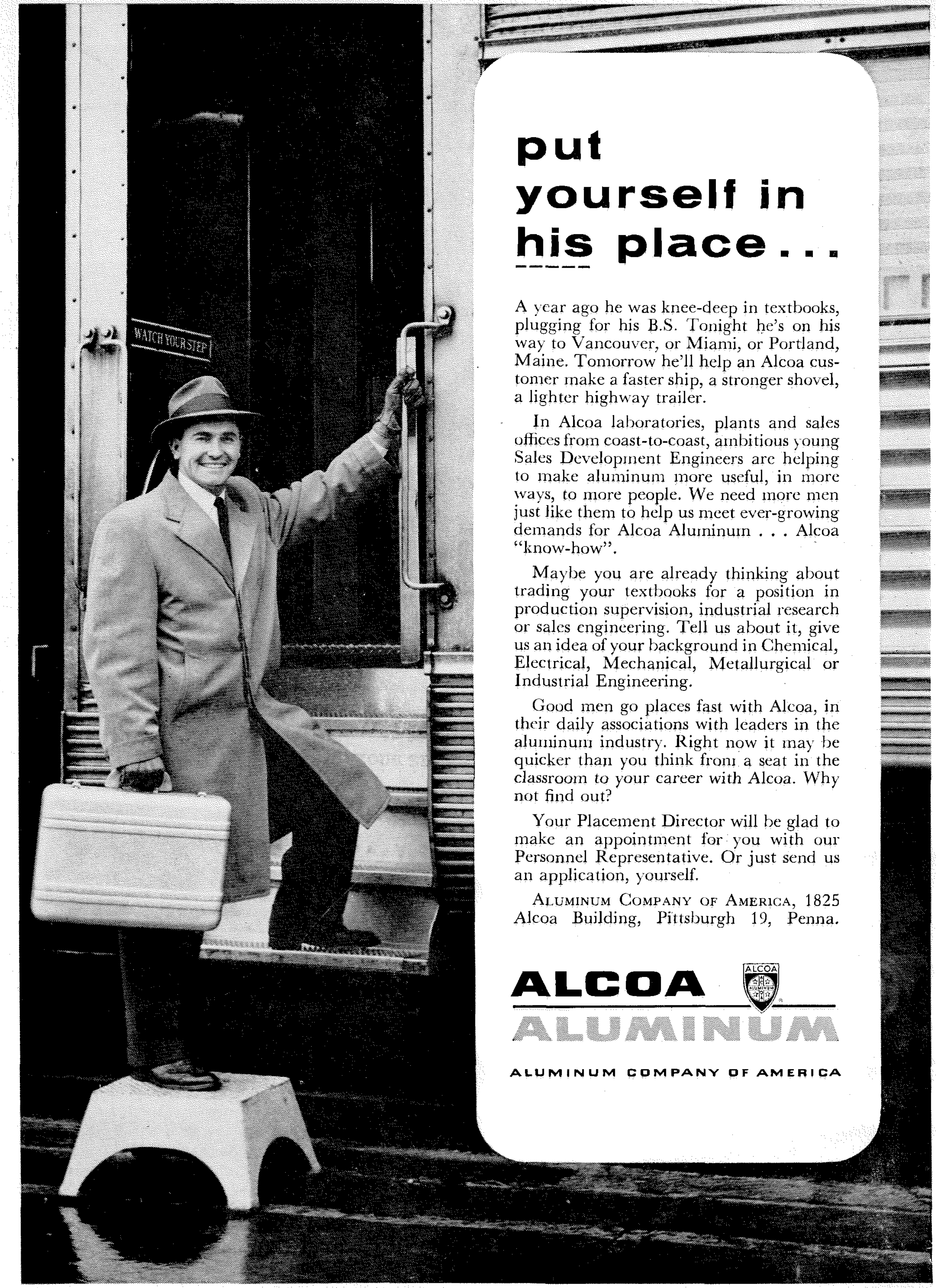
FIVE CALTECH faculty members will serve on the National Advisory Committee for Aeronautics this year.

Dr. Pol Duwez has been appointed to serve on the Subcommittee on Aircraft Structural Materials, and Dr. S. S. Penner to serve on the Subcommittee on Combustion.

Reappointments were given Dr. Hans W. Liepmann (Subcommittee on Fluid Mechanics, Subcommittee on Aircraft Noise), Dr. Clark Millikan (Committee on Aerodynamics, Subcommittee on Fluid Mechanics), and Dr. E. E. Sechler (Subcommittee on Aircraft Structures).

Dr. A. J. Stosick, of the Jet Propulsion Laboratory, was also reappointed to the Subcommittee on Rocket Engines.

These men serve the NACA in a personal and professional capacity, without compensation. They are selected for their technical ability, experience, and leadership in a special field.


WATCH YOUR STEP

Materials and their preparation

Preparation of Rubber Insulation and Jacket Compounds

MATERIALS AND THEIR PREPARATION. The materials used in the preparation of rubber insulation and jacket compounds may consist of natural or synthetic rubber along with mineral rubber and reclaimed rubber and the necessary compounding ingredients consisting of anti-oxidants, fillers, pigments, plasticizers and vulcanizing agents. The rubber or rubber-like materials are given a preliminary mastication or break-down on rubber mills or internal mixers to facilitate subsequent compounding operations. They are stored in a suitable form until required for compounding.

The required compounding ingredients, except the vulcanizing agents, used in insulating compounds, are carefully weighed into a suitable container. The plasticized rubber or rubber-like materials are weighed last. The vulcanizing agents are weighed in a separate container.

COMPOUND MIXING. Rubber insulation and jacket compounds may be mixed on rubber mills or in internal mixers.

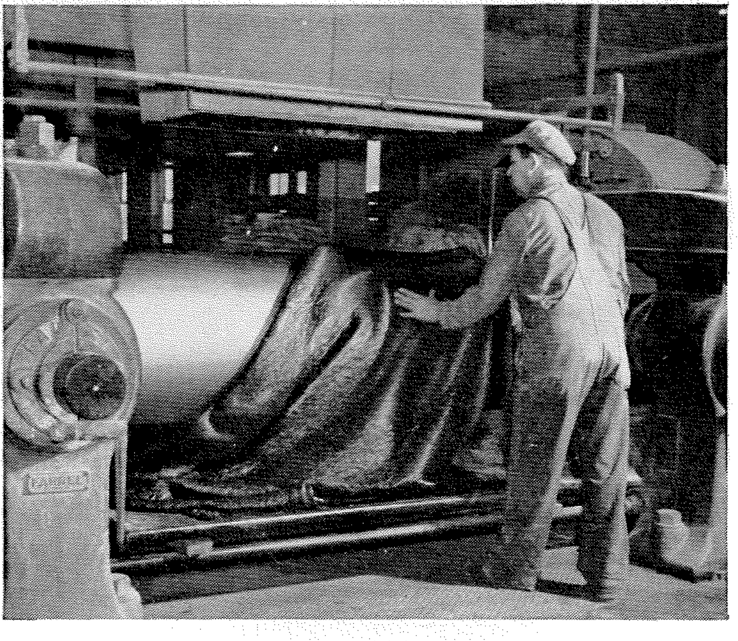
The rubber mill consists of two driven rolls about 28 inches in diameter and from 60 to 84 inches in length. The axes of the rolls are held in a single horizontal plane by the mill frame above a suitable pan. Adjustments are provided to control the spacing between the rolls. Each roll is equipped—for water circulation—for cooling. The rolls rotate in opposite directions in such a manner that the surfaces approach each other at the top. The surface speed of the back roll is about 1.2 times that of the front roll. This difference in surface speed assists greatly in break-down of the rubber and incorporation of the compounding materials.

The rubber-like materials, and mineral rubber, when used, are placed between the rolls first and masticated until so plasticized that they form a continuous sheet on the front roll. The solid ingredients, except the vulcanizing agents for insulating compounds, are then placed on the mill and incorporated in the rubbers. Any solids which drop between the rolls are retained in the mill pan and then returned to the mill.

After the solid materials have been incorporated, the batch is thoroughly blended by cutting the rubber sheet about half way across the roll from alternate ends and folding it back over the uncut portion. This blending may require about fifteen minutes and the entire mixing cycle approximately a half hour. After blending, the compound is removed from the mill in rolls suitable for feeding to the strainer.

The internal mixing unit consists of a mixer located above a rubber mill. The mixer consists of essentially two rotors with spiraled blades rotating in opposite directions at different speeds in a closed chamber. The direction of the spiral of the blades changes at the middle of the rolls. An air-controlled ram forces the materials into the mixing chamber. The mixed batch is discharged from the bottom through a hydraulically operated gate.

The effectiveness of the internal mixer as compared with the mill for breaking down and compounding rubber is evident from a consideration of its method of operation. In addition to the difference in the rate of rotation of the rotors, the interrupted spiral of the blades produces a continuous and uniform movement of the compound from the middle to the ends of the rotors. The walls of the chamber are stationary and hence the difference in rate of movement of material adjacent to the rotors and the walls is great. These conditions insure that every part of the batch being mixed will come in contact with every other part in a relatively short time. Mixing requires about fifteen minutes. After mixing, the compound is discharged to the mill below from which it is removed in a form suitable for feeding to the strainer.


Compound mixing

STRAINING. The strainer consists essentially of a mechanically driven screw located in a cylindrical cast iron housing. The housing is provided with an opening for feeding the screw and supports the head of the strainer. The head at the outlet end of the screw provides a suitable support for a thirty-six mesh screen through which the rubber insulating compounds are forced by the screw. The strainer operates on the same general principle as the ordinary household food chopper.

The mixed compound is fed into the strainer and forced through the screen. Large particles of foreign or undispersed materials are retained on the screen. The strained rubber compound is returned to a mixing mill or internal mixer where the vulcanizing agents are added. The complete insulating compound is then removed from the mill in sheets for immediate application to wire or for storage.

Jacket compounds are prepared in the same general way as insulating compounds except that the vulcanizing agents are incorporated along with the other solid fillers in mill mixing or on the sheeting mill of the internal mixing unit. Jacket compounds are not strained.

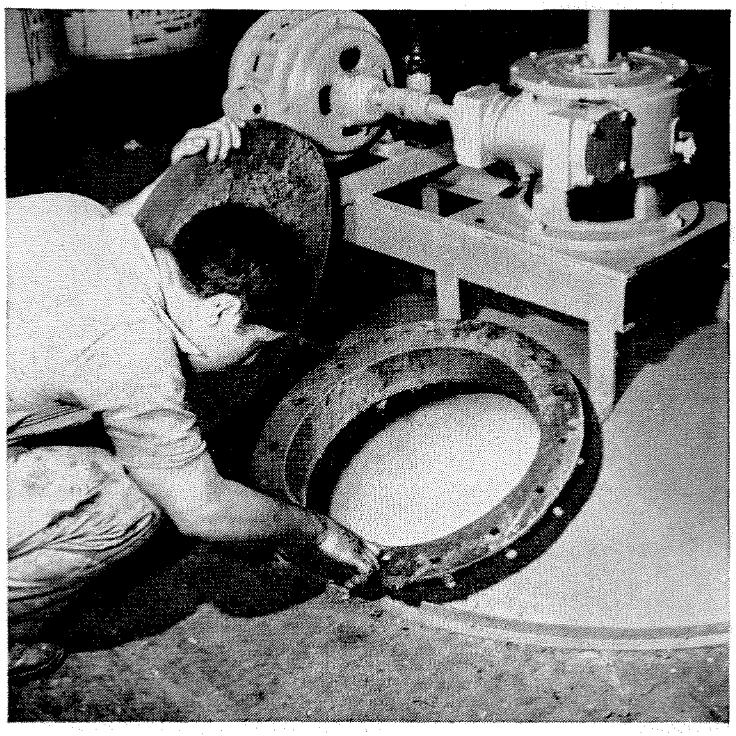
LATEX COMPOUNDING. Compounding rubber in the form of latex involves the handling of rubber in the form of a liquid and, therefore, requires lighter and less costly equipment than that just described for the compounding of plastic rubber. In addition to the actual preparation of the compound, it involves, for latex insulation, the purification of the rubber in latex form.

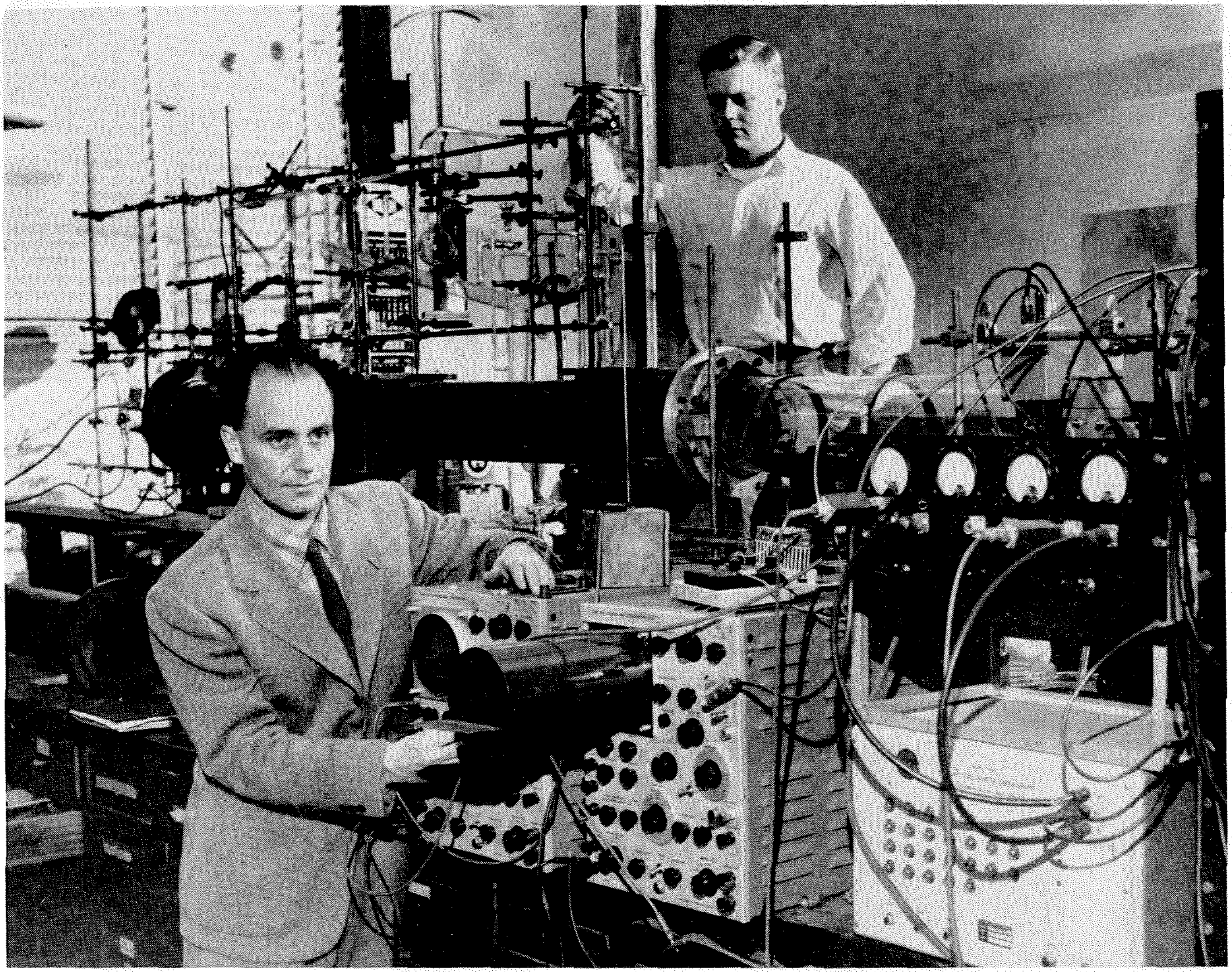
Latex rubber is purified by diluting a known quantity of latex to approximately 33 per cent solids and heating to a temperature of 150°F. in a steel tank provided with a stirrer. The required amount of creaming agent, dissolved in water, is then added and the mixture stirred. The stirring is discontinued and the warm latex allowed to stand for about 48 hours. The rubber, being lighter than water, rises to the top in much the same way that cream separates from milk. The bottom layer, the serum containing the major portion of the impurities, is discarded leaving the purified rubber in the form of a cream in the tank. This process is repeated until rubber of the desired purity is obtained.

For use in latex compounds, ordinary rubber compounding ingredients are ground more finely, thoroughly protected, and wet with water. This is accomplished in a ball mill. A ball mill consists of a porcelain lined steel drum, provided with a suitable opening and supported with its axis horizontal in such a manner that it can be rotated. The cylinder is about half-filled with flint pebbles.

Definite amounts of the various compounding ingredients, together with the required amounts of protective agents and water, are then placed in the ball mill and suitably ground. Sulfur, being the most difficult material to grind, wet and protect, is milled for about three weeks. All the other ingredients require about one week.

The required amounts of these properly protected and wet ingredients are then carefully weighed and added, along with the stabilizers and water, to a known amount of purified rubber, in the form of latex. The mixture is stirred for about two hours to insure thorough mixing. It is then transferred through a 100 mesh strainer to a storage tank until applied to wire.


Latex compounding



Dr. Norman Davidson, graduate student Garry Schott, and the shock tube used in their studies of very fast reactions.

MICROSECOND CHEMISTRY

A progress report on Caltech reseach into chemical reactions which take place in less than a thousandth of a second

by NORMAN R. DAVIDSON

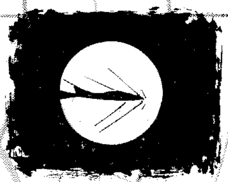
CHEMICAL KINETICS is the study of the rates of chemical reactions. The study is worth while for two reasons—one practical and one theoretical. The practical reason is that chemical reactions are used to make useful substances or to convert chemical energy into mechanical energy. Obviously such reactions must proceed at a suitable rate, neither too fast nor too slow, if they are to be useful. The theoretical reason is that an undersanding of the mechanism of a chemical reaction—a picture of how the molecules actually collide and rearrange—can be gained by measuring the reaction rate and its variation with the experimental conditions, such as temperature, pressure, or concentration of reactants.

It is relatively straightforward, in principle, to measure the rates of slow chemical reactions. One mixes the reactants and at a suitable time subjects the reacting mixture to a chemical analysis which indicates how much reaction has occurred. Alternately, one can measure

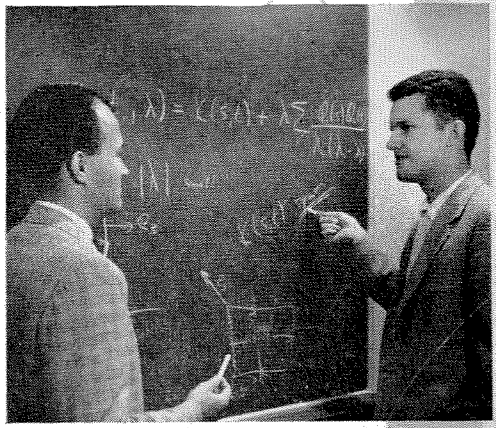
CALTECH grads are *FORTUNATE*

—because their training enables them to fill top positions in their chosen fields of science.

The Institute's Jet Propulsion Laboratory, one of the most comprehensive research and development facilities in the United States, gives CIT men the opportunity to supplement their professional education both through analytical investigation of a variety of theoretical problems and through close association with experts in most fields of science and engineering.



Developer of the Corporal, America's first tactical long-range supersonic guided missile, JPL has pioneered successful rocket motors of both the solid and the liquid types, has originated many unique guidance and communication theories and techniques, and has made significant contributions to all aspects of guided-missile research and development. The Laboratory employs more than 1,100 persons and maintains a physical plant valued at $15,000,000.00, which includes two supersonic wind tunnels, a hypersonic wind tunnel now in the early stages of construction, and extensive electronics facilities encompassing approximately 50,000 square feet.



Several new long-range research and development programs are being initiated at the Jet Propulsion Laboratory at the present time in order to fulfill continuing requirements of the Department of Defense. Vacancies have been created which require top-caliber engineers in all of the physical sciences; these vacancies must be filled by men who are capable of undertaking responsible assignments that require a high degree of personal initiative and professional competence.

Contact: Placement Office
Campus

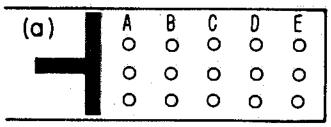
or Call: Personnel Office
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena 3, California

some physical property of the reacting system—for example, its color, electrical conductivity, or pressure—which changes as the reaction takes place. In practice, of course, a great deal of skill and hard work is required for a successful measurement.

Chemical kinetics is a comfortably big subject. There are many slow reactions whose rates and mechanisms have not yet been properly studied. Why then should chemists set up elaborate apparatuses and go to a great deal of trouble to measure the rates of fast reactions? One reason is that some fast reactions are of considerable practical importance. A high explosive, for example, must react and liberate hot gases extremely rapidly if it is to perform its destructive function properly. On the other hand, a propellant charge in an artillery shell or a rocket must burn rather rapidly so that the hot gases generated can propel the shell or rocket forward—but it must not burn so fast that it acts as a high explosive and blows the cannon or rocket to pieces.

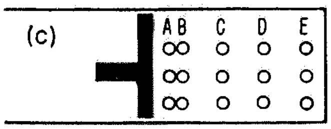
Acetylene is made by rapid heating and cooling of methane. If the cooling process is somewhat slower, carbon black is the main product. Both of these products are used in ton quantities in America, but acetylene sells for about one dollar per pound and carbon black for compounding rubber sells for about ten cents a pound. Thus, an understanding of the factors which control the relative rate of acetylene formation as against carbon formation may be of great commercial value.

A second reason for interest in fast reactions is theoretical. A simple reaction such as the attack of a hydrogen atom on a bromine molecule, $H + Br_2 \rightarrow HBr + Br$ is very fast; it probably takes place on almost every collision. Part of the reason why the reaction occurs so readily is that the molecular rearrangement is so simple. The hydrogen atom comes up on one side of the bromine molecule and attaches itself to the nearest atom, simultaneously ejecting the other atom. This example is typical of a large class of reactions frequently encountered. Precise knowledge of these simple molecular rearrangements is necessary as a basis for a theory which will enable us to predict what happens in more complicated cases.



(a) Molecules inside cylinder will be compressed and heated by inward motion of piston.

(b) Piston has moved in slowly: molecules have been compressed into a smaller volume and have been heated.



(c) By rapid inward motion of piston, molecules A and B are compressed and heated before pressure disturbance reaches C, D, and E.

The two problems involved in measuring a fast rate are: (1) to prepare the reaction system so that there is a zero time when the reactants are mixed but have not yet reacted very much, and then (2) to measure the rate of reaction. The standard solution to the second problem, when one of the reactants or products absorbs visible or ultraviolet light, is to make rapid measurements of the change in light absorption by the system by means of a photoelectric cell and a cathode ray oscilloscope. This is a fast and sensitive method.

The most obvious solution to the first problem is to mix the reactants as fast as possible. This is fine. In fact, it is the only method for some reactions. But it takes a certain amount of time to mix two chemicals, and, if the reaction occurs as fast as the mixing, all one can measure is the rate of mixing.

Another general approach is to add energy, in some form or another, in a short period of time to a system which is not reacting. If this pulse of energy initiates a chemical reaction, the rate of this reaction can be followed by the method outlined above. There are several ways of realizing this energy pulse idea—by passing an electrical discharge through a gas; by shining a lot of light into a system in a short period of time by means of a high-speed flash lamp; or by heating a gas rapidly by compression.

Rapid compression

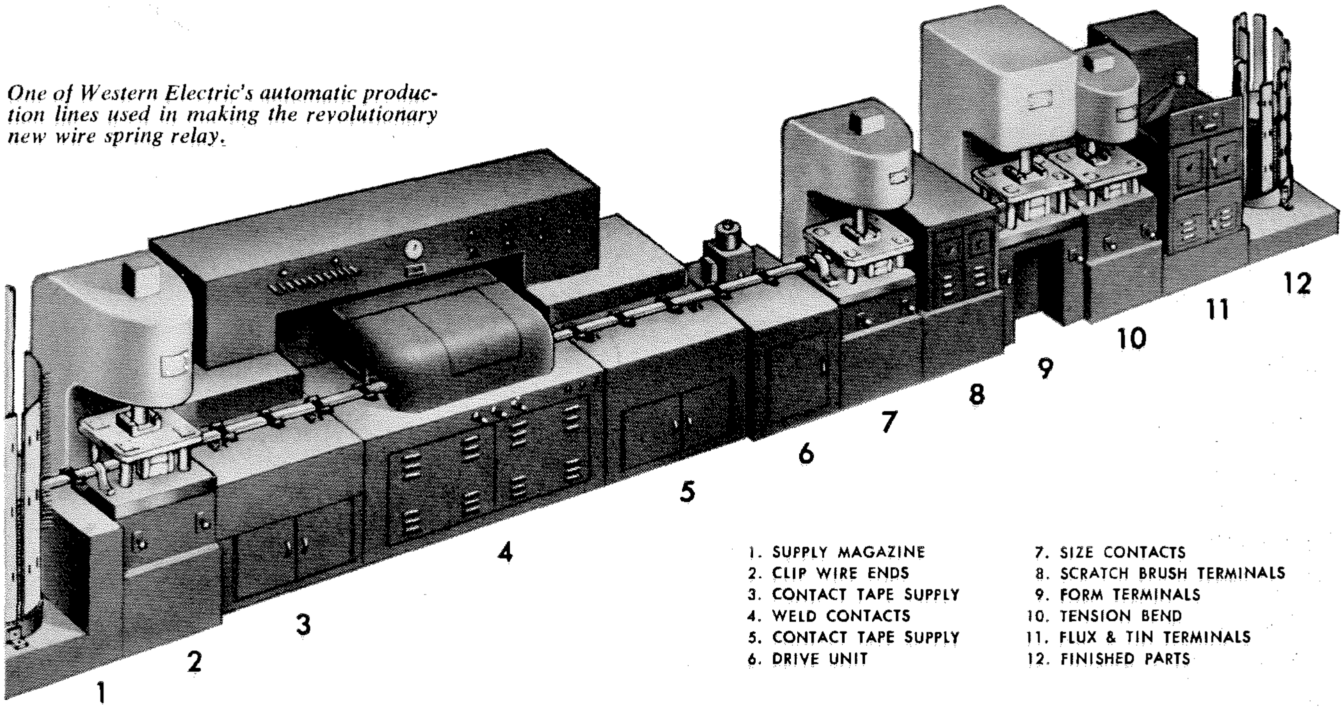
The rapid compression method is illustrated in the diagram at the left. The gas in the cylinder is rapidly compressed and heated by moving the piston inward. The molecules are depicted as being stationary; they are, of course, actually moving quite rapidly in all directions and their average velocity of random motion is a measure of the gas temperature. The inward-moving piston hits the gas molecules and thereby increases their velocity and temperature. This must be done so rapidly that the gas molecules are not cooled by collisions with the cooler walls of the cylinder. A small motion of the piston imparts additional motion to molecule A, which then moves over and hits molecule B, which then hits C, and so on. The heating is transmitted from A to E at a velocity that is approximately the velocity of the molecules.

If the piston is moving at a velocity considerably lower than this, then it does not move very far in the time required for its effect to be transmitted from A to E; the gas is being uniformly heated and compressed. This is depicted in (b). It is what happens in the normal operation of an automobile engine (with each piston going at about 4000 revolutions per minute); in the compression cycle preceding ignition by the spark, the

AUTOMATION at work

How a revolutionary new design was translated into a production reality

One of Western Electric's automatic production lines used in making the revolutionary new wire spring relay.



1. SUPPLY MAGAZINE
2. CLIP WIRE ENDS
3. CONTACT TAPE SUPPLY
4. WELD CONTACTS
5. CONTACT TAPE SUPPLY
6. DRIVE UNIT
7. SIZE CONTACTS
8. SCRATCH BRUSH TERMINALS
9. FORM TERMINALS
10. TENSION BEND
11. FLUX & TIN TERMINALS
12. FINISHED PARTS

So great was the departure in design of the new Bell System wire spring relay as compared with conventional relays that it posed a major undertaking for development engineers at Western Electric, the manufacturing and supply unit of the Bell System. Indeed, it was an undertaking that called for new machines and new methods because none was available to do the job.

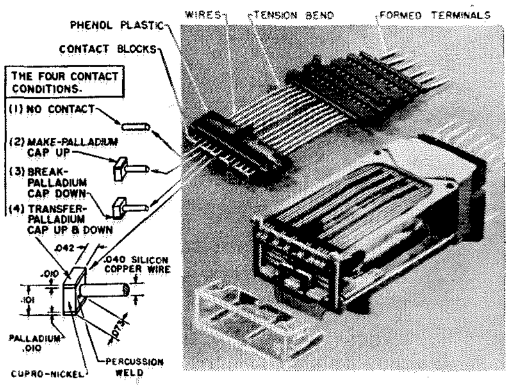
Longer life, higher operating speed, lower power consumption, and lower manufacturing cost were some of the advantages promised by the new relay design. Engineers reasoned that a lower manufacturing cost could be achieved through greater precision in manufacture (which would cut adjustments) and through extensive use of automatic processes.

One of the products of this reasoning is pictured at the top of this page. This battery of equipment, developed by Western Electric product engineers, constitutes one phase of wire spring relay manufacture, which automatically performs several separate operations. Its function begins after one of the fundamental elements of the new relay has been fabricated. This element, known as a "comb," consists of a multiplicity of small diameter wires in parallel array imbedded for part of their length in molded phenol plastic.

These molded elements, of which there are two types used in the new relay, are delivered to this line of machine units in magazines. By fully automatic means they are removed from the magazine, carried by a reciprocating conveyor through each of the several processes and, when completed, placed into another magazine to await further assembly.

Between the first and final magazine the automatic battery of equipment does the following operations: clips wire ends, attaches palladium contacts to wire ends by means of percussion welding, sizes contacts, forms terminal, tension bends wires, fluxes and tins terminals.

Most remarkable of all is the fact that this is a *precision* operation throughout. For example, the small block contacts, which are percussion welded to the tips of wires of one type of "comb," must be located on the same plane across the twelve contact positions to within a tolerance of ± .002".



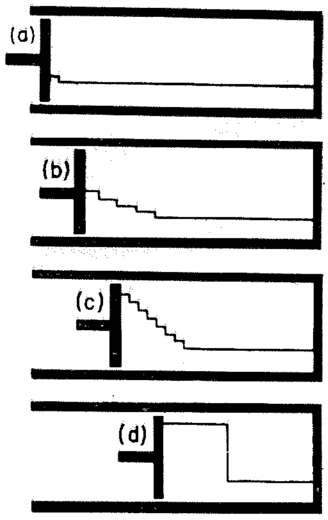
Single Wire Comb with Percussion Welded Contacts, Wire Spring Relay Designed by Bell Telephone Laboratories

One type of "comb" element is shown at top while a completed wire spring relay is below. The small blocks of metal on the ends of the wires are cut from a composite tape during the automatic multiple percussion welding operation. "Contact conditions" are determined by the code of relay being manufactured and may vary greatly.

Western Electric

MANUFACTURING AND SUPPLY UNIT OF THE BELL SYSTEM

Manufacturing plants in Chicago, Ill.; Kearny, N. J.; Baltimore, Md.; Indianapolis, Ind.; Allentown and Laureldale, Pa.; Burlington, Greensboro and Winston-Salem, N. C.; Buffalo, N. Y.; Haverhill and Lawrence, Mass.; Lincoln, Neb.; St. Paul and Duluth, Minn. Distributing Centers in 29 cities and Installation headquarters in 15 cities. Company headquarters, 195 Broadway, New York City.



A shock wave is formed because the rearward pressure steps of a large pressure wave travel faster than the front ones and catch up with them. In this diagram the pressure steps are generated by the inward motion of the piston. The magnitude of the pressure is indicated by the height of the line inside the cylinder.

piston compresses the gasoline-air mixture in about 0.0075 second; the piston moves at a velocity of about 1000 centimeters per second, which is about 1/40 the velocity of the gas molecule; and with a compression ratio of 6, the gas is heated by about 300°C.

Suppose it is desired to heat the gas more rapidly and the experimenter manages to get the piston moving at a velocity comparable to or greater than that of molecules. Now he must worry about the fact that the piston moves an appreciable distance while the pressure and temperature are being transmitted from molecule A to molecule E. In effect, molecules A and B are heated as much as they are going to be before molecules D and E are heated at all, as depicted in (c). The compressional pressure wave which travels from left to right down the cylinder has interesting and surprising properties which we now consider.

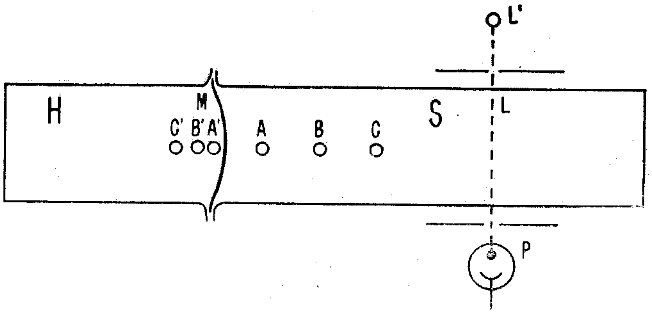
In (a) of the diagram at the top of this page, a small compressional pressure wave has been generated by a single inward jerk of the piston. This pressure wave travels from left to right along the tube at a velocity which is the velocity of sound in the gas—sound being a collection of such small pressure waves. This velocity is approximately the average velocity of the molecules, because the disturbance is transmitted by one molecule moving over and hitting the next one, etc. Obviously, this argument is not an exact one, so that the velocity of sound and the average molecular velocity are not exactly the same.

In (b) more pressure steps have been generated by further inward jerks of the piston. These travel along the tube, pursuing the preceding one. Each pressure step moves through gas which has been heated by all the previous compressions. Therefore, each step travels faster than the one in front of it, and catches up with it. The final result, therefore, is a single large step-shaped pressure wave. This is called a shock wave.

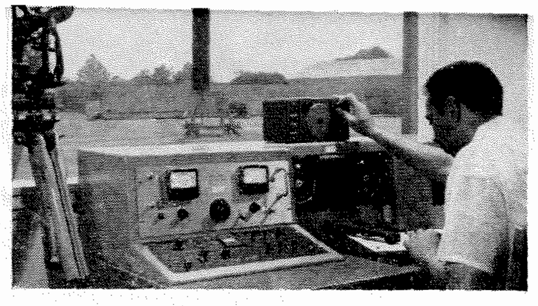
A shock wave is a wonderful way to heat a gas molecule in a hurry. Each molecule in its path is hit and heated as the wave moves down the tube. It takes only a few molecular collisions for each molecule to pass through the shock front—that is, to go from the unshocked, unheated condition to the shocked, heated condition. Therefore, at atmospheric pressure, where each molecule undergoes about 10^{10} collisions per second, it takes between 10^{-10} and 10^{-9} second to heat up a molecule of a gas by passage of a shock wave.

The only impractical feature of the rapid heating apparatus described so far is the piston. To move it at a velocity of 1.1×10^4 centimeters per second (2500 miles per hour)—which would be required to heat air from room temperature to 1000°C—would probably require that the piston be propelled by a cannon. It is practical, however, to push on one gas with another gas. The device for doing this, called a shock tube, is illustrated in the drawing below.

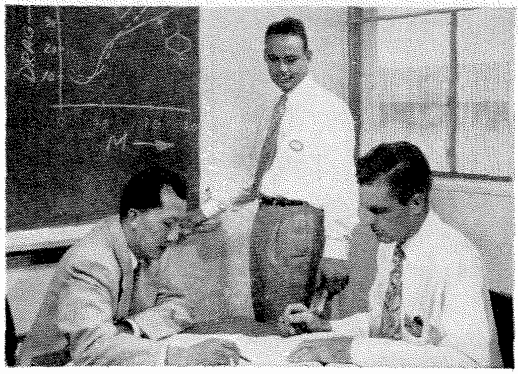
In this diagram, a membrane M separates the tube into two compartments. The one on the left, labelled H, contains high-pressure gas to push the piston, the compartment S on the right contains gas, at a lower pressure, which is to be compressed and heated. When the membrane M breaks (or is broken by touching a pin to it), Molecule A^1 from the high pressure side moves over and hits molecule A. A hits B. B hits C, and the compressional pressure wave travels down tube S. At the same time, B^1 pushes on A^1, C^1 pushes on B^1, etc. That is, the high-pressure gas in H expands and pushes on the low-pressure gas in S; it plays the role of a piston.



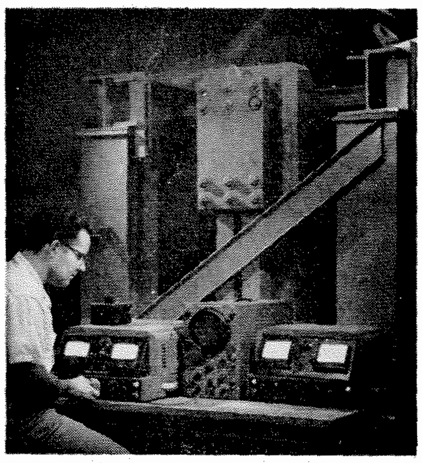
Schematic diagram of a shock tube. Molecules A^1, B^1, and C^1 are in the high-pressure (driving) section H, separated by the membrane M, from molecules A, B, and C in the low-pressure (driven) section S. L is a beam of light from the lamp L^1, shining through the tube S, on the photocell P.



Electronics Research Engineer Irving Alne records radiation *antenna patterns* on Lockheed's Radar Range. Twenty-two foot plastic tower in background minimizes ground reflections, approximates free space. Pattern integrator, *high gain* amplifier, square root amplifier and logarithmic amplifier shown in picture are of Lockheed design.



Jim Hong, Aerodynamics Division head, discusses results of high speed wind tunnel research on drag of straight and delta wing plan forms with Richard Heppe, Aerodynamics Department head *(standing)*, and Aerodynamicist Ronald Richmond (seated right). In addition to its own tunnel, Lockheed is one of the principal shareholders in the Southern California Cooperative Wind Tunnel. It is now being modified for operation at supersonic Mach numbers.



Research Engineer Russell Lowe measures dynamic strain applied by Lockheed's 500,000 lb. Force Fatigue Machine on test specimen of integrally-stiffened Super Constellation skin. The Fatigue Machine gives Structures Department engineers a significant advantage in simulating effect of flight loads on a structure. Among other Lockheed structures facilities are the only shimmy tower in private industry and largest drop test tower in the nation.

C. H. Fish, design engineer assigned to Lockheed's Icing Research Tunnel, measures impingement limits of ice on C-130 wing section. The tunnel has a temperature range of −40°F. to +150°F. and maximum speed of more than 270 mph. It is the only icing research tunnel in private industry.

Advanced facilities speed Lockheed engineering progress

Lockheed's unmatched research and production facilities help make possible *diversified* activities in virtually all phases of aviation, military and commercial.

They enable engineers to test advanced ideas which would remain only a conversation topic in firms lacking Lockheed's facilities. They help give designers full rein to their imagination. They make better planes – and better careers.

Engineering students interested in more information on Lockheed's advanced facilities are invited to write E. W. Des Lauriers, Lockheed Student Information Service, Burbank, California.

Lockheed

AIRCRAFT CORPORATION
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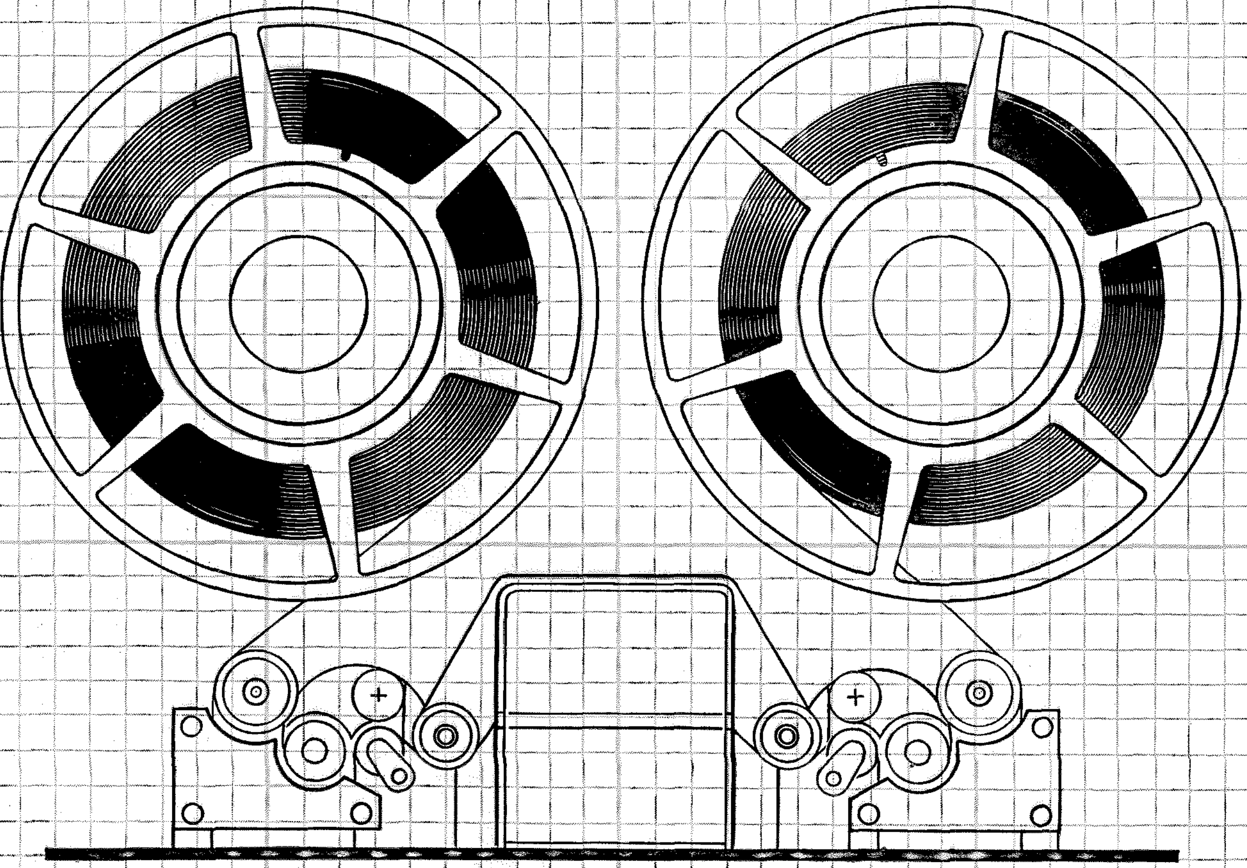
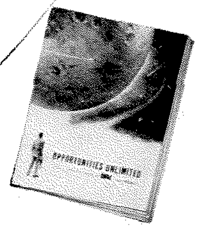
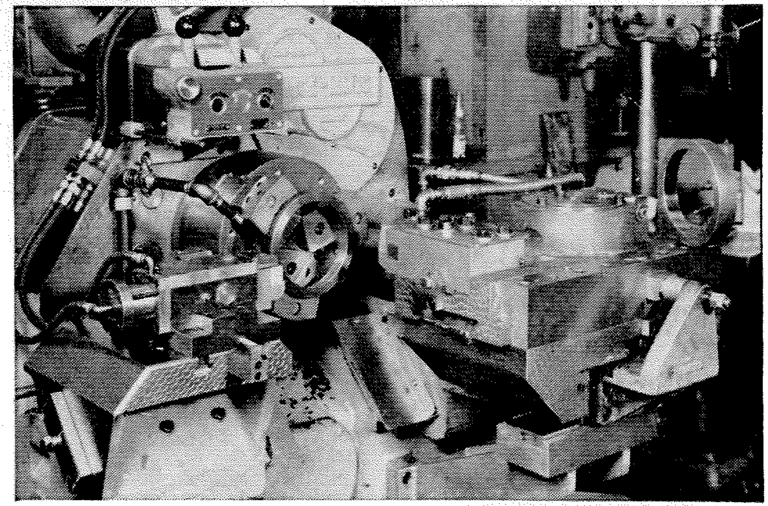



OPPORTUNITIES UNLIMITED

Another page for YOUR BEARING NOTEBOOK

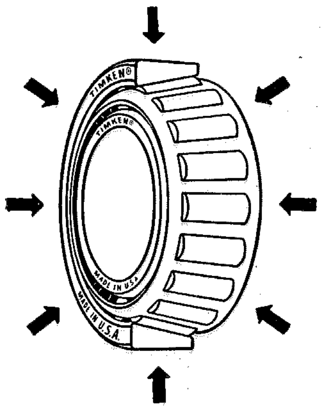


How to machine with high precision at high speeds

This lathe is designed to machine the races of bearings from 4″ to 8″ in diameter. And it must deliver high precision at speeds and feeds as fast as carbide tools can handle. To keep the spindle rigid under heavy combination loads, it's mounted on Timken® tapered roller bearings.

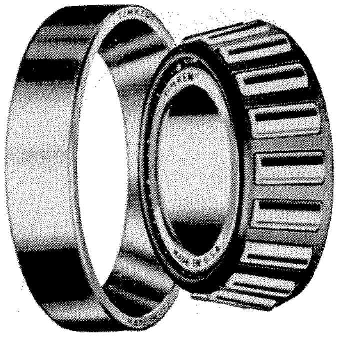
How TIMKEN® bearings maintain spindle rigidity

Because Timken bearings take radial and thrust loads in any combination, they hold spindles in rigid alignment, insure precision. And full line contact between the rollers and races of Timken bearings provides extra load-carrying capacity, prevents breakdowns.

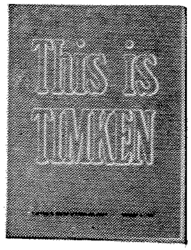


Want to learn more about bearings or job opportunities?

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS



Many of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, Ohio.


This is TIMKEN

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ↕ AND THRUST ↔ LOADS OR ANY COMBINATION ✳

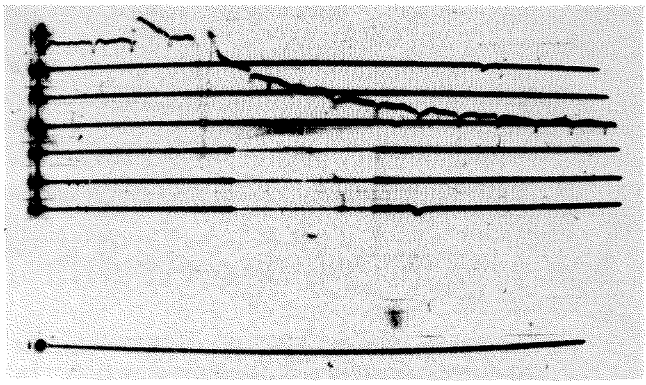
With this device it is comparatively easy (that is, just an ordinary difficult scientific job) to generate good shock waves. For example, with a pressure of about 1 pound gauge of air in S, a pressure of about 130 pounds of hydrogen in H produces a shock wave which travels through the air at a velocity of about four times the velocity of sound and heats the air up to 1000°C. (It is assumed here that the hydrogen does not mix with the air and react with it but simply pushes on it. Because of their low mass, hydrogen molecules have a high molecular velocity and are good pushers.)

Photo-electric measurement

One other feature is shown in this shock tube. There is a light beam, L, that shines through the tube. As already described, the rate of a chemical reaction in a color change can be measured by photo-electric measurement of the change in the light transmission of the system. An example of this sort of investigation was conducted in our laboratory by Dr. Tucker Carrington. The chemical reaction is

$$\underset{\text{colorless}}{N_2O_4} \rightarrow \underset{\text{brown}}{2\ NO_2}$$

Nitrogen dioxide, NO_2, is a brown gas—it absorbs blue light. Two NO_2 molecules stick together to form one N_2O_4 molecule, which is colorless. At low temperatures, the stable form is N_2O_4. When the temperature is raised, the molecules are broken apart into NO_2 molecules and the gas becomes more colored. The rate of this reaction has been measured by passing a shock wave through a gas containing N_2O_4 (nitrogen was present as an inert diluent gas). The shock wave heats up the N_2O_4 which then dissociates into NO_2 molecules. Depending on the temperature and nitrogen concentration, the reaction takes place in about 0.000010 to 0.000100 second. One of the measurements of the rate of this reaction is recorded below.



Oscilloscope record of rate of reaction $N_2O_4 \rightarrow 2NO_2$. *Line starting at top left is photocurrent; bottom line is zero photocurrent. Other horizontal lines are calibration marks. Downward pips on photocurrent trace are timing markers 10 microseconds apart. The first small positive signal is a time marker from a delay circuit and is related to the measurement of the velocity of the shock wave. The large negative spike occurs as the shock wave intersects the light beam and is due to refraction of the light beam by the large refractive index gradient at the shock front. After this we are looking at heated gas in which the reaction* $N_2O_4 \rightarrow 2NO_2$ *is occurring. As* NO_2 *is formed over a period of 70 to 80 microseconds, light transmission and photocurrent decrease.*

A shock wave, generated in a shock tube, can be used to heat up a gas either by a few degrees or by a few thousand degrees. It requires 1 to 3 microseconds for such a shock wave to pass through a light beam 1 millimeter thick. This method can be used to study any reaction which is caused by the heating by the shock wave and in which there is a change of color that affects the transmissions of the light beam, and which takes place in a time of from 10 microseconds to 1 millisecond.

Fast high-temperature reactions

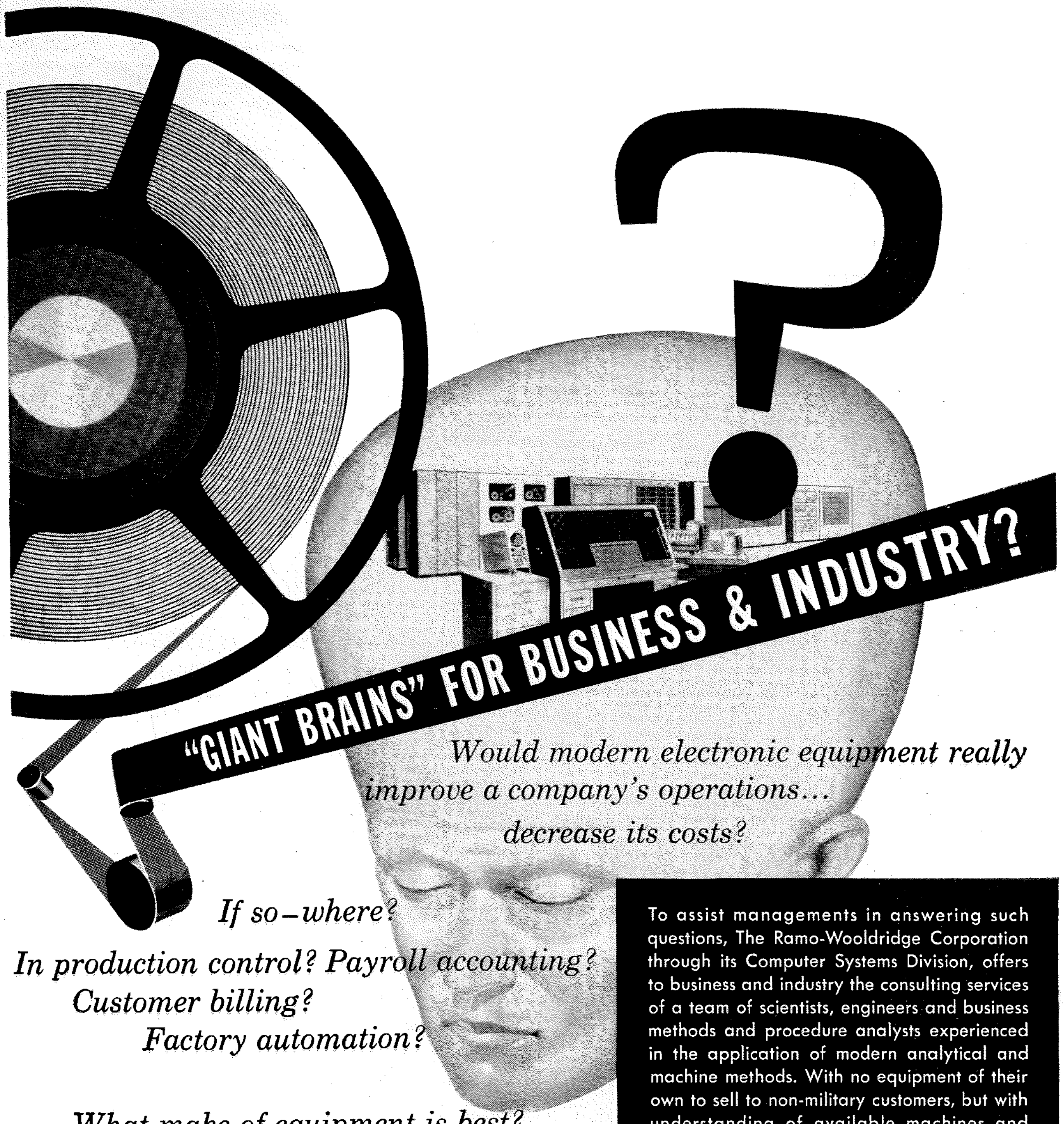
We have been particularly interested in applying this technique to the study of fast high-temperature reactions. In intial investigations, we have chosen reactions which are simple both experimentally and theoretically.

An example from the work of Mr. Doyle Britton is the rate of dissociation of bromine molecules into the atoms, $Br_2 \rightarrow 2\ Br$. The diatomic molecules are brown—they absorb blue-green light—and the atoms are colorless. The reaction takes place at temperatures of the order of 1500-2000°.

The results show that the mechanism of the reaction is indicated by the equation, $A + Br_2 \rightarrow A + Br + Br$; that is, the dissociation reaction occurs when another gas molecule, such as the argon atom in the equation above, collides with a bromine molecule with great vigor and knocks it apart into atoms. These dissociation reactions are models for a class of reactions that occur in practically important high temperature processes, such as combustion reactions, and therefore their study is of some practical significance.

It would be particularly interesting to study the reactions that occur when air is rapidly heated. These phenomena are of importance for understanding the heating problem when a hypersonic projectile goes through the atmosphere. At high temperature, the nitrogen molecules (N_2) and oxygen molecules (O_2) will dissociate into atoms and will react to form NO.

None of these atoms or molecules absorb the right kind of light for the methods described above to be applicable. We are trying to think of a new idea—of a new technique—which will enable us to study this interesting system.



"GIANT BRAINS" FOR BUSINESS & INDUSTRY?

Would modern electronic equipment really improve a company's operations... decrease its costs?

If so–where?

In production control? Payroll accounting?
Customer billing?
Factory automation?

What make of equipment is best?
What changes in company methods and procedures would be required?

To assist managements in answering such questions, The Ramo-Wooldridge Corporation through its Computer Systems Division, offers to business and industry the consulting services of a team of scientists, engineers and business methods and procedure analysts experienced in the application of modern analytical and machine methods. With no equipment of their own to sell to non-military customers, but with understanding of available machines and techniques, this group is in a position to be objective in its recommendations.

Other activities of the Computer Systems Division include a program of development of an advanced type of digital computer for military applications and operation of the company's own computing center, consisting of extensive, general-purpose computing equipment.

These activities comprise a part of the program whereby The Ramo-Wooldridge Corporation seeks to maintain broad coverage of the important field of automation, computation and control.

The Ramo-Wooldridge Corporation

8820 BELLANCA AVENUE, LOS ANGELES 45, CALIFORNIA

ALUMNI NEWS

Seminar Day

THE ALUMNI SEMINAR COMMITTEE has arranged an excellent program for Saturday, April 16, on the campus. Willard E. Baier '23 is the Director-in-charge, with Willis R. Donahue '34 as General Chairman. The program is being arranged by Chester Lindsay '35, Chairman, with Frank Bumb '51, Lind Davenport '35, Arthur J. Schneider '42, Lyle D. Six '47, and D. W. Stillman '50. Arrangements for the luncheon at the Student Houses and dinner at the Pasadena Elks Club are in the hands of Paul Schaffner '37. Registration will be supervised by Robert J. Barry '38. Institute facilities for the Seminar are under the direction of Wesley Hertenstein '25.

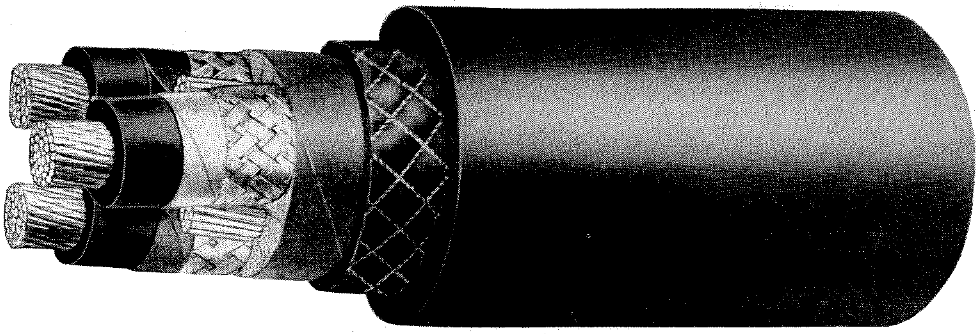
The speakers for the daytime program, with their tentative subjects, will be as follows:

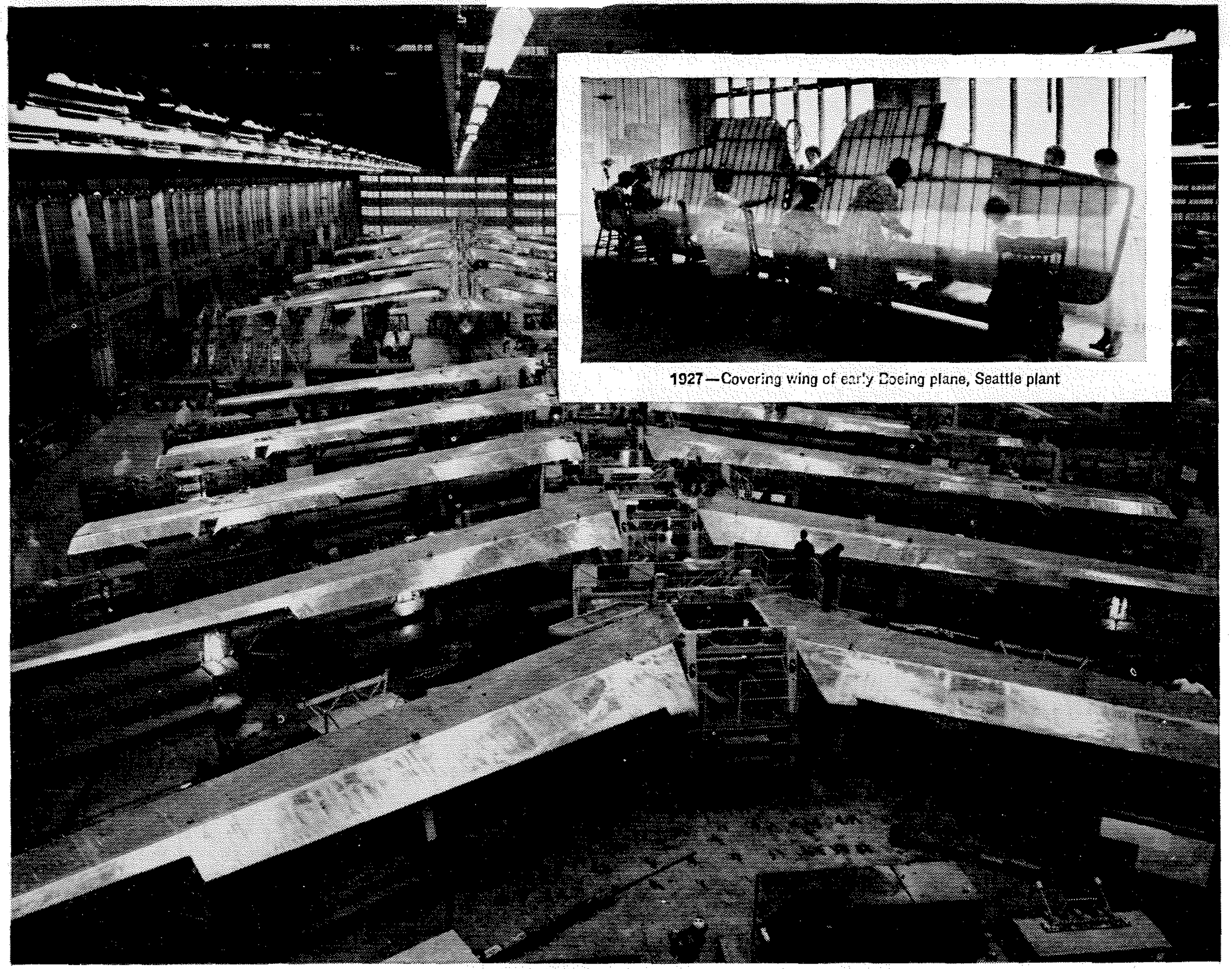
Prof. Peter Kyropoulos—Chemical Hay for Mechical Horses
Prof. Dan Piper —Observations on the French People
Dr. Wm. A. Baum —The Size of the Universe
Prof. A. J. Haagen-Smit—Historical Uses of Essential Oils
Prof. Lester M. Field —Background and Development of Microwave Tubes
Prof. Henry Hellmers —Vegetation and Flood Control.
Prof. John R. Pellam—Low Temperature Research
Mr. Wm. H. Hildemann—Tropical Fish

The Alumni Swimming Pool will be dedicated in the afternoon in a very short program followed by an exhibition. Sufficient time will be provided for Alumni and their guests to swim in the pool, to play badminton in the gym, or to have a game of tennis.

The dinner speaker will be Dr. Robert M. Hutchins, President of The Fund for the Republic, Inc., and former President of the University of Chicago. Dr. Hutchins has not announced his subject.

The final program will be published in the March issue of *Engineering and Science* and the announcement will be mailed to all Alumni in Southern California the latter part of March. SAVE THIS DAY.





1927—Covering wing of early Boeing plane, Seattle plant

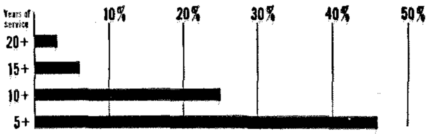
1955—B-47 Stratojet assembly, Boeing Wichita Division

Boeing offers engineers long-range careers

Throughout its 38-year history, Boeing has consistently pioneered advanced new types of military and commercial aircraft, and new methods of production. This history of leadership has meant continued growth for the company. It means continued opportunities for Boeing engineers to move ahead according to their ability in Research, Design and Production.

Today Boeing is producing the jet age's outstanding bombers, the B-52 and the B-47. Other Boeing projects that mean continued growth and stability include: America's first jet transport (the Boeing 707). Research in nuclear-powered and supersonic flight. And one of the nation's major guided missile programs. These and other new-horizon projects are expanding at such a rate that Boeing now employs more engineers than even at the peak of World War II.

The high inherent interest of these programs, together with the stimulation of expanding opportunities, add to the stability of careers at Boeing. One measure of stability is given in this chart.



It shows that 46% of Boeing engineers have been with the company for five or more years; 25% have been here 10 or more years, and 6% for 15 or more years. Another measure is the increasing proportion of engineers to total employees. Fifteen years ago the figure was one to 16. Today one out of each seven employees is an engineer.

Boeing promotes from within and holds regular merit reviews to assure individual recognition. Engineers are encouraged to take graduate studies while working and are reimbursed for all tuition expenses.

Boeing has openings for virtually all types of engineers—electrical, civil, mechanical, aeronautical and related fields, and for applied physicists and mathematicians with advanced degrees.

For further Boeing career information consult your Placement Office, or write:

JOHN C. SANDERS, Staff Engineer – Personnel
Boeing Airplane Company, Seattle 14, Wash.

BOEING

SEATTLE, WASHINGTON WICHITA, KANSAS

ALUMNI NEWS . . .

Changes in By-Laws

THE FOLLOWING CHANGES have been made in the By-Laws of the Caltech Alumni Association:

Alumni Fund

The Alumni Fund was established in 1947 by the joint action of the Alumni Association and The California Institute of Technology as an instrument for the cooperation of the Association and its members in support of the Institute. Any specific objectives of the Fund are mutually agreed upon by the Board of Directors and the administration of the Institute.

The first objective was funds for improvement of the athletic facilities which culminated in the Alumni Swimming Pool and Locker Rooms. This effort stimulated the Board of Trustees to make funds available for the construction of the Scott Brown Gymnasium.

The next objective was the establishment of four four-year full-tution scholarships. This program is progressing, and with one scholarship now a reality, another great service will be rendered to the Institute by the Alumni.

Coordination of the Alumni Fund activities on a long-term basis with the best interests of the Institute, is most important. Previously this has been done by the Board of Directors of the Association. The Board, believing that a permanent structure should be established, has amended Article VI of the By-Laws by adding Section 6.05 forming an Alumni Fund Council. The new section adopted November 23, 1954 is as follows:

> The coordination of solicitation of funds from Alumni for the California Institute of Technology shall be the responsibility of an Alumni Fund Council. The function of this Council shall be the long-range planning of the objectives and operations of the Alumni Fund and the making of appropriate recommendations to the Board of Directors of the Association. The Council shall consist of the President and the Secretary of the Association, the Director or Directors responsible for Alumni Fund solicitation, and an alumnus-at-large, appointed by the President of the Association with the approval of the Board of Directors of the Association. The President of the Institute shall be invited to serve as a member of this Council. The alumnus-at-large shall serve at the pleasure of the Board of Directors for a period of five years, subject to renewal and shall act as chairman of the Alumni Fund Council. This Council shall meet at least once each year.

The President, Kenneth F. Russell '29, with the approval of the Board of Directors, appointed Howard B. Lewis '23 as the alumnus-at-large and Chairman of the Alumni Fund Council. Howard Lewis was instrumental in the establishment of the Alumni Fund and served as President of the Association for the year 1948-49. The Board of Directors are proud to have Howard Lewis in this most important Alumni activity.

ALUMNI ASSOCIATION OFFICERS

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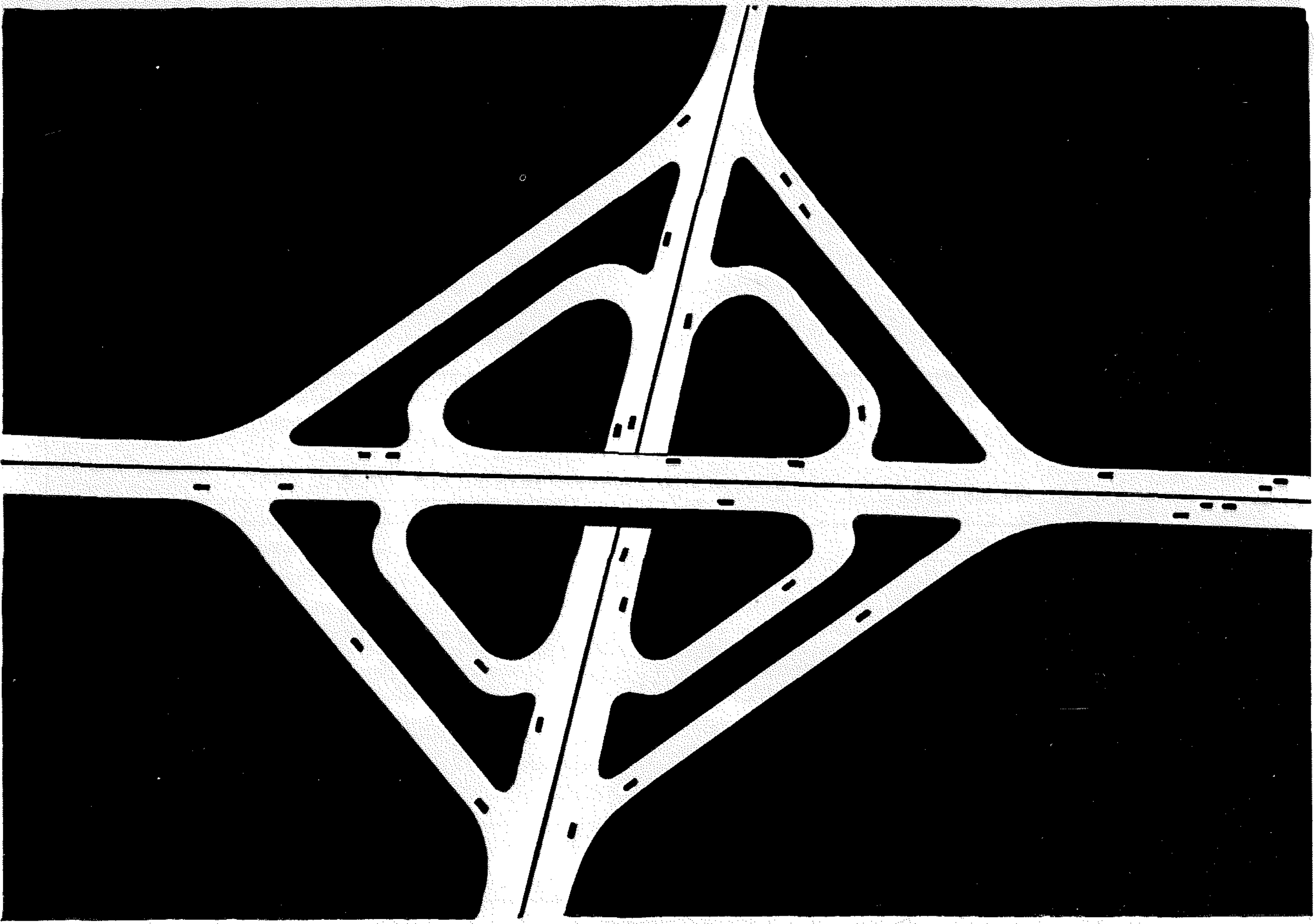

FROM COW-PATHS TO CLOVERLEAFS...

The narrow, twisting, rut-ridden roads of yesteryear are being replaced by new multi-lane, high-speed highways. Crossroads have been bridged and cloverleafed . . . hills have been leveled . . . curves lengthened.

These changes have happened in the half century since the advent of the automobile. For more and better cars and trucks demand faster, safer roads and turnpikes.

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The traffic that flows over America's three-million mile network of roads represents the very life stream of our progress. Nowhere else in the world do people travel so far and so freely . . . nor do so many trucks deliver such a wide and plentiful supply of merchandise so fast and to so many places.

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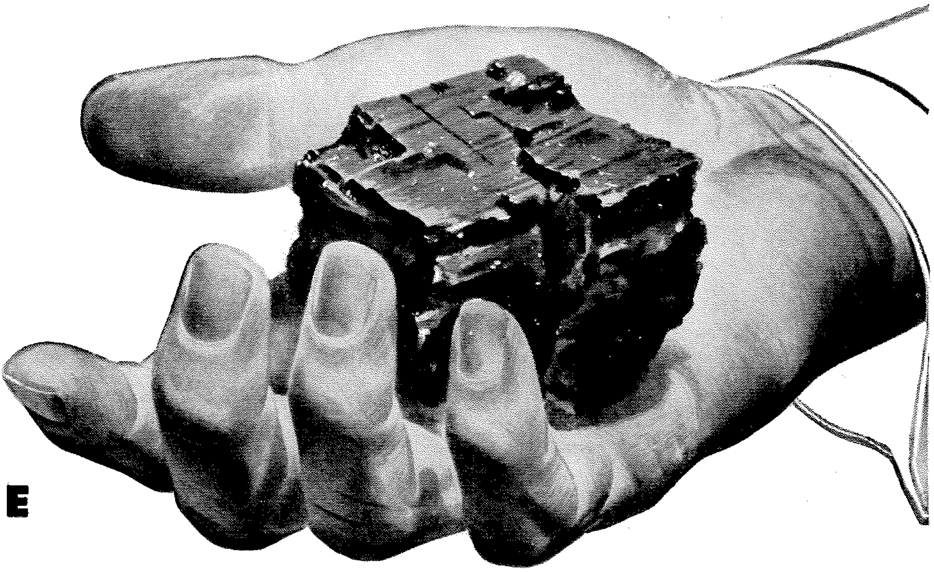
Alumni Magazine

The Alumni Magazine, *Engineering and Science*, under the very capable supervision of Dr. Richard C. Armstrong '28 as publisher, and Edward Hutchings Jr. as editor, has been guided by a Management Board consisting of three representatives of the Alumni Association and three representatives of the Institute.

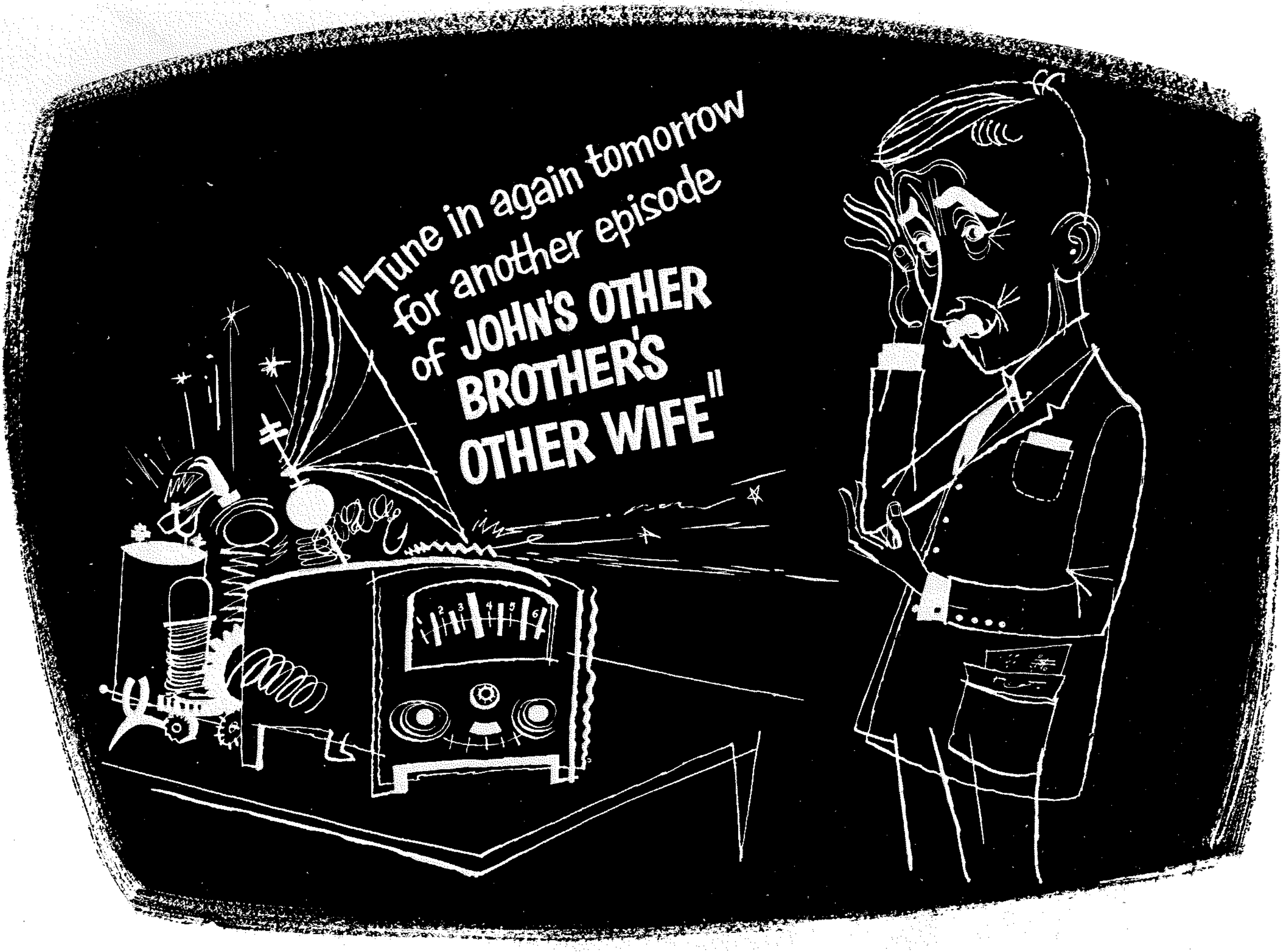
The Board of Directors has given this body an official status and changed its name by an amendment to the By-Laws of the Association. The following amendment was adopted at the meeting of the Board on November 23, 1954:

> **Article VII Alumni Magazine**
>
> **Section 7.01—Publication.**
> The chief publication of the Association shall be a magazine issued monthly, October through June, for the undergraduates, graduate students, and alumni of the Institute.
>
> **Section 7.02—Publishing Agent.**
> The California Institute of Technology is authorized to act as the agent of the Association with respect to the publication of the magazine. The Institute appoints the Editor and Business Manager and supplies him with an adequate staff and a place in which to work.
>
> **Section 7.03—Publisher.**
> An alumnus shall be appointed by the President of the Association with the approval of the Board of Directors of the Association to serve as the publisher of the magazine. He shall serve continuously at the pleasure of the Board of Directors, act as Chairman of the Alumni Magazine Council, and provide liaison between this Council and the Board of Directors of the Association. He shall serve without salary.
>
> **Section 7.05—Alumni Magazine Council.**
> The Council shall consist of the Publisher as Chairman, the President and the Secretary of the Alumni Association, together with three members representing the Institute, appointed by the President of the Institute. The Council shall consider all matters pertaining to the magazine, with special emphasis on matters of broad policy. It shall meet at least once a year and make recommendations to the Board of Directors of the Association for whatever action seems advisable.
>
> **Section 7.05—Finances.**
> It shall be the continued aim of the Association to make the magazine self-supporting. Until this state is reached, it is expected that the Institute will furnish whatever additional funds are necessary to provide suitable salaries for the staff of the magazine.

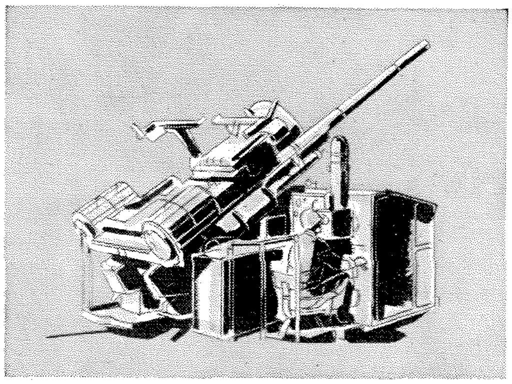
This amendment does not change the operation of *Engineering and Science* in any way, but clarifies the function of the policy-recommending group. Dr. Armstrong continues as the Publisher of *Engineering and Science* and Chairman of the Alumni Magazine Council. The Alumni are proud of *Engineering and Science* and appreciate the outstanding job Ed Hutchings is doing and the help Dick Armstrong is giving in looking after the Association's interests.



"NEW DEPARTURES" IN SCIENCE & INVENTION



WHAT HATH MARCONI WROUGHT?



The amazing Skysweeper — which sights, tracks and shoots down air targets with fantastic accuracy — depends on New Departure instrument ball bearings for its internal accuracy.

Of course, it was years before Mr. Marconi's wireless developed into radio as we know it. Then such wonders as the give-away program, the comedy show and the soap opera blossomed full-blown.

True wonders, too, have sprung from Mr. Marconi's "new departure" of 1897. And New Departure ball bearings have played a vital role . . . in electronic brains for business . . . in automation for industry . . . in radar for defense. In fact, New Departure was a pioneer in developing methods that could turn out ball bearings of ultra-high precision in the mass quantities needed for today's electronic marvels.

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PERSONALS

1920

William C. Renshaw is the new chief engineer and general manager of the Las Vegas Water District. Bill was formerly water engineer and superintendent of the water department at Inglewood, California, and has had long experience in the San Francisco Water Dept.

1921

Manton M. Barnes answers some of the questions we hopefully ask in our search for news. *Q. Got a new job?* A. Nope, same one. Am a Depreciation Studies Engineer with the Pacific Telephone and Telegraph Company in San Francisco. *Q. Any additions to your family?* A. Nope, too old for that, but my sons' wives are doing all right, thank you. *Q. Been made president of anything lately?* A. Not since 1936 when I was chosen president of the Palo Alto Haywire Orchestra (mandolins, guitars, etc.) in an off-guard moment. The office has been perpetuated by subsequent general inertia.

1922

Linne C. Larson is employed as executive officer of the Los Angeles Regional Water Pollution Control Board, serving Los Angeles and Ventura Counties. The Larsons have two children: Linne Charles, who graduated from Occidental last June, and at the same time received a commission as 2nd Lt. in the Army Air Force Reserve (he'll probably be called to active duty next April); and Inez Anne, who is married to a Navy man and has two children.

1925

Thomas P. Simpson has been elected vice-president and director of manufacturing for the General Petroleum Corporation in Los Angeles. Tom joined the company as a chemical engineer right after graduation, and has been advancing steadily ever since.

1927

Harry K. Farrar writes from San Francisco: "Still concerned with the coordination of certain engineering matters for Pacific Telephone in San Francisco. Enjoy Tech luncheons at the Fraternity Club on Thursdays where I see *Bob Stirton, Bob Jones, Maury Jones, Phil Henderson, Chuck Lewis, Manley Edwards, Ken Anderson,* and *Howard Fisher* fairly regularly. Less frequent, but recent members of the group were *Ray Untereiner, Don Morrell,* and *Fred Hough.* (Fred is now with Bechtel in San Francisco.) We keep up to date on everything from automotive advances through nuclear physics to photography."

1928

C. Y. Hsiao returned to China soon after receiving his PhD from MIT. Both before and during the war he held government posts, and immediately after the war was sent to Canada as purchasing agent for the Chinese Nationalist government. He was also appointed technical advisor to their U. N. delegation—a post he still holds today. The Hsiao family now lives in Washington, D.C.

Arnold Beckman, PhD, president of Beckman Instruments, Inc., has expanded his firm through the purchase of Specialized Instruments Corp. and the Spinco Service Company of Belmont, California.

1929

Duane Roller, PhD, joined the technical staff of the Ramo-Wooldridge Corporation on February 1. Duane had been serving as editor of *Science* and of *The Scientific Monthly* for the AAAS in Washington, D. C.

1930

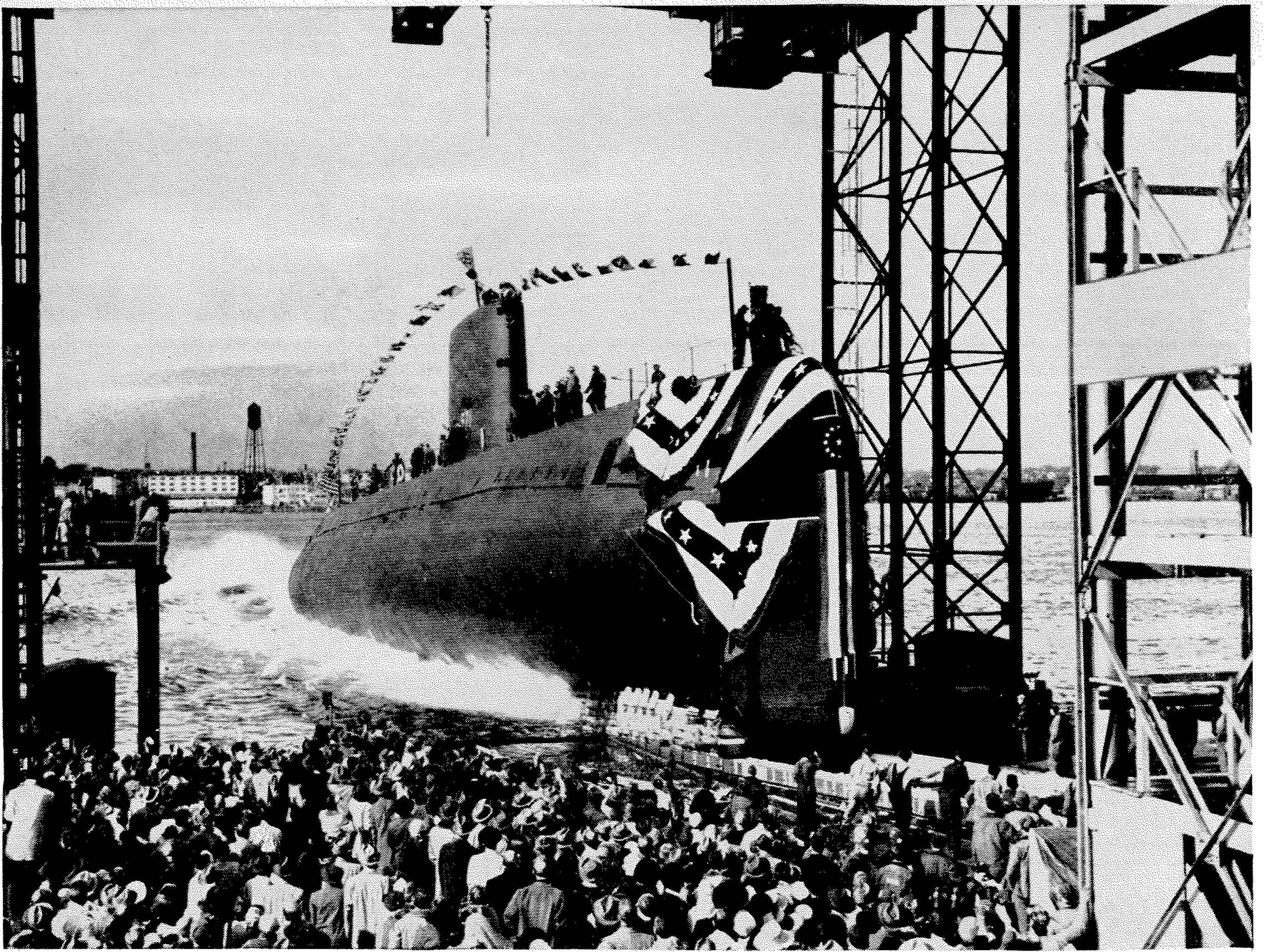
Ralph B. Atkinson, PhD, president of the Atkinson Laboratory, reports that the firm has had to move its Photo Chemical Division to larger quarters on Santa Monica Boulevard in Hollywood. Ralph's company, started almost immediately after he received his PhD, was originally a lab for processing color film, but now it manufactures photo chemicals almost exclusively. The lab has been expanding steadily, and recently branched out to manufacture magnetic recording materials.

1934

Morton E. Moore, MS '35, has joined Hughes Aircraft as a member of their Research and Development Laboratories, Radar Division. Morton was formerly with the AiResearch Manufacturing Company.

1935

Paul F. Genachte, PhD, is now in the public utilities department of the Chase National Bank in New York City, serving as technical advisor. A native of Belgium, Paul returned home immediately after receiving his PhD, to work with a utilities holding company that had headquarters in Brussels. Later he was associated with the Mexican Light & Power Company (1939 to 1952), serving at various times as assistant to the chairman of the board, and special assistant to the president. In 1952 Paul joined the Indussa Corporation in New York as technical manager and also served as vice president of the Balteau Electric Corporation in New York. Earlier this year he was retained by the World Bank as power con-



SLIDING DOWN THE WAYS at Groton, Conn., goes the USS Nautilus, newest and fastest member of our underseas fleet. During welding, Worthington heavy-duty turning rolls rotated the hull sections.

How the world's first atomic sub was welded

Welding the hull of the USS Nautilus, world's first atomic submarine, presented a tough problem.

Submerged-arc automatic welding seemed to be ideal for the job. Question was—could you rotate the hull sections of the Nautilus to take advantage of this fast, high-quality welding method?

Worthington's answer to General Dynamics Corporation's Electric Boat Division, builder of the Nautilus, was the largest turning roll ever built.

The result? Welding of the Nautilus hull was accomplished in record-breaking time — and cost less than originally estimated. Unchanged, the Worthington roll set-up is also being used in the construction of the nation's second atomic sub, the USS Sea Wolf.

Turning rolls for submarines aren't all that Worthington makes. The long list of Worthington-designed, Worthington-built equipment includes air conditioning units, construction machinery, compressors, Diesel engines, steam power equipment and, of course, pumps of all kinds. For the complete story of how you can fit into the Worthington picture, write F. F. Thompson, Manager, Personnel and Training, Worthington Corporation, Harrison, New Jersey. You may be glad you did.

4.25 B

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sultant on a two-month mission to Ceylon.

Louis T. Radar, MS, PhD '38, is general manager of General Electric's Specialty Control Department. Louis started *with GE even before receiving his PhD* from Tech, and with the exception of a two-year stint (1945-1947) as head of the Electrical Engineering Department at the Illinois Institute of Technology, he has been with them ever since, serving in a supervisory capacity in various engineering departments. The Specialty Control Department is currently in the process of being moved from Schnectady, N.Y. to Waynesboro, Virginia, and in a few months Louis expects to be settled permanently at the new location.

1936

Walfred E. Swanson is serving as vice president and general manager of the Roberts Construction Company of Lincoln, Nebraska. Wally reports that this is a general contracting firm engaged in heavy construction and highway construction, operating in several surrounding states.

1939

Andrew L. Hannon was elected vice president of the Los Angeles chapter of the National Electrical Contractors Association at a recent meeting.

1941

Albert P. Petraitis, MS, has joined *Hughes Research and Development Lab*oratories at Culver City as a member of their Guided Missile Division.

1942

Joseph Franzini, MS '43, CE '44, is now back at Stanford University as Assistant Professor of Civil Engineering after having been away for 13 months with a severe case of peripheral neuritis, induced by insecticide poisoning. Joe and his wife now have four children—two boys and two girls.

Parameswar Nilakantán, MS, is with the Ministry of Defense at Delhi, India, as Joint Director of Technical Development and Production (Air). In addition, he is serving as vice president of the Aeronautical Society of India.

1943

William Snyder, MS '46, reports from Palo Alto: "I'm still a bachelor, still writing a PhD thesis at Stanford, now working with the Detroit Controls Research Division in Redwood City. Still have the ancient '33 sloop which I sail around in the bay from time to time in the season. It has lots of room for jovial companions, in case any such happen by at the right *time.*"

1944

Enrique Silgado, MS, is teaching Applied Geophysics at the University of Lima in Peru. He also holds the position of Chief of the Geophysical Section of the Instituto Nacional de Investigación y Fomento Mineros.

1945

Paul Kohlhaas, sales engineer for Fishbach & Moore, Inc. in San Francisco, has been very active in the newly formed Western Section of the AISE. He holds the office of program chairman and arrangements chairman for 1954-55, and has just been nominated as a director for 1955-56. Paul and his wife have two children—Kerry, 7, and Cassie, 3½.

Charles Melville Davis, MS '46, received his PhD in Electrical Engineering from Iowa State College, Ames, Iowa, in December.

William H. Cook returned to Long Beach in September, after a summer in Europe. He writes: "I was studying photogrammetric engineering at the International Training Center for Aerial Survey in Delft, Holland. I am pleased to report that I received the full degree of I.T.C. Photogrammetric Engineer in July, the first American to hold this particular certificate from the Institute at Delft.

"My father flew over for the graduation, and during the month of August we toured most of Europe by automobile, visiting all the major cartographic offices and instrument plants in these countries. One of the more interesting side trips was a swing through Yugoslavia and Trieste, during our journey to the Galileo Instrument Company, from Vienna.

"I *returned home to Long Beach on* September 2nd, happily in time to take my wife to the hospital where our second daughter was born on September 10th."

1946

Jerome S. Field is employed by the Packard-Bell Company in Los Angeles, as Project Administrator of the Technical Products Division.

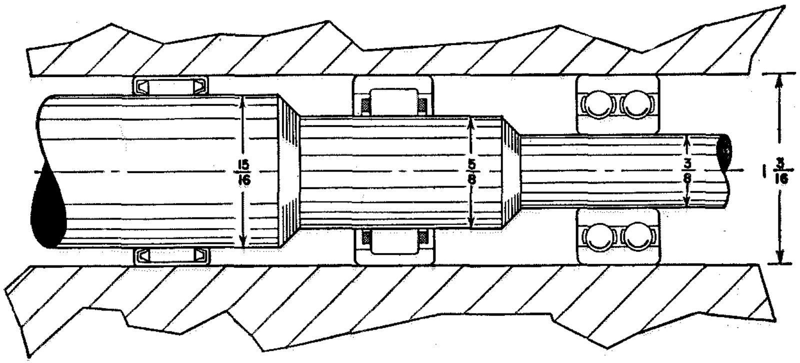
Louis K. Jensen finished his work for a PhD in Nuclear Physics at UCLA last September, and expects to receive his degree in June. He is now working for the Ramo-Wooldridge Corporation and living in Palos Verdes, and he reports that he somehow managed to raise two boys and a girl while in graduate school (the children being 5, 3, and 1 by now).

1947

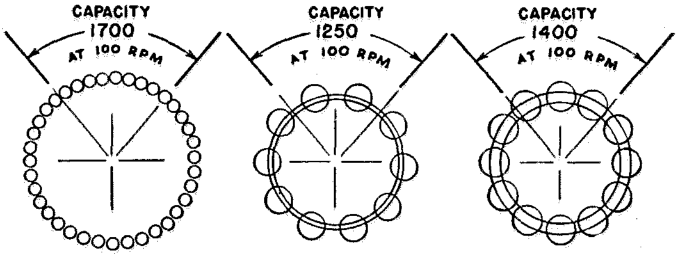
Jack Slaton, MS, was married last December to Dorraine Locken of Pasadena. Jack is an electronic scientist at the U. S.

The Torrington Needle Bearing
is designed for high radial loads

The many lineal inches of contact provided by the larger number of small diameter rollers give the Torrington Needle Bearing an unusually high load rating. In fact, a Needle Bearing has greater radial capacity in relation to its outside diameter than any other type of anti-friction bearing.



1. *Illustrates the fact that for a given housing bore size, a larger and, therefore, stiffer shaft can be used with Needle Bearings than with a roller or ball bearing.*



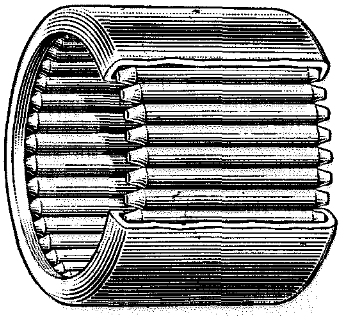
2. *Shows the greater number of lines of contact in the load zone of a Needle Bearing compared with a ball or roller bearing.*

Precision Manufacture and Unique Design

The exceptional load capacity of the Needle Bearing is the result of proper selection of steels, precision workmanship to close tolerances, and the application of modern anti-friction principles.

The one-piece shell, which serves as the outer raceway and retains the rollers, is accurately drawn from carefully selected strip steel. After forming, it is carburized and hardened. There is no further grinding or other operation that might destroy the wear-resistant raceway surfaces. The full complement of thru-hardened, precision-ground rollers is retained by the turned-in lips of the one-piece shell.

The small cross section of the Needle Bearing allows a large shaft which permits a rigid design with minimum shaft deflection, a factor of utmost importance to good bearing design.



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PERSONALS . . . CONTINUED

Naval Ordnance Test Station in Pasadena.

Guy C. Omer, Jr., PhD, has left the University of Chicago, where he was an assistant professor of physics, to become Professor of Physical Sciences at the University of Florida in Gainesville, Fla.

1948

John Rasmussen, Assistant Professor of Chemistry at UC, reports a third addition to the family—David, born last March. John also passes on the information that *Byron Youtz*, '48, is now Professor of Physics at the American University in Beirut, Lebanon. Byron and his wife have a daughter—their first child—five months old.

Welko Gasich is now chief of the Preliminary Design Department at Northrop Aircraft in Los Angeles. He's responsible for all missile and airplane developments for the company.

Carl R. Oberman received his PhD from Ohio State University on December 17.

Norman E. Olson, according to word received from his family, was accidentally drowned last September 26 while on an outing in Mexico with a group of co-workers from the Hunter-Douglas Company of Riverside. Norman joined the company immediately after graduation and was working in the research department.

1949

Donald Hibbard writes: "My family and I were transferred from Arkansas, via Dallas, to Denver, Colorado, where Seaboard Oil Company has now established its Rocky Mountain Division office. My present assignment is a sub-surface and surface geologic study of the San Juan Basin in New Mexico and Colorado.

"On December 22nd my wife Maritya presented me with a premature Christmas gift, a baby boy, Mark Edward. This makes #2 for us.

"While we were in Dallas we had a good time visiting *George Lyon*, '47, and his family. George was capitalizing on Texas' hot weather and was selling (Lyon Engineering Co.) air conditioners by the dozens."

1950

Scott Lynn, MS '51, began working for the Dow Chemical Company in Midland, Michigan, last December, as a research and development engineer. Scott has just returned from a year in Delft, Holland, where he worked at the Technical University.

Donald W. Stillman, Western Divisional Manager for the NYLOK Corporation in Los Angeles, reports the birth of his third son, Stephen T.

Donald Glaser, PhD, spent the month of January here at Caltech, where he gave a number of lectures on "Bubble Chambers." After leaving Pasadena, Don moved on to the Brookhaven National Laboratories for several months.

1951

Joseph M. Denney, MS '52, is a newly appointed research associate in the metallurgy department at the General Electric Research Laboratory in Schenectady, N.Y. Joe, formerly a research engineering consultant at the North American Aviation Company in Los Angeles, will receive his PhD from Caltech in June.

Robert E. Cobb is located in Caracas, working for Socony-Vacuum of Venezuela. Bob and his wife Ann are very happy over the birth of their first child, Susan Ann.

Kaarlo J. Temmes, MS, is in Helsinki, Finland, working for the Finnish Office of Civil Aviation. Kaarlo and his wife now have three children: Laila, 4½; Eeva, 2; and baby Jaako, 7 months. Kaarlo further reports: "They made me president of Aeronautical Engineers of Finland—'they' meaning about 30 heads, smaller or bigger chiefs of Finnish aviation."

1952

James N. Shoolery, PhD, staff engineer for Varian Associates in Palo Alto, will be making a trip to England in April, to present a paper on "Nuclear Resonance" at the Faraday Society Discussions at Cambridge.

1953

John C. Behnke, Jr. was married on December 20 to Rachel Morgan of San Marino. John and his wife are now living in Westwood, and they are both working for their doctorates at UCLA. Rachel used to be at Caltech, doing research work with Dr. Frits Went in the Earhart Lab.

Capt. Joseph J. Rochefort, MS, U. S. Army Engineers, is now assigned to the G-3 (Training) Section of the Office of the Chief of Army Field Forces, at Fort Monroe, Virginia. He was previously stationed with the Korean Military Advisory Group in Korea.

1954

James N. Pinkerton is now attending grad school at the University of Illinois.

Moses Lerner is busily pursuing an MS degree in mechanical engineering at Stanford. "Engineering classes here look just as dismal as at Tech," Moe writes, "but the campus generally offers better adornments. I think it'll be Uncle Sam in June —but in the meantime, I'm happy here."

Albert R. Pitton was recently married to Claudette Catherine Ardanaz of Inglewood, and they now live in Ypsilanti, Michigan, where Al works for the Ford Motor Company, and Claudette attends Michigan State Normal College. *George H. Moore*, MS '54, also is working at Ford, has a room in the same house, and boards with Al and his wife. Both fellows are in the Engine Drafting Section of Ford's Engine Engineering Dept. and are classified as Graduate Engineer Trainees.

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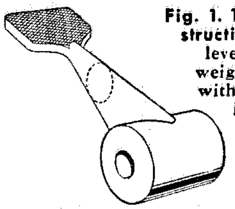


Fig. 1. Traditional Construction. Machine foot-lever, 10 inches long, weighs 6 pounds. Cost with broached keyway is $1.15.

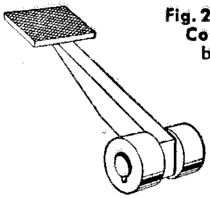


Fig. 2. Simple Steel Design Costs 41% Less. Can be built by the shop with only saw and shears. Weighs 2.7 pounds. Costs 68¢ complete with keyway.

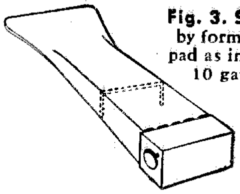


Fig. 3. Saves 53% Cost by forming lever arm and pad as integral piece from 10 gauge metal. Weighs 2.5 pounds. Costs 54¢.

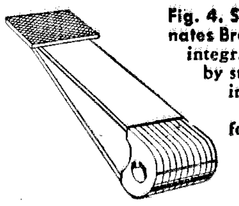


Fig. 4. Saves 73%, Eliminates Broaching. Hub with integral key is produced by stacking stampings in assembly. Arm is 10 gauge, brake formed and welded to hub. Cost is only 31¢. Weighs 2.2 pounds.

LETTERS

Fort Collins, Colorado

Sirs:

I was interested in reading the article in your November issue about the Alumni Scholar. He had a mighty fine high school record and it looks like the committee made an excellent choice in Timothy Harrington.

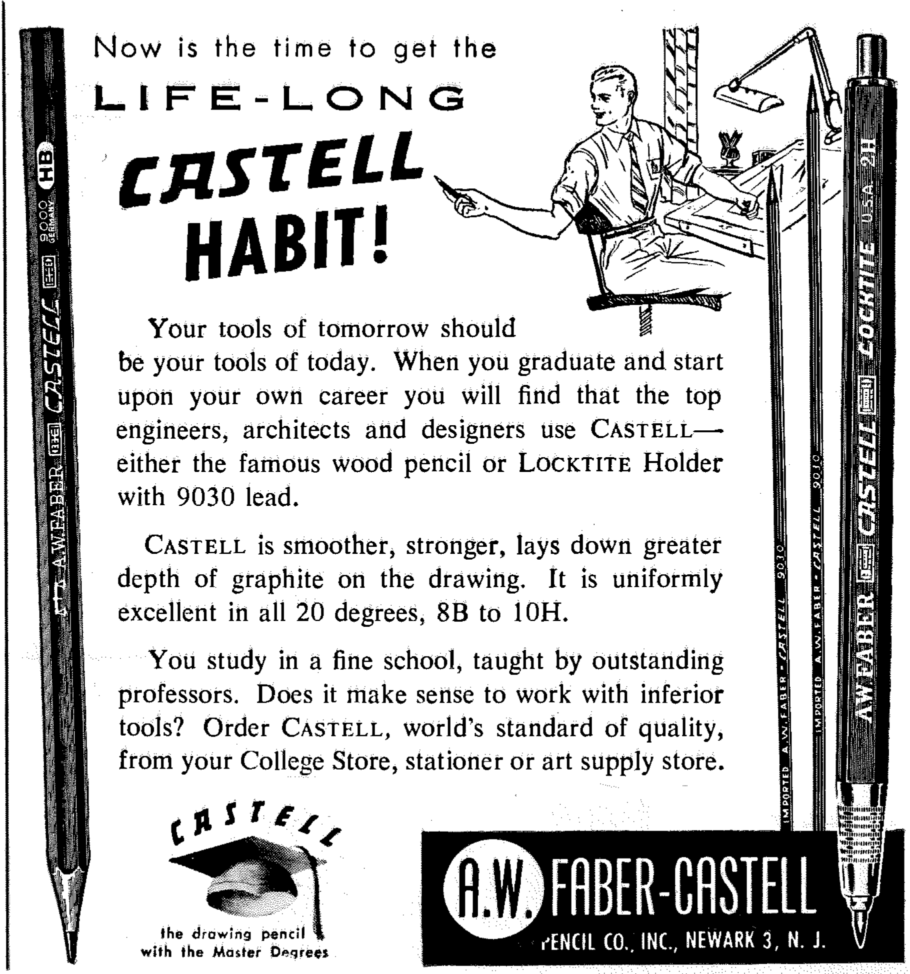
Without wishing to detract in the least from Harrington's honor, I believe your claim that this is the *first* Alumni Scholarship to a Caltech freshman is in error. It has probably been so long since one was awarded that everyone but a few former recipients has forgotten. Almost 30 years ago, however, I was fortunate enough to have received a so-called "Alumni Prize Scholarship" that paid for tuition and books the freshman year. In my case, I might never have gone to college without that break. There were others awarded in those years (I remember Robley Evans, '28, now Professor of Physics at MIT, received one in 1924) but I do not know when they ceased. Apparently there was no stable fund to finance them as the alumni are planning now.

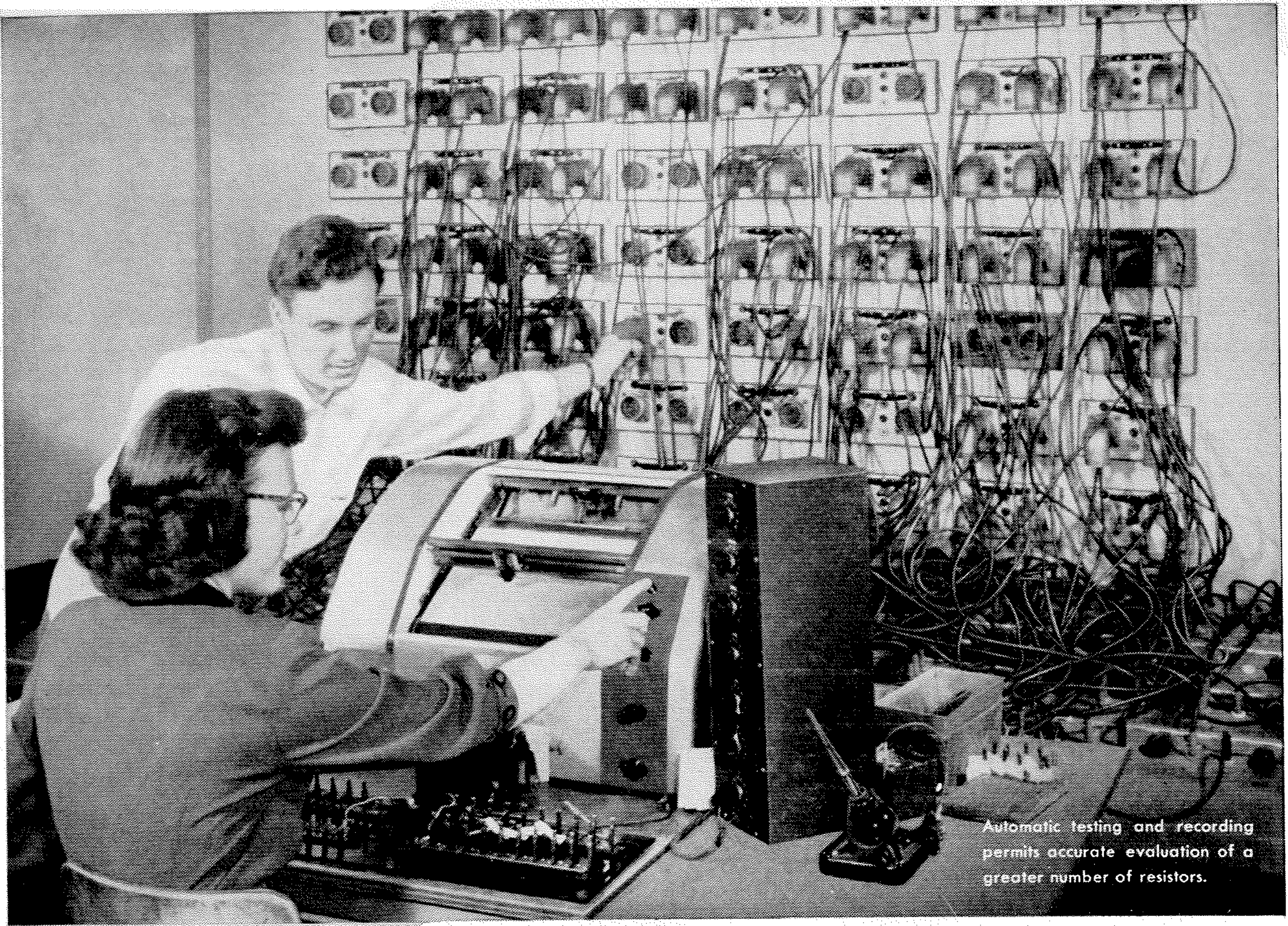
Congratulations to the Alumni organization, and to Timothy Harrington, from an Alumni Scholar of another generation. (Boy, how time flies!)

Thomas H. Evans '29
Dean of Engineering

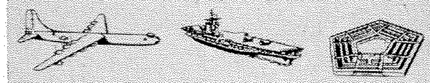
Colorado Agricultural and Mechanical College

In actual fact, the old Alumni Prize Scholarships were quite different from the present Alumni Scholarships. The Alumni Prize Scholars used to be selected by the alumni (not by the Caltech Committee on Undergraduate Scholarships and Honors, as the present Alumni Scholars are) and the funds were based on a note signed by the donor of the scholarship.





Automatic testing and recording permits accurate evaluation of a greater number of resistors.



BASIC REQUIREMENTS

JAN and MIL Specifications are basic guideposts for electronic advancement, whether used as engineering reference points or as procurement standards. IRC's dual emphasis on mass production and exacting testing assures highest performance standards at lowest possible cost.

SPECIFIC EXAMPLES

Type BT Insulated Composition Resistors
MIL-R-11A Specification

IRC Power Wire Wound Resistors
MIL-R-26B Specification

Type BW Low Wattage Wire Wounds
JAN-R-184 Specification

Sealed Precision Voltmeter Multipliers
JAN-R-29 Specification

ONLY IRC MAKES SO MANY JAN AND MIL TYPE RESISTORS

. . . another reason why engineers prefer IRC Resistors

56 different IRC resistors is today's figure—all equivalent to JAN or MIL specifications. Manufacturers of military equipment who must meet these specifications depend on IRC for all their resistor requirements. Offering the widest line of resistors in the industry—138 different types in all—IRC is the logical source of JAN and MIL type units.

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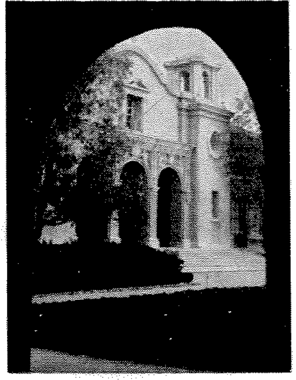
CALTECH CALENDAR

February, 1955



ALUMNI CALENDAR

April 16	Seminar Day
June 8	Annual Meeting
June 25	Annual Picnic

FRIDAY DEMONSTRATION LECTURES

Lecture Hall, 201 Bridge, 7:30 p.m.

Feb. 18—

Search for Uranium and Thorium in Southern California—
Dr. D. Foster Hewett

Feb. 25—

Flames and Explosions—
Dr. Stanford S. Penner

March 4—

Phenomena Near Absolute Zero—
Dr. John R. Pellam

March 11—

High Speed Photographic Studies of Strain Waves and Cavitation Bubbles—
Dr. Albert T. Ellis

March 18—

Transistors and Other Semiconductor Devices—
Prof. Francis S. Buffington

ATHLETIC SCHEDULE

Varsity Basketball

Feb. 18—Caltech at Nazarenes
Feb. 19—Caltech at L.B. State
Feb. 22—Occidental at Caltech
Feb. 25—Caltech at Pomona

Varsity Track

Feb. 26—LaVerne, Nazarenes, & Cal Poly at Caltech
March 5—All Conference Relays at Pomona
March 11—Whittier & Caltech vs. Occidental at Caltech

Varsity Baseball

Feb. 22—Nazarenes at Caltech
Feb. 26—Nazarenes at Caltech
March 5—Caltech at LaVerne
March 9—Cal Baptist at Caltech

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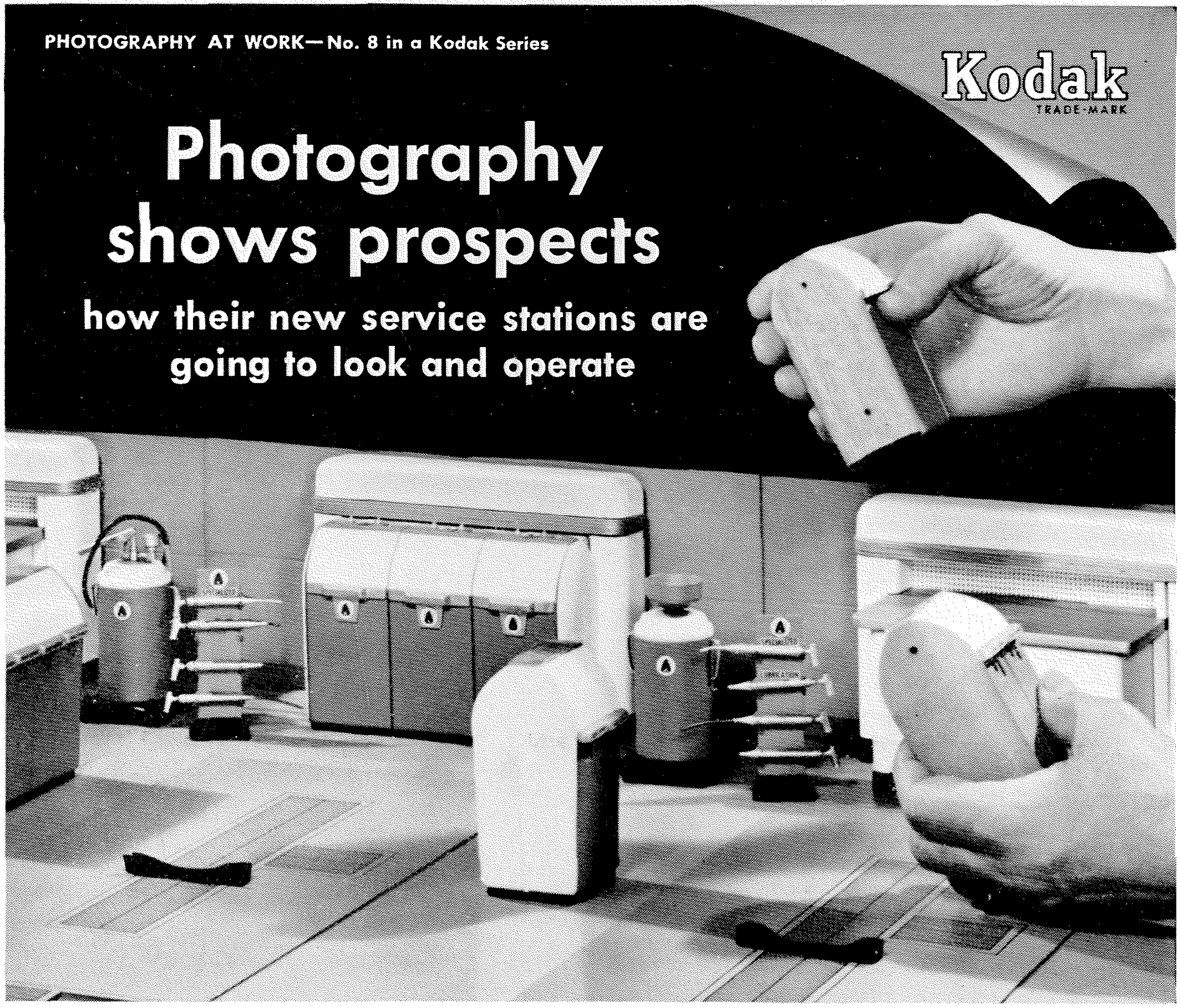


PHOTOGRAPHY AT WORK—No. 8 in a Kodak Series

Photography shows prospects

how their new service stations are going to look and operate

Alemite sets up scale models of their service station equipment on the customer's own floor plan—photographs them—and portrays the new custom-built station ready for action

SALESMEN don't just pull lube racks, grease pumps and other service station equipment out of a sample case. They're far too big—far too bulky. Besides, final location and arrangement count heavily in how well they are going to work out.

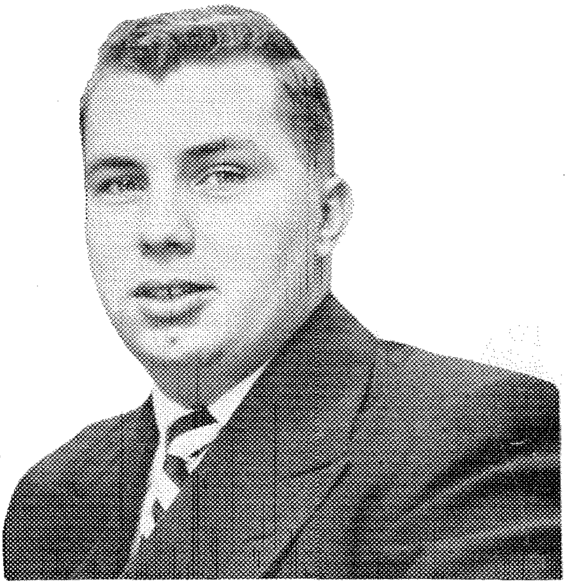
The Alemite Division of Stewart-Warner solves the problem with photography. Prospects see new service station equipment virtually right in their own premises.

It works this way. The salesman sends in a rough sketch of the space available, with windows and columns marked. Experts fit exact replicas of racks, lifts, and other equipment to the plan, then put the camera to work. The customer pictures his new station—modern, efficient, handsome—and the sale is well on its way. It's an idea for any company with bulky products to sell. Photography is a great salesman for any business, large or small. And it's very much more. It works in all kinds of ways to save time, cut costs, reduce error and improve production.

Graduates in the physical sciences and in engineering find photography an increasingly valuable tool in their new occupations. Its expanding use has also created many challenging opportunities at Kodak, especially in the development of large-scale chemical processes and the design of complex precision mechanical-electronic equipment. Whether you are a recent graduate or a qualified returning service man, if you are interested in these opportunities, write to Business & Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N.Y.

Eastman Kodak Company, Rochester 4, N.Y.

JOHN B. NOLTE, Purdue University '54, asks:



"What is G.E.'s Manufacturing Training Program?"

The Manufacturing Training Program at General Electric is a program of basic training for manufacturing leadership, including planned rotational work assignments and related classroom study for outstanding young men who are interested in a career in manufacturing. It was organized to meet the increased demand for effective manufacturing leadership and technical "know how," in line with the expansion and development of the Company's operations by developing trained men to fill future key positions in the organization.

Who is eligible for this program?

In general, the Program is open to college graduates with degrees in engineering and science, and a limited number of business administration and liberal arts graduates. We are looking for outstanding young men with sound educational backgrounds, well-balanced personalities, demonstrated thinking abilities, and having the potential to develop toward top level responsibility in key assignments.

How long is the program?

The normal length of the Program is three years. Assignments are normally 6 months in duration and provide experience opportunities in diversified manufacturing operations. Geographical moves occur at annual intervals.

What type of work assignments are made?

Work assignments are provided in all phases of manufacturing and related functions so that each man will acquire knowledge of manufacturing engineering, including manufacturing methods and techniques, shop operation, production control, personnel administration, labor relations, engineering activities, sales and manufacturing co-ordination, and general business administration.

In addition to job assignments, related study courses cover such subjects as Company organization, manufacturing operations, labor and personnel relations, business administration, law and relationships between manufacturing and other functions of the business. Progress on the job and in classroom work is carefully observed and reviewed periodically with each man to assist him in his career.

What happens after training is completed?

After completing the training program, graduates are placed in operating departments and divisions throughout the Company in positions where leadership and initiative are needed. All placements are made in relation to the aptitudes, abilities, and interests of the graduates.

At General Electric, manufacturing operations involve the administration and supervision of activities of more than 100,000 men and women in more than 100 plants, who are involved in the making of some 200,000 different products.

The wide scope of these activities, the great variety of products, and the diversity of manufacturing activities offer limitless opportunities and exciting challenges to college graduates today.

Manufacturing training is a foundation for leadership—and an opportunity to build a satisfying, rewarding career in one of America's most important industries.

If you are a graduate engineer, or a graduate with definite technical inclinations that include an interest in the career possibilities in manufacturing, see your college placement director for the date of the next visit of the General Electric representative on your campus. Meanwhile, for further information on opportunities with General Electric write to Manufacturing Training Services Section, Bldg. 36, General Electric Company, Schenectady 5, New York.

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